

# BONNER ZOOLOGISCHE MONOGRAPHIEN

Nr. **56**  
2011

Herausgeber: Zoologisches Forschungsmuseum Alexander Koenig, Bonn



*Olaf Jahn*

**BIRD  
COMMUNITIES  
OF THE  
ECUADORIAN  
CHOCO:  
A CASE  
STUDY IN  
CONSERVATION**

# BONNER ZOOLOGISCHE MONOGRAPHIEN

Schriftleitung / Editor

Karl-L. Schuchmann

Zoologisches Forschungsmuseum Alexander Koenig (ZFMK)

Ornithologie

Adenauerallee 160

D-53113 Bonn, Germany

Email: kl.schuchmann.zfmk@uni-bonn.de

Die Reihe BONNER ZOOLOGISCHE MONOGRAPHIEN (BZM) erscheint seit 1971 in regelmäßiger Folge. Publiziert werden Originalbeiträge in englischer Sprache. Die BZM nehmen vor allem solche Arbeiten auf, die zu umfangreich sind, um in der Zeitschrift BONN ZOOLOGICAL BULLETIN zu erscheinen. Schwerpunkte der BZM sind: Systematik, Taxonomie, Biogeographie, Anatomie und Evolutionsbiologie. Alle eingereichten Manuskripte werden begutachtet. Autoren werden gebeten, sich vor Manuskriptvorlage mit dem Schriftleiter in Verbindung zu setzen.

Erwerb der BZM: Bibliothek, Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Adenauerallee 160, D-53113 Bonn, Germany, Kontakt: d.steinebach.zfmk@uni-bonn.de.

The peer-reviewed series BONNER ZOOLOGISCHE MONOGRAPHIEN (BZM) has existed since 1971. The BZM consist of original zoology papers too long for inclusion in our institute's journal BONN ZOOLOGICAL BULLETIN. Preferred manuscript topics are: systematics, taxonomy, biogeography, anatomy, and evolutionary biology. Manuscripts must be in American English. Authors are requested to contact the editor prior to manuscript submittal.

The BZM may be obtained from: The Library, Alexander Koenig Zoological Research Institute and Museum of Zoology, Adenauerallee 160, D-53113 Bonn, Germany, contact: d.steinebach.zfmk@uni-bonn.de.

Author of this issue: Olaf Jahn

Published: December 2011

Bonner zoologische Monographien Nr. 56, 514 pp.

This issue was financially supported by Sparkasse KölnBonn, Conservation International - Ecuador, and Corporación Sociedad para la Investigación y Monitoreo de la Biodiversidad Ecuatoriana.

Editorial assistants: Alexandra Schuh and Brian Hillcoat.

Cover: Uniform Crake (*Amaurolimnas concolor guatemalensis*) with pulli on nest platform, Playa de Oro, Esmeraldas, Ecuador, photograph by Olaf Jahn.

Price: EUR 155,-



*Olaf Jahn*

BIRD COMMUNITIES OF THE  
ECUADORIAN CHOCO:  
A CASE STUDY IN CONSERVATION

*Dedicated to*

Hannelore and Werner Jahn,  
Rocío Alarcón,  
the late Ruth Moore, and John V. Moore  
for all their encouragement and support, and  
the people of Playa de Oro,  
in whose hands the future of a spectacular landscape,  
mystic forest, and unique biodiversity lies.

## CONTENTS

Abstract.....	9
Acknowledgments.....	10
Abbreviations.....	12
1. General introduction.....	15
The broader context.....	15
Aims of the study.....	15
General aims.....	15
Specific aims.....	16
Design of the publication.....	16
2. Study area.....	19
Introduction to the country.....	19
The Chocó region.....	20
Biogeographical aspects.....	20
Bioclimatic setting of western Ecuador.....	21
Conservation status of the Ecuadorian Chocó.....	21
Playa de Oro.....	23
Historical and socio-economic aspects.....	23
Location, topography, geology, and soils.....	23
Sunrise, sunset, and daylight period.....	24
Climate and El Niño.....	24
Life zones.....	26
Natural formations – main vegetation types.....	26
Vegetation cover and land use.....	27
Comparison with other Neotropical sites.....	28
Principal design of the study.....	29
3. Habitats.....	33
Introduction.....	33
Methods.....	34
Mapping of habitats, vegetation structure, and human impact.....	35
Characterization of main habitats of the mist-netting transects.....	36
Data analysis.....	36
Results.....	38
The habitats covered by the transect network.....	38
The habitats of the mist-netting transects.....	38
The MNT1 habitats: a qualitative characterization.....	40
The MNT2 habitats: a qualitative characterization.....	42
Structural features of the main habitats of MNT1 and MNT2.....	45
Discussion.....	55
The habitats covered and the completeness of bird surveys.....	55
The main habitats of the mist-netting transects.....	55
Structural features of the open-country samples.....	55
Structural features of the young successional forest samples.....	57

Structural features of the medium-age forest samples.....	59
Identified biases and challenges.....	60
Conclusion.....	62
4. Surveying tropical bird communities: in search of an appropriate rapid assessment method.....	63
Introduction.....	63
Methods.....	64
Mist-netting study.....	65
Transect-mapping study.....	66
Reasoning for the selection of the survey method.....	66
The transect-mapping (MTW) protocol of the pilot study.....	67
Data collection in transect-mapping surveys.....	70
Dates and effort of surveys.....	70
Non-standardized observation hours.....	70
Bird species identification and taxonomy.....	71
Data analysis.....	71
Results.....	73
Mist-netting study.....	73
Transect-mapping study.....	75
Transect-mapping study of MNT1 and MNT2.....	75
Complete MTW study of the transect network.....	77
Standardized and non-standardized surveys.....	77
Comparative aspects.....	77
Species richness and species accumulation.....	77
Influence of taxonomic affinities.....	80
Influence of body size.....	82
Influence of breeding/non-breeding status and territory/home-range size.....	83
Influence of habitat.....	85
Influence of main survey stratum.....	88
Discussion.....	88
Comparative effectiveness and efficiency of mist-netting and audiovisual surveys.....	88
Species richness and species accumulation.....	88
Influence of taxonomic affinities.....	92
Influence of body size.....	95
Influence of breeding/non-breeding status and territory/home-range size.....	95
Influence of habitat.....	98
Influence of main survey stratum.....	98
Comparison of MTW with other potential rapid assessment methods.....	99
Guidelines for an optimized transect-mapping protocol for rapid assessments.....	103
Conclusion.....	106
5. Structure and organization of the bird community.....	109
Introduction.....	109
Methods.....	110
Bird survey methods.....	110
Data analysis.....	110
Characterization of the bird community of Playa de Oro.....	110
Estimation of population densities on the basis of transect-mapping data.....	110
Species richness estimators.....	115
Species-abundance relationship, species diversity, and similarity coefficients.....	116



Other statistical methods.....	117
1000-capture sample for <i>terra firme</i> forest.....	117
Results .....	117
The bird community of Playa de Oro .....	117
Species richness and confirmation status.....	117
Taxonomic affinities .....	118
Breeding/non-breeding status, seasonal movements, and related aspects.....	119
General habitat selection .....	119
Main foraging strata .....	119
Foraging guilds and diet .....	120
Body size relationship .....	123
Foraging flocks and foraging associations .....	126
The bird community of human-influenced habitat mosaics.....	135
Observed and estimated species richness .....	135
Species-abundance relationship.....	140
Species diversity.....	142
Similarity between transects MNT1 and MNT2.....	143
Body size relationship and guild structure.....	146
Population density and biomass .....	147
Available area per breeding territory .....	149
1000-capture sample for <i>terra firme</i> forest.....	150
Discussion.....	151
Comparability of relative abundance values in bird studies .....	151
Comparison with other Neotropical sites.....	155
The bird community of human-influenced habitat mosaics.....	161
Performance of species richness estimators.....	161
Performance of diversity indices and similarity coefficients .....	163
How real are the modeled community data based on transect mapping? .....	164
Comparison of the community structure at MNT1 and MNT2 with other sites.....	166
Guidelines for the use of transect mapping (MTW) in monitoring studies.....	169
Conclusion.....	175
6. Conservation status, habitat selection, and indicator species.....	179
Introduction.....	179
Methods.....	179
Collection of habitat and bird data.....	179
Endemic and threatened species.....	179
Flagship and umbrella species.....	180
Life zone assemblages.....	180
Assessment of the conservation value of MNT1 and MNT2 .....	181
Data analysis.....	182
Multivariate analysis.....	182
Determination of indicator species.....	184
Other statistical methods.....	185
Results .....	185
Endemic species .....	185
Threatened species .....	188
Surrogate species .....	188
Flagship species.....	188

Umbrella species.....	192
Life zone assemblages.....	193
Avian habitat selection and indicators in human-influenced mosaic landscapes .....	193
Multivariate analysis .....	193
Indicator species.....	198
Assessment of the conservation value of MNT1 and MNT2 .....	201
Discussion.....	202
Tropical birds as indicators for biodiversity, forest condition, and environmental change .....	202
Assessing birds with objective criteria for the selection of indicator taxa.....	202
Birds as surrogates in biodiversity .....	209
Birds as indicators of environmental change .....	210
Assessing conservation value at the local level.....	216
The example of transects MNT1 and MNT2.....	216
Recommendations for the use of the 'bird community index' .....	217
Avian habitat selection and indicators in human-influenced mosaic landscapes .....	218
Identified biases and challenges .....	218
Influence of the survey methods.....	218
What do we know about the original habitats of open-country species?.....	219
Few species show a strong association with secondary forest and edges.....	220
Forest species .....	220
Conclusion.....	221
7. The use of avifaunistic data for adaptive management of biological resources .....	223
Introduction.....	223
Methods.....	223
Results .....	225
Discussion.....	226
How transect mapping improved conservation efforts.....	226
Data on threatened birds changed the land-use planning in Playa de Oro .....	226
Transect mapping generated important data at many other sites.....	228
Did the land-use zonings survive the end of SUBIR?.....	228
Lessons learned for the use of transect mapping.....	228
Transect mapping as a tool for adaptive management.....	229
The challenge of biodiversity conservation in managed tropical forests.....	238
Conclusion.....	239
8. Summary.....	241
9. Resumen.....	243
10. Zusammenfassung.....	245
11. References .....	247
12. Plates .....	280
13. Appendices.....	292
Appendix 1:	
Summary of complete (not standardized) mist-netting study .....	292

Appendix 2:	
Summary of standardized mist-netting study of MNT1 and MNT2.....	295
Appendix 3:	
Summary of transect-mapping study.....	297
Appendix 4:	
System of 6-letter codes for scientific names of South American birds.....	306
Appendix 5:	
Birds of Playa de Oro: 6-letter codes, subspecies, English names, and taxonomy.....	311
Appendix 6:	
Birds of Playa de Oro: status of confirmation, type of record, abundance rank, breeding/non-breeding status, and core/non-core species .....	327
Appendix 7:	
Birds of Playa de Oro: published erroneous records.....	349
Appendix 8:	
Birds of Playa de Oro: altitudinal range, abundance rank per life zone, and habitat selection .....	350
Appendix 9:	
Birds of Playa de Oro: territoriality, foraging flocks and aggregations, use of strata, main foraging and survey strata, foraging guilds, and body masses .....	365
Appendix 10:	
Mist-netting study: number of birds captured per species in the complete (not standardized) surveys .....	380
Appendix 11:	
Birds of Playa de Oro: body masses and morphometric data of living birds.....	385
Appendix 12a:	
Standardized mist-netting and MTW surveys of transect MNT1 .....	420
Appendix 12b:	
Standardized mist-netting and MTW surveys of transect MNT2 .....	429
Appendix 13a:	
MNT1: influence of taxonomic affinities on bird species detectability.....	437
Appendix 13b:	
MNT2: influence of taxonomic affinities on bird species detectability.....	444
Appendix 13c:	
MNT1 and MNT2: influence of taxonomic affinities on bird species detectability.....	450
Appendix 14a:	
MNT1: influence of body size on bird species detectability .....	454
Appendix 14b:	
MNT2: influence of body size on bird species detectability .....	457
Appendix 14c:	
MNT1 and MNT2: influence of body size on bird species detectability.....	460
Appendix 15a:	
MNT1: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability .....	462
Appendix 15b:	
MNT2: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability .....	465
Appendix 15c:	
MNT1 and MNT2: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability.....	468

Appendix 16a:	
MNT1: influence of habitat selection on bird species detectability.....	470
Appendix 16b:	
MNT2: influence of habitat selection on bird species detectability.....	472
Appendix 16c:	
MNT1 and MNT2: influence of habitat selection on bird species detectability.....	474
Appendix 17a:	
MNT1: influence of main survey stratum on bird species detectability.....	475
Appendix 17b:	
MNT2: influence of main survey stratum on bird species detectability.....	477
Appendix 17c:	
MNT1 and MNT2: influence of main survey stratum on bird species detectability.....	479
Appendix 18a:	
MTW-study: detection threshold distance, abundance, population density, and biomass of the bird community in the transect area of MNT1 .....	480
Appendix 18b:	
MTW-study: within-habitat abundance, population density, and available area per territory of the bird community in the transect area of MNT1 .....	490
Appendix 19a:	
MTW-study: detection threshold distance, abundance, population density, and biomass of the bird community in the transect area of MNT2.....	499
Appendix 19b:	
MTW-study: within-habitat abundance, population density, and available area per territory of the bird community in the transect area of MNT2.....	507



## ABSTRACT

Between 1995 and 1998 I studied bird communities through mist netting (MN) and the 'Multi Time-Window Transect-Mapping' (MTW) technique for audiovisual surveys of tropical bird communities. The research was carried out in Playa de Oro (0°52'35"N, 78°47'40"W; 45-590 m a.s.l.), Esmeraldas, northwestern Ecuador. A total of 344 bird species are known to occur, though I presume that >400 species might be present in the study area, or migrate through it, on a regular basis. I sampled 18 transects (25.14 km), using the MTW method for rapid assessments. In order to perform a comparative study of the effectiveness of mist-netting and transect-mapping protocols, I chose two independent transects, MNT1 (625 m) and MNT2 (550 m), which were studied with both methods. They were located in a similarly structured habitat mosaic of cultivated land and selectively logged forest. The greater variety of human-managed habitats was the principal cause for higher species richness and diversity at MNT1 ( $n_{MN} = 117$ ;  $n_{MTW} = 162$ ) in comparison with MNT2 ( $n_{MN} = 96$ ;  $n_{MTW} = 144$ ). Nevertheless, according to the MTW data, the number of forest-dependent species (MNT1 = 78, MNT2 = 90) and threatened taxa (world: MNT1 = 4, MNT2 = 7; Ecuador: MNT1 = 37, MNT2 = 48) was higher at MNT2, likely due to the lower degree of fragmentation, higher foliage complexity, and lower hunting pressure. Biomass density was almost identical, with an estimated 193 kg/km<sup>2</sup> for MNT1 and 198 kg/km<sup>2</sup> for MNT2. The number of breeding 'pairs' was roughly 2000 /km<sup>2</sup> and 1800 /km<sup>2</sup>, and the average biomass per individual 36 g and 41 g, respectively. In conclusion, the conservation value of study sites should be ranked on the basis of a detailed comparison of habitat association as well as threat status of the bird species present, whereas species richness, diversity indices, and biomass density should not be used in this context. For example, the 'bird community index' (BCI) sensu Canterbury *et al.* (2000) clearly reflected the higher value of MNT2 in comparison with MNT1 for the conservation of forest-dependent birds (BCI: MNT1 = -0.049 versus MNT2 = 0.541). Regarding the comparative effectiveness and efficiency, the results indicate that, in only 8-9% (21-23 h) of the study time, 39-50% (45 and 48) more bird species were recorded by transect mapping than by mist netting. High costs and low time efficiency, as well as inaccurate representation of entire bird groups, make the use of mist netting prohibitive for most survey purposes, unless the status and habitat selection of altitudinal and latitudinal migrants are concerned. Transect mapping is highly effective at detecting avian taxa that regularly vocalize. However, dispersing birds, floaters, long-distance migrants on passage, and very silent breeding residents were overlooked or underestimated. Thus, I developed optimized MTW protocols to further increase bird species detectability. For instance, implementing the specifically designed MTW monitoring protocol, a well-trained observer might record *c.* 70% of the total species richness and 80-90% of all breeding residents present in the transect area within as little as six days. For transects of up to 1200 m, sufficient data for rough estimations of absolute population and biomass densities can be obtained in the same period.

*Key words:* Abundance, adaptive management, Aves, BCI, biological indicators, biological resources, biodiversity conservation, biomass, bird community index, birds, body size, Chocó, conservation value, detectability, diversity indices, Ecuador, endemic species, environmental change, Esmeraldas, forest management, guild structure, habitat mosaic, habitat selection, indicator species, land-use planning, mist netting, monitoring, Multi Time-Window Transect Mapping, multivariate analysis, MTW, Neotropics, Playa de Oro, population density, rapid assessments, richness estimators, similarity coefficients, survey bias, survey methods, tropical forest, threatened species, territory size, transect mapping.

## ACKNOWLEDGMENTS

A work of this scope would have been impossible without the assistance of so many people who supported me at every stage of its development. The following list will be far from complete, and I want to thank anyone who was at some point involved in the project.

First and foremost I owe an enormous debt to the people of Playa de Oro. Their hospitality and continued support during the 480+ days I spent on their land between 1995 and 2005 were essential for the success of this project.

My studies from 1995 through 1998 in Playa de Oro were part of the 'Flanking Program for Tropical Ecology' (TÖB; project no. 90.2136.1-03.100) of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, and was coordinated by the Zoological Research Museum Alexander Koenig (ZFMK), Bonn, Germany. The research would have been impossible without additional funding by the Brehm Fund for International Bird Conservation, Bonn, Germany. The project was carried out in cooperation with the Fundación para el Estudio e Investigación de los Colibríes Ecuatorianos (FEICE), Quito, as a national partner, with the Fundación Ecuatoriana de Estudios Ecológicos (EcoCiencia), Quito, as a logistical partner, and with the logistic help, for which I am most grateful, of the SUBIR Project, CARE Ecuador, and the Deutscher Entwicklungsdienst (DED), Berlin, Germany, and Quito, Ecuador. Between 1998 and 2001, I performed field work in the Ecuadorian Chocó for EcoCiencia with the generous financial support of the SUBIR Project, CARE Ecuador, USAID, Washington, USA, and The John D. and Catherine T. MacArthur Foundation, Chicago, USA. Concluding research and data analysis were made possible through generous funding by the Population Biology Foundation, Grand Junction, USA, and the Brehm Fund for International Bird Conservation, Bonn, Germany. I would like to thank the Bonner Zoologische Monographien, Conservation International – Ecuador (CI-Ecuador), and Corporación Sociedad para la Investigación y Monitoreo de la Biodiversidad Ecuatoriana (SIMBIOE) for sharing the printing costs of the present work; the Instituto Ecuatoriano Forestal de Áreas Naturales y Vida Silvestre (INEFAN), Quito, and the Ministerio del Ambiente del Ecuador (MAE), Quito, for issuing the research permissions; the communities of Playa de Oro, San Miguel, Agua Blanca, Corriente Grande, Guadual, Gualpi de Ónzole, Colón de Ónzole, Palma Real, La Pampa, Majua, and Tsejpi for permission to work on their lands; and the many field assistants for their much needed help, which made my work in often extremely remote areas possible.

I am grateful to Rocío Alarcón whose continued encouragement and support helped me survive the most challenging years of my life; the late Ruth Moore and John V. Moore, whose engagement in promoting knowledge on bird sounds and in conserving Ecuadorian biodiversity will be remembered forever; Prof. Dr. Karl-L. Schuchmann for his crucial help in raising research funds, for supervising my thesis project, for his invaluable support over all the years it took to conclude, and for providing basic funding for printing the present publication through the Bonner Zoologische Monographien; Gertrud Schuchmann-Wegert for all her generous support during the final phase of the project; Luis Suárez and Paul Tufiño for co-financing the printing of the monograph through a CI-Ecuador/SIMBIOE grant; Dr. Jody Stallings for the opportunity to apply the transect-mapping technique presented here within the scope of the SUBIR Project; Dr. Peter Horschler for all his help in the establishment of methods for the habitat characterizations and for indispensable support concerning multivariate analyses, TWINSPAN, IndVal, and other analysis tools. Dr. Patricio Mena V. for extensive discussions on survey methods and interchange of knowledge; Dr. Ulrike Wittmann for all the help during the first years of the project and for her comments on the manuscript; Prof. Dr. Peter Feinsinger, Prof. Dr. David L. Pearson, and Prof. Dr. Martin Schaefer for excellent remarks on early drafts of my Ph.D. thesis and logistic support during its preparation; Dr. John H. Rappole and an anonymous reviewer for their critical comments on the manuscript; Brian Hillcoat for proofreading the first draft; Paul Van Gasse for his many suggestions on style and punctuation of the English, Spanish, and German texts, for conscientiously reviewing the bird names and references, and for thoroughly proofreading the pre-final draft; Prof. Dr. Wolfgang Böhme for accepting the role of the second thesis reviewer; Dr. Mark Hill (TWINSPAN), Dr. Robert K. Colwell (EstimateS), and Dr. Marc Dufrêne and Dr. Pierre Legendre (IndVal), for making helpful software programs available to a wide audience; Susana Arroyo, Julia Beintmann, Jessica Brandes, María Alexandra Endara G., Susanne Etti, Dr. Cornelia Hafner, Maria Eugenia Jara V., Marlies Leutfeld, Heike Lutermann, Petra Wester, Dumar Ayovi, Albino Corozo, Dr. Fabian Herder, Dr. Edgar Kaeslin, the late Juan

C. Matheus, Dirk Plätzen, Dino Renvert, Ulrich Stahlhut, Dr. Florian Werner, and Dr. Ulrike Wittmann for their help and assistance during the mist-netting study; Edwin E. Vargas G. for his assistance during the transect-mapping study; P. Gabriela Castañeda G., Anna C. Treydte, Katja Kunz, Nadia Vieira, Martín R. Bustamante R., Albino Corozo, Asinto Corozo, Fabricio Guaman M., Dr. Peter Horchler, Hugo F. Mogollon P., and Ricardo F. Oliva P. for their help during the characterization and mapping of the habitat types along the transects; Domingo Arroyo, Isaias Arroyo, Jimmy Arroyo, José Arroyo, Julio Arroyo, Marco Arroyo, Fredul Caisero V., and Albino Corozo for the maintenance of the 25.15 km transect network in Playa de Oro and the transportation of the field equipment; Gualberto Añapa, Raúl Añapa, Carlos Aparicio, Desiderio Arboleda, Pastor Arroyo, Mario Ayovi, Darwin Caicedo, Miguel Chapiro, Otto Corozo, Domingo Medina, Angel W. Nazareno, and Germán Vernaza for their assistance during my field work between 1998 and 2001; Fernando Rodríguez, Guillermo Sanchez, and Belen Herrera for the preparation of the maps; Prof. Dr. Laura Arcos, Universidad Católica del Ecuador, Quito, for her help in finding various dedicated students, interested in the project; the late Paul Coopmans, whose exceptional knowledge on Ecuadorian bird sounds will remain unmatched for many years to come, and Dr. Robert S. Ridgely for the identification of various tape-recorded bird vocalizations; Dr. Ericson López I., Observatorio Astronómico de Quito, for the calculation of the exact hours of sunrise and sunset in 1998 at Playa de Oro; Sandra Loor-Vela for revising the Spanish summary; Mirella Espinoza T. for preparing the Spanish summary and for bearing with me through the long and difficult time of field work and data analysis; and to my parents for encouraging me during all those years and for supporting me in every possible way.

The following people provided much appreciated logistic help and/or interchanged information: Veronica Benítez, Karl S. Berg, Julio Bernal, Friederike Böttcher, Markus Böttcher, Dr. Heike Brieschke, Angie Buitron, Dr. Stuart Butchart, Adriana Cárdenas, Fernando Carillo, Carlos Carrera R., Olivier Chassot, Dan Codea, Rubén Cueva, Ian Davidson, Hans-Peter Debelius, Dr. Carsten F. Dormann, Fernando Echeverría, Volker Eschen, Lorena Falconi, Dr. Lorenzo von Fersen, Dr. Robert Fimbel, Prof. Dr. Jon Fjeldså, Dr. Martin Flade, Juan Freile, Tatiana Frias, Mario García S., Jürgen Geldbach, Tarsicio Granizo, Dr. Richard D. Gregory, Esteban Guevara, Richard Haep, Ingo Heimfeld, Thomas Heindrichs, Dr. Sebastian K. Herzog, Eric von Horstman, Dr. Alex E. Jahn, Thorsten Jolitz, Rosa Jordan, Dr. Edgar Kaeslin, Dr. Jordan Karubian, the late Elisabeth Kietzmann, Dr. Friedemann Köster, Dr. Niels Krabbe, Reinhard Krusche, Marlies Leutfeld, Dr. Jörg Linke, Alyssa Luboff, Mitch Lysinger, the late Juan C. Matheus, Lilly de Matheus, Edwin Mediavilla, Galo Medina, Johanna Mew, Guisselle Monge A., Margarita Mora, Manuel Morales, Dr. Antje Müllner, Ruth Muñoz L., Xavier Muñoz C., the late Prof. Dr. Clas M. Naumann, Lelis Navarrete, Jörg Neumann, Heike Nowatzki, Erika Olmedo, Dorothea Otto, Byron Palacios, Walter Palacios, Rocio Pastillo, Christian Peter, Dr. Gustav Peters, Dr. Albrecht Pfrommer, Lindon Prado, Francisco J. Prieto A., Dr. Klaus, Riede, Dr. Günter Riethmacher, Mercedes Rivadeneira, Dr. Mark B. Robbins, Dr. Paul Salaman, Torsten Schmidt, Dr. Veronica Schmidt, Gertrud Schuchmann-Wegert, Alexandra Schuh, Danilo Silva C., Francisco Sornoza M., Yves de Soye, Klemens Steiof, Dr. Jeffrey Stratford, Luis Suárez M., Ewa Szpala, Christian Terán, David Thomas, Paúl Tufiño, Roberto Ulloa, Charlie Vogt, Dr. Thomas R. Walla, Dr. André Weller, Prof. Dr. Matthias Winiger, and Dr. Doris Zimmermann.

This work was accepted as a Ph.D. thesis by the Fac. of Mathematics and Life Sciences, Rheinische Friedrich-Wilhelms-Universität Bonn, Germany, in January 2005.

## ABBREVIATIONS

ANOVA	analysis of variance
BCI	Bird Community Index sensu Canterbury <i>et al.</i> 2000
BDFFP	Biological Dynamics of Forest Fragments Project, Manaus, Brazil
c.	circa (about)
CA	Correspondence Analysis
CARE	Cooperative for American Relief Everywhere
CCA	Canonical Correspondence Analysis
cf.	confer, compare
DBH	diameter at breast height; measured at 1.3 m above the ground
DCA	Detrended Correspondence Analysis
DCCA	Detrended Canonical Correspondence Analysis
DTD	detection threshold distance
EBA	Endemic Bird Area
Ec	Ecuador
elev.	elevation (m above sea level)
F	test statistic of the F test; in ANOVAs the F-value expresses the 'between samples variance' divided by 'within samples variance'. The degrees of freedom of the number of samples and the number of measurements are indicated as subscript numbers of F (e.g., 'F <sub>5,36</sub> ' is the difference in means of 6 samples, where n = 7 in each case).
FAO	Food and Agriculture Organization of the United Nations
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
H <sub>0</sub>	null hypothesis
H <sub>1</sub>	alternative to a null hypothesis
HSD	'honestly significant difference' tests for pair-wise multiple comparisons sensu Tukey (1977), which were performed when final F values of the ANOVAs indicated a significant difference between the means of the groups analyzed
IBA	Important Bird Area
ICDP	integrated conservation and development project
IndVal	Indicator Value
MN	mist netting
MN <sub>cap1</sub>	first captures for each complete mist-netting survey
MN <sub>cap2</sub>	all kinds of captures, including recaptures
MN <sub>fc</sub>	first captures for the complete study of each transect
MNH	mist-net hours
MNT1	Mist-Netting Transect 1
MNT2	Mist-Netting Transect 2
MTW	Multi Time-Window Transect Mapping
MTW <sub>c</sub>	raw MTW data of each survey, including repeated records for some individuals



MTW <sub>pop</sub>	the modeled MTW population data for areas of one square kilometer (= 100 ha) per transect
n	number of sampling units
n <sub>exp</sub>	expected number
NMDS	Nonmetric Multidimensional Scaling
n <sub>obs</sub>	observed number
n <sub>spp</sub>	number of species
NSMH	net-square-meter-hours
p	probability; expressed in test statistics on a scale between 0 and 1
R <sup>2</sup>	coefficient of determination
RA	Reciprocal Averaging
r <sub>s</sub>	Spearman rank correlation coefficient
SD	standard deviation
SUBIR	Sustainable Use of Biological Resources Project
TWINSPAN	Two-way Indicator Species Analysis
U	test statistic of the Mann-Whitney U-test, which compares the medians of two unmatched samples in nonparametric tests, for up to 20 sampling units
UNEP	United Nations Environmental Program
USAID	United States Agency for International Development
viz.	videlicet, namely, that is to say
vs.	versus (in comparison with)
z	standard deviation unit of the normal curve; in Mann Whitney U-tests z-scores are used for samples with more than 20 sampling units in either group
$\chi^2$	Chi square: test statistic of the Chi-squared test



## 1. GENERAL INTRODUCTION

### The broader context

Over the past 50 years the natural environment has experienced the stresses imposed by a 2.3-fold increase in human population (U.S. Census Bureau 2003, 2004). There are now 6.7 billion people in the world, a figure that is increasing by c. 77 million per year (U.S. Census Bureau 2008), whereas an 'optimal' population size would be in the vicinity of merely 2 billion people (Daily *et al.* 1994). Human activities may have exceeded the biosphere's regenerative capacity since the 1980s, and this imbalance grew to about 120% in 1999 (Wackernagel *et al.* 2002). The accelerating loss of biodiversity arose as a major cause of concern because it implies a reduced ability of the world's ecosystems to provide key products and services for present and future generations (Ehrlich 1988, Pimm *et al.* 1995, UNEP 1999, 2002, 2007). Data are still very vague, but rough estimates indicate that we are losing around 0.5-1.5% of many natural habitats and species populations each year (Balmford *et al.* 2003, Jenkins *et al.* 2003). Land conversion, climate change, pollution, unsustainable harvesting of natural resources, and the introduction of exotic species are the most important drivers of these trends (Sala *et al.* 2000). The ultimate causes of biodiversity loss are, apart from human population growth, the continuing poverty of the majority of the world's inhabitants and excessive consumption by the minority (UNEP 2002).

At the present time, the total number of biological species inhabiting our planet remains unknown. Taxonomists have described about 2 million species (UNEP 2007), but many more are believed to exist, with estimates ranging from 5 million to almost 100 million (Erwin 1983, Wilson 1988b, Hammond 1992, Stork 1997, UNEP 2000). Recently, a figure of 14 million has been proposed as a reasonable working estimate, though uncertainties remain due to lack of information about the total number of invertebrate (e.g., insect and nematode), fungus, and bacteria species (UNEP 2002).

Tropical rain forest ecosystems are critically important for maintaining biological diversity (UNEP 2002). Although they cover only about 7% of the earth's surface, they may contain more than 50% of the planet's species (Wilson 1988b). About 68% of the world's remaining tropical rain forests are found in the Neotropics. In 1995 natural forest covered 48% of the total land area of the Latin American and

Caribbean region (FAO 1997), and 95% of it was tropical forest (humid and dry). However, logging, human-induced fires, clearance for cropland and cattle pastures, as well as mining and other large-scale development projects, are causing loss of forest cover in all countries. During 1980-1990 alone, the extent of forest in the region decreased by 6% (61 million ha), the largest absolute loss in the world during those years (FAO 1995). In the period 1990-2000 an additional 5% (42 million ha) of the forest cover in the Neotropics disappeared (FAO 2001, 2007). Although the numbers seem to indicate that deforestation rates are slowing down (cf. Archard *et al.* 2002), it has been pointed out that the figures are not fully comparable due to a recent change in the definition of 'forest' by the Food and Agriculture Organization of the United Nations (FAO), and also because the studies focus on a net rate of forest change in which destruction of natural forests is offset by plantation establishment (Holmgren & Davis 2000, Matthews 2001). Furthermore, some authors have questioned the low coverage of the remote sensing surveys used by FAO for the estimation of pantropical deforestation rates (Tucker & Townshend 2000, Stokstad 2001, Czaplewski 2002). Monastersky (1999) pointed out that existing calculations might underestimate total deforestation by up to 50%. Whatever the true numbers are, it is obvious that we have to decisively slow down the unsustainable exploitation of tropical forest ecosystems in order to minimize the magnitude of the ongoing anthropogenic extinction catastrophe.

### Aims of the study

#### General aims

The United Nations Conference on Environment and Development (UNCED), held in Río de Janeiro in 1992, was a landmark in the effort to define, and to agree on, international rules for the sustainable use of the planet's natural resources. One of the most important multilateral environmental agreements discussed in Río was the Convention on Biological Diversity (CBD), which came into force in 1993, and was signed by 187 contracting parties by 2006 (Secretariat of the Convention on Biological Diversity 2006). It was the first global agreement on the conservation and sustainable use of biodiversity and serves as a blueprint for national action. The convention establishes the following main goals: (1) the

conservation of biological diversity, (2) the sustainable use of its components, and (3) the fair and equitable sharing of the benefits from the use of genetic resources (UNEP 2002).

Fundamental aspects of the convention are the identification and monitoring of important “components of biological diversity” as well as of “processes and categories of activities, which [...] are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity [...]” (Articles 7a,b,c; UNEP 1992). The contracting parties are also encouraged “to introduce appropriate procedures requiring environmental impact assessments of [...] proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects [...]” (Article 14a). The importance of these issues for achieving the principal goal of sustainable use of natural resources was also stressed at the World Summit on Sustainable Development (WSSD), held in Johannesburg in 2002 (WEHAB 2002).

Because there is presently no widely accepted international standard for conducting environmental impact assessments, it is unclear to what extent basic data on local biodiversity are to be included in this process. For tropical regions, the lack of affordable and effective standard protocols for inventory and monitoring studies of at least some biological taxa has been a general barrier to the proper consideration of biological diversity data in the development of management strategies for natural resources. Besides the question of accurate data collection, the interpretation of biodiversity patterns remains hampered by our markedly incomplete knowledge of the natural history and ecology of most species.

I choose to focus on birds because they are probably the most appropriate ecological indicators for tropical habitats (Stotz *et al.* 1996); see p. 202–209, Assessing birds with objective criteria for the selection of indicator taxa. Studying a bird community in the megadiverse but threatened tropical lowland forest of northwestern Ecuador, it was my intention to address the following aims and potential solutions of how to assess biodiversity rapidly but accurately in the face of ongoing forest destruction.

The general aims of my study were:

- to develop standardized, effective, and affordable rapid assessment and monitoring methods for tropical bird communities;
- to demonstrate how avifaunistic data can be integrated in the development of adaptive management strategies for natural resources.

### Specific aims

The specific aims of the study were:

- to demonstrate that tropical birds can be more accurately as well as more time- and cost-efficiently surveyed by using a standardized transect-mapping protocol instead of mist netting;
- to present a comprehensive inventory of the birds of Playa de Oro, a previously poorly studied area in the Ecuadorian Chocó;
- to analyze the structure and organization of this avian community;
- to describe the habitats covered by the study transects and to examine the differences in vegetation structure of three habitat types in the Río Santiago floodplain and adjacent *terra firme* areas;
- to demonstrate differences in habitat selection between bird species;
- to provide data on potential indicator species for specific habitats and life zones;
- to present information on endemic species and on the conservation status of the bird community;
- to explain how avifaunistic data have been integrated in the decision-making procedures of a real-world development and conservation project carried out in the study area.

### Design of the publication

Playa de Oro is located in one of the least known tropical regions of the world: the Chocó center of endemism. It seems therefore vital to provide comprehensive information on biogeographical, physical, and environmental factors characterizing the area and influencing its bird communities (Chapter 2). In the same chapter I have also included a brief introduction to the country, a description of the conservation status of the Ecuadorian Chocó, and some background information on the local people.

The central part of the work is composed of five result chapters, commencing with the description of habitat types and vegetation structure of the study transects (Chapter 3). The second result chapter focuses on the methods I used for the bird surveys and provides a detailed comparative analysis of the effectiveness and efficiency of mist-netting vs. audiovisual protocols. The structure and organization of the avian community are examined in the following chapter. Chapter 6 addresses the conservation status and habitat selection of the bird taxa and presents lists of potential indicator species. The use of avifaunistic



data for an adaptive management of biological resources is demonstrated in the final chapter. Detailed information on survey dates, efforts, results, and effectiveness as well as on the composition, taxonomy, status, and ecology of the bird community, is provided in numerous appendices.

The data analysis was carried out in 2003/04 and the original manuscript was finished by Nov. 2004. Due to a lack of time it was impossible to include any newer data in the scientific analyses. Likewise,

more recent revisions on bird taxonomy (e.g., Banks *et al.* 2008, Remsen *et al.* 2011) had to be ignored throughout the main chapters and the appendices, with the exception of Appendix 5, where I address various taxonomic questions in detail. Only in a very few cases have I actualized the text with new information and references. This was particularly necessary in the sections on bird survey methods, both to reflect new developments and to include key publications that had been omitted in earlier drafts.



## 2. STUDY AREA

### Introduction to the country

Ecuador is located in western South America at the latitude of the equator, bordering the Pacific Ocean in the west, Colombia in the north, and Peru in the east and south (Fig. 1a). With a land area of 276 840 km<sup>2</sup> (including the Galapagos Islands) it is the fourth smallest country on the subcontinent. The population grows at an annual rate of about 1.9%, and is currently estimated at 13.7 million inhabitants, of whom 70% live below the poverty line (CIA 2003). The country has substantial oil resources and rich agricultural areas, and exports primary products such as petroleum, bananas, and shrimp, but fluctuations in world market prices can have a substantial domestic impact. Continued economic instability and low international competitiveness cause widespread underemployment and an estimated annual net emigration rate of 0.52 emigrants per thousand inhabitants in 2003.

Population growth and poverty have been important driving forces in the accelerating conversion of forest to cultivated land and, together with inadequate agricultural practices, the cause of rapid soil degradation in more arid areas of the Andean slopes and valleys as well as in the southwestern lowlands. Ecological degradation and the unsatisfactory living conditions of landless farmers caused periodic migration waves from traditional rural areas to the once unbroken rainforests of the northwestern and eastern lowlands (Vollmar 1971, Preston & Taveras 1976). In addition, wealthy people of the major cities, as well as national and international food companies, have acquired large areas of land for intensive livestock farming and large-scale cultivation of cash-crops like cacao, banana, coffee, palm oil, and soy. The rapid expansion of road systems into previously undisturbed forest areas, either through government projects, the oil and mining industries, or the timber

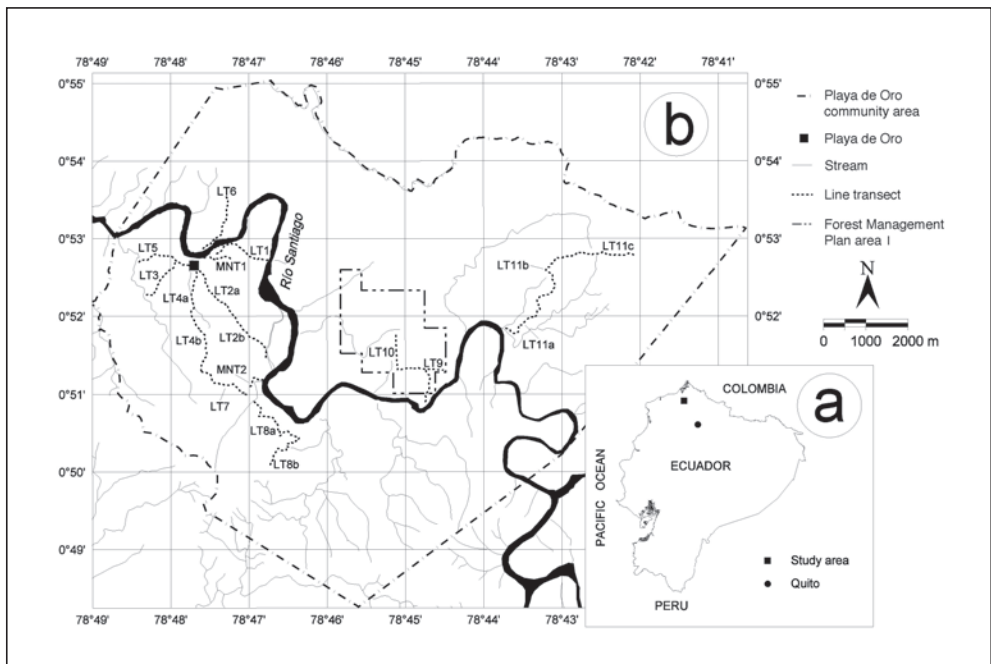


FIG. 1. Locations of: (a) the study area in Ecuador; (b) the area of the community of Playa de Oro, the transects studied (MNT = mist-netting transect, LT = line transect), and the area of the initial Community Forest Management Plan I that was established in 1996 by the SUBIR-Project in collaboration with the local people (Chapter 7).

companies, has been another catalyzing factor for the ongoing deforestation (Bromley 1981, Dodson & Gentry 1991).

The information on current deforestation rates in Ecuador is surprisingly sketchy. In several studies quoted by Sierra (1996), annual rates for the period 1981-1990 varied between 0.5 and 2.4%, and the area deforested between 60 000 and 400 000 ha per year (Corrales 2000). According to FAO (2007), 198 000 ha or 1.5% of the remnant forest cover disappeared annually in the decade 1990-2000. Absolute annual loss remained constant for the period 2000-2005, meaning that the deforestation rate increased to 1.7% per year, which corresponds to the fastest loss in all of South America.

## The Chocó region

### Biogeographical aspects

Historically, most authors regarded the Chocó as being the region that extends from the eastern Panamanian lowlands south through the Pacific lowlands and western Andean slopes of Colombia and Ecuador to the eastern end of the Golfo de Guayaquil (Chapman 1917, Gentry 1982, Cracraft 1985). Recently, Stattersfield *et al.* (1998) used range-restricted bird species (*sensu* Terborgh & Winter 1983) to identify areas of endemism at a global level. They separated the area of eastern Panama and extreme northwestern Colombia, including the Baudó mountains and the Río Atrato valley, as an Endemic Bird Area (EBA) of its own, the Darién Lowlands EBA. According to their comprehensive study, the Chocó EBA traverses the length of western Colombia and Ecuador, from Córdoba Dept. in the north to Cañar Province in the south, with some isolated pockets of humid Chocoan forest occurring as far south as El Oro Province. To the west the region is bordered by the Pacific and to the east by the temperate biome of the high Andes. In southwestern Ecuador it gradually turns into the dry biotas of the Tumbesian region, another important center of endemism. The Chocó comprises an area of roughly 100 000 km<sup>2</sup> and has an elevational range from sea level to over 3000 m.

The Chocó region is characterized by one of the wettest and most non-seasonal climates on earth, with annual precipitation between about 2000 and 16 000 mm per year, depending on the latitude and altitude of the localities (Stattersfield *et al.* 1998). The enormous annual precipitation supports one of the richest forest biotas in the world, with exceptional

levels of endemism in a wide range of taxa including plants (Gentry 1986), butterflies (Dinerstein *et al.* 1995), reptiles and amphibians (Lynch 1979), as well as birds (Terborgh & Winter 1983, Stattersfield *et al.* 1998). Not surprisingly, the Chocó region forms part of one of the earth's 25 'hotspots' of biodiversity that are urgent priorities for biological conservation efforts – the Chocó-Darién-Western Ecuador hotspot (Myers 1988a, Myers *et al.* 2000).

The Chocó EBA supports over 60 range-restricted bird species, which is the highest concentration of avian endemism for any continental endemic center in the world, and second only to the Solomon Islands archipelago (Stattersfield *et al.* 1998, Salaman 2001). In recent years several new endemic bird species were discovered in the region, namely the Chocó Vireo *Vireo masteri* (Salaman & Stiles 1996), Chocó Tapaculo *Scytalopus chocoensis* (Krabbe & Schulenberg 1997), Cloud-forest Pygmy-Owl *Glaucidium nubicola* (Robbins & Stiles 1999), Munchique Wood-Wren *Henicorhina negreti* (Salaman *et al.* 2003), and Gorgeted Puffleg *Eriocnemis isabellae* (Cortés-Diogo *et al.* 2007).

Terborgh & Winter (1983) demonstrated that various discrete subregions of high bird endemism within the Chocó roughly correlate with areas of high rainfall. Similar patterns of heterogeneously distributed centers of endemism within the region have been previously postulated for plants (Gentry 1982). Borchsenius (1997) identified four distinct subregions of plant species endemism in the Ecuadorian Chocó alone, indicating that its biogeographical history has been rather complex.

The high degree of endemism of the Chocoan biotas may be the result of a unique combination of paleogeographic changes, alterations in river systems, and climatic fluctuations that have taken place in northern South America throughout the Cenozoic (Cracraft & Prum 1988), starting about 65 million years ago with the uplift of the Northern Andes. The mountain building created a complex topography that influenced historic and current climate patterns, gradually causing vicariance of more widespread biota. The uplift of the Sierra de Perijá, Eastern Cordillera, and Mérida Andes in the late Oligocene-Miocene (Irving 1975, Macellari 1984), beginning c. 25 million years ago, probably created periodic physiogeographic barriers for at least some elements of the Amazonian lowland forest biota. However, another important contact zone between Amazonian and trans-Andean forests existed at the southern end

of the Chocó region, where the Río Amazon drained into the Pacific Ocean well into the Miocene, roughly in the area that is today the Golfo de Guayaquil (Jenks 1956, Beurlen 1970, Goulding 1980). It is now believed that the Andean uplift altered the course of the river to its present west-to-east orientation as recently as 15 million years ago, eventually cutting off this southern contact zone. The biogeographic history of the region was further complicated by the formation of the Panamanian land bridge during the Pliocene, c. 2.5 million years ago (Marshall *et al.* 1982) enabling otherwise non-migratory bird taxa to expand their ranges from South America to Central America and, to a lesser extent, vice versa (Haffer 1967). Probably much of the speciation in Chocóan forest birds took place in the Pleistocene, when relatively small populations of Amazonian taxa were repeatedly isolated in trans-Andean forest refuges during dry glacial periods that had broken the forest connections between them, resulting in vicariance (Haffer 1975). The repeated expansion of forest in humid interglacial periods restored the connections and allowed an increasing number of Amazonian founder populations (*sensu* Mayr 1963) to invade trans-Andean and Central American forests. The process led to a gradual accumulation of endemic forms in various stages of taxonomic differentiation within the Chocó region. The close relationship between many Chocóan and Central American bird taxa is very probably due to immigration of South American forms into Middle America.

Although many of the present-day bird species encountered in the Chocó may have evolved during the Pleistocene, Cracraft & Prum (1988) have pointed out that, compared with the taxa of the Amazon basin, some Chocóan species may represent rather deep phylogenetic branches that may have originated earlier. At least one typical trans-Andean bird species, the Broad-billed Sapayoa *Sapayoa aenigma*, has been shown to be a phylogenetic relict of the Old World Suboscines dating back to the Gondwanic and Late Cretaceous origin of the passerine birds (Cracraft 2001, Barker *et al.* 2002, Ericson *et al.* 2002, Fjeldså *et al.* 2003).

#### Bioclimatic setting of western Ecuador

Western Ecuador, below the 900 m contour line on the Andean slopes, harbors 12 or 13 life zones *sensu* Holdridge (1967), in a land area of approximately 80 000 km<sup>2</sup> and, therefore, is exceptionally diverse ecologically (Cañadas 1983, Dodson & Gentry

1991). Five to six of these life zones belong to the humid and wet forest biotas of the Ecuadorian Chocó, the rest to the dry Tumbesian region. The rapid change in vegetation types is caused by an extremely steep precipitation gradient, with mean annual rainfall gradually increasing from less than 250 mm in the Santa Elena Peninsula in the southwest to over 6000 mm close to the Colombian border in the northwest. Most life zones form only narrow bands along the coastal cordilleras and Andean slopes or, due to changes in topography, occur in irregularly distributed pockets. Dodson & Gentry (1991) estimated that the flora of western Ecuador embraces roughly 6300 species of vascular plants, of which about 1260 were believed to be endemic to the region.

#### Conservation status of the Ecuadorian Chocó

In the first half of the 20th century, at least 75% of western Ecuador was still covered by intact forest (Dodson & Gentry 1991). Extensive deforestation began soon after World War II, due to population growth, road construction, and the increasing demand for tropical fruits and forest products from national and international markets (Lanfer 1995). The land reform programs of the early 1960s, which effectively promoted colonization of forested government-owned lands, aggravated the situation further. Hacienda owners, as well as small-scale farmers, were keen to clear the forest on their land in order to avoid the invasion of allegedly 'unproductive' land by landless farmers (Best & Kessler 1995). By 1996 the humid evergreen forest of the coastal lowlands, and the evergreen premontane forest of the western Andean slopes, had been reduced to, respectively, 18.3% (581 264 ha) and 36.8% (420 208 ha) of their original cover (Sierra 1999). Most of the remnant Chocóan forests are located in Esmeraldas Province, but even there forest conversion has reached unsustainable levels in recent decades. By 1993, about 28% of northern Esmeraldas had already been deforested (Sierra 1996). Since two important road projects were finished in the mid-1990s (Ibarra – San Lorenzo and Esmeraldas – Mataje), deforestation in the region has accelerated to alarming rates. In the few years since their inauguration, the number of side roads and, especially, timber extraction roads has increased exponentially. Between 1998 and 2007, average annual deforestation rates of lowland evergreen forest in northern Esmeraldas were 3.8% and accumulated loss of primary forest >38% in the same

period (Cárdenas 2007). In the vicinity of San Lorenzo the extension of oil palm plantations rose from only 3 km<sup>2</sup> to 225 km<sup>2</sup> since 1998 (+ 900% per year). Other agricultural activities were also on the rise, with an increase in area from 98 km<sup>2</sup> to 280 km<sup>2</sup> (+ 20.5% per year).

For years now the fragmented forest biotas of western Ecuador have been considered as one of the most severely threatened ecosystems on earth (Myers 1986, 1987, 1988a; Simberloff 1986). Extrapolations based on the theory of island biogeography (MacArthur & Wilson 1967, Simberloff & Able 1976) suggest that biological extinction in this region has been severe (Gentry 1989). However, due to the time lag between habitat loss and species loss (Brooks *et al.* 1999), most extinction events may still lie ahead and will continue for many decades even if remaining forest fragments could be preserved (Myers 1988b). Pitman *et al.* (2002) estimated that 18 taxa of vascular plants endemic to the region became globally extinct during the last 265 years, but >200 species already qualify as critically endangered and so are likely to disappear in the near future. Thus, the recent extinction rate of plants has been c. 24–115 times higher than the natural background rate, which is estimated at one extinction per 5–10 million species per year (May *et al.* 1995).

The last extensive forest tracts of the Ecuadorian Chocó are now located in the vicinity of or within protected areas, namely in the upper drainages of the Santiago, Cayapas, and Ónzole rivers as well as in the coastal cordillera. The most important protected area of the region is the 'Cotacachi-Cayapas Ecological Reserve' (243 638 ha, 80–4900 m; Esmeraldas, Imbabura) (IUCN 1992, INEFAN-GEF 1998, MAE 2007). Although uninhabited, it has in recent years suffered from increased human activities like illegal hunting, logging, and invasions (Benítez *et al.* 2002, Jahn & Mena V. 2002, Jahn *et al.* 2007). The 'Awá Reserve' (101 000 ha; Esmeraldas, Carchi, Imbabura) is not a nature reserve but was established to maintain the traditional culture of the indigenous Awá people. Hence, the area is inhabited and subsistence agriculture, hunting, selective logging, and even the establishment of oil palm plantations are common and legal. The 'Cayapas-Mataje Ecological Reserve' (51 300 ha; Esmeraldas) is principally a mangrove reserve, but also covers a periodically inundated forest type (Guandal) that exclusively occurs in the estuaries of the lower Cayapas and Mataje rivers (Cerón *et al.* 1999, Sierra *et al.* 1999c). The area is densely popu-

lated, and 26 Afro-Ecuadorian villages are located within the reserve (INEFAN-GEF 1998). Illegal activities like the clearing of mangrove forest for the establishment of shrimp farms and extensive plantations of coconut palms are on the rise and, in the medium term, threaten the ecological integrity of the area. Furthermore, the reserve is now isolated from the once continuous *terra firme* forest to the east, due to conversion of natural vegetation to extensive oil palm plantations. Another important protected area, the 'Mache-Chindul Ecological Reserve' (70 000 ha, 300–800 m; Esmeraldas, Manabí), is located in the coastal cordillera about 35 km south of Esmeraldas city. Unfortunately, it is already isolated from the continuous forests of northern Esmeraldas (Sierra 1999) and rapidly degrading due to illegal logging.

In recent years a few private reserves have also been established in the Ecuadorian Chocó, the most extensive being the 'Biological Corridor Awacachi' (c. 12 000 ha, 60–650 m; Esmeraldas; SIRUA Foundation), which interconnects the Cotacachi-Cayapas Ecological Reserve and the Awá Reserve (F. Echeverría, SIRUA, and J. Bernal, Fauna & Flora International, pers. comm.). The 'Bilsa Reserve' (2200 ha; Esmeraldas; Jatun Sacha Foundation) shares its western border with the Mache-Chindul Ecological Reserve. Of growing importance is also the 'Río Canandé Reserve' (current size c. 1400 ha, target size 10 000 ha; Esmeraldas; Jocotoco Foundation), which protects an important tract of forest in the lowermost foothills close to the ever-expanding colonization frontier in the Río Esmeraldas drainage (F. Sornoza M., pers. comm.).

Encouragingly, even some local communities have established forest reserves on their lands. The most promising is the 'Gran Reserva Chachi' (3000 ha) of two indigenous communities, located in the drainages of the Río Ónzole and the Río Cayapas, Esmeraldas (D. Villacrés, GTZ, pers. comm.). The mid- and long-term success of this and other conservation efforts will mostly depend on economic incentives that could be generated either through the sustainable management of natural resources (e.g., ecotourism and non-timber forest products) or through compensation payments to communities that provide environmental services (e.g., maintenance of natural forest as carbon sinks, biodiversity, and integrity of watersheds).

Although the total area covered by these governmental, private, and community reserves looks quite impressive, it has to be emphasized that the true

Chocoan lowland forests, such as the tropical humid forest in the Río Ñonzole drainage and the tropical wet forest of the Río Santiago and Río Cayapas drainages, are not part of any legally protected area. Only a few thousand hectares of forest below an elevation of 300 m are currently included in governmental or private reserves, and due to the fact that they are widely dispersed over various sites, they may not sustain viable populations of some species (Jahn *et al.* 2000, Mena V. & Jahn 2002j). Furthermore, with a growing human population and rapidly diminishing natural resources outside the reserves, anthropogenic impacts are increasingly being felt within the protected areas. Owing to the threat of isolation, the opportunity to interconnect at least some of the existing protected areas through biological corridors has to be taken immediately. Probably the most viable alternative to the continuing deterioration of the environmental integrity in the region would be the establishment of a biosphere reserve with a zoning and management of its natural resources that, ideally, would take into account the interests of the local people as well as the ecological prerequisites of threatened species and their habitats. Only a few years remain to avoid most nature preserves being totally isolated from other tracts of forest.

## Playa de Oro

### Historical and socio-economic aspects

According to historical records, some of the Afro-Ecuadorian communities located in the drainages of the Mataje, Cayapas, and Santiago rivers were established several hundred years ago after two ships, transporting African slaves, were wrecked in the coastal waters of what is today Esmeraldas Province. The first shipwreck reportedly took place in the mid-16th century, the second around 1600 (INEFANG-GEF 1998). The survivors fled the rivers upstream to start a new life in the Chocoan rainforests, sometimes side by side with the indigenous Chachi people, but more often separated from them by cultural differences. It is uncertain whether Playa de Oro was established by the first wave of Afro-Ecuadorian migrants who escaped in the shipwrecking incidents, but the community was reportedly founded more than 250 years ago. The precise location of the village apparently changed a few times in its history.

In the early 20th century the community gained importance due to its gold deposits. One mining

company constructed kilometer-long iron pipes (c. 75 cm in diameter) in the hills south of the Río Santiago in order to transport water to the mines. Today, these oxidized pipeline-like tubes look extremely odd inside the continuous forest. They are clear evidence that considerable human pressures on the environment already existed in Playa de Oro almost a century ago.

To this day Playa de Oro can be reached only by canoe. Until 1998 it took a four- to six-hour ride in a launch from Borbón (01°05'11.6"N, 78°59'21.7"W), a town located on the opposite side of the confluence of the Río Santiago and Río Cayapas, just 16 km inland from the Pacific coast. Since then it has been possible to go by car to Selva Alegre (0°55'51.4"N, 78°51'35.8"W), a small town on the Río Santiago, and to travel by canoe from there to Playa de Oro in roughly one hour.

The local people live on subsistence agriculture, hunting, fishing, gold prospecting, small-scale timber trade and, more recently, also ecotourism. Although total fertility rate has been very high, with about 7-10 children born per woman in the current generation, the number of inhabitants of Playa de Oro actually decreased from about 600 in the mid-1970s to 300 today. The main reason for this decrease was the continuous emigration of younger people to the cities, principally in search of work (Wunder 1996).

### Location, topography, geology, and soils

The village of Playa de Oro (0°52'34.5"N, 78°47'40.3"W; 50 m a.s.l.) is located in the upper valley of the Río Santiago, District of Eloy Alfaro, Province of Esmeraldas, northwestern Ecuador (Fig. 1a). In 1996 the community obtained the official land title for an area of roughly 10 900 ha (Fig. 1b). To the west it borders on the Comuna Río Santiago, to the north on the community of Wimbí, to the east on the Cotacachi-Cayapas Ecological Reserve, and to the south on the Centro Chachi Tsejpi. The area of Playa de Oro covers an elevational range from about 45 m on the westernmost banks of the Río Santiago to 590 m in the Andean foothills at its northeastern corner. It forms part of BirdLife International's Important Bird Area (IBA) 'Cayapas-Santiago-Wimbí' (EC004), which covers c. 60 000 ha at altitudes between about 50 and 700 m in the river drainages of the same name (Freile & Santander 2005).

The topography in the western part of the community is characterized by gently rolling lowland hills, with hilltops generally not exceeding 300 m and



most of them being less than 150 m high. To the east the landscape gradually rises to the lower base of the Andean foothills, with the Río Santiago cutting deep into the landscape and frequently breaking into rapids.

The geomorphological setting of western Ecuador, as well as that of southern Panama, western Colombia and the Cordillera Occidental of the Andes, has been developing on an oceanic (not continental) crust that was accreted to the margin of the South American continent during the Cretaceous and Cenozoic (Case *et al.* 1971, Feininger & Bristow 1980, Kennerley 1980, Baldock 1982, Dengo 1985). In the Tertiary repeated marine transgressions resulted in the deposition of marine sediments in western Ecuador. Atop these Tertiary sediments, volcanic and other eroded materials of the still uplifting Andes were deposited during the Quaternary (Sauer 1971). Therefore, a mosaic of geologic formations can be found in the area of Playa de Oro (Baldock 1982). In hilly *terra firme* areas a layer of relatively poor soils, varying in depth, overlies the Tertiary rock composed of sandstones, slates, and conglomerates. As nutrients have been leached out due to the heavy rainfall in the region, soil fertility is often low, especially on the slopes. In flat *terra firme* areas, however, it is possible to cultivate the soils for up to five consecutive years. By contrast, the young soils of the narrow floodplain and adjacent alluvial terraces are much more fertile. In the floodplain, nutrient-rich sediments are deposited from time to time during floods. Alluvial soils are often found above layers of gravel that represent ancient riverbeds of the Río Santiago. They can be cultivated for 30 to 40 consecutive years in the lower part of the floodplain.

#### Sunrise, sunset, and daylight period

In 1997 the time of sunrise at Playa de Oro varied between 06:25 h (Feb.) and 05:54 h (Oct./Nov.), and the time of sunset between 18:34 h and 18:03 h. The absolute daylight length varied only  $\pm 7$  min throughout the year (E. López, Observatorio Astronómico de Quito, *in litt.*). Twilight periods at dawn and dusk are principally very short at latitudes so close to the equator, but their duration markedly increased on days with low and dense cloud cover or dense mist.

#### Climate and El Niño

There are no climatic data available for Playa de Oro. However, from existing data collected by meteorological stations at Cayapas (0°51'N, 78°59'W; 65 m;

1971-1981), Esmeraldas, and Lita (0°50'N, 78°26'W; 571 m; 1971-1981), Imbabura (Cañadas 1983, Lanfer 1995), I estimate that the mean annual rainfall varies between about 3500-4000 mm in the western part of the community area to over 4000 mm in the foothill zone. The precipitation pattern for the southernmost part of the Chocó region is seasonal, with wetter periods between January and June, drier periods between July and December. November is the driest month with a long-term mean of c. 135 mm. However, all months of the year are humid, according to the criteria of Lauer (1952; based on monthly precipitation/temperature ratios). Rain falls mainly in the late afternoon or at night, on about 300 days per year. Although daily precipitation is only between 0.1 and 5 mm per day on about 120 days per year, maximums of 120-150 mm per day may be reached occasionally. The variation coefficient of monthly precipitation is 20-40% (Lanfer 1995).

The relative humidity is very high, maintaining a saturation of more than 90% on average. However, occasionally it might sink to c. 50% in semi-open country during sunny midday hours. The daily variance is much lower in closed canopy forest. Nevertheless, water stress might occur even in the forest interior during intense and prolonged dry seasons. The formation of mists occurs at all elevations, but is much more frequent and continuous in the foothills than in the lowlands, and is especially prevalent above 400 m.

The mean annual temperatures decrease from c. 25° C in the lower parts of the community area to c. 23° C in the upper foothill zone. Mean monthly temperatures fluctuate only little more than 1° C above and below the annual average due to the high water vapor content in the atmosphere (Lanfer 1995). Daily changes in temperatures are significantly greater than seasonal variations. In the dry seasons absolute maximums of c. 35° C and absolute minimums of c. 17° C can be reached, rarely and locally, in semiopen areas on calm cloudless days and nights.

The lower parts of the community area are located in the doldrums zone that is characteristic for the western Ecuadorian lowlands north of the equator. This wind regime is characterized by frequent calm and the absence of a dominant wind direction. By contrast, a mountain-to-valley wind system is predominant in the foothill zone (Lanfer 1995). In the lowlands, average monthly wind speeds vary



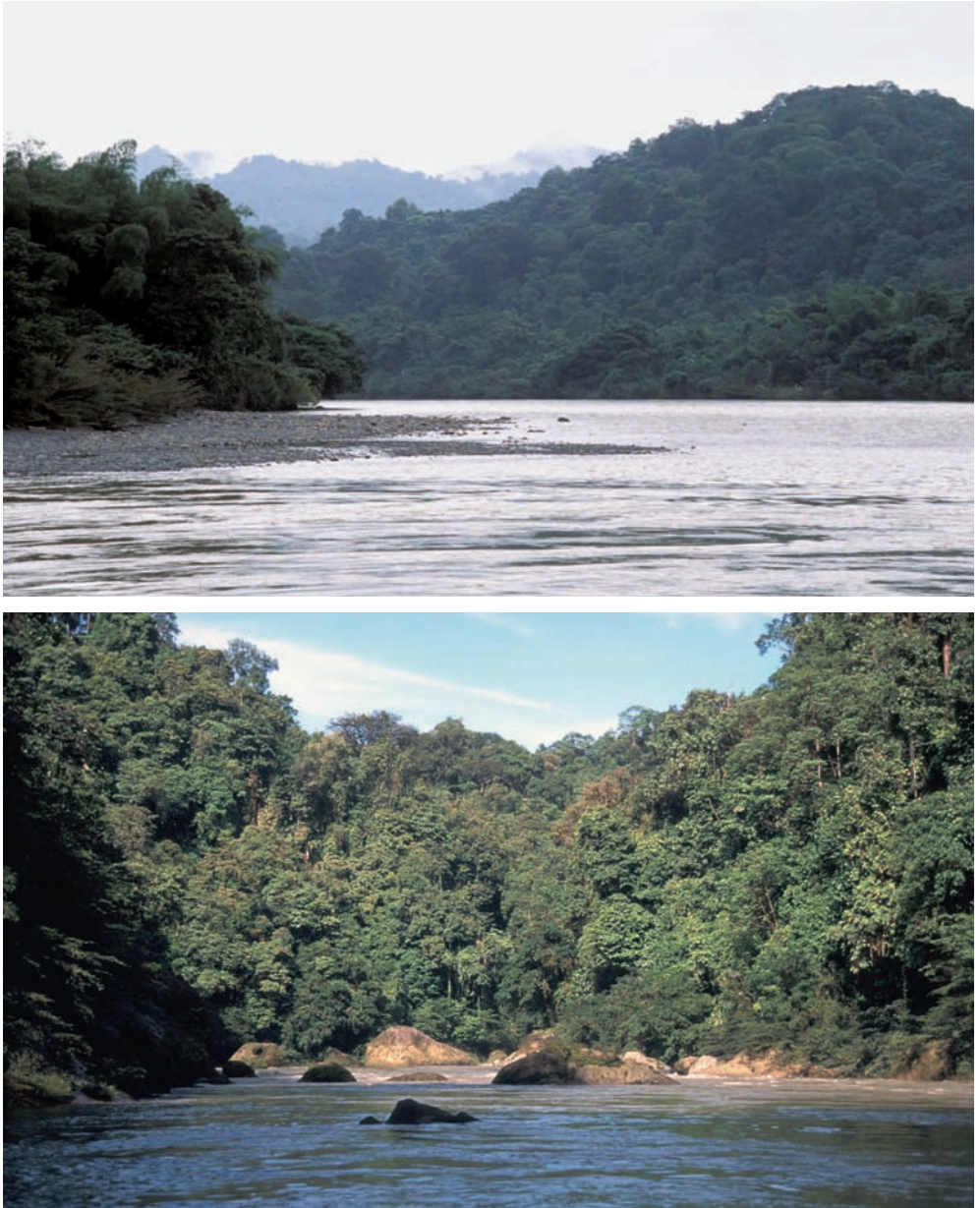


FIG. 2. Río Santiago valley, Playa de Oro. Above: View from the southern bank of the Río Santiago up to the Andean foothills. The foothills are partially covered by low-hanging clouds, in contrast to the lowland hill in the foreground. The altitude of the latter is c. 150 m, whereas those of visible peaks in the foothills are c. 300 m (second hill chain) and 500 m (third hill chain; hardly visible). Each hill chain may represent a different life zone sensu Holdridge (1967); see text for details. (Playa Rica, close to the start of transect MNT2, cf. Figs. 1b and 8; 60 m, 23 Nov. 95.). Below: In the Andean foothills the river is cutting increasingly deep into the landscape and breaking frequently into rapids. The area is covered by primary forest, presumably belonging to the wet premontane forest life zone (upper Río Santiago valley, elev. c. 100 m, 21 Jun. 97).

between 0.4 and 0.6 m/s, and relative frequency of calm is almost 70%. However, short periods of relatively strong wind sometimes occur during afternoon hours in the dry season, typically from July to September, and may cause considerable forest damage.

The 1997-1998 El Niño event was the strongest on record, developing much faster and showing greater increases of the sea surface temperature than any other. The equatorial eastern Pacific surface temperatures rose between 2 and 5° C above normal, impacting global climate patterns and causing torrential rainfalls and severe inundations in western Ecuador and Peru (UNEP 2000, 2002). However, the overall effects in Playa de Oro were not as pronounced as in other areas. In general, the climate in 1997 was slightly wetter than during previous years. From Sep. 1997 to Apr. 1998 the Río Santiago drainage suffered various severe inundations. Although I presume that breeding residents were not affected by the El Niño phenomena, some results indicate that the abundance of certain short-distance migrants was different in comparison with previous drier years (p. 90f, Species richness and species accumulation).

#### Life zones

According to the life zone map presented in Dodson & Gentry (1991), which was based on the classification scheme of Holdridge (1967), and the corresponding bioclimatic map for Ecuador (Cañadas 1983), the community area of Playa de Oro may consist of three life zones: (1) 'tropical wet forest' in the lowlands, (2) 'premontane wet forest' in the lowermost foothills, and (3) 'premontane pluvial forest' in the upper foothill zone (Fig. 2, Table 1). However, critical climatic data for an unambiguous determination of the local distribution pattern of life zones are not available.

Tropical humid forest, which is found in the lower drainages of the Ónzole, Cayapas, and Santiago rivers, is probably not represented at Playa de Oro. Several characteristic bird species of this life zone in western Ecuador breed as close as 10-20 km west of the study area, but do not regularly occur at Playa de Oro. Thus, I presume that the hilly country in the western half of the community area is covered by tropical wet forest (p. 193, Life zone assemblages). Some of the highest isolated hilltops in the lowlands and, particularly, the lowermost Andean foothills between about 150 and 350 m may pertain to the premontane wet forest zone due to slightly lower

mean temperatures and higher annual precipitations, which they receive in the form of rain as well as mists. In consequence, tree branches and trunks show a denser cover of epiphytes and mosses. Canopy height is very similar to that of lowland forest, with 30-40 m in mature forest, and some emergent trees reaching up to 55 m (e.g., 'lirio', Bombacaceae). However, mature forest is less frequent in the foothills for natural reasons. Here it is mostly restricted to ridge tops and gentle slopes, whereas steeper slopes are usually covered by forest in different stages of regeneration, probably because soils are poorer and less stable in such situations than in level areas.

In general, the transition between hilly lowlands and lowermost foothills is rather gradual. A much more noticeable transition is found above an elevation of c. 350 m, where mists are so frequent and continuous that trees are often completely enveloped by mosses and epiphytes. Canopy height of this mossy forest rarely exceeds 30 m, even when mature. Most likely the area belongs to the premontane pluvial forest zone. In Playa de Oro the distribution of some avian taxa is restricted to this poorly studied forest type (p. 193, Life zone assemblages).

#### Natural formations – main vegetation types

In contrast to the life zone classification system of Holdridge (1967), which is based on bioclimatic criteria, Sierra *et al.* (1999b) used a hybrid of eco-physiological and physiognomical criteria in order to determine the distribution of natural formations in Ecuador (Sierra *et al.* 1999c). The latter concept is consistent with the U.S. standard for the classification of vegetation established by FGDC (1997). According to this system, only two natural formations are represented in Playa de Oro: (a) 'evergreen forest of the coastal lowlands' below c. 300 m, and (b) 'evergreen forest of the western Andean foothills' above 300 m (up to 1300 m; Cerón *et al.* 1999).

In the evergreen lowland forest of Playa de Oro, floristic samples of woody plants with  $\geq 10$  cm diameter at breast height (DBH) usually contain more than 100 species of tree per hectare (Palacios *et al.* 1996, Cerón *et al.* 1999). Therefore, tree species diversity is lower than in the 'evergreen forest of the Amazonian lowlands' of Ecuador (Balslev *et al.* 1987, Palacios *et al.* 1999) or in the Colombian Chocó lowlands (e.g., Bajo Calima, Valle Dept., 100 m; Faber-Langendoen & Gentry 1991), where more than 200 species of tree per hectare were reported in the same DBH class for *terra firme* forests. However,

TABLE 1. Life zones sensu Holdridge (1967) in humid areas of northwestern Ecuador (Cañadas 1983, Dodson & Gentry 1991). Playa de Oro may embrace three of the four life zones. See text for details. Notes: a = annual sum of all positive monthly mean temperatures between 0 and 30° C divided by 12; b = biotemperature times empirical factor 58.93 divided by annual precipitation; c = according to Cañadas (1983); d = elevational range was not defined by Cañadas (1983) and so is estimated on the basis of his bioclimatic map and own observations; e = estimated from observed changes in the physiognomy of the forest and composition of the bird communities (p. 193, Life zone assemblages).

Characteristics	Tropical humid (moist) forest	Tropical wet forest	Premontane wet forest	Premontane pluvial forest
Biotemperature <sup>a</sup> (°C)	> 24	> 24	18-24	18-24
Annual precipitation (mm)	2000-4000	4000-8000	2000-4000	4000-8000
Potential evapotranspiration ratio <sup>b</sup>	0.5-1.0	0.25-0.5	0.25-0.5	< 0.25
Elevational range in NW Ecuador <sup>c</sup> (m)	< 300	< 300	(150-900) <sup>d</sup>	300-1.800
Elevational range in Playa de Oro <sup>e</sup> (m)	—	< 350	c. 150-350?	> 350
Landscapes where the life zones can be found in NW Ecuador	coastal lowlands and rolling hills	lowlands and rolling hills close to base of Andes and eastern base of coastal cordillera (Mache-Chindul)	ridge tops of high lowland hills; lowermost base of Andean foothills; upper eastern slopes of coastal cordillera (Mache-Chindul)	Andean foothills north of Río San Miguel drainage (may extend further south)

Gentry (1986) pointed out that even floristic samples of the Ecuadorian Chocó (e.g., Río Palenque, Pichincha Province, 200 m) are more species-rich than any other Neotropical samples outside this biogeographic region, when small diameter individuals ( $\geq 2.5$  cm DBH) are considered, due to the fact that such small diameter woody plants are disproportionately represented in Chocoan floristic samples.

In Playa de Oro 'gualte' palms *Wettinia quinaria* (Arecaceae) often account for 20% or more of the individuals with  $\geq 10$  cm DBH (Palacios *et al.* 1996, Cerón *et al.* 1999). Other common tree species belong to the families Moraceae, Lauraceae, Fabaceae, Myristicaceae, Meliaceae, and Lecythidaceae. Epiphytes, hemiepiphytes, lianas, and vines are abundant on tree trunks and branches. The herbaceous stratum of the forest undergrowth is dominated by ferns (Pteridophyta) and by terrestrial or hemiepiphytic climbing aroids (Araceae). Common shrubs and understory trees belong to the families Melastomataceae (e.g.,

*Miconia*, *Conostegia*), Rubiaceae (e.g., *Psychotria*, *Palicourea*), and Gesneriaceae (e.g., *Besleria*).

In Playa de Oro the natural formation 'evergreen forest of the western Andean foothills' roughly occupies the same elevational range as the 'premontane pluvial forest' of the Holdridge system. That is to say that canopy height is lower and trees are much more densely enveloped by epiphytes like mosses, liverworts, ferns, aroids, bromeliads, and orchids than at lower elevations. Common tree species belong to the families Arecaceae, Mimosaceae, Fabaceae, Burseraceae, and Meliaceae (Cerón *et al.* 1999). The forest undergrowth is often dense, with ferns and aroids dominating the herbaceous stratum. At present, no floristic inventories have been carried out for this vegetation type in Playa de Oro.

#### Vegetation cover and land use

In 1996 about 96% of the total community area of 10 900 ha was still covered with forest (EcoCiencia

1996). I estimate that c. 2-5% of it was secondary forest (rastrojo), 60-70% primary forest that had been selectively logged with varying intensity, and the rest untouched primary forest.

About 400 ha were converted to agricultural land, and about half of this area was abandoned for regeneration. For subsistence, most families cultivated two to four traditional mixed-culture plantations of a size of c. 0.3 to 1 ha, mostly on the fertile but narrow floodplain of the Río Santiago. Slash-and-burn agriculture that is widespread throughout humid and dry tropical forest areas in Latin America cannot be used as a cultivation technique in the wet Chocoan forests. For establishment of new plantations, the undergrowth of a forest plot is cleared first, whereby mid-sized to larger trees remain until initial crop plants, such as plantain, have formed their root systems. Thereafter, all but a few trees are felled or girdled. The remaining trees of heights of up to 40 m cast some shadow on the plantations, and are normally also of economic interest (e.g., timber and rubber), like 'caucho' *Castilla elastica* (Moraceae), 'balsa' *Ochroma pyramidale* (Bombacaceae), 'laurel' *Cordia alliodora* (Boraginaceae) and 'cuángare' *Oroba gordoniiifolia* (Myristicaceae) trees.

Common cultivated plants were plantain *Musa paradisiaca* (Musaceae), sugar cane *Saccharum officinarum* (Gramineae), manioc *Manihot esculenta* (Euphorbiaceae), cacao *Theobroma cacao* (Sterculiaceae), 'guaba' *Inga* spp. (Mimosaceae), 'chontaduro' palm *Bactris gasipaes* (Arecaceae), citrus tree *Citrus* sp. (Rutaceae), breadfruit tree *Artocarpus altilis* (Moraceae), bamboo *Guadua* sp. (Gramineae), and less common were banana *Musa* sp., 'hoja de camacho' *Xanthosoma* sp. (Araceae), rice *Oryza sativa* (Gramineae), papaya *Carica* sp. (Caricaceae), passion fruit *Passiflora* sp. (Passifloraceae), pineapple *Ananas comosus* (Bromeliaceae), coffee *Coffea* sp. (Rubiaceae), 'zapote' *Quararibea cordata* (Bombacaceae), calabash tree *Crescentia* sp. (Bignoniaceae), avocado *Persea* sp. (Lauraceae), and 'annoná' *Annona* sp. (Annonaceae). Weeds, grasses, ferns, herbs, vines, and saplings of fast growing shrub and tree species form a dense undergrowth in the plantations. About every 3-4 months local people weeded this herbaceous vegetation when it reached a height of c. 1 m and threatened to overgrow the cultivated plants.

Between 1995 and 2000 cattle breeding was not a major issue in Playa de Oro, with only about three head of livestock. In recent years, however, numbers have increased considerably to about 50 animals.

Several hundred hectares of forest, especially in the vicinity of the village, were intensively logged for house construction and the manufacture of canoes, whereas the area of extensive timber harvest, especially of hardwoods and of species used in the canoe construction, covered several thousand hectares. Most commonly used in house construction were hardwoods like 'guayacán' *Minquartia guianensis* (Olacaceae) for pillars, 'chanul' *Humiriastrum procerum* (Humiriaceae) and 'mascarey' *Hyeronima chocoensis* (Euphorbiaceae) for crossbeams, and softwoods like 'sande' *Brosimum utile* (Moraceae), 'anime pulgande' *Dacryodes* spp. (Burseraceae), 'cuángare' *O. gordoniiifolia*, 'chalviande' *Virola* sp. (Myristicaceae), and 'peine de mono' *Apeiba aspera* (Tiliaceae) for boards and planks. Traditionally, leaves of 'gualte' *Wettinia quinaria*, an abundant forest palm, have been used for thatching. Today, however, most of the palm leaf roofs have given way to tin roofs. Important tree species for the canoe construction are 'guadaripo' *Nectandra guadaripo* (Lauraceae), various species of 'jigua' *Ocotea* sp. and *Nectandra* sp., and 'anime pulgande'.

Historically, timber and other non-timber forest products were harvested exclusively to meet the demand within the community. Commercial timber trade, particularly of chanul, a valuable hardwood traded in Borbón, did not start before the late 1970s. Apart from house construction, manufacture of canoes, and trade in chanul, there were other important reasons for the felling of trees, e.g., the hunting of sloth and the harvesting of wild honey (Table 2).

#### Comparison with other Neotropical sites

In the following chapters I will frequently compare the data collected at Playa de Oro with those published for other Neotropical areas. Therefore, I here present some geographic and environmental variables for well-studied lowland rainforest localities (Gentry 1990b, Thiollay 1994b, Robinson *et al.* 2000), as well as for a Chocoan site on the western Andean slope (Salaman 2001), to facilitate comparison with the conditions at Playa de Oro (Table 3).

Of the lowland rainforest localities considered here, La Selva Biological Station (McDade & Harts-horn 1994, Sanford *et al.* 1994), Costa Rica, is doubtless the most similar site in comparison with the study area. Annual precipitation in Playa de Oro has comparable levels, especially in areas close to the base of the Andean foothills, though the dry season might be slightly more pronounced than at La Selva.



TABLE 2. Reason for felling and estimated number of trees felled in Playa de Oro in 1998; according to interviews with local people. Without trees harvested in the management plan area (Fig. 1).

Reason	Number of trees felled per year	Trunks not used
Canoe manufacture	60	20
House construction	100	0
Chanul trade on local markets	30-50	0
Sloth hunting	30	30
Honey harvest	10-20	10-20
Sum	230-260	60-70

Twelve of my 18 transects were located partially or entirely within the elevational range and life zone of La Selva (Table 6). Furthermore, both sites are characterized by very similar landscapes. The forest of La Selva continues on the slopes of the volcanoes within Braulio Carrillo National Park, where the elevation reaches almost 3000 m. Similarly, in Playa de Oro continuous forest extends from the lowlands up to the tree line at c. 3460 m in the Cordillera de Toisán within the Cotacachi-Cayapas Ecological Reserve.

The only other site with a similar geomorphological setting is Cocha Cashu, Peru, on the floodplain of the Río Manu (Terborgh 1990, Terborgh *et al.* 1990). This biological station is located within the immense Manu National Park, which extends from the lowlands to over 4000 m. However, Cocha Cashu itself is more distant from the foothills than La Selva or Playa de Oro. Due to the much lower annual precipitation, more pronounced dry season, and slightly higher elevation, it is located in the transition zone between tropical humid forest and premontane humid forest. From a purely bioclimatic perspective, conditions at Nouragues field station, French Guiana (Thiollay 1994b), also closely resemble those at Playa de Oro. Both sites are located in the same altitudinal range, receive similar amounts of precipitation, and experience comparable dry periods. However, Nouragues is located within continuous primary forest with sparse human population (Thiollay 2002a, b) and has no connection with high mountains (the highest peaks in central French Guiana reach only 850 m), making it very distinct from Playa de Oro. Similarly, Panama Canal Zone, Panama, and Manaus, Brazil, are characterized by rolling lowland hills and flat lowlands, respectively (Leigh & Wright 1990, Lovejoy & Bierregaard 1990). Both areas have even more pronounced dry seasons than Cocha Cashu and

much poorer soils. Thus their environmental conditions are less comparable with Playa de Oro than those of the Costa Rican, Peruvian, and French Guianan sites.

The Río Nambí Nature Reserve was included here because it is the only other locality within the Chocó region where birds have been extensively studied (Salaman 2001). Of course, its climatic and ecological conditions are very different from those of Playa de Oro due to the much higher altitude and annual precipitation, and the considerably lower mean temperature. However, the upper foothill zone of Playa de Oro seemingly belongs to the same life zone, premontane pluvial forest, and thus shares a considerable number of bird species with the Río Nambí area.

### Principal design of the study

The design of the present study was chosen to compare the effectiveness of mist-netting and transect-mapping protocols, and to optimize the transect method for rapid assessments and monitoring of tropical bird communities. It also aimed at generating a comprehensive inventory of the bird species of the study area. Furthermore, it attempted to relate the presence of bird species at a certain locality to the habitat type and the vegetation structure of the site.

In order to carry out the comparative study of survey methods, I chose two independent transects, MNT1 and MNT2, with similar habitat characteristics. Due to time and manpower constraints, the mist-netting transects (= MNT) naturally had to be rather short. The mist-netting study was carried out in 1995/96. In the following year, I surveyed the same transects with a standardized spot-mapping protocol (MTW = Multi Time-Window Transect Mapping).

TABLE 3. Comparison of geographic and environmental variables of Playa de Oro with six other Neotropical study sites. Adapted and enhanced on the basis of Karr *et al.* (1990: Table 14.1), Thiollay (1994b), Robinson *et al.* (2000), and Salaman (2001). Abbreviations used: BCI = Barro Colorado Island; LP = Limbo plot; TrWF = tropical wet forest; TrHF = tropical humid (moist) forest; PmWF = premontane wet forest; PmHF = premontane humid forest (subtropical moist forest); PmPF = premontane pluvial forest.

Factor	La Selva	Canal Zone	Rio Nambí	Playa de Oro	Nouragues	Manaus	Cocha Cashu
Country	Costa Rica	Panama	Colombia	Ecuador	French Guiana	Brazil	Peru
Geographic coordinates	10°26'N, 83°59'W	BCI: 9°09'N, 79°51'W	1°18'N, 78°05'W	0°52'N, 78°47'W	4°05'N, 52°41'W	2°20'S, 60°00'W	11°54'S, 71°22'W
Endemic Bird Area	Central American	on the western limits of the 'Darien lowlands'	Chocó	Chocó	none	none	Southeast Peruvian lowlands
(sensu Stattersfield <i>et al.</i> 1998)							
Elevational range (m)	35-137	BCI: <165; LP: 35-80	1150-1450	45-590	40-400	<100	≈400
Annual precipitation (mm)	3993	2656	7160	3500-4500	3500	2186	2028
Mean temperature (°C)	25.8	27	19	23-25	26	26.7	22-25
Dry season	Feb.-Apr.	Dec.-Apr.	Jul.-Aug.	Jul.-Dec.	Aug.-Nov.	Jul.-Sep.	May-Sep.
Life zone	TrWF	TrHF	PmPF	TrWF, PmWF, PmPF	TrHF, TrWF	TrHF	TrHF, PmHF
(sensu Holdridge 1967)							
Topographic complexity	floodplain, alluvial terraces, rolling lowland hills; base of foothills with connection to highlands	BCI: rolling lowland hills with recently broken connection to foothills; LP: circular basin surrounded by steep terrain and ravines	Andean slope	floodplain, alluvial terraces, rolling lowland hills; lower foothills with connection to highlands	vast lowlands with rolling hills, rocky inselbergs, and valleys	vast and flat lowlands	floodplain, alluvial terraces; vast lowlands with distant connection to highlands
Presence of water	small medium rivers, small streams, swamp forest	near two oceans; BCI: large river, artificial lake; LP: small streams	small streams; headwaters of medium river	medium river, small streams	small streams	small streams	large river, oxbow lakes, seasonal swamps
Regional landscape	remnant forest in matrix of pasture and farmland	BCI: forested island in artificial lake; forest on adjacent mainland; LP: 7.2 km east of BCI, within forest of Soberania National Park (22 000 ha)	mostly continuous forest; mosaic of young secondary forest, selectively logged forest, and primary forest close to a road	mostly continuous <i>terra firme</i> forest; in the floodplain and vicinity of village also mosaics of traditional subsistence plantations and secondary forest	unbroken primary <i>terra firme</i> rainforest and a few sparsely wooded rocky inselbergs	mosaic of <i>terra firme</i> forest, cattle ranches, secondary areas, and fragments of primary forest; surrounded by continuous forest	dynamic floodplain area in extensive river valley surrounded by continuous <i>terra firme</i> forest
History of human impacts	massive deforestation regionally; high hunting pressure ceased	regional forest destruction due to construction of channel and pipeline road; creation of artificial lake; hunting pressure ceased on BCI and is low to moderate at LP	moderate disturbance and levels of subsistence hunting after road construction	selective logging, clearing of forest for creation of small subsistence plantations, and severe hunting pressure in the vicinity of the village	very low human impacts	regional deforestation due to road construction and creation of cattle ranches; moderate hunting pressure	very low human impacts

In 1997/98, I studied a total of 18 transects (25.14 km, including MNT1 and MNT2), using the MTW method (Fig. 1b, Table 6). Most transects were located in the vicinity of the village to cover the greater habitat heterogeneity compared with the intact forests in areas further upstream. Logistical constraints necessarily influenced the study design and were the principal reason for not establishing any transect in the upper foothill zone above 400 m.

The habitat types and vegetation structure were mapped along the entire transect network and, in the

case of MNT1 and MNT2, were studied in more detail.

The heterogeneity of habitats in the western part of the community area, the fact that the length of the transects had to differ greatly in order to optimize the MTW protocols, limitations of time and manpower, as well as logistical difficulties, sometimes rendered the fulfillment of statistical considerations impossible. As a consequence, tests were only used where appropriate and descriptive data account for a considerable part of this monograph.





### 3. HABITATS

#### Introduction

The term 'habitat' has been used in conflicting ways (Karr 1980b). Although some authors regard it as equivalent to 'vegetation type' (e.g., Stotz *et al.* 1996), Karr (1980b) emphasizes that the latter concept recognizes only the horizontal component of the habitat. However, birds may select specific horizontal (vegetation type) and vertical (e.g., leaf density, twig diameter and angle) components of habitat gradients. Here I will employ a relatively broad definition of 'habitat', which includes both the living and non-living environment of a species or community (Smith 1974, Flade 1994).

Detailed accounts of habitats are rarely provided in the literature on tropical birds. Yet these data are critical for a better understanding of avian community composition, habitat selection, and the species's vulnerability to environmental change. Thus the objective of the present chapter is to provide background information on geomorphological factors (e.g., altitude, topography) and vegetation structure, as well as on anthropogenic impacts that might influence the bird communities of the transect areas.

Tropical rainforests are structurally very complex (Hartshorn 1983) in their vertical stratification as well as in their horizontal structuring (Gentry 1990d, Hallé 1990). Vertically, they are often not neatly layered (Rollet 1974, Pires 1978, Stotz *et al.* 1996); historically, three stories of trees have been recognized, with one or two layers of shrubs and herbs (Richards 1952, Klinge *et al.* 1975). Oldeman (1974) emphasized that an architectural analysis discriminating between trees of the future, the present, and the past clearly demonstrates the existence of vertical stratification, while tropical forests may appear homogeneous in their vertical structure if all demographic classes of trees are considered together. In the horizontal dimension, they represent shifting small-scale mosaics of different habitat patches due to cyclic regeneration patterns of the forest vegetation (Oldeman 1989, Haffer 1991). In continuous forests, structural heterogeneity is largely due to tree falls and subsequent regeneration, which create a mosaic of light gaps, dense pioneer vegetation, and various stages of forest succession (Schemske & Brokaw 1981). The successional phases differ in area, physiognomy, and plant species composition (Oldeman 1978, Brokaw 1985). Thus tropical forests are highly

dynamic ecosystems (Clark 1994). It has been estimated that the tropical wet forest of La Selva, Costa Rica, has a turnover rate of only 118 years (Hartshorn 1978) and that 6% of its primary forest is in the young gaps stage at any one time (Sanford *et al.* 1986). While smaller gaps are generated by only a few trees or larger branches that fall to the ground and smash other plants in the process, storms and fires are important disturbance factors that may cause large gaps and clearings in some tropical forests (Webb 1958, Sanford *et al.* 1985, Uhl *et al.* 1988, 1990; Tanner *et al.* 1991, Yih *et al.* 1991).

Another important source of natural disturbance in tropical forests are rivers. In floodplain areas, shifting river courses provide habitat mosaics on a landscape level as they erode their banks on the outside of bends and create new land on the inside (Terborgh 1985, Haffer 1991). Furthermore, the vegetation cover is greatly affected by river flood cycles, which may occur in the form of annual cycles in the lowland plains or irregular flash flooding in hilly country and foothills. Terborgh (1985) differentiated between six distinct serial stages of riparian succession on the Río Manu floodplain at Cocha Cashu Biological Station, southeastern Peru. He estimated that the meandering river sweeps out the entire floodplain every 500-1000 years, and that the average meander loop develops in a period of just 100-200 years. Consequently, much of the vegetation in the meander belt is undergoing primary succession (Foster 1990).

Periodic natural disturbances are partially responsible for the mosaic pattern in the distribution and composition of plant and animal communities, greatly influencing the abundance of particular species (Levin & Paine 1974, Whittaker & Levin 1977, Levey 1988b, Schupp *et al.* 1989, Remmert 1991). However, in contemporary landscapes such natural ecological processes are increasingly distorted by human activities. Thus one aim of my study was to document the changes in vegetation structure and bird community composition along successional gradients in anthropogenic habitat mosaics. To achieve this I surveyed two mist-netting transects in the floodplain and adjacent *terra firme* forest of the Río Santiago valley. Much of the information presented in later chapters was gathered at these transects, for which reason I describe their habitats

in more detail than those of the other transects. Furthermore, the multivariate analyses on habitat selection, as well as the determination of potential indicator species (Chapter 6), were based on the environmental factors characterized here.

## Methods

The methods used for the characterization of habitat types, vegetation structure, and magnitude of human

impact were adapted to the principal design of the study (p. 29f). All line transects (LT) were marked with conspicuous distance markers (Forestry Suppliers Vinyl Flagging, Jackson, MS, USA), each 25 m apart, on both sides of the path. By contrast, the mist-netting transects (MNT) were divided further into segments of 12.5 m to facilitate the relocation of the nets. On a larger scale, MNT1 and MNT2 were subdivided into four sections (A-D) of 125 to

TABLE 4. Overview of habitat types covered by the transect sections of MNT1 and MNT2, which were sampled separately in the standardized mist-netting study (p. 65f, Mist-netting study).

Transect	Section	Distance (m)		Length of section	Description of habitat types
		Start	End		
MNT1	A	0	162.5	162.5	Semi-open country on the floodplain: cultivated mixed-culture plantations; field-wood-like young successional vegetation; natural backwater pond; water-filled artificial channels.
	B	162.5	337.5	175	Semi-open country and young secondary forest on the floodplain: weedy and field-wood-like successional vegetation on recently abandoned plantations; forest/open country borders; secondary forest (rastrojo) in different stages of succession on former plantations; <i>Heliconia</i> and <i>Calathea</i> thickets; water-filled artificial channels.
	C	337.5	487.5	150	Forest/open country border and medium-age forest on <i>terra firme</i> : border between plantation and young forest; selectively logged medium-age forest on a ridge; light gaps; forest streams.
	D	487.5	625	137.5	Medium-age forest on <i>terra firme</i> : selectively logged medium-age forest on a ridge with some mature trees; light gaps; former gold-mining areas with rocky ground; forest streams.
MNT2	A	0	137.5	137.5	Semi-open country on the floodplain: weedy, shrubby, and field-wood-like successional vegetation in a clearing, which was clear-cut in 1992; <i>Heliconia</i> and <i>Calathea</i> thickets; <i>Guadua</i> bamboo stands; forest/open country border.
	B	137.5	287.5	150	Secondary forest on the floodplain: young successional forest with few medium-age trees, partially on former plantation; areas of former gold-mining activities to the left; swampy area to the right; <i>Heliconia</i> and <i>Calathea</i> thickets; clearing with <i>Guadua</i> bamboo stands.
	C	287.5	412.5	125	<i>Terra firme</i> forest on alluvial terrace: selectively logged medium-age forest, perhaps partially secondary, with some scattered mature trees on level ground; light gaps; forest stream; few areas of backwater after heavy rainfalls.
	D	412.5	550	137.5	Secondary medium-age forest on <i>terra firme</i> : selectively logged medium-age forest, perhaps partially secondary, with some scattered mature trees on plain ground; light gaps; forest stream.

175 m each, which were mist-netted one by one (Table 4; p. 65f, Mist-netting study). These subdivisions were irrelevant for the audiovisual surveys, where I mapped the position of each bird with the help of the 25-m distance markers, differentiating between records within the near belts of a fixed width of 25 m and the unlimited far belts. Accordingly, the habitat characterization was carried out in much more detail within the two near belts to the left and right of the transects than beyond. The area covered by the near belts of all transects was 125.75 ha (2012 plots of 25 x 25 m; ignoring loss of coverage due to curves in the transect routes). The habitats of the far belts were characterized up to a distance of 100 m, resulting in a total area of 503 ha (including the area of near belts). The corresponding field work was carried out from Jul. to Sep. 1997 and from Jan. to Mar. 1998, in collaboration with up to seven biology students and local assistants.

#### Mapping of habitats, vegetation structure, and human impact

The orientation of all transects was determined with a compass, and the geographic coordinates of the initial and final points with Global Positioning System (GPS) equipment. The information was used to generate base maps of the transects (scale 1:1000). Furthermore, the elevation and inclination of the terrain were measured at each 25-m marker, or more often when necessary.

The base maps showed the limits of the near belts and the far belts on both sides of the transects. Within the near belts, I incorporated into the maps extreme changes in topography (e.g., banks, cliffs, and gullies) as well as visible limits between distinct types of habitats and microhabitats. For the far belts the same information was mapped exclusively along perpendicular lines that were established at every 100-m distance marker. I used a pre-established code system to put the habitat information on the maps

(cf. Table 6 and Appendix 8). For predominant habitat types, I generated lists of common names of frequently encountered plant species with the help of local assistants.

Within the 25- and 100-m belts I mapped the course of streams and rivers and recorded detailed information for tree-fall gaps (e.g., extent, estimated age, and reasons for their generation).

To assess the general state and structure of the vegetation along the transects, I randomly chose 2 to 4 points within each 25-m section of the near belts as well as along the 100-m perpendicular lines that extended into the far belts, where I estimated the vegetation cover for each stratum. I used flexible ranges for the height of the strata (Table 5), as these structural features vary locally and greatly depend on succession stage as well as on other environmental factors, e.g., topography and soil quality.

The lowest stratum was defined as the layer of herbaceous plants (herbs, ferns, aroids, seedlings, and saplings) from the soil surface up to knee-height. The shrub layer included, apart from shrubs, also small palms and treelets, larger herbs (e.g., Musaceae), as well as leaves of hemiephytic climbers on the lower tree trunks. The more general term 'undergrowth' is used here for the combined stratum of herbs and shrubs (>0 to 4 ± 1 m). Due to the heterogeneous distribution of tree-fall gaps in varying stages of succession, it often proved impossible to separate understory and subcanopy trees and palms. Therefore, I defined the stratum above the shrub layer up to the height of the lowest branches of taller trees as the midstory. In other words, the term midstory here refers to the combined stratum of understory and subcanopy. Only the crowns of taller trees above 20 ± 5 m were recorded as the canopy.

At each randomly chosen point I estimated the vegetation cover in a plot of 5 x 5 m, which was projected through each stratum. The cover was estimated in scores between zero and four, each score

TABLE 5. Scores for the estimation of vegetation cover in four forest strata.

Vegetation stratum	Height above ground (m)	Scores of vegetation cover (%)				
		0	1	2	3	4
Herbs	0 to 0.4 (±0.1)	0	> 0-25	> 25-50	> 50-75	> 75
Shrubs & treelets	0.4 (±0.1) to 4 (±1)	0	> 0-25	> 25-50	> 50-75	> 75
Midstory (understory + subcanopy)	4 (±1) to 20 (±5)	0	> 0-25	> 25-50	> 50-75	> 75
Canopy (including emergent trees)	>20 (±5)	0	> 0-25	> 25-50	> 50-75	> 75

greater than zero spanning 25 percentage points. Owing to constraints in time and manpower, it was not possible to reach an adequate sample size for statistical tests in the general habitat characterization of the transects.

#### Characterization of main habitats of the mist-netting transects

The habitat mapping described in the previous chapter was carried out for all transects. In addition, to characterize the vegetation structure of the mist-netting transects in more detail, I selected seven 25 x 25-m plots for each of the three main habitat types per transect (semi-open country, young successional forest, and medium-age forest). This design allowed me to compare habitat characteristics between the two transects. I thus first tested whether the habitat structure of the 21 MNT1 plots together was significantly different from that of MNT2 ( $H_1$ ) or not ( $H_0$ ). Second, I tested whether the structural features of the 7 sampling units per habitat and transect were similar ( $H_0$ ) or not ( $H_1$ ), when the same habitats were compared between the transects and, third, whether the habitat characteristics of the main habitat types were different ( $H_1$ ) or not ( $H_0$ ), when compared with other habitats of the same and of the other transect.

Owing to the mosaic distribution of habitat types in small patches, a random design for the selection of the study plots proved difficult. Instead, I located the plots in those transect sections in which the corresponding habitat types were present in their presumed representative composition and structure. Within the plots, at six randomly chosen points, I determined the overstory cover, using a 'spherical crown densiometer' (Forestry Suppliers Inc., Jackson, MS, USA) according to the method developed by Lemmon (1957), as well as the vegetation cover of each stratum according to the method explained in the previous subchapter. Furthermore, I recorded the number, diameter at breast height (DBH), and height of trees and palms  $\geq 10$  cm DBH. Characteristic plant species were identified to family, genus, or species level whenever possible. For frequently encountered trees, I recorded the common names with the help of local field assistants, and identified the corresponding tree genera or species by referring to Little & Dixon (1969) and Gentry (1993), as well as to an unpublished list of the Jatun Sacha Foundation (E. Mediavilla, Jatun Sacha, pers. comm.).

#### Data analysis

For the complete transect network, I only carried out a preliminary analysis of the geomorphological and habitat data in the form of tables and graphics. In the case of the mist-netting transects, I provide detailed accounts of general habitat features and common plant species encountered along their courses, as well as quantitative data on some habitat characteristics. Note that diameter measurements were always made at breast height (1.3 m) and that I did not determine the diameters above buttresses and stilt roots of larger trees (cf. Clark & Clark 2000, Clark 2002). Therefore, I do not present the data on basal areas of the main habitats, which, in the case of the mid-age forest, were about 2.5 to 4 times higher than the values expected from the literature (e.g., Lieberman *et al.* 1990, Rankin-de-Merona *et al.* 1990) and from a forest inventory carried out in Playa de Oro (Palacios *et al.* 1996). However, I present figures on the relative abundance of trees and palms per DBH class and habitat, which have to be interpreted with the necessary caution.

Based on the data on vegetation cover, which were collected according to the method explained in the previous two subchapters, the density of each stratum in percentage was calculated by subtracting 0.5 from values  $> 0$  and multiplying the result by a factor of 25. In other words, the cover estimates were transformed from scores between 0 to 4 to the corresponding percentage values between 0 and 87.5%, limiting the maximum error of each individual estimate  $> 0$  to  $\pm 12.5\%$ . For subsequent analysis, I used the plot means of the 6 individual cover estimates per sampling unit, which together represented 24% (150 m<sup>2</sup>) of the total area of 625 m<sup>2</sup> of each plot.

For descriptive statistics and the generation of graphics, I employed Microsoft Excel (Microsoft 2001), and for all other statistics SPSS software (SPSS 2003). Before using parametric methods, such as one-way ANOVA (analysis of variance), which allows the comparison of several sample means in a single test (Fowler & Cohen 1986, NIST/SEMATECH 2003), I investigated the data sets on normal distribution and homogeneity of variance, using Shapiro-Wilk (Shapiro & Wilk 1965) and Levene tests (Levene 1960), respectively. If necessary, the data were transformed (e.g., by lognormal transformations). If the final F values of the ANOVAs indicated a significant difference between the means of the groups, I carried out post hoc Tukey HSD (honestly significant difference) tests for pair-wise mul-

TABLE 6. Physical characteristics and habitats of the transect network in Playa de Oro (Fig. 1b). Abbreviations used: (a) transect codes; MNT = mist-netting transect; LT = line transect; (b) life zone (cf. Tab. 1): TrWF = tropical wet forest; PmWF = premontane wet forest; refers to the lowermost base of the Andean foothills, which either pertain to the previous life zone (p. 26, Life zones); PmPF = premontane pluvial forest; (c) natural formation (main vegetation type): EFcoLL = evergreen forest of the coastal lowlands (below c. 300 m); EFwAFH = evergreen forest of the western Andean foothills (above c. 300 m; p. 26f, Natural formations – main vegetation types); (d) main habitat types: OC = open country and semi-open country (e.g., mixed-culture plantations, abandoned plantations, and young successional scrub); ysF = young successional forest (low-canopy, low-diameter forest in early stages of regeneration; only a few tree stems have a DBH > 30 cm); magF = medium-age forest (high-canopy forest in sub-mature stages; trunks of bigger trees have medium-sized diameters; i.e., a DBH of 30–60 cm, rarely more); matF = mature forest (high-canopy forest, either primary or secondary, with numerous old and large-diameter trees per area; i.e., with a DBH > 60 cm); (e) less important habitats and microhabitats: strF = stream within forest; strOC = stream within open country or semi-open-country; OC/R = open-country-to-river edge or semi-open-country-to-river edge; ritF = ridge-top forest; HEL = *Heliconia* thickets; guaB = *Guadua* bamboo stands; tsR/V = river edge trees and scrubs (regularly inundated). Note: the list below of habitats and microhabitats encountered in the transect areas is not complete.

Transect	Length (m)	Altitudinal range (±10m)		Distance to river (m)		Inclination of transect main belts	Life zone <sup>b</sup>	Natural formation <sup>c</sup>	Main habitat types per transect (m) <sup>d</sup>				Less important habitats and microhabitats <sup>e</sup>
		Min.	Max.	Min.	Max.				OC	ysF	magF	matF	
MNT1	625	49	69	91	558	level, sloping	TrWF	EFcoLL	275	175	175	0	strF, strOC, OC/R, HEL
MNT2	550	66	75	30	388	level	TrWF	EFcoLL	150	125	275	0	strF, strOC, OC/R, HEL, guaB
LT1	1550	47	90	2	460	level, sloping	TrWF	EFcoLL	825	450	275	0	strOC, OC/R, tsR/V, HEL, guaB
LT2a	1500	51	115	310	1075	level, sloping	TrWF	EFcoLL	75	150	1275	0	strF, HEL, guaB
LT2b	1500	50	95	300	925	level, sloping	TrWF	EFcoLL	250	0	1250	0	strF, strOC, OC/R, tsR/V, HEL
LT3	1225	64	85	310	1380	level	TrWF	EFcoLL	250	400	575	0	strF, strOC, HEL, guaB
LT4a	1325	49	141	390	1540	level, sloping	TrWF	EFcoLL	450	75	800	0	strF, strOC, HEL, guaB
LT4b	1300	140	160	1460	1700	level	TrWF	EFcoLL	0	0	1175	125	strF
LT5	1525	52	82	155	770	level	TrWF	EFcoLL	675	650	200	0	strF, strOC, OC/R, HEL, guaB
LT6	1600	48	77	10	615	level, sloping	TrWF	EFcoLL	450	550	600	0	strF, strOC, OC/R, tsR/V, HEL, guaB
LT7	1425	95	163	385	1460	level, sloping	TrWF	EFcoLL	0	0	1125	300	strF
LT8a	1625	83	156	290	460	level, sloping	TrWF	EFcoLL	0	0	1625	0	strF, ritF, HEL
LT8b	1600	135	176	270	1230	level, sloping	TrWF	EFcoLL	0	0	1025	575	strF, ritF
LT9	1300	130	150	90	540	level	PmWF?	EFcoLL	0	225	575	500	strF
LT10	1500	150	200	585	1540	level	PmWF?	EFcoLL	0	0	725	775	strF
LT11a	1650	105	230	140	1300	sloping	PmWF?	EFcoLL	0	150	600	900	strF, strOC, HEL
LT11b	1650	232	340	1300	2380	level, sloping	PmWF?	EFcoLL, EFwAFH	0	0	0	1650	strF, ritF
LT11c	1700	338	398	2380	3690	level, sloping	PmWF?, PmPF	EFwAFH	0	475	0	1225	ritF
Sum	25150								3400	3425	12275	6050	

multiple comparisons (Tukey 1977, NIST/SEMATECH 2003). To demonstrate that parametric and nonparametric methods lead to similar results for variables that fulfilled the prerequisites of parametric statistics, I also employed (Mann-Whitney) U-tests in addition to ANOVAs (summarized in Table 7). The data on the vegetation cover did not meet the requirements of parametric statistics. Consequently, they were analyzed only with pair-wise U-tests, a nonparametric ranking method, which compares medians of two unmatched samples (Fowler & Cohen 1986). Presumed associations between the cover of various vegetation strata were analyzed with nonparametric Spearman's rank correlation tests, which calculate correlation coefficients for paired observations and are carried out on the ranks of data that are at least ordinal in scale (Conover 1980). Since a negative correlation is hypothesized between the vegetation cover of the upper and lower strata, I employed one-tailed tests. In all tests, differences were regarded as significant at a probability level of  $P < 0.05$ .

## Results

The habitats covered by the transect network

About 13.6% of the total transect length of 25.15 km were located within non-forest habitats, principally in cultivated or abandoned plantations (Table 6). In Playa de Oro, semi-open habitats were not present in large continuous blocks, but rather in patches of 0.3 to several hectares within a mosaic of field-wood-like assemblages of pioneer trees, *Guadua* bamboo stands, and patches of secondary forest in various stages of succession. Most of the non-forest habitats were located on the floodplain and alluvial terraces in the vicinity of the Río Santiago and, especially, of the village itself. Consequently, transects in these areas covered a wider spectrum of habitats and microhabitats than transects located in *terra firme*, like rolling lowland hills or foothills. Most of the latter transects exclusively covered forest. Regarding the coverage of forest types, 13.6% of the total transect length was located within young successional forest, 48.8% within medium-age forest, and 24.1% within mature forest. These figures represent rough estimates, since the main habitat types were not mapped at the resolution of the 25 x 25-m main belt plots, but at a larger scale of noticeable changes in the general vegetation structure and plant community composition. That is to say that average-sized tree-fall gaps with young successional vegetation were mapped as microhabitats within medium-age or mature forest,

without changing the main habitat type. Likewise, smaller patches of mature forest within an extended area of medium-age forest were not recorded as a different main habitat type.

Mature forest was much more widespread in remote *terra firme* areas than in the vicinity of the Río Santiago and of the village. However, not even the remotest parts of the community area have been entirely spared from human impact. Over the last decades various groups of illegal settlers (colonos) have tried to establish farms in the foothill zone, e.g., in the last half of transect LT11c (Fig. 1b), at a walking distance of 4450 m from the Río Santiago and c. 20 km from the Ibarra – San Lorenzo road. Fortunately, until now, all intentions of establishing illegal settlements within the community of Playa de Oro have been unsuccessful due to the decisive resistance of the villagers, sometimes with the additional help of the Ecuadorian military.

The transects covered an altitudinal range of between c. 47 to 398 ( $\pm 10$ ) m a.s.l. (Fig. 3a). In total, 1678 (83.4%) of the main belt plots, equaling a transect length of 20 975 m, were located below 200 m. Only transects LT11a to LT11c covered elevations above 200 m. Regarding the distribution over the life zones of the Holdridge (1967) system, approximately 17 350 m (69.0%) of the total transect length was located in tropical wet forest, c. 7600 m (30.2%) in the wet foothills (either tropical wet forest or premontane wet forest; see p. 26, Life zones), and only 200 m (0.8%) in premontane pluvial forest. The transition between wet forest and premontane pluvial forest was determined here by a surprisingly distinct change in the composition of the bird community (p. 193, Life zone assemblages). According to the classification of Sierra *et al.* (1999b), only about 2500 m (9.9%) of the total transect length was located within the natural formation 'evergreen forest of the western Andean foothills', while all the rest belonged to 'evergreen forest of the coastal lowlands'. The straight line distance between the transects and the Río Santiago varied widely between a minimum of only 2 m and a maximum of c. 3690 m. The terrain of a total of 784 (37.2%) main belt plots was level to slightly sloping, at 0° to 4.9°, while only 134 (6.7%) plots had inclinations above 30° (Fig. 3b).

The habitats of the mist-netting transects

Basically, MNT1 and MNT2 had a very similar sequence of habitats, which started in semi-open



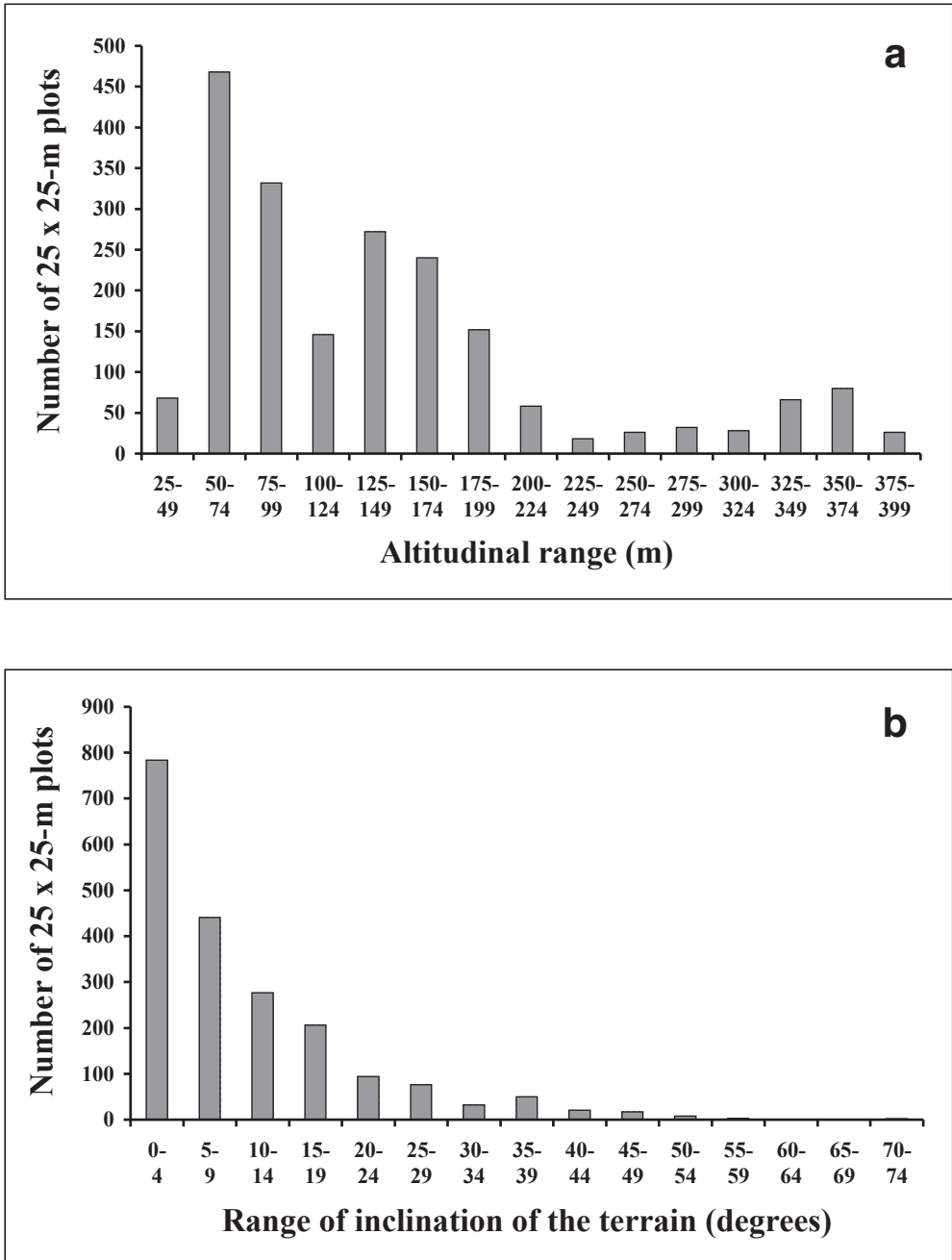


FIG. 3. Distribution of the 2012 plots of 25 x 25 m located within the main belts of the 18 study transects: (a) over altitudinal range classes of 25 m each; (b) over range classes for the inclination of the terrain of 5° each. For the latter figure, I used absolute values of the maximum angles of inclination measured in each plot.



FIG. 4. View from section A of MNT1 onto a traditional mixed-culture plantation with cacao, plantain, and many other cultivated plants, as well as scattered shade trees. The undergrowth of the plantation was cleared about 2-3 weeks earlier. A forest edge is visible in the background (marker 112.5 m, cf. Fig. 5; elev. 49 m, 1 Jul. 96).

country on the floodplain of the Río Santiago, continued in young successional forest, and eventually ended in medium-age forest with some scattered mature emergent trees on *terra firme* (Table 4). They were both located below 100 m a.s.l., and thus belonged to the same life zone and natural formation (Table 6).

The MNT1 habitats: a qualitative characterization

The transect started on the outskirts of the village (0-m marker: 0°52'35.5"N, 78°47'33.6"W), 90 m from the southern bank of the Río Santiago, had a total length of 625 m, and an altitudinal range of 49-69 m (Fig. 5). The riverbank and the village itself were rich in coconut palms *Cocos nucifera*. Section A and the first part of section B (up to marker 237.5 m) were located on the floodplain within semi-open country of cultivated (Fig. 4) or recently abandoned subsistence plantations (Fig. 6, left; Table 4). The area was interspersed by higher secondary vegetation of shrubs and small trees, mainly along a system of water-filled channels from former gold-mining activities, as well as by delimiting field-wood-like

structures between the plantations of different owners. These mainly linear vegetation elements were often very dense, only a few meters in width, and up to 20 m high. Some were connected to nearby secondary forest and literally acted as 'biological corridors'. Whenever possible, I established those sections of the mist-netting transect that ran through semi-open country within the successional vegetation. Typical weedy and herbaceous plants in this part of the transect were *Anthurium* spp. (Araceae), *Heliconia* spp. (Musaceae), *Costus* spp. (Costaceae), *Calathea* spp. (Marantaceae), and *Burmeistera* sp. (Campanulaceae); frequent shrubs were *Clibadium* sp. (Compositae), *Palicourea* sp. (Rubiaceae), *Miconia* spp. (Melastomataceae), and various *Piper* spp. (Piperaceae); common small and medium-sized trees were 'mora' *Miconia prasina* (Melastomataceae), 'guaba' *Inga* spp. (Mimosaceae), different species of 'guarumo' *Cecropia* spp. (Moraceae), and *Rudgea* sp. (Rubiaceae).

The mixed-culture plantations themselves were well structured and the plant species composition varied widely (for frequently encountered cultivated



plants and shading trees see p. 27f, Vegetation cover and land use).

The area between markers 237.5 m and 375 m, corresponding to sections B and C (Table 4), was also located on the floodplain but consisted mainly of young secondary forest on former plantations, which had been abandoned for at least six years and often much longer (Fig. 6, center and right). Numerous water-filled channels were evidence that this zone was also influenced by historic gold-mining activities. The average height of the forest canopy was 20 to 25 m, with only a few trees emerging to about 35 m. The tree species composition was typical for secondary forest on ancient plantations (rastrojo). Frequent tree species were 'balsa' *Ochroma pyramidalis*, 'cuángare' *Otoba gordoniiifolia*, 'chalviande' *Vireola* sp., 'peine de mono' *Apeiba aspera*, 'guaba blanca' *Inga* sp., 'caimitillo' *Chrysophyllum* sp., and *Pouteria* sp. (Sapotaceae); some individuals of the palms 'gualte' *Wettinia quinaria* and 'pambil' *Iriarteia deltoidea* were also present. The undergrowth was relatively dense with herbaceous stands of *Heliconia* spp. and *Calathea* spp. in the wetter spots, as well as

frequent shrubs like *Acalypha* sp. (Euphorbiaceae), *Piper* spp., and *Miconia* sp. Two species of *Inga* and 'mora blanca' *Miconia* sp. were frequent small trees in the understory.

The transect left the floodplain after passing a forest stream at marker 375 m and continued on a ridge (section C; Fig. 7, left), gradually rising by at least 20 m up to the transect end. Small streams were located in the valleys at both sides of the ridge. This hilly area was probably never clear-cut or cultivated, but contained some abandoned goldmines with rocky ground, and was covered with selectively logged medium-age forest with some scattered mature trees. The forest contained many tree species that were only infrequently found in secondary forest on former plantations, such as 'anime' *Dacryodes* spp., 'sande' *Brosimum utile*, 'guadaripo' *Nectandra guadaripo*, 'jigua' *Ocotea* spp. and *Nectandra* sp., 'indio hediondo' *Osteophloeum platyspermum* (Myristicaceae), 'carrá' *Huberodendron patinoi* (Bombacaceae) and 'sapotillo' *Matisia* sp. (Bombacaceae). The average canopy height was 25 to 30 m, with a few emergent trees of almost 50 m (Fig. 7, right). Light gaps

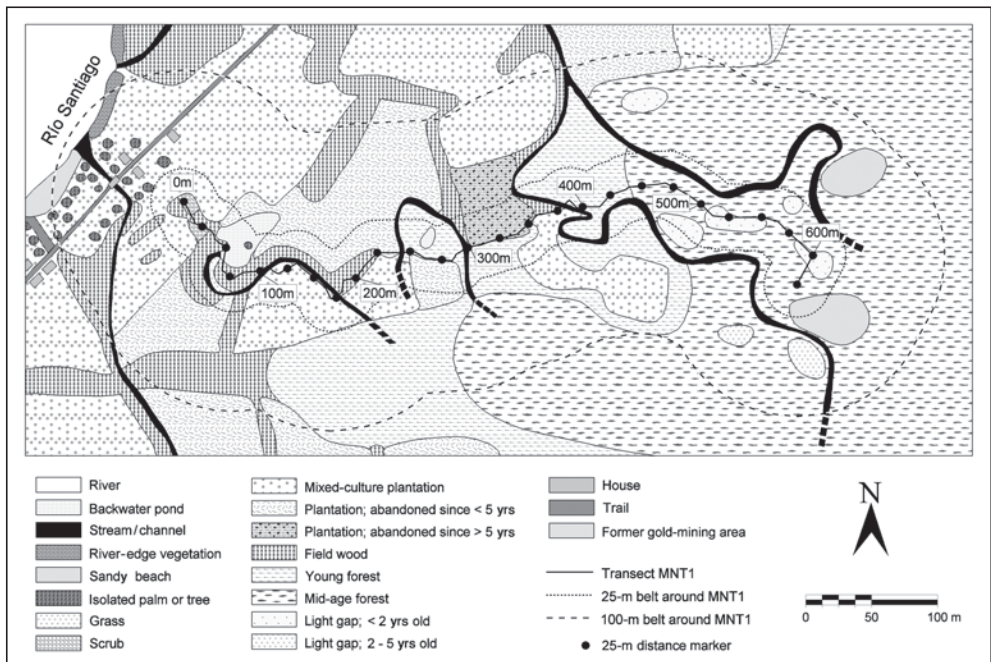


FIG. 5. Habitat mosaic in the transect area of MNT1, located on the outskirts of the village (see text for details). The limit of the 100-m belt circumscribes the transect area of 15.6 ha to which I refer in later chapters.

were frequent, and the shrub layer was relatively dense. In comparison with the undergrowth of the early-stage forest on former plantations, additional genera of woody plants occurred more frequently, for example *Besleria* spp. (Gesneriaceae) and the small tree 'monterillo' *Heisteria macrophylla* (Olacaceae). Plant species richness and epiphyte cover on trees was evidently higher in the last part of the transect.

The general succession of habitat types along the transect remained nearly constant during the study period. However, the borders of some plantations changed slightly, while selective logging as well as natural tree falls locally altered the forest structure.

The MNT2 habitats: a qualitative characterization

The second transect was located about 7 km upstream on the Río Santiago (0-m marker: 0°51'01.0"N, 78°46'52.4"W), c. 3 km in a straight line from the village, at a location named Playa Rica (Figs. 1b and

8). There, a gold-mining company cleared about 1.4 ha of young successional scrub and secondary forest and constructed a two-story wooden building in the center of the clearing around the year 1992. Since the company left, the building has been maintained by the local community as part of the infrastructure for ecotourism and was used as accommodation by the author and his team from 1995 to 1998.

The total length of MNT2 was 550 m (Fig. 8), and the altitude lay between 66 and 75 m. The initial point was about 30 m from the bank of the Río Santiago and less than 40 m from the mouth of the Playa Rica stream.

The clearing where transect section A was located was covered by different stages of young successional vegetation (Table 4; Fig. 9). Local people regularly cut the meadow-like vegetation in the entrance area of the building (c. 250 m<sup>2</sup>). The closer vicinity of the building and path to the river was cut



FIG. 6. Three different habitats on the floodplain of the Río Santiago within section B of MNT1. This was the most variable of all transect sections covered by MNT1 and MNT2. The muddy conditions of the trail were typical for this wet region. Left: recently abandoned, overgrown plantation with field-wood-like vegetation to the right and young successional scrub as well as *Anthurium* sp. in the center and to the left; in the background the edge of the forest that is shown in the next photo (marker 200 m, cf. Fig. 5; elev. 49 m, 1 Jul. 96). Center: young to medium-age secondary forest patch with relatively dense undergrowth of herbaceous plants and saplings; the fallen tree hanging over the trail was alive and sprouting; the forest bordered on an abandoned plantation just a few meters to the right (marker 250 m, elev. 50 m, 1 Jul. 96). Right: young successional forest with dense shrubby undergrowth on a plantation that was abandoned c. 6 years earlier; the trees with the light bark were 'balsa' trees *Ochroma pyramidale*; the soil in this area was only 10 to 20 cm deep, overlying the gravel of an ancient river bed or gold-mining area (marker 312.5 m, elev. 51 m, 1 Jul. 96).





FIG. 7. Selectively logged *terra firme* forest of MNT1. Left: young to medium-age forest on the ridge of a lowland hill (section C, marker 450 m, cf. Fig. 5; elev. 61 m, 1 Jul. 96). Right: mature forest patch at the end of the transect; the big tree in the background, a 'sande' *Brosimum utile*, was c. 48 m high (section D, marker 625 m, elev. 69 m, 1 Jul. 96).

about once or twice a year (around 500 to 1000 m<sup>2</sup>). This thicket of grasses, ferns, vines, seedlings, and saplings grew hip-high within a few months. Its composition was very similar to the weedy undergrowth of cultivated or recently abandoned plantations. The peripheral areas of the clearing consisted of a mosaic of successional vegetation like weedy patches, dense shrubs, and small trees (Fig. 10, left). The species composition and structure of this zone were very similar to the secondary and field-wood-like vegetation on the outskirts of Playa de Oro. In contrast to MNT1, the large bamboo *Guadua* sp. (Gramineae) was also present. Common small to medium-sized trees were four different species of 'guarumo' *Cecropia* spp., 'guaba' *Inga* spp., and 'masamorro' or 'lulo' *Aegiphila alba* (Verbenaceae). The maximum tree heights in this area varied between c. 12 and 20 m.

The number and density of trees increased on the left side of the transect from marker 75 m onwards. The undergrowth of this young forest contained various shrub genera, which were also encountered at MNT1, like *Palicourea* sp. and various *Piper* spp. The course of the transect followed the border between the young forest and semi-open habitat up to marker 137.5 m, where the paths entered the forest. In section B it continued through young to medium-age forest on the floodplain up to marker 262.5 m (Fig. 10, right). On the left side of the transect the ground was covered with gravel and rocks, probably due to former gold-mining activities. By contrast, the terrain was flat on the right side, where the groundwater level stood so high that the area was swampy and frequently flooded after heavy rainfalls. At spots with thin canopy cover, *Heliconia* spp. and *Calathea* spp. were dominant herbaceous plants. In general,

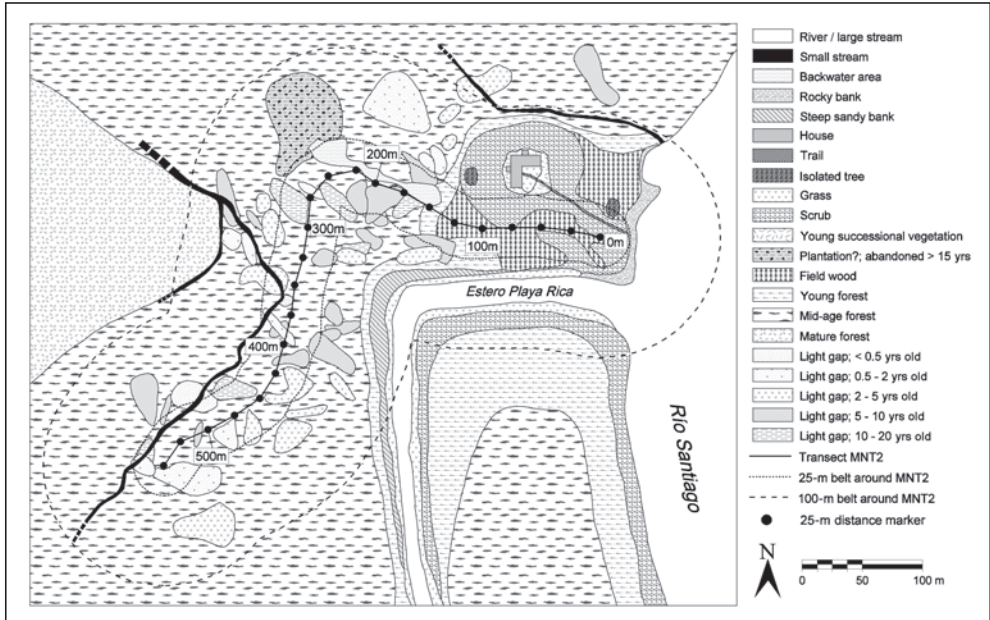


FIG. 8. Habitat mosaic in the transect area of MNT2, Playa Rica (see text for details). The limit of the 100-m belt circumscribes the transect area of 14.1 ha to which I refer in later chapters.



FIG. 9. View from the second floor of the building in Playa Rica. The trail leads to the bank of the Río Santiago (Fig. 8). Transect MNT2 was located within the field-wood-like successional vegetation in the right half of the photo (Fig. 10, left). The big tree to the left was a 'matapalo' *Ficus* sp. (Moraceae), a strangler fig, which stood on the bank of the river. Rolling lowland hills in the background (MNT2, section A, elev. 66 m, 27 Apr. 97).





FIG. 10. The first two sections of MNT2 in the floodplain of the Río Santiago at Playa Rica. Left: semi-open country with shrubs, *Heliconia* stands, and *Cecropia* trees; the grass cover on the transect path indicates the high light intensity in this part of the transect (section A, marker 50 m, cf. Fig. 8; elev. 66 m, 27 Apr. 97). Right: young successional forest, c. 5 years old (section B, marker 150 m, elev. 66 m, 27 Apr. 97).

the high proportion of pioneer species indicated that the area was cultivated some time ago. The whole area was rich in light gaps, only a few tree stems had diameters  $> 50$  cm, and the canopy height varied between 20 and 35 m. Three genera of palms were present: the common 'gualte' *Wettinia quinaria*, the understory palm *Geonoma* sp., and a few individuals of 'pambil' *Iriarteia deltoidea*. The most abundant shrub species belonged to the genera *Besleria* and *Miconia*.

At marker 262.5 m the transect ascended an elevational difference of c. 10 m on a small slope, and continued on an alluvial terrace (sections C and D). This mostly level area was covered with medium-age to patchily mature forest on *terra firme* (Fig. 11). According to local people it had not been cultivated for c. 60 years. However, selective logging has had a continuing impact on the forest structure in recent decades. Nevertheless, some large trees with a DBH

$> 100$  cm and heights of about 40 to 50 m remained. The average canopy height was 25 to 35 m. Tree species diversity was higher in this area than in any other section of MNT2 and MNT1. Frequently noted and identifiable species were, in addition to those listed for MNT1, 'uva' *Pourouma minor* (Moraceae), and 'arrayán' *Eugenia myrobalana* (Myrtaceae). The occurrence of a young individual of the valuable hardwood 'guayacán' *Minquartia guianensis* (Olacaceae) shows that this forest still contained species that tend to disappear rapidly under human pressure. The most abundant shrub species were *Besleria* sp. and *Miconia* spp.

Structural features of the main habitats of MNT1 and MNT2

*The number of trees and palms.* – A total of 895 trees and palms with a DBH  $\geq 10$  cm were counted in the



FIG. 11. *Terna firme* forest on alluvial terrace in the second half of MNT2. Left: mature forest patch with sparse undergrowth and emergent 'sande' *Brosimum utile* with a height of c. 45 m (section C, marker 300 m, cf. Fig. 8; elev. 74 m, 27 Apr. 97). Right: medium-age forest with high density of small-diameter trees and lianas (section D, marker 487.5 m, elev. 75 m, 27 Apr. 97).

42 plots of 625 m<sup>2</sup> each. Not less than 59.2% ( $n = 530$ ) of the individuals were recorded in the MNT2 sample and only 40.8% ( $n = 365$ ) in the MNT1 plots. The difference between sample means of MNT1 and MNT2 was significant (ANOVA:  $F_{1,40} = 5.214$ ,  $P = 0.028$ ,  $n = 21$  plots per transect).

In the case of MNT1, the number of individuals gradually increased in the sequence from open country to medium-age forest, whereas for MNT2 the maximum number of trees as well as palms was recorded for young successional forest, not medium-age forest (Fig. 12). On the basis of the number of stems counted in the total plot area of 4375 m<sup>2</sup> per habitat and transect, the extrapolated combined number of trees and palms per hectare were (a), for MNT1, 130 in open country, 299 in young successional forest, and 405 in medium-age forest and (b), for MNT2, 183, 539, and 489, respectively. Not surprisingly, differences in sample means of the number

of stems were highly significant in the between-habitat analyses (ANOVA:  $F_{5,36} = 14.229$ ,  $P < 0.001$ ,  $n = 7$  plots per habitat and transect). However, post hoc pair-wise comparisons showed that for pairs of the same habitat, only the number of stems in young successional forests differed (Tukey HSD,  $P = 0.005$ ; Table 7). In pair-wise comparisons of unequal habitat types, differences in the mean number of stems existed between the open country of both transects and young forest of MNT2 (Tukey HSD,  $P < 0.001$  in both cases), but not MNT1. As expected, differences were also significant for pair-wise comparisons between open country and medium-age forest (Tukey HSD,  $P = 0.012$  to  $P < 0.001$ ). However, differences were not significant between samples of young successional forest and medium-age forest, with the exception of the habitat pair 'young forest of MNT1 and medium-age forest of MNT2' (Tukey HSD,  $P = 0.044$ ).

*The diameter at breast height (DBH).* – For all habitats, the proportion of trees and palms declined rapidly with increasing DBH class (Figs. 13a and 13b), with most stems in the smallest category (10.0-19.9 cm). There was no difference between the plot means for MNT1 and MNT2 in a one-way ANOVA. However, the difference in sample means was highly significant in the between-habitat analyses (ANOVA:  $F_{5,36} = 11.073$ ,  $P < 0.001$ ,  $n = 7$ ). Particularly, the early stage forest of MNT1 had relatively fewer stems in the first two DBH classes (10.0-29.9 cm), but more trees in the diameter range 30.0-59.9 cm than the medium-age forest of the same transect, while in the case of MNT2, relatively more individuals fell in the first three DBH classes (10.0-39.9 cm) than the medium-age forest (Figs. 13a and 13b). Thus, regarding the habitat feature ‘DBH’, at least some of the MNT1 samples categorized here as young forest were, in fact, in a rather advanced stage of early succession. Consequently, in the pair-wise comparisons of the habitats, the differences in DBH plot means for young forest of MNT1 and MNT2 were signi-

ficant (Tukey HSD,  $P = 0.048$ ; Table 7). In comparisons between unequal habitat pairs, the young successional forest of MNT1 was not different from the medium-age forest of both transects. On the other hand, the young successional forest of MNT2 did not differ from the open-country samples of both transects.

*The height of trees and palms.* – In forest, the proportion of trees and palms per height class showed a positively skewed distribution, whereas this pattern has not yet evolved in open-country samples (Figs. 14a and 14b). For both transects and all habitat samples, the percentage of individuals was greatest in the height class 15.0-19.9 m. As for the previous habitat feature, the plot means of MNT1 and MNT2 did not differ in a one-way ANOVA, while the difference in sample means was highly significant in the between-habitat analyses (ANOVA:  $F_{5,36} = 17.803$ ,  $P < 0.001$ ,  $n = 7$ ). However, the pair-wise Tukey HSD analyses of plot means for tree height revealed no differences in any of the four possible combinations of young forest and medium-age forest, neither

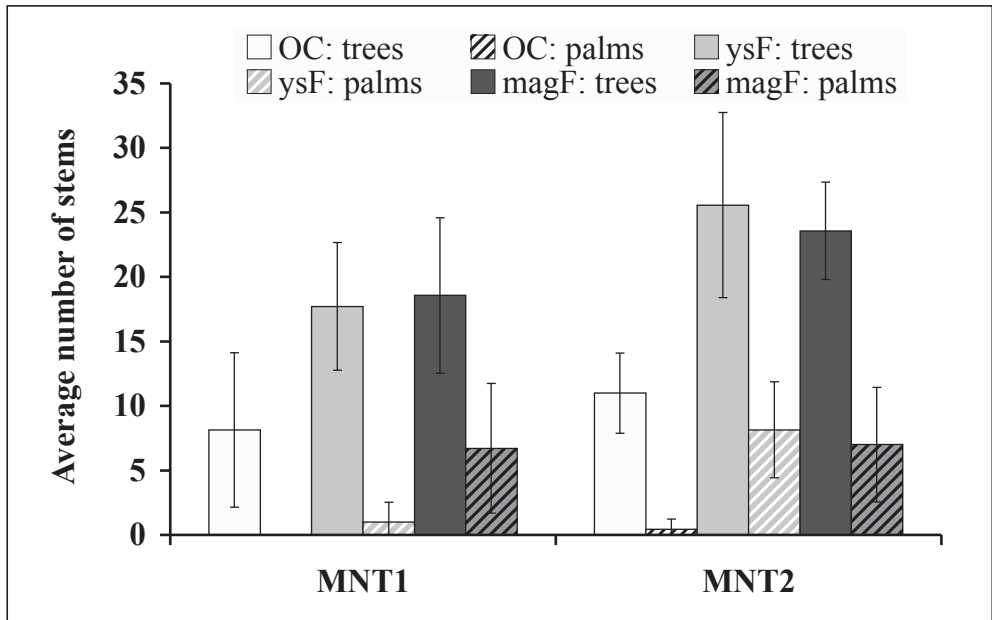


FIG.12. Average number of trees (MNT1:  $n = 311$ ; MNT2:  $n = 421$ ) and palms (MNT1:  $n = 54$ ; MNT2:  $n = 109$ ) with a DBH  $\geq 10$  cm in the seven 25 x 25-m plots per main habitat type and transect; with standard deviation. Abbreviations used: see Table 6. Note: statistical tests described in the text and summarized in Table 7 refer to the combined number of trees and palms per habitat type and transect.



TABLE 7. Results of the statistical analysis of differences in four habitat features of the main habitat types ( $n = 7$  plots per habitat and transect), comparing them between the two mist-netting transects as well as within each transect: (a) above the diagonal, significance of the difference between medians according to the (Mann-Whitney) U-test, which is shown for comparative reasons and, (b) below the diagonal, between means according to Tukey's honestly significant difference (Tukey HSD), used as a post hoc test to one-way ANOVAs that rejected the null hypothesis (see text for details). Light gray cells indicate cases where  $H_0$  was accepted in the pair-wise comparisons when its rejection was assumed, and dark gray cells where  $H_0$  was rejected when its confirmation was assumed. The cells are unshaded if the assumed hypothesis was confirmed by the tests (either  $H_0$  or  $H_1$ ). Significance levels of the tests: n.s. =  $P \geq 0.05$  (not significant), \* =  $P < 0.05$  (significant), \*\* =  $P < 0.01$  (highly significant), \*\*\* =  $P < 0.001$  (very highly significant). Abbreviations used: see Table 6.

			Number of trees and palms					
		<i>U</i> -test	MNT1			MNT2		
	Tukey		OC	ysF	magF	OC	ysF	magF
Number of trees and palms	MNT1	OC		*	**	n.s.	**	**
		ysF	n.s.		n.s.	*	*	**
		magF	***	n.s.		**	n.s.	n.s.
	MNT2	OC	n.s.	n.s.	*		**	**
		ysF	***	**	n.s.	***		n.s.
		magF	***	*	n.s.	***	n.s.	
Mean diameter at breast height (DBH)								
		<i>U</i> -test	MNT1			MNT2		
	Tukey		OC	ysF	magF	OC	ysF	magF
Mean DBH	MNT1	OC		**	**	n.s.	n.s.	**
		ysF	*		n.s.	**	**	n.s.
		magF	**	n.s.		**	**	n.s.
	MNT2	OC	n.s.	**	***		n.s.	**
		ysF	n.s.	*	**	n.s.		**
		magF	***	n.s.	n.s.	***	**	
Mean height of trees and palms								
		<i>U</i> -test	MNT1			MNT2		
	Tukey		OC	ysF	magF	OC	ysF	magF
Mean height of trees and palms	MNT1	OC		**	**	n.s.	**	**
		ysF	**		n.s.	*	n.s.	*
		magF	***	n.s.		**	n.s.	n.s.
	MNT2	OC	n.s.	*	***		**	**
		ysF	***	n.s.	n.s.	**		n.s.
		magF	***	n.s.	n.s.	***	n.s.	
Maximum tree height								
		<i>U</i> -test	MNT1			MNT2		
	Tukey		OC	ysF	magF	OC	ysF	magF
Maximum tree height	MNT1	OC		**	**	n.s.	**	**
		ysF	n.s.		n.s.	n.s.	n.s.	**
		magF	***	n.s.		*	n.s.	n.s.
	MNT2	OC	n.s.	n.s.	**		*	**
		ysF	***	n.s.	n.s.	*		n.s.
		magF	***	**	n.s.	***	n.s.	



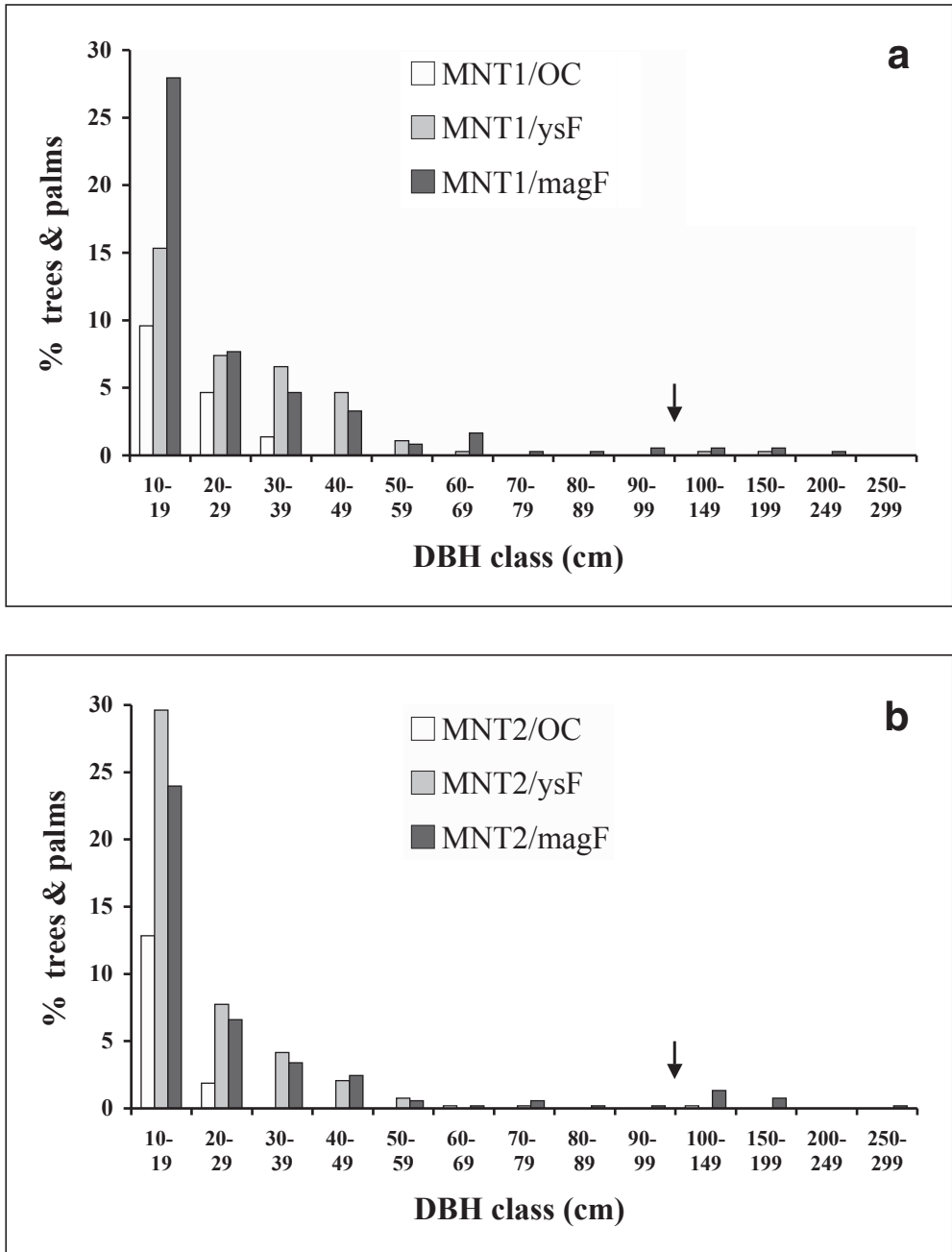


FIG. 13. Proportion of trees and palms per DBH class and main habitat type in the seven 25 x 25-m plots per habitat and transect, (a) of MNT1 ( $n = 365$ ) and (b) of MNT2 ( $n = 530$ ). Note that the scale changes from 10 to 50 cm per DBH class for diameters above 100 cm (indicated by an arrow). Abbreviations used: see Table 6.

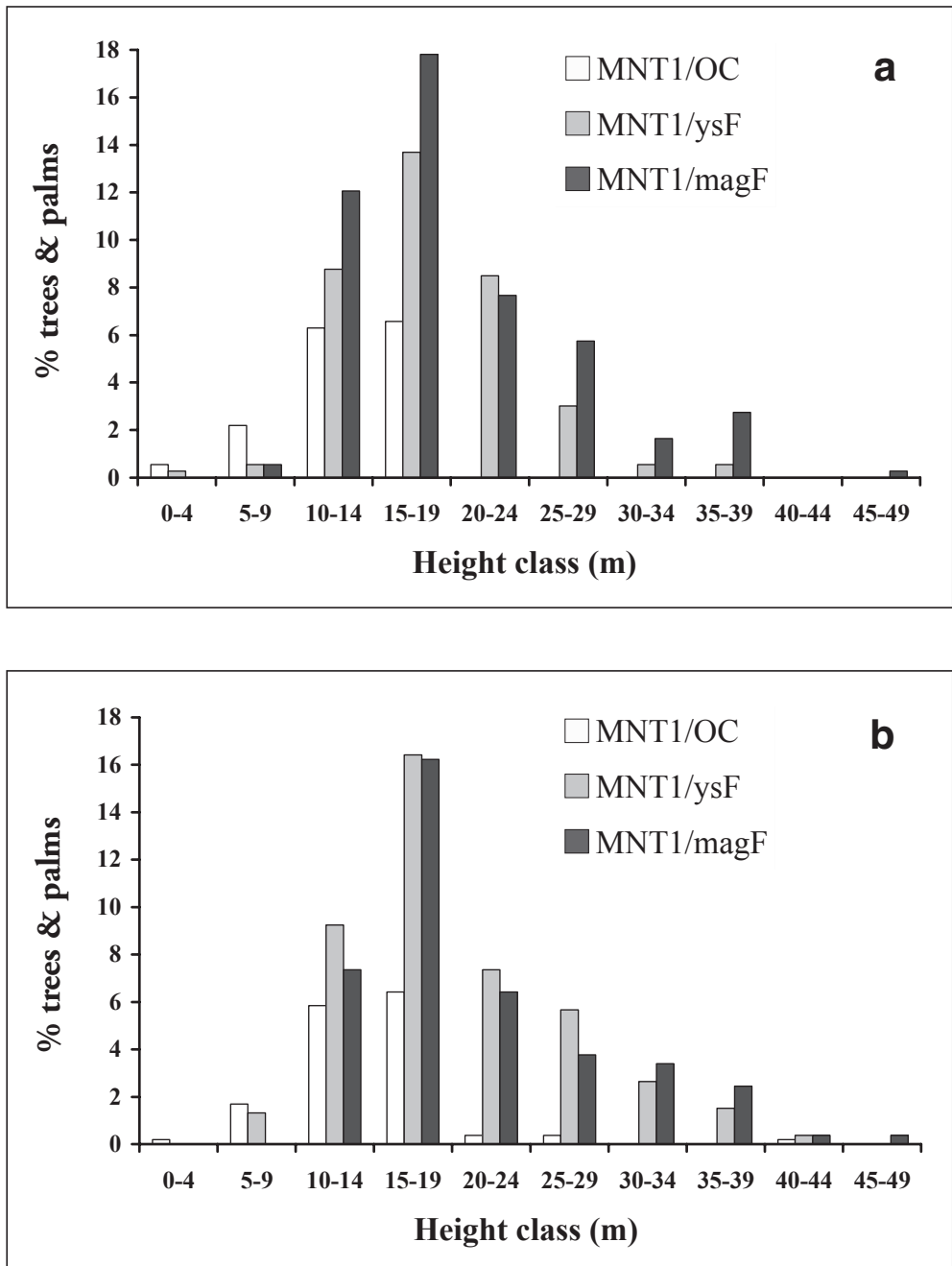


FIG. 14. Proportion of trees and palms with a DBH  $\geq 10$  cm per height class and main habitat type in the seven 25 x 25-m plots per habitat and transect, (a) of MNT1 ( $n = 365$ ) and (b) of MNT2 ( $n = 530$ ). Abbreviations used: see Table 6.

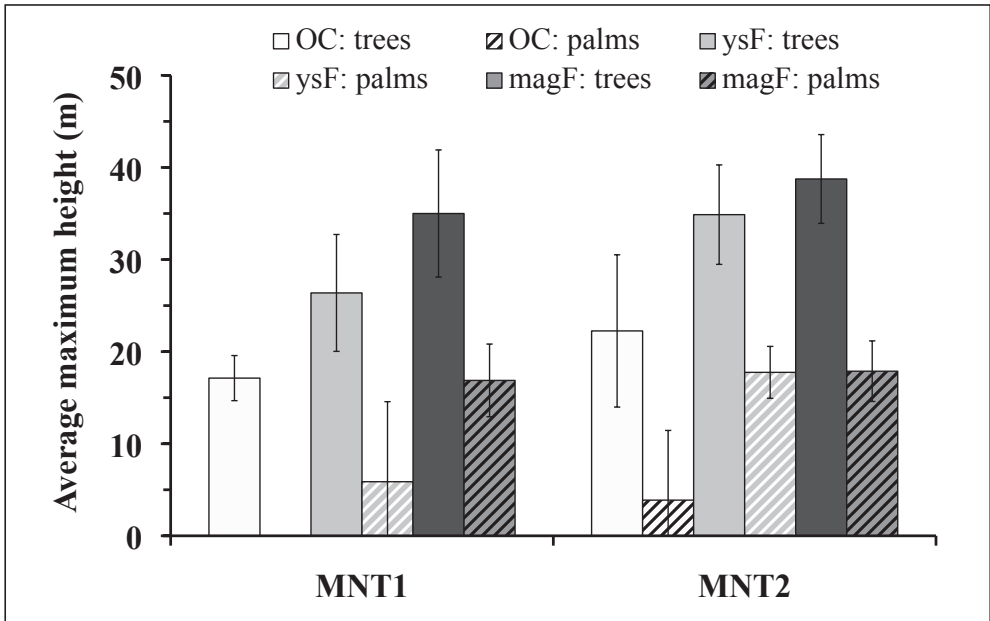


FIG. 15. Average maximum height of the tallest trees (MNT1:  $n = 311$ ; MNT2:  $n = 421$ ) and palms (MNT1:  $n = 54$ ; MNT2:  $n = 109$ ) with a DBH  $\geq 10$  cm in the seven 25 x 25-m plots per main habitat type and transect; with standard deviation. Abbreviations used: see Table 6. Note: statistical tests described in the text and summarized in Table 7 refer to the combined number of trees and palms per habitat type and transect.

within the transects nor between them. The analysis also showed that the open-country samples of both transects were different when compared with any of the other habitat samples, but not with each other (Table 7).

Regarding the tallest trees per study plot, the dicots were always taller than the monocots. In general, the average maximum height of palms was considerably lower than that of trees (Fig. 15). For MNT1 the average maximum height of trees and palms gradually increased from open country over young successional to medium-age forest. By contrast, the mean maximum height of palms was equal in the young forest and medium-age forest of MNT2, and even the trees were only slightly taller in the latter habitat. On average, the samples of MNT2 had greater maximum heights than those of the corresponding habitats of MNT1, for trees as well as palms. Not surprisingly, sample means in the between-transect analyses differed in an ANOVA ( $F_{1,40} = 4.18$ ,  $P = 0.048$ ,  $n = 21$ ).

In the between-habitat comparison, the difference in sample means was highly significant (ANOVA:

$F_{5,36} = 14.086$ ,  $P < 0.001$ ,  $n = 7$ ). However, the post hoc analysis demonstrated that the young successional forest of MNT2 differed only from the open-country samples and the same habitat type of MNT1 differed only from the medium-age forest of MNT2 (Tukey HSD,  $P = 0.004$ ).

*Vegetation cover.* – Some pronounced differences were noted in the vegetation cover per stratum between transects (Figs. 16a and 16b). With 23–36%, the mean cover of herbaceous plants was denser in all three habitats of MNT1 than of MNT2 (15–19%). Consequently, the difference in sample means was significant in the between-transect analyses (Mann-Whitney:  $U = 53.5$ ,  $z = -4.275$ ,  $P < 0.001$ ;  $n = 21$ ).

With 45–78% the shrub layer of MNT1 was also denser in all habitat types than in the corresponding habitat samples of MNT2 (36–68%). For the former transect, the mean cover fell gradually from open country over young successional forest to medium-age forest. By contrast, in the case of MNT2 an abrupt reduction in the density of shrubs and treelets was noted from open country to young forest, while

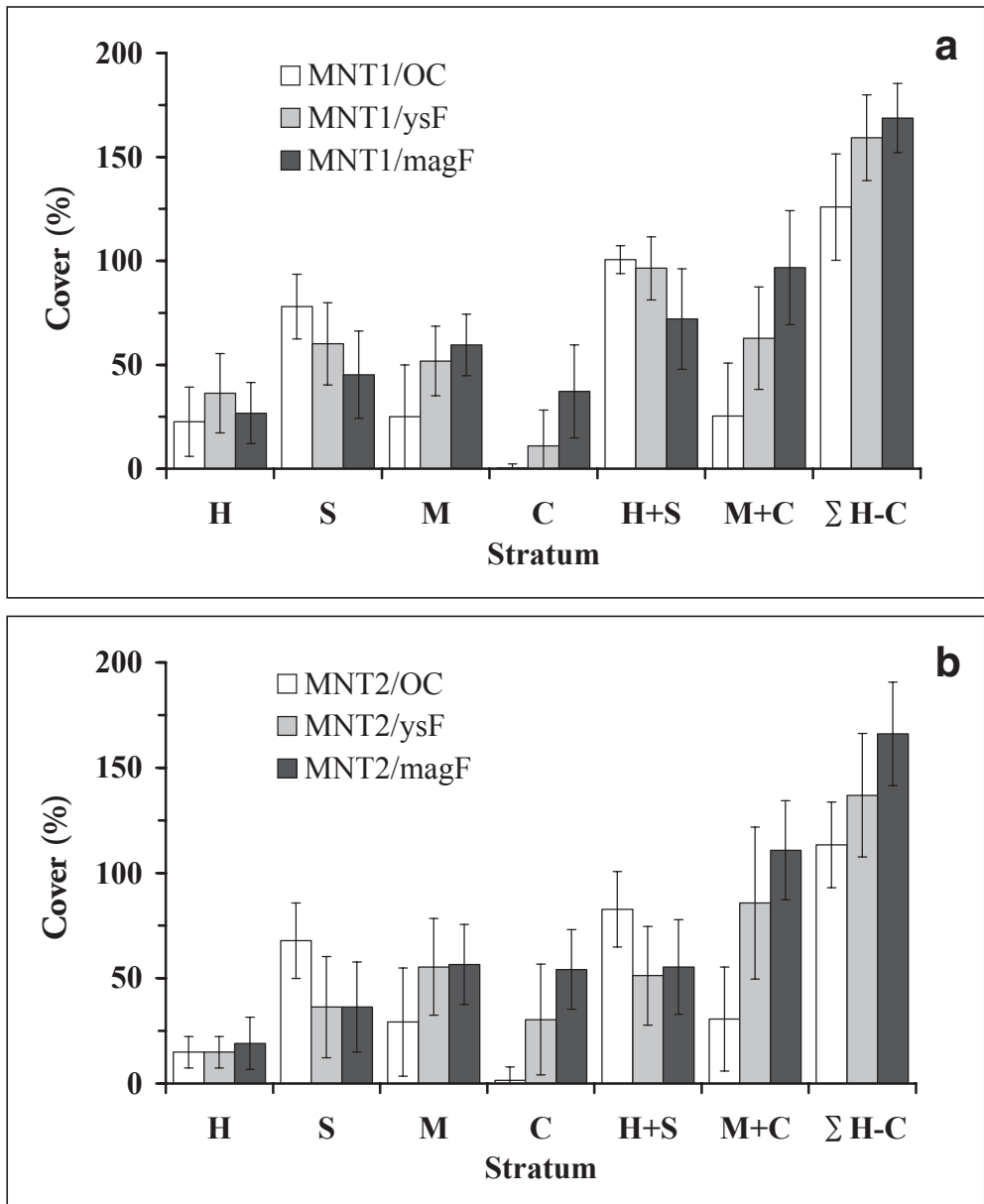


FIG. 16. Average vegetation cover per stratum and per combined strata in the seven 25 x 25-m plots per habitat and transect, (a) of MNT1 and (b) of MNT2; with standard deviation. Note that I used the sum of the vegetation cover of each single stratum to express the combined cover of strata (i.e., H+S, M+C, and  $\Sigma$ H-C), which resulted in values above 100%. Obviously, the cover of each single stratum does not exceed values of  $87.5 \pm 12.5\%$ . For details on the methodology see p. 35f, Mapping of habitats, vegetation structure, and human impact; and Table 5. Abbreviations used: H = herbs, S = shrubs and treelets, M = midstory (understory plus subcanopy), C = canopy, H+S = combined stratum of herbs plus shrubs and treelets, M+C = combined stratum of midstory plus canopy, and  $\Sigma$ H-C = sum of all four strata. See Table 6 for the abbreviations used for main habitat types and Table 8 for the U-test results on differences between medians.

the cover was very similar for both forest types. The sample medians for the cover of the shrub layer differed between transects ( $U = 125$ ,  $z = -2.412$ ,  $P = 0.016$ ;  $n = 21$ ). In comparisons between equal habitat pairs (Table 8), the differences were significant for open country ( $U = 8.5$ ,  $P = 0.039$ ,  $n = 7$ ) and young successional forest ( $U = 5.0$ ,  $P = 0.012$ ). A difference was also recorded for the between-transect habitat pair 'young successional forest of MNT1 and medium-age forest of MNT2' ( $U = 5.5$ ,  $P = 0.015$ ).

For MNT1, the cover of the midstory gradually increased from 25 to 60% from open country to medium-age forest, whereas for MNT2 a pronounced change was recorded from open country (29%) to young forest (55%), and only a weak further increase to 57% for medium-age forest. In the U-test, the differences between transects were not significant for this stratum. Furthermore, no differences were found in comparisons between equal habitat pairs as well as in all possible combinations of forest samples. By contrast, all but one of the possible eight combinations of the open-country samples with the forest habitats showed significant differences. Note that in all forest samples the mid-story (including subcanopy) is the densest stratum and not the canopy. This is in accordance with the distribution pattern of trees and palms over the height classes (Figs. 14a and 14b), where their number is greatest between 5 and 19.9 m, with 58-64% of all trees and palms falling in these height classes.

For both transects, canopy cover increased gradually and considerably from open country to medium-age forest, from 0.5 to 37% for MNT1 and from 1.5 to 54% for MNT2. The sample medians did not differ between transects. For equal habitat pairs a difference was found only between the samples of young successional forest ( $U = 8.5$ ,  $P = 0.04$ ,  $n = 7$ ).

Analyzing the two lower strata together, it is conspicuous that the sum of their covers was considerably higher for MNT1 (72-101%) than for MNT2 (51-83%), and this was the case for all equal habitat pairs. In consequence, the difference in sample medians was highly significant in the between-transect analyses ( $U = 59.5$ ,  $z = -4.067$ ,  $P < 0.001$ ,  $n = 21$ ). For equal habitat pairs a difference was found between the samples of open country ( $U = 0.5$ ,  $P = 0.002$ ,  $n = 7$ ) as well as young successional forest ( $U < 0.001$ ,  $P = 0.002$ ).

For MNT1 as well as MNT2, the combined cover of midstory and canopy increased gradually

from open country to medium-age forest, from 25 to 97% and from 30 to 111%, respectively. The sample medians did not differ statistically in the between-transect comparison. Likewise, in the analyses of equal habitat pairs, no differences were found. In stark contrast, there was a difference for almost all odd habitat pairs. Only for the young successional forest of MNT2 were no differences found when compared with the medium-age forest of both transects.

The pattern for the cover of all four strata together was again a gradual increase from open country to medium-age forest, from 126 to 169% for MNT1 and from 113 to 166% for MNT2. The sample medians between the two transects yielded no difference. However, a difference was found for the equal habitat pair of young successional forest ( $U = 7.0$ ,  $P = 0.024$ ;  $n = 7$ ). For this habitat type the combined vegetation cover of all strata was higher for MNT1 (159%) than for MNT2 (137%).

Since foliage density is a function of light intensity, it can be concluded that a dense foliage cover of the upper forest strata will negatively affect the cover of the lower strata. Therefore, I tested the presumed negative correlation between the cover of the shrub layer and the combined cover of the midstory plus canopy for all habitat types. A one-tailed Spearman's rank analysis confirmed a significant negative correlation for both transects (MNT1:  $r_s = -0.86$ ,  $P < 0.001$ ; MNT2:  $r_s = -0.711$ ,  $P < 0.001$ ;  $n = 21$  plots per transect). Pooling of the sample units of equal habitat pairs of MNT1 and MNT2 revealed negative correlations for all habitat types (open country:  $r_s = -0.744$ ,  $P = 0.001$ ; young successional forest:  $r_s = -0.522$ ,  $P = 0.028$ ; medium-age forest:  $r_s = -0.636$ ,  $P = 0.007$ ;  $n = 14$  plots per habitat type).

The overstory cover measured according to the method of Lemmon (1957) was very similar for both transects. In the between-transect comparison, no differences in sample medians were found. The mean cover was very similar for all forest samples (92 to 97%), and no differences in medians were found between them, with the single exception of the habitat pair 'young successional forest of MNT1 and medium-age forest of MNT2' ( $U = 7.0$ ,  $P = 0.025$ ,  $n = 7$ ). No difference was found between the non-forest samples of MNT2 (75%) and MNT1 (65%). However, the open-country samples of both transects were significantly different when compared with any of the forest habitats (Table 8).

TABLE 8. Results of the statistical analysis of differences in the vegetation cover of the main habitat types ( $n = 7$  plots per habitat and transect). The cover of each stratum is compared between the habitats of the mist-netting transects as well as within each transect, using the differences between medians according to the (Mann-Whitney) U-test. Light gray cells indicate cases where  $H_0$  was accepted in the pair-wise comparisons when its rejection was assumed, and dark gray cells when  $H_0$  was rejected when its confirmation was assumed. The cells are unshaded if the assumed hypothesis was confirmed by the tests (either  $H_0$  or  $H_1$ ). In a single case no statistics were computed, as there were not enough valid cases (too many ties) to perform the analysis. Significance levels of the tests: n.s. =  $P \geq 0.05$  (not significant), \* =  $P < 0.05$  (significant), \*\* =  $P < 0.01$  (highly significant), \*\*\* =  $P < 0.001$  (very highly significant). Other abbreviations used: see Table 6.

		Shrubs & treelets					
		MNT1			MNT2		
		OC	ysF	magF	OC	ysF	magF
Herbs	MNT1	OC	*	**	*	**	**
		ysF	n.s.	n.s.	n.s.	*	*
		magF	n.s.	n.s.	**	n.s.	n.s.
	MNT2	OC	n.s.	***	***	**	**
		ysF	n.s.	**	**	n.s.	n.s.
		magF	n.s.	**	no statistics	n.s.	n.s.
		Canopy					
		MNT1			MNT2		
		OC	ysF	magF	OC	ysF	magF
Midstory	MNT1	OC	n.s.	***	n.s.	***	***
		ysF	*	*	n.s.	*	**
		magF	**	n.s.	***	n.s.	n.s.
	MNT2	OC	n.s.	**	**	**	***
		ysF	**	n.s.	n.s.	*	*
		magF	**	n.s.	n.s.	**	n.s.
		Midstory + canopy					
		MNT1			MNT2		
		OC	ysF	magF	OC	ysF	magF
Herbs & shrubs & treelets	MNT1	OC	*	**	n.s.	**	**
		ysF	n.s.	**	*	n.s.	**
		magF	**	*	**	n.s.	n.s.
	MNT2	OC	**	n.s.	**	**	**
		ysF	***	**	*	**	n.s.
		magF	***	**	n.s.	*	n.s.
		Overstory (sensu Lemmon 1957)					
		MNT1			MNT2		
		OC	ysF	magF	OC	ysF	magF
All strata	MNT1	OC	*	**	n.s.	**	**
		ysF	**	n.s.	*	n.s.	*
		magF	**	n.s.	*	n.s.	n.s.
	MNT2	OC	n.s.	**	**	**	**
		ysF	n.s.	*	n.s.	n.s.	n.s.
		magF	**	n.s.	n.s.	**	*

## Discussion

The habitats covered and the completeness of bird surveys

Although the bird surveys covered a wide spectrum of habitats in the lowlands and lowermost foothills of Playa de Oro, it is evident that some life zones and their respective habitats remain poorly studied (Table 6). In general, the altitudinal range above 200 m was surveyed with much less intensity than the true lowlands, with only 16.6% (4175 m) of the total transect length located there. The abrupt change in bird species composition noted at an elevation of c. 400 m (p. 193, Life zone assemblages) underlines the importance of further field work along altitudinal gradients in the foothill zone.

Non-forest habitats, representing only 13.6% (3400 m) of the total transect length, were almost entirely restricted to the tropical wet forest life zone. Thus we know virtually nothing about potential differences that might exist between the foothill zone and the lowlands regarding the composition and structure of the avian community of cultivated or otherwise cleared lands. Furthermore, semi-open habitats were present in the form of a diverse patchwork of cultivated and recently abandoned plantations side by side with fragments of secondary forest in various stages of succession. One consequence of the limited extent of non-forest habitats was that many open-country species were strikingly uncommon or rare in the study area, making them prone to be underrepresented or even overlooked in bird surveys.

The main habitats of the mist-netting transects

Although MNT1 and MNT2 had a similar sequence of habitats, some structural differences existed between transects when comparing their main habitats. The course of their respective recent land-use histories was the likely cause of these differences. In the following I will discuss these aspects in detail.

Structural features of the open-country samples

Regarding vegetation cover, the likely reason for the denser stratum of herbaceous plants in the open-country samples of MNT1 (Figs. 16a and 16b, Table 8) was the continued maintenance of the cultivated plantations in which some of the plots were located. At least one plot was sampled a few weeks after its lower strata had been weeded, and due to the low density of shrubs a dense carpet of grasses, weeds, ferns, seedlings, and aroids had already formed.

Other plots were in a stage where dense undergrowth had already recovered, but small weedy plants had not yet completely thinned out. By contrast, those plots of MNT1 located in recently abandoned plantations had a very dense tangled undergrowth of shrubs, tall herbaceous plants, and vines, but only a sparse stratum of smaller herbs. This stage was also represented in some of the open-country plots of MNT2. In the area of the latter transect, non-forest habitats were confined to a clearing that was established about 5 to 6 years before the surveys (Fig. 9). Since then, only the close vicinity of the wooden building was regularly weeded, and most open-country plots were located in a very early but ongoing stage of forest succession. Not surprisingly, the average number of trees and palms in this sample was higher than for MNT1 (Fig. 12), where pioneer trees had been more frequently cut. On the other hand, the greater average maximum tree height recorded for MNT2 might be, at least partially, an artifact of the plot-site selection, as a few isolated canopy trees were present there but not in the MNT1 sample (Figs. 14a and 14b). Thus, none of the tall shading trees of the plantations were included in the MNT1 plots, decreasing the mean maximum tree height for this transect. The greater number of trees and palms in the semi-open country of MNT2 explains why the mean density of the midstory and canopy was slightly higher there than for MNT1 (Figs. 16a and 16b). Considering the negative correlation between the density of the shrub layer and the combined cover of the midstory and canopy, it is no surprise that the undergrowth was less dense in the MNT2 sample.

Mixed-culture plantations in the Chocó lowlands of Ecuador are structurally very diverse. Like other traditional subsistence agriculture systems of indigenous peoples, they promote the regeneration of forest and, to some degree, are even analogous to natural succession (e.g., Hart 1980, Ewel *et al.* 1981, Uhl 1987, Nations 1988, Andrade & Rubio 1994, Ferguson *et al.* 2003). Unlike large-scale monocultures of cash crops or industrial plantations of exotic timber trees, they are also very rich in biodiversity (Daily *et al.* 2003, Petit & Petit 2003, Donald 2004). As demonstrated in later chapters, more avian taxa were recorded by standardized mist netting, as well as audiovisual surveys, at transect MNT1 than at MNT2. The higher species richness in the outskirts of the village was evidently due to the greater variability of managed habitats there. However, although the bird community was more species-rich and di-

verse at the more disturbed site, the conservation value was nevertheless higher for transect MNT2 (p. 201f, Assessment of the conservation value of MNT1 and MNT2).

It should be emphasized that, in the study area, most abandoned plantations that were cultivated for extended periods of time do not regenerate to young successional forest within a few years. An exception was the early-stage forest in section B of MNT1, shown in Fig. 6 (right), which regenerated on a plantation that was given up soon after establishment because it turned out to be not sufficiently productive. The presence of 'balsa' trees *Ochroma pyramidale*, either on the plantation or within the nearby 'rastrojos', made the unusually rapid regeneration of young secondary forest possible. On the other hand, the relatively dense stands of pioneer trees, found in the first section of MNT2 only 5 to 6 years after the area was clear-cut (Figs. 8 and 9 left), also indicate that the clearing had not been weeded very often since then. Furthermore, the rarity of juvenile non-pioneer forest tree species makes it likely that the clearing was established on an abandoned plantation in early stages of forest succession rather than in fully regrown secondary forest.

The regrowth dynamic of typical plantations, like those found in the first half of MNT1 (Figs. 4 and 6 left), is very distinct. Once abandoned, an extremely dense tangled undergrowth of sunlight-tolerant plant species is established. This community of shrubs, tall herbaceous plants, and vines is often stable for up to 8 years and, according to local people, sometimes even longer. Several reasons might be responsible for the considerable stability of this early successional community. (1) From studies in the Amazon basin it is known that continued cultivation and repeated weeding cause striking shifts in the composition of the regrowth (Uhl 1988). Most notably, with each weeding the soil seed bank is depleted of seeds of woody pioneer species, as these plants are cut before they have had time to produce new seeds. By contrast, the density of grasses, weeds, ferns, and other herbaceous plants increases, as they are able to germinate, flower, and set seed in the interval between weedings. Because the plantations in the Ecuadorian Chocó are usually cultivated for more extended periods than in most parts of Amazonia, shifts in the seed bank composition might be even stronger. (2) However, many of the pioneer shrub species and herbaceous plants that quickly overgrow abandoned plantations have, in addition to their sexual repro-

ductive system, very effective methods of vegetative reproduction (pers. obs.). As a consequence, these species often survive repeated weedings, not only at the periphery of the plantations, as at forest borders or along streams, but locally also within the plantations themselves, in the form of rootstocks or fragments of stems and sticks, which sprout again and again after they have been cut. In other words, although the seed bank is depleted of the seeds of woody plant species, some individuals of certain pioneer shrubs and large herbs are still there – ready to regrow quickly as soon as the plantations have been abandoned. (3) In Neotropical forests, vertebrates disperse the seeds of more than 80% of the tree and shrub species (Howe & Smallwood 1982). Many common plant species of the regrowth community are also animal-dispersed (endozoochorous); e.g., *Piper* (bats, birds, and marsupials), *Clibadium* (birds), *Miconia* (birds), *Heliconia* (birds), and *Passiflora* (birds and mammals), to give just a few examples. Thus once these plants successfully produce fruits, their seeds are dispersed widely within the abandoned plantations. (4) On the other hand, seed dispersal of most tree species is very limited, with small-seeded species being more widely dispersed than large-seeded ones (Whitmore 1991, Silman 1996). Frequent calm weather in the study area hinders long-distance dispersal of small-seeded wind-dispersed (anemochorous) pioneer trees like 'balsa' *Ochroma pyramidale* and 'ceibo' *Ceiba pentandra* (Bombacaceae). Although the seeds of some other pioneer species, e.g., 'guarumo' *Cecropia* sp., are animal-dispersed (Estrada *et al.* 1984, Charles-Dominique 1986), the effectiveness of these vectors is limited when no or relatively few trees remain in the regrowth area (Guevara & Laborde 1993, Guevara *et al.* 1998, da Silva *et al.* 1996). One likely reason is that, in the case of avian dispersal, tall remnant trees are usually visited by canopy-dwelling species, which tend to move from tree crown to tree crown. These birds only occasionally descend to the shrub layer (pers. obs.). In Playa de Oro, relatively few bird species that regularly feed on *Cecropia* infructescences, like *Ramphocelus icteronotus*, *Euphonia xanthogaster*, and *Saltator maximus*, are also frequently encountered in the shrubby undergrowth of abandoned plantations. Only when fleshy fruits are abundant do canopy-inhabiting avian taxa, like *Patagioenas*, *Dacnis*, and *Tangara*, more regularly feed at shrub level within young regrowth. These observations are in general agreement with the results of da Silva *et al.*



(1996) from the Brazilian Amazon, who found that most movements of frugivorous birds between second-growth forest and abandoned pastures occurred during the end of the wet season, when small fleshy fruits were most numerous. Since birds deposit a majority of seeds from a perch, regeneration of woody plants often starts in the surroundings of isolated remnant trees (Yarranton & Morrison 1974, McDonnell & Stiles 1983, Guevara *et al.* 1986, McClanahan & Wolfe 1993, Nepstad *et al.* 1996, Ferguson *et al.* 2003). By contrast, bats defecate in flight and thus produce a more extensive seed shadow than birds (Charles-Dominique 1986, Thomas *et al.* 1988).

(5) Tree seed survivorship is reportedly low in disturbed areas (Nepstad *et al.* 1991) due to seed predation and pathogens, with these factors generally affecting small-seeded species more than large-seeded ones (Silman 1996). Uhl (1988) reported that in one experiment *Atta sexdens* leaf-cutter ants were carrying off the seeds of *Inga* sp. trees to their subterranean colonies within minutes of placement. Seed removal rates of 27–84% within 4 days were found for *Cecropia obtusifolia* in forest gaps and mature patches at Los Tuxtlas, Mexico, with ants and grasshopper nymphs being the main predators (Alvarez-Buylla & Martínez-Ramos 1990). A rapid turnover rate of 1.02 to 1.07 years of the species's seed bank was calculated in the same study. Thus the alteration of seed-rain regimes, e.g., in areas of extensive deforestation, prevents a rapid regeneration of pioneer trees (Alvarez-Buylla & García-Barrios 1991).

(6) In addition, dense groundcover of grasses and herbs exerts competitive suppression on the regeneration of woody colonists (Kellmann 1980, Ferguson *et al.* 2003). Seeds defecated by vertebrates from tall trees or in flight rarely reach the soil directly as they are caught by the broad leaves of herbaceous plants, where they are exposed to predators (e.g., ants) and heat (Zahawi & Augspurger 1999); and if they manage to get to the ground, the dense leaf cover may filter out the light necessary for their germination (Aide *et al.* 1995).

(7) Finally, high levels of insect and mammal herbivory may destroy a great portion of tree seedlings (Nepstad *et al.* 1991). Janzen (1975) estimated that insect density is five to ten times greater in successional areas than in the undergrowth of mature forest, presumably because successional plant species are more palatable to insects. This high density of insects in disturbed areas likely also increases the risk of tree seedlings and saplings falling victim to herbivory.

The regrowth community on abandoned plantations is slowly replaced by forest when the cover of pioneer trees is eventually high enough to cause the thinning of its dense tangled undergrowth. A positive correlation between initial basal area and the regeneration of fleshy-fruited plant species has been found in various studies and interpreted as a consequence of behavioral responses of animal dispersers to greater structural complexity (MacArthur *et al.* 1966, da Silva *et al.* 1996, Wunderle 1997, Ferguson *et al.* 2003). The changes in light intensity, microclimate, abundance of herbivores, and the constant and augmenting seed rain, among other factors, lead to the reestablishment of forest and a gradual increase in species diversity.

In contrast to the former scenario, Fernandes & Sanford (1995) found a negative correlation between initial basal area and log-series diversity index  $\alpha$  for seven-year-old regrowth communities at La Selva, Costa Rica. Abandoned pastures were more species-rich than either regenerating palm (*Bactris gasipaes*) orchards or cacao (*Theobroma cacao*) plantations. The authors concluded that especially cacao treelets and remnant shading trees inhibited the regeneration of other woody plants due to low light levels. Similarly delayed regeneration of plantations has also been reported in other studies (Fernandes & Vinha 1984, Lugo 1992). Thus many interacting factors are responsible for how long natural reestablishment of forest on abandoned agricultural land takes. Differences in the composition of cultivated plants, density and composition of remnant shading trees, duration and intensity of land use, soil types, as well as the distance to forest fragments or continuous forest, may be just the most obvious ones.

#### Structural features of the young successional forest samples

The distinct differences in various structural features between early-stage forest sites are clearly due to differences in their recent land-use history. The plots of MNT1 were located in 'rastrajo', which is secondary forest on abandoned plantations, in various stages of succession. The variations in age, structure, and composition were considerable between the sample units, and at least one site had characteristics of a medium-age forest. The reason why some of these plots were included in the 'young forest' sample in the first place was their high proportion of pioneer trees as well as low canopy height (Figs. 14a and 15). By contrast, the young forest of most MNT2 plots

had reestablished after many of the bigger trees of an advanced secondary forest were cut down. At other sites, the forest seemingly remained in early stages of succession because of high groundwater levels as well as alterations in soil quality in an old gold-mining area. Although the vegetation structure of the MNT2 sample was not entirely homogeneous either, it was much more so than in the case of MNT1.

The number of stems  $\geq 10$  cm DBH was significantly higher in the MNT2 sample (Fig. 12, Table 7), probably because the forest regenerated from a seed bank that was left intact, and not on abandoned plantations, which after repeated weedings were depleted of seeds of woody plants. In addition, given that most of the secondary forest plots at MNT1 must be regarded as quasi-fragments because they were located within a mosaic of active and abandoned plantations, edge effects were also likely an important factor for the low stem density there. Although recruitment rates of trees into the  $\geq 10$  cm DBH category were significantly elevated in small forest fragments in comparison with continuous forest near Manaus, Brazil, the opposite was true for seedling density (Benitez-Malvido 1998, Laurance *et al.* 1998b). These findings might seem contradictory at first, but elevated tree mortality in small fragments was the probable reason for both results. Tree-fall gaps proliferate within the first 100–300 m of edges, partly as a result of microclimatic changes and increased wind turbulence, profoundly altering the vertical structure of forest fragments (Lovejoy *et al.* 1986, Williams-Linera 1990, Laurance & Yensen 1991, Bierregaard & Lovejoy 1992, Kapos *et al.* 1993, Ferreira & Laurance 1997, Laurance *et al.* 1998a, 2000, 2002). Once tree falls have formed, lateral growth of tree crowns at gap margins destabilizes neighboring trees and makes them prone to falling (Young & Hubbell 1991). Thus, low seedling density in forest fragments might be caused by a reduction of the reproductive potential of some tree species (Alvarez-Buylla & García-Barrios 1991, Alvarez-Buylla *et al.* 1996), resulting in a decreased seed rain. Other factors negatively affecting seedling numbers might be reduced abundances of some pollinators and seed dispersers (Lovejoy *et al.* 1983, Powell & Powell 1987, Rylands & Keuroghlian 1988, Klein 1989) as well as increased levels of seed predation and herbivory (Laurance 1994, Rao *et al.* 2001). Simultaneously, lower canopy foliage density (Malcolm 1994), reduced canopy height (Laurance

*et al.* 2002), and altered height of greatest foliage density (Camargo & Kapos 1995) evidently increase the recruitment and turnover rates of trees (Kapos *et al.* 1993, Laurance *et al.* 1998b). In the study area, similar processes may also have caused the significantly lower canopy density as well as higher undergrowth foliage cover at MNT1 in comparison with MNT2 (Table 8; Fig. 15).

Interestingly, at section C of MNT1 (Table 4; Fig. 7 left), where some of the young forest plots were located, less birds were mist-netted than in any other section of both transects (Appendix 2). The low abundance of some frugivorous species at MNT1 was especially evident, e.g., *Mionectes olivaceus*, *Pipra mentalis*, and *Turdus daguae* (Appendices 12a and 12b). Of course, it is unclear to what degree low population densities of fruit-eating birds was a relevant factor for the low average number of stems  $\geq 10$  cm DBH in the young forest sample of MNT1.

In contrast to the situation at MNT1, the dynamic of forest regeneration in section B of MNT2 (Table 4; Fig. 10 right) was more similar to that of the building phase within a large tree-fall gap, such as massive ‘wind throws’, for which a high density of tree stems is very typical (Brokaw 1985). This might also be the reason why the number of trees and palms in the MNT2 young forest sample was higher than in the medium-age stands of both transects. In general, after a rapid recruitment phase, which levels off after only 3 to 6 years, increasing tree mortality leads to a slow and sometimes even dramatic decrease in stem density (Brokaw 1982, Garwood 1983, Swaine & Hall 1983). This was exactly the period of time that had passed between the massive felling of larger trees for the construction of the wooden building at Playa Rica and the sampling of the plots.

The subsequent thinning of stem density is mainly attributed to the dieback of pioneer trees and is accompanied by an increase in the basal area of primary forest species (Brokaw 1982, 1985). At a reduced rate, the decrease in stem density and simultaneous increase in basal area might continue during the entire building phase of the forest. Unfortunately, most long-term studies on tree growth, demography, and forest dynamics in the Neotropics have focused on the monitoring of late successional and mature forests (cf. Gentry 1990b, McDade *et al.* 1994). Thus confirmatory data for the above statement are not easily found. Although not entirely conclusive, at least some data seem to indirectly support the hy-

pothesis. In three permanent plots at La Selva, Costa Rica, the mean number of stems  $\geq 10$  cm DBH per hectare decreased from 453.4 to 449.7 ( $-0.82\%$ ) between 1969 and 1985 (Lieberman *et al.* 1990). The annual loss of stems within the three plots ranged from 1.8% to 2.2%, while the annual loss of canopy area was only 0.8% to 1.3%. In other words, approximately half the trees died without forming or contributing to a notable light gap, either because subcanopy-level trees were involved or because the gradual dieback of canopy tree crowns was sometimes matched by lateral growth of branches of neighboring trees into the available space. Although the basal area in the three La Selva plots decreased by 7.5% between 1969 and 1982, it should be taken into account that the death of large trees, which disproportionately contribute to the basal area, is not unusual in mature forests. Turnover times of Neotropical primary forests, calculated on the basis of the average annual area in gaps (Hartshorn 1978), typically range from 60 to 140 years (Hartshorn 1990). By contrast, secondary forests like Barro Colorado Island's late successional forest have longer projected turnover rates, up to 159 years, simply because few large trees or tree falls occur there (Brokaw 1982, Lang & Knight 1983). To conclude the argumentation: trees that die without forming recognizable canopy openings hardly contribute to the rejuvenation of the stand. Other mid-size and large individuals will occupy the newly available space, and no massive germination of soil seeds or rapid growth of saplings will be induced, as it would in light gaps. Thus, for maturing successional forest, this process should result in both a slow decrease in stem density and a simultaneous increase in basal area. Of course, the dynamic of secondary forests that regenerate on abandoned plantations is very different (see above), and, in this case, the number of stems per hectare, as well as the basal area, may well increase simultaneously during the first phases of maturing.

The difference in mean DBH per plot was also significant between the young forest samples of the transects (Table 7), with greater values found for MNT1 (Figs. 13a and 13b), indicating that some of the plots were located in 'rastreros' in relatively advanced stages of succession. The picture was further complicated by the fact that some trees of these 'rastreros' were much older than the average age of the vegetation, most likely representing individuals that were maintained as shading or timber trees at

the time when the plantations were cultivated. However, other habitat features confirm a striking difference between the young forest sample of MNT1 and the medium-age forests of both transects, but especially that of MNT2. For example, the average number of trees and palms (Fig. 12), as well as the mean height of the tallest tree per plot (Fig. 15), were lower for the MNT1 early-stage forest than in the advanced secondary forest sample at MNT2, as confirmed by statistical testing (Table 7). Furthermore, the foliage cover per stratum of early-stage forest plots of MNT1 was very different from that of the medium-age forest of both transects (Table 8), with differences found for canopy density, the combined cover of the undergrowth, as well as midstory plus canopy (Figs. 16a and 16b). Nevertheless, numerous differences in vegetation cover were also confirmed between the early-stage forest samples of MNT1 and MNT2. In general, the lower strata were much denser and the canopy considerably less dense at the former transect.

#### Structural features of the medium-age forest samples

The two medium-age forest samples were rather similar in structure as well as species composition. None of the tested variables revealed significant differences (Tables 7 and 8). Subjectively, the forest at MNT2 seemed to be in a more advanced stage of regeneration. It is unclear whether the sloping terrain, in combination with the slightly lower number of tall trees as well as lower canopy density in the area of MNT1, was partially responsible for this perception.

The extrapolated combined number of trees and palms  $\geq 10$  cm DBH per hectare at MNT1 ( $n = 405$ ) and MNT2 (489) was within the range found in the three permanent plots of mature forest at La Selva. From there, 394–534 stems per hectare were reported (Lieberman *et al.* 1990). Even the number of trees and palms in the young forest sample of MNT2 was similar (539 stems/ha). Interestingly, higher densities of stems  $\geq 10$  cm DBH were published for most other Neotropical forests, e.g., 513–858 stems per hectare for various localities in the Amazon basin (Gentry 1988a,b; Rankin-de-Merona *et al.* 1990) and 675 for Bajo Calima, Valle Dept., Colombia (Gentry & Terborgh 1990, Faber-Langendoen & Gentry 1991). It remains unclear which factors might have caused these differences in tree stem densities. La Selva belongs to the tropical wet forest life zone (*sensu*

Holdridge 1967), like transects MNT1 and MNT2, and the climate (Sanford *et al.* 1994) as well as the geomorphology (McDade & Hartshorn 1994) are very similar in comparison with the conditions at Playa de Oro (Table 3). However, the similar number of tree stem densities at La Selva and Playa de Oro might be merely coincidental, since some of the localities where higher numbers of stems per hectare were found have drier (e.g., localities in the Amazon basin) and others wetter climates (e.g., Bajo Calima). Other parameters, like soil type and quality, topography, as well as historical factors (e.g., Clark *et al.* 1995), might be equally or even more important in this context than climatic factors.

Palms are a very conspicuous element in the forest of Playa de Oro. Their relative abundance was 26.6% in the medium-age forest sample of MNT1 and 22.9% for MNT2. 'Gualte' *Wettinia quinaria* is often the most common species in forest inventories, representing 15% or more of all monocot and dicot plants  $\geq 10$  cm DBH, e.g., 22.6% in the first management plan area of Playa de Oro (Palacios *et al.* 1996; Fig. 1b) and 14.9% in the second (E. Mediavilla, Jatun Sacha, pers. comm.). 'Pambil' *Iriartea deltoidea* is usually the second most common palm species, and a relative abundance of between 3.8% and 6.7% was recorded in the forest inventories. High population densities of palms are a feature shared with many other Neotropical sites, especially on nutrient-rich to moderately infertile soils. However, high abundances with up to one quarter or more of all individuals  $\geq 10$  cm were found only on rich clayey soils in Tambopata, Peru (Gentry & Terborgh 1990), and at La Selva, Costa Rica (Lieberman & Lieberman 1987).

The DBH-class distribution of woody plants is very similar for all Neotropical forests, with most individuals appearing in the smallest DBH class and rapidly decreasing numbers recorded in higher DBH classes (Gentry & Terborgh 1990, Hubbell & Foster 1990). For the aforementioned reasons (p. 36, Data analysis), it was not possible to calculate the basal area for the habitat samples of MNT1 and MNT2, but a mean basal area of 17.5 m<sup>2</sup>/ha was determined for a selectively logged forest in the first management plan area of Playa de Oro (Palacios *et al.* 1996). Considerably higher values were recorded in mature forest plots at other Neotropical sites, e.g., 25.5–33.0 m<sup>2</sup>/ha at La Selva (Lieberman *et al.* 1990) and 30.6 ( $\pm 3.5$ ) m<sup>2</sup>/ha near Manaus, Brazil (Rankin-de-Merona *et al.* 1990).

Interestingly, the number of forest-dependent bird species recorded during standardized audio-

visual surveys was considerably higher at MNT2 (n = 90) than at MNT1 (n = 78) (p. 201, Assessment of the conservation value of MNT1 and MNT2; Appendices 16a and 16b). A lower degree of fragmentation, as well as higher foliage density and vertical complexity of the upper strata at MNT2, might explain the difference in species richness of forest-inhabiting birds. Various studies have demonstrated that the increased foliage complexity of tropical forests leads to higher foraging substrate diversity, including vines, epiphytes, and clusters of dry leaves, which create additional niches and food resources for birds (Karr & Roth 1971, Karr 1975, Pearson 1975, Remsen & Parker 1984, Rosenberg 1990b).

#### Identified biases and challenges

It can be criticized that the plot selection did not follow a strictly random design. However, due to the fact that the main habitat types were present rather in the form of a diverse mosaic of small patches in various stages of succession than in well-defined and homogeneous blocs, it was necessary to actively select the plots (p. 36, Characterization of main habitats of the mist-netting transects). Otherwise it would have been impossible to cover the habitat characteristics in the transect areas. Of course, the results should be viewed as descriptive and preliminary rather than fully conclusive.

The method used here for the determination of the foliage cover of each stratum (p. 35f, Mapping of habitats, vegetation structure, and human impact) demands considerable training. To obtain reproducible results, researchers, field assistants, and volunteers have to readjust their perception of forest stratification as well as estimation capacity every day before starting to collect data. Initially, it was challenging for most participants to virtually 'blend out' the foliage of the lower strata that had already been estimated, as well as to focus on an area of roughly 5 x 5 m in the upper strata. Potentially confusing was also the definition of the strata heights in variable ranges (Table 5). For most people, though, it worked well once they had learned to use the mean heights of each stratum as an orientation. The height classes for this study were chosen to ensure that non-forest and forest habitats of different types and successional stages could be characterized and distinguished in the study area. Some variability in the definition of strata heights was necessary because tropical forests are often not neatly layered (p. 33, Introduction), and the precise stratification greatly depends on the

maturity of the stands, among many other factors. In the case of open country it should even be possible to distinguish between similarly structured habitats, e.g., active pastures should be easily separable from traditional mixed-culture plantations by their higher cover of grasses and weeds as well as lower density of shrubs and treelets.

In general, the definitions of tropical forest strata found in the literature are rather variable. To give just three examples: Hubbell and Foster (1990) classified woody plants according to the mean height of adult individuals as (a) shrubs and treelets (<4 m tall), (b) understory trees (4–10 m tall), (c) midstory trees (10–20 m tall), and (d) canopy plus emergent trees (20–45 m tall). Referring to the same Panamanian moist forest, ornithologists like Karr (1990) distinguished between shrub bird species typically foraging between 0.5 and 5.0 m above the ground, understory species concentrating on from 5 to 20 m, and canopy species feeding at or near the foliage-air interface above 20 m. On the other hand, Hartshorn & Hammel (1994) differentiated at La Selva between (a) the layer of seedlings, woody lianas, and perennial herbs (<1 m), (b) the layer of shrubs c. 1–5 m (*sensu* Richards 1952), (c) understory trees (c. 5–15 m tall), (d) subcanopy palms and dicots (height not explicitly defined, but presumably 15–25 m), and (e) canopy and emergent trees (c. 25–55 m). Thus these authors regarded the strata between the shrub layer and canopy as (a) understory and midstory, (b) understory, and (c) understory and subcanopy, respectively. In contrast to the above definitions, I used the term ‘midstory’ as an equivalent for the combined stratum of understory and subcanopy layers (roughly between 4 and 20 m).

Very important for an assessment of forest structure and condition is the differentiation between low-canopy and high-canopy forest. Stands with only a few (or without) canopy-level and emergent trees but relatively dense midstory cover represent low-canopy forests, which are very distinct from typical mature forests. Thus, I included subcanopy level trees principally within the midstory in order to detect the presence of a well developed canopy of large and emergent trees. This study elucidates that even early-stage secondary forest and medium-age forest can be differentiated this way (Figs. 16a and 16b; Table 8). Since the canopy cover in the young ‘rastrojos’ of MNT1 was rather low, and some trees were present in the semi-open habitats of both transects, the sum of the midstory and canopy

worked best for the differentiation between the three main habitats. The latter statement may seem contradictory at first, but high-canopy forests tend to have not only a relatively dense canopy cover, but also a well developed midstory (i.e., subcanopy). In other words, if we estimate the foliage density independently for the midstory and canopy, the sum of their covers is highest in mature forest, much lower in early-stage forest, and lowest in open-country habitats. In statistical tests, the combined cover of midstory and canopy was significantly different for all unequal habitat pairs except for ‘young successional forest of MNT2’ and medium-age forest of both transects.

Interestingly, the mean midstory cover in the semi-open-country samples was 25% for MNT1 and 29% for MNT2, and the mean tree height 13 and 14 m, respectively, thus greater than the  $\geq 10\%$  canopy cover and minimum tree height of 5 m which are the FAO thresholds for separating ‘open canopy forest’ from non-forest habitats (Holmgren & Davis 2000). In other words, according to the criteria of FAO, the semi-open country in the transect areas would simply be treated as ‘forest’. However, in the following chapters I will demonstrate that the differences in vegetation structure between main habitats and transects did indeed have profound consequences on the structure and composition of the avian community.

Note that if we use a definition of strata heights that rigorously separates midstory and canopy levels, true closed-canopy forest exists only locally at best, even in mature stands, as the canopy is almost always very irregular in texture. The frequent occurrence of tree falls further accentuates these vertical discontinuities (Hartshorn & Hammel 1994). A median distance of only 12 m was determined between natural gaps (> 40 m<sup>2</sup>) in primary forest at La Selva, Costa Rica, using large-scale aerial photographs (Sanford *et al.* 1986). In the Ecuadorian Chocó, mean canopy cover rarely exceeds 60% (*pers. obs.*), even in mature forests, because canopy and emergent trees are often widely spaced, small-leaved, and their foliage density is relatively low. The latter two characteristics might be an adaptation against crown damage during heavy rainfalls and thunderstorms. Thus the midstory (including subcanopy) was found to be the densest stratum in all types of *terra firme* forests studied in the lowlands of the Ecuadorian Chocó (*pers. obs.*), with c. 70–80% of all trees and palms  $\geq 10$  cm DBH falling in the height classes between 10 and 24.5 m (e.g., Figs. 14a and 14b).



Considering the above, it is evident that the determination of canopy cover is an important and challenging task in humid tropical lowland forests. Most widely used methods, like the 'spherical crown densimeters' developed by Lemmon (1957) (see also Jennings *et al.* 1999), overestimate canopy closure in areas with a high understory-to-canopy ratio (Sekercioglu 2002a). Consequently, they are often not appropriate for differentiating between stages of tropical forest succession. The reason is quite simple: the user holds a densiometer in front of his/her body, and thus views the cover of the entire overstory from the middle shrub layer up to the canopy. The result is a relatively high measurement even in semi-open habitats, such as the open-country samples of MNT1 and MNT2, where a mean cover of 65% and 75%, respectively, was recorded. In the multi-layered forests of the study area the mean overstory cover surpasses 90% once midstory-level trees are fully developed; e.g., 92-97% was measured in the forest habitats of the mist-netting transects. As a consequence, with only one exception, no differences could be found between overstory densities of the four forest samples (Table 8).

An alternative approach was described by Sekercioglu *et al.* (2002), who took photos of the overstory from ground level with a 17-mm 'fisheye' lens and subsequently determined the vegetation cover using Adobe Photoshop (Mountain View, CA). Although this method suffers from the same problem as the 'spherical crown densimeters' in measuring overstory and not canopy cover, the simple fact that in the age of digital photography many images can be taken and analyzed at low cost might allow robust statistical testing of even the smallest differences in vegetation cover.

## Conclusion

Although the 25-km-long transect network covered a wide spectrum of habitats, it is evident that the intensity of sampling varied considerably between altitudinal ranges and life zones. In Playa de Oro further avifaunistic research should be carried out in the lowermost foothills (200-400 m) and, especially, between about 400 and 600 m a.s.l. Aside from the limitations in scope and coverage, the present work may be one of the most comprehensive studies on the structure and ecology of avian communities carried out in the lowlands and lowermost foothills of the Chocó region to date. Considering the ongoing and expected future changes in land use and

regional climate, it will represent the scientific basis for multi-temporal comparisons of the status and composition of bird communities at Playa de Oro and other Chocoan lowland sites. Beyond Playa de Oro additional ornithological inventories and monitoring are urgently needed in the highly threatened tropical humid forest life zone of the Río Ónole drainage and in the Andean foothills, particularly in the premontane pluvial forest life zone (c. 300-1800 m).

At the two mist-netting transects, the general sequence of habitat types as well as the vegetation structure of the main habitats were rather similar. However, statistical analysis revealed that some habitat features of MNT1 and MNT2 differed from each other, especially of the young secondary forest samples (e.g., average number of trees and palms  $\geq 10$  cm DBH and foliage cover of most vegetation strata). For the other two main habitats, semi-open country and medium-age forest, differences were found only between the non-forest samples, regarding the foliage density of the shrub layer as well as the combined vegetation cover of the undergrowth (herb plus shrub layers). Different recent land-use histories as well as varying degrees of habitat fragmentation in the transect areas were identified as the likely causes of these differences.

The greater variability of managed habitats on the outskirts of the village was the principal reason why, according to standardized mist netting as well as audiovisual surveys, the avifauna was more species-rich and diverse at transect MNT1 than at MNT2. Nevertheless, the number of forest-dependent bird species was higher at the latter transect, likely due to the lower degree of fragmentation and higher foliage complexity of the upper strata (e.g., in the young forest plots), among other factors.

The habitat feature that was most appropriate to differentiate between the three main habitats of the mist-netting transects was the combined cover of the midstory and the canopy. To minimize sampling bias, future studies on vegetation cover should use digital cameras with 'fisheye' lenses, remote controls, and corresponding photo editing software, facilitating the collection and analysis of large amounts of 'overstory' photographs. Ideally, for each sampling spot, photographs should be taken at various heights above the ground (e.g., 0.1, 0.5, and 5 m), to get better information on the contribution of the lower strata to the total vegetation cover and a reliable measurement of the combined cover of the midstory and the canopy.

#### 4. SURVEYING TROPICAL BIRD COMMUNITIES: IN SEARCH OF AN APPROPRIATE RAPID ASSESSMENT METHOD

##### Introduction

Standardized survey protocols are now routinely used to gather accurate data on different biological taxa in many developed countries (e.g., International Bird Census Committee 1969, 1970, 1977; Ralph & Scott 1981, Cooperrider *et al.* 1986, Droege 1990, Goldsmith 1991, Koskimies & Väisänen 1991b, Bibby *et al.* 1992, 2000; Buckland *et al.* 1993, 2001; Heyer *et al.* 1994, Ralph *et al.* 1995, DO-G 1995, Bonham *et al.* 2001, Schmid *et al.* 2004, Südbeck *et al.* 2005). This procedure has greatly improved the usefulness of data on biological communities and on threatened species for planning processes and for environmental impact assessments (e.g., Ellenberg 1979, USDI 1980a,b, 1981; Usher 1986, Flade 1994, Bonham *et al.* 2001). However, in tropical countries standard procedures for surveying and monitoring biological diversity are rarely in use. Several factors account for the slow development and application of such methods in tropical habitats: (1) the species-level taxonomy is poorly known for most biological taxa (Gentry 1990c, Wilson 1992, Stotz *et al.* 1996); (2) species diversity in tropical latitudes is very high in most habitats (e.g., Connell 1978, Wilson 1988a, Stevens 1989, Platnick 1991, Willig *et al.* 2003); and (3) few biologists have attained the skills necessary to carry out comprehensive surveys (Terborgh *et al.* 1990).

Karr (1981a) and Terborgh *et al.* (1990) have discussed various behavioral peculiarities of tropical birds which make it necessary to adapt the survey protocols routinely used in northern temperate zones. In addition to the already mentioned high species richness of most tropical habitats, other potential problems may arise due to permanent occupation of territories leading to decreased levels of song activity in some avian species; the fact that males and females of numerous species have territorial songs; the occurrence of seemingly non-vocal species; the existence of complex intra- and inter-specific social systems in many taxa, like single-species and mixed-species foraging flocks, leks, or communal breeding systems, as well as species that straggle over relatively large areas in search of mobile (e.g., army ant columns) or otherwise spatially patchy food resources (e.g., mineral licks).

Daunted by these characteristics of tropical bird communities, many studies have relied heavily on mist nets (e.g., Fogden 1972, Lovejoy 1974, Terborgh & Weske 1975, Karr 1976b, 1980a, 1990; Willson & Moriarity 1976, Wong 1985, Levey 1988a, Blake 1989, Bierregaard 1990b, Dyrce 1990, Loiselle & Blake 1991b, Lefebvre *et al.* 1994, Poulsen 1994, Blake & Rougès 1997, Salaman 2001, Sekercioglu *et al.* 2002). Some researchers have combined different survey techniques to overcome the difficulties of tropical bird detectability and then often used mist netting as a principal or complementing method (e.g., Terborgh & Weske 1969, Karr 1971, Pearson 1971, Terborgh 1971, Lynch 1989, Robinson *et al.* 1990, Terborgh *et al.* 1990, Thiollay 1990c, 1994b; Bloch *et al.* 1991, Navarro 1992, Wunderle 1995, Wallace *et al.* 1996, Wunderle & Latta 1996, Robinson & Terborgh 1997, Whitman *et al.* 1997, Stiles & Rosselli 1998, Blake & Loiselle 2000, 2001; Robinson *et al.* 2000, Herzog & Kessler 2002). Others have focused on only a small section of the local avifauna, like raptors, cracids, columbids, parrots, certain suboscine taxa, or Nearctic-Neotropical migrants, using specific methods for the detection of the taxonomic groups in question (e.g., Reichholf 1974, Thiollay 1989a, Lynch 1992, Rivera-Milán 1992, 1995a,b; Sliwa & Sherry 1992, Jullien & Thiollay 1996, Casagrande & Beissinger 1997, Gram & Faaborg 1997, Gilardi & Munn 1998, Rappole *et al.* 1998, 1999; Martínez-Morales 1999, Stratford & Stouffer 1999, Jiménez *et al.* 2003). Relatively few researchers have employed audiovisual methods to study entire tropical bird communities. Fortunately, the rising number of high-quality field guides, widespread use of audio recorders, as well as the growing number of available sound publications and, more recently, WEB archives on the vocalizations of tropical birds, gradually led to an increasing number of workers relying only on observational survey methods. This development is clearly reflected in the growing number of published studies based on such methods as territory mapping, line transects, roadside counts, point counts, as well as on combinations of various audiovisual techniques (e.g., Pearson 1975, Emlen 1977, Oelke 1981b, Blake 1992, 2007; Thiollay 1992, 1997, 2002a; Ornelas *et al.* 1993, Lynch



1995, Poulsen *et al.* 1997, Zimmer *et al.* 1997, Poulsen & Krabbe 1998, Aleixo 1999, Anjos & Boçon 1999, Cresswell *et al.* 1999, Fjeldså 1999, Robinson 1999, Wunderle 1999, Haselmayer & Quinn 2000, Sekercioglu 2002a, Petit & Petit 2003, Ribon *et al.* 2003).

Until recently, mist netting remained the single, most widely accepted method for surveying tropical bird communities (Karr 1981a, Stotz *et al.* 1996), despite the fact that many biases and limitations have been described (e.g., Heimerdinger & Lebermann 1966, Karr 1979, 1981b; Graves *et al.* 1983, Remsen & Parker 1983, Greenberg & Gradwohl 1986, Terborgh *et al.* 1990, Pardieck & Waide 1992, Remsen & Good 1996, Robinson & Terborgh 1997, Robinson *et al.* 2000). Stotz *et al.* (1996) mentioned that many ornithologists now have the skills to survey tropical bird communities in a few days by sampling them exclusively by their vocalizations, plumage patterns and coloration, behavioral characteristics, and habitat preferences, but the authors did not quote any scientific publication that describes how to carry out such a rapid assessment in a proper and standardized way.

Theodore A. Parker III performed the first rapid assessments of tropical birds as coordinator of the Rapid Assessment Program, implemented in 1989 by Conservation International, Washington (Parker & Bailey 1991, Parker & Carr 1992, Parker *et al.* 1993). His principal survey methods were to tape-record the dawn chorus (Parker 1991) and to carry out random walks, identifying the birds by their vocalizations and other field characters. Owing to his tragically early death in 1993, there was no opportunity for him to combine this effective inventory technique with a standardized census method such as point counts, line transects, or '20-species lists'.

Relatively few workers have tried to fill this gap since. Notable exceptions are the studies that focused on the estimation of bird species richness and relative abundance using the '20-species-list' approach sensu MacKinnon & Phillippis (1993). Its strategy is to group observations into consecutive lists of 20 (or less) species and to generate a species-accumulation curve by adding those species not present in any previous list to the total number of species recorded. Thus the cumulative species richness is plotted as a function of the number of observations (i.e., number of lists). Until now, two different survey methods have been employed for data collection, namely point counts (Poulsen *et al.* 1997, Poulsen & Krabbe 1998)

and the 'random walk' method (Fjeldså 1999, Herzog *et al.* 2002). In a different approach, Haselmayer & Quinn (2000) compared the effectiveness and efficiency of standardized sound recording schemes with point counts in Amazonian Peru. They found standardized sound recording to be a suitable alternative to point count surveys for the determination of species richness in tropical habitats, but did not provide any conclusive protocol for its application in rapid assessment studies.

Unfortunately, all approaches mentioned above have addressed only a few aspects of rapid assessments of tropical bird communities, namely the determination of species richness and estimation of relative abundance. Although the knowledge of species richness patterns might be very useful for achieving some conservation goals, like the protection of biodiversity on a regional scale, for other purposes it will certainly be necessary to characterize the bird communities in much more detail. For the elaboration of management plans at a local level (e.g., for community areas, forestry projects, or protected areas), we need to know where exactly threatened, endemic, and other sensitive bird species occur in order to develop an appropriate zoning of human activities (e.g., ecotourism, extraction of non-timber forest products, selective logging, subsistence hunting). Thus an appropriate rapid assessment method should facilitate the detection even of rare species as well as the elaboration of GIS (Geographic Information System) based maps showing their occurrence on a local scale.

As a step in this direction, I present a transect-mapping method specifically designed to surmount (most of) the obstacles encountered when surveying tropical bird communities. Here, I critically compare this technique with the traditionally used mist-netting method to evaluate the effectiveness, accuracy, and efficiency of the transect method. Furthermore, I discuss its advantages and disadvantages in comparison with territory mapping, point counts, traditional line transect censuses, distance sampling, and the random walk approach.

## Methods

For the comparative study of survey methods I selected two independent transects, MNT1 (Fig. 5) and MNT2 (Fig. 8), which were separated from each other by c. 3000 m in a straight line (Fig. 1b). The letters MNT stand for 'mist-netting transect', to distinguish these transects where I also used the mist-netting method from the 16 other line transects

(LT), which I surveyed exclusively with a standardized transect-mapping protocol. The length of the 18 transects varied between 550 and 1700 m and the total length of all transects was 25.15 km (cf. Chapter 3 and Table 6 for details on their geomorphological characteristics, the habitat types covered, and the method used for marking them). With the exception of MNT1, MNT2, LT8a, and LT8b, I established most transects on existing trails.

#### Mist-netting study

I started the comparative study with mist netting because capture/recapture surveys are much more time-consuming than audiovisual methods. Furthermore, the routine of identifying hand-held birds was perfect training for the identification skills necessary for making accurate field observations.

After I had carried out some mist-netting tests in August 1995 (Appendix 1), I established the two transects MNT1 and MNT2 at Playa de Oro and Playa Rica, respectively. Each transect covered a habitat gradient and was divided into four sections (A to D; Table 4). Although I tried to select the habitat characteristics of each transect section to be as homogeneous as possible, the habitat composition of the sections at MNT1 was more diverse than of those at MNT2. It was not possible to standardize the length of the sections absolutely, since various obstacles interfered with the ideal of establishing one continuous mist-net line at each transect (e.g., topography, channels, backwater areas, streams, paths used by local people). The lengths of the transect sections varied between 125 and 175 m, with an average ( $\pm$  SD) of  $156.25 \pm 16.1$  m for MNT1 and  $137.5 \pm 10.2$  m for MNT2. In each transect section I trapped with 17 black 4-shelved nylon mist nets, each about 6 m long, 3 m high, and with a mesh size of c. 18 mm. During the study the nets increased in length due to the continuous tension. The average net length for the study was c.  $6.25 \pm 0.25$  m. Thus the mean length of the mist-net line used in each transect section was c.  $106.25 \pm 4.25$  m. The nets were positioned at the same locations on the transects for each capture period.

In general, there are two ways to standardize mist-netting samples. Karr (1981b, 1990) preferred 100-capture samples as the best compromise between the number of captures and the time effort, especially in view of the fact that capture rates decline throughout the period of netting (Karr 1979, 1980a). Furthermore, capture rates are also dependent on weather

conditions and time of day (Poulsen 1994, Kaeslin 2002), factors that obviously bias constant time-effort samples. Nevertheless, recent studies mainly applied constant time-effort schemes (Bibby *et al.* 1992, 2000; Salaman 2001), since constant numbers of captures are hardly achievable in many circumstances.

I started the mist-netting study with 100-capture samples. However, constant capture sampling did not work in section C of MNT1. Therefore, I applied a time-effort scheme of at least 20 h, and maximally 32 h, to achieve 100 captures or less. For the comparative analysis presented here, I finally used three standardized samples per section and transect. The time effort for each of the 12 samples analyzed for MNT1 varied between 20.5 and 23 h, with an average capture time of  $22.6 \pm 0.7$  h ( $= 7198 \pm 224$  net-square-meter-hours, NSMH). For MNT2 the effort was between 22.5 and 23 h with a mean survey time of  $22.8 \pm 0.3$  h ( $= 7252 \pm 83$  NSMH) per sample (Appendix 2).

The standardized mist-netting study for MNT1 was carried out from Mar. to Nov. 1996 and for MNT2 from Nov. 1995 to Nov. 1996. The average net-operation time for a complete survey of MNT1 was  $90.3 \pm 1.3$  h and for MNT2  $91.0 \pm 0.5$  h. The corresponding mean capture effort was  $28794 \pm 401$  NSMH, equaling  $800 \pm 11$  MNH (mist-net hours), for MNT1 and  $29006 \pm 159$  NSMH ( $= 806 \pm 4$  MNH) for MNT2 (Appendix 2). I netted only two sections per transect and field work period. The intervals per complete survey (I to III) were 86, 88, and 45 days for MNT1 and 145, 215, and 185 days for MNT2. As a consequence, the data pools for the complete surveys, especially those of MNT2, do not reflect the composition of the understory bird community in the transect areas at a given moment, but include seasonal fluctuations of unknown magnitude. Thus the results regarding the community structure of the complete transects have to be interpreted with caution, and seasonal changes should be analyzed at the level of subsamples of each section rather than between the complete surveys. On the other hand, the significance of the results on bird species detectability, as well as species accumulation, should not be affected by these survey biases.

When weather conditions permitted we opened the nets at 06:00 h to 06:30 h and kept them open until 16:30 h to 17:00 h. Sometimes we had to close them for a few hours due to rainfall or, in semi-open transect sections, extreme sun exposure of the

net lines. We usually positioned the lowest pocket of the nets 20–30 cm above the ground, because the transects quickly turned muddy or flooded locally after heavy rainfall. Under ‘normal’ conditions we checked the nets at intervals of about 30 min; more often during drizzle or sun exposure. Another strategy to reduce losses to below 1% of captures was the use of distinctly colored and patterned textile bags for different ‘delicacy classes’ of birds. Thereby the bander(s) could handle the birds in the order of their fragility (i.e., hummingbirds, other small or fragile species, recaptures, medium-sized birds, and larger species).

Directly at the nets we noted the time, net number, net shelf, and the side of the net from which the bird flew in. At the banding station we documented body measurements (Appendix 11), state of molt, and details important for identification on preprinted file cards. With the exception of hummingbirds, we banded almost all species either with aluminum or plastic color bands. For hummingbirds two or three rectrices were collected in a predefined order to enable the identification of recaptures, at least for a couple of weeks. Whenever possible I photographed bird species and distinctive plumage variants that were captured for the first time in different positions.

### Transect-mapping study

#### Reasoning for the selection of the survey method

To develop an accurate, time- and cost-effective rapid assessment protocol for tropical bird communities, I started with an evaluation of the four most extensively used standard survey methods in temperate zones (i.e., territory or spot mapping, point counts, line transects, and mist netting). Comprehensive discussions of the advantages and disadvantages of these techniques in temperate habitats were presented in Ralph & Scott (1981), Koskimies & Väisänen (1991b), Bibby *et al.* (1992, 2000), and Flade (1994). The applicability of these methods for bird surveys in tropical latitudes was analyzed by Karr (1981a), Oelke (1981b), Lynch (1989), Terborgh *et al.* (1990), Poulsen *et al.* (1997), Robinson & Terborgh (1997), Whitman *et al.* (1997), Bibby *et al.* (1998), Rappole *et al.* (1998), Stiles & Rosselli (1998), and Blake & Loiselle (2001).

For the evaluation I defined a list of criteria that I considered crucial for the suitability of a rapid assessment method for surveys of tropical birds (cf. Table 11). An ideal rapid assessment protocol

must be inexpensive, applicable in large and remote areas, and should be able to detect most species with a high probability. Considering these requirements, it was possible to entirely exclude two of the survey techniques, mist netting and territory mapping, from any further consideration. Although mist netting has been, until recently, the most widely accepted method for surveying tropical birds (e.g., Karr 1981a, Stotz *et al.* 1996), only small to medium-sized undergrowth- and understory-dwelling species are adequately recorded, and therefore entire groups of the avian community are excluded from detection (p. 88–99, Comparative effectiveness and efficiency of mist-netting and audiovisual surveys). Furthermore, capture/recapture studies are very expensive, time-consuming, and not suitable for surveying large areas (Flade 1994). The only reason I used mist netting in this study was to obtain data for a direct comparison with the survey protocol I have been developing.

Spot or territory mapping is one of the most widely accepted breeding bird census methods in various temperate zone countries (e.g., SOVON 1985, Flade 1994, DO-G 1995). One important reason is that an experienced observer can obtain almost complete bird species lists for the study plots. Another striking advantage of territory mapping is its suitability for estimating absolute population densities and even for calculating territory sizes for many species (e.g., Terborgh *et al.* 1990, Flade 1994). On the other hand, it is the most time-consuming of the general bird count methods for a fixed number of birds finally counted (Bibby *et al.* 1992) and is therefore inefficient, especially for surveying large or remote areas (Koskimies & Väisänen 1991a). Ideal study plots measure only between 10 and 100 ha and present a close-meshed system of trails. Very detailed maps at a scale of about 1:2000 to 1:10 000 are necessary prerequisites (International Bird Census Committee 1969, 1970; Bibby *et al.* 1992, 2000; DO-G 1995). Obviously such accurate maps are not available for most study sites in remote tropical areas. The alternative, which is establishing and maintaining a dense checkerboard-like grid of trails (e.g., Thiollay 1994b, Robinson *et al.* 2000), is costly and thus not feasible in many circumstances. All in all, the traditional territory-mapping method is unsuitable as a standard rapid assessment technique for tropical bird communities.

Point counts and line transects possess at least a moderate suitability for standard rapid assessments in the evaluation (Table 11). These bird survey tech-

niques are relatively fast, low budget, and can be used in large and remote areas (Järvinen & Väisänen 1981, Tomialojć 1981, Koskimies & Väisänen 1991b, Svensson 1992). The obvious weakness of both methods is that they tend to widely underestimate both the number of species and the number of individuals present in a study area (Walankiewicz 1977, Anderson & Ohmart 1981, DeSante 1981, Franzreb 1981, Hildén 1981, Mayfield 1981, Tomialojć 1981). In particular, rare (and often threatened) species as well as cryptic and skulking taxa are easily overlooked (Flade 1994). Yet data on some of these species are most urgently needed as basic information for the elaboration of environmental impact assessments, the design of protected areas, and for landscape planning procedures in general. Thus, it is necessary to develop alternative protocols for these counting techniques to increase the probability of detection of rare and secretive tropical bird species.

As a next step I had to decide which of the two audiovisual methods would most likely be more cost and time effective in rapid assessments and would produce more complete and accurate information on tropical bird communities. In the scientific literature discussions in this context are often controversial. Some researchers claim that line transect censuses generate more accurate data than point counting (Anderson & Ohmart 1981, Flade 1994), whereas others demonstrate that the opposite is the case (Edwards *et al.* 1981, Verner & Ritter 1985). Bibby *et al.* (1992, 1998, 2000) stress that point counts are the more appropriate survey method for structurally complex and species-rich forest habitats. However, one truly negative feature of point counting influenced my decision: the counting stations should be at least 200 to 300 m apart to assure independence of counts, thus time spent traveling is lost from the observation time (Anderson & Ohmart 1981, Bollinger *et al.* 1988). Point count studies have used count durations of c. 2 to 20 minutes (Bibby *et al.* 1992) and typical travel times are 3 to 6 min (e.g., Lynch 1995). Thus, depending on the count duration and the distance between the points, about 13 to 75% of valuable observation time is lost in traveling, assuming that transport by car is not an option in most remote tropical areas. This feature of the point count method is hardly consistent with the requirements of a rapid assessment technique that must be absolutely time efficient. In summary, of all survey methods commonly used in temperate latitudes, the line transect technique seems to have the

best potential for the development of a time-efficient and cost-effective standard rapid assessment procedure for tropical birds.

The challenge remained to find appropriate solutions for the numerous imperfections of the standard temperate line transect protocol in the context of surveys of tropical birds. Important drawbacks of the method are that populations of flock-forming species, breeding residents with high proportions of non-breeding individuals as well as taxa with very short song periods are heavily underestimated (Mayfield 1981, Svensson 1981). As mentioned in the introduction, such species amount to a considerable proportion of tropical bird communities (Karr 1981a, Terborgh *et al.* 1990). Another disadvantage of the standard temperate protocol is that the observer moves with a constant speed of about 1 km/h, and thus must expend a considerable part of his/her concentration on trail navigation, especially in rugged terrain (Dawson 1981).

#### The transect-mapping (MTW) protocol of the pilot study

After I had carried out some line transect census tests in Playa de Oro in Mar. and Jun. 1996, it was clear that the standard temperate protocol could not provide accurate data for the bird community at my study site. With a speed of about 6 min per 100 m (= 1 km/h) it was inevitable that many species and individuals were missed, at least during hours of maximum bird activity. In addition, it was impossible to do justice to the identification challenge an observer faces when he/she encounters mixed-species flocks while simultaneously moving with constant speed. And how to meet the apparent requirement of tropical bird surveys that the observer should be at all locations at the same time all day long, because many species have very short song activity peaks during different periods of the day?

Taking into account the experiences and information I had gathered, I eventually decided to break with almost all rules of the standard temperate protocols for line transect censuses. Instead, I tried to combine the advantages of the spot-mapping method (almost complete breeding species lists; high probability of detecting even rare, threatened, and secretive species) with the benefits of the line transect technique (fast, cost-efficient, suitable for large and remote areas). To increase the number of recorded species and individuals, I increased the number of samples per transect and slowed the average observer speed

during hours of maximum bird activity. Considering that twilight periods at dawn and dusk are very short in the tropics, and that bird activity changes considerably during the course of the day, I used different average speeds, adapted to the level of vocal activity. For the accurate identification of species accompanying mixed flocks and during periods of high vocal activity, I allowed the observer to stop for appropriate intervals. Furthermore, I decided to sample the transects on the way out as well as on the way back, to reduce inefficient travel time. Finally, I mapped the position of each bird with the help of the 25-m distance markers to obtain a detailed picture of the species distribution pattern along the transect routes. To express this latter characteristic of the survey technique, as well as its feature of allowing the detection of species that have activity peaks at different periods of the daily cycle, I named it 'Multi Time-Window Transect-Mapping' (MTW) method; see p. 99, Comparison of MTW with other potential rapid assessment methods, for details on the similar plot-mapping approach sensu Thompson *et al.* (1992).

In rapid assessments according to the original protocol, one complete MTW survey of a transect consists of six individual samples at different periods of the day and can be carried out in only two days, under optimal conditions. The time schedule of an MTW survey depends on the time of sunrise and sunset, as well as on the transect length (Tables 9, 12, 42, and 43). In my experience the ideal transect length is 1200 m.

The first sample (1A) was performed before sunrise at a maximum travel speed of 4 min per 100 m (1.5 km/h). The rather high observer speed during pre-dawn periods can be justified by low population densities of most nocturnal and crepuscular species (e.g., owls, potoos, and caprimulgids) and other 'early' birds (e.g., some tinamous and cracids). The activity of most of them peaked or started between about 60 and 20 min before sunrise. In rugged terrain I chose lower observer speeds, but in any case it was my aim to reach the transect end about 20 min before sunrise, just when typical diurnal species began to vocalize (e.g., motmots, forest-falcons, *Rhynchortyx cinctus*, or *Rhytipterna holerythra*). In Playa de Oro, the first forest-dwelling passerine species started to sing c.  $18 \pm 3$  min ( $n = 45$ , mornings without mist) before sunrise, unless low-hanging cloud cover or dense mist postponed the beginning of the dawn chorus some 5 min or more. On the other hand, in semi-open landscapes diurnal bird

activity often began 5 to 10 min earlier than in forest. The second sample (1B) was carried out directly on the way back, as soon as the dawn chorus had fully started. The average observer speed during early morning samples was c. 12 min per 100 m (0.5 km/h), or lower when bird activity was very high.

On another morning I started sample 2A about 20 min before sunrise at the initial transect marker, just as diurnal species activity began. In fact, I regularly started sample 2A a few (5-10) minutes earlier than sample 1B, to also record the last active nocturnal and crepuscular species that often were not heard in this transect section during the pre-dawn sample 1A due to persisting darkness. As soon as the dawn chorus set in, I moved with an average speed of c. 12 min per 100 m. After a pause, which was adapted to the transect length (Table 9), I surveyed the transect again on the way back (sample 2B) because the activity maximum of some bird species (e.g., some raptors, pigeons, toucans, mixed-canopy flocks, and others) is not in the earliest but in the mid-morning hours (Blake 1992; pers. obs.). The travel speed was roughly the same as for early morning visits because canopy species were difficult to identify from the forest floor. Thus I spent a considerable amount of time on the observation of mixed-species canopy flocks, but I moved relatively quickly in transect sections with low bird activity.

Some species tend to be more obvious in the late afternoon or around dusk (Terborgh *et al.* 1990, Robinson *et al.* 2000), e.g., *Hyllopezus perspicillatus*, *Rhynchortyx cinctus*, and *Amaurolimnas concolor*. For this reason I performed another pair of samples during final daytime hours. Because bird activity is distinctly lower in the afternoon than in the morning, I traveled at about 9 min per 100 m (0.67 km/h) while carrying out sample 3A. The aim was to reach the end of the transect c. 20 min before sunset. At the transect end light was usually still bright enough for some diurnal species to continue vocalizing. Nevertheless, I immediately started way-back sample 3B, moving at c. 4 min per 100 m to survey the middle section of the transect just in the last of the twilight. By the time I reached the initial marker of the transect again, bird activity was often zero due to absolute darkness.

The total study time of the six individual samples (1A to 3B) for one complete MTW survey added up to an effort of c. 53 min per 100-m transect (see p. 106, Guidelines for an optimized transect-mapping protocol for rapid assessments, for factors that might



TABLE 9. Idealized time schedules and minutes surveyed per time window of 30 min in transect-mapping (MTW) surveys for trail lengths of (a) 500 m, (b) 1000 m, and (c) 1500 m, according to the scheme used in the pioneer study. 'Samples A' started at the initial marker of the transects, corresponding to the 'way out' (→), whereas 'samples B' were carried out on the 'way back' (←) and began at the final markers. The times of sunrise and sunset were arbitrarily chosen and roughly corresponded to the annual mean for the daily cycle at Playa de Oro (p. 24, Sunrise, sunset, and daylight period). In 1997 they were the actual times of sunrise and sunset on 26 Apr. to 2 May as well as on 27 May. Those times written in bold, either for the start or for the end of the samples, exclusively depended on the time of sunrise (1A-2B) or sunset (3A and 3B), and thus were independent of the transect lengths. The only exceptions were the samples 2B (start times written in bold italics), which started 140 min after sunrise for transects of 500 and 1000 m but 170 min after sunrise for transects of 1500 m. The reason was to cover also for shorter transects the peak activity of canopy species, which is usually reached in the third hour after sunrise (Blake 1992), for shorter transects as well. Also note the improved MTW protocols for rapid assessments (Table 12) and monitoring studies (Tables 42 and 43).

Minutes surveyed in time windows of 30 min																														
(min/ Effort				Before sunrise												After sunrise														
Sample	100m)	(min)		Start	End	Sunrise	Sunset	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	-6	-5	-4	-3	-2	-1	1	2
1A →	4	20		05:30	05:50	06:10	18:15	10	10																					
1B ←	12	60		05:50	06:50	06:10	18:15	20	30	10																				
2A →	12	60		05:50	06:50	06:10	18:15	20	30	10																				
2B ←	12	60		08:30	09:30	06:10	18:15								10	30	20													
3A →	9	45		17:10	17:55	06:10	18:15																			5	30	10		
3B ←	4	20		17:55	18:15	06:10	18:15																					20		
Sum	53	265						10	50		60	20			10	30	20									5	30	30		
Minutes surveyed in time windows of 30 min																														
(min/ Effort				Before sunrise												After sunrise														
Sample	100m)	(min)		Start	End	Sunrise	Sunset	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	-6	-5	-4	-3	-2	-1	1	2
1A →	4	40		05:10	05:50	06:10	18:15	30	10																					
1B ←	12	120		05:50	07:50	06:10	18:15	20	20	30	30	30	10																	
2A →	12	120		05:50	07:50	06:10	18:15	20	20	30	30	30	10																	
2B ←	12	120		08:30	10:30	06:10	18:15								10	30	30	20												
3A →	9	90		16:25	17:55	06:10	18:15																			20	30	30	10	
3B ←	4	40		17:55	18:35	06:10	18:15																					20		
Sum	53	530						30	50		60	60	20	10	30	30	20									20	30	30		
Minutes surveyed in time windows of 30 min																														
(min/ Effort				Before sunrise												After sunrise														
Sample	100m)	(min)		Start	End	Sunrise	Sunset	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	-6	-5	-4	-3	-2	-1	1	2
1A →	4	60		04:50	05:50	06:10	18:15	20	30	10																				
1B ←	12	180		05:50	08:50	06:10	18:15	20	20	30	30	30	30	10																
2A →	12	180		05:50	08:50	06:10	18:15	20	20	30	30	30	30	10																
2B ←	12	180		09:00	12:00	06:10	18:15								10	30	30	20												
3A →	9	135		15:40	17:55	06:10	18:15																			5	30	30	30	10
3B ←	4	60		17:55	18:55	06:10	18:15																					20	30	10
Sum	53	795						20	30	50	60	60	60	60	30	30	30	20							5	30	30	30	30	10

increase the survey effort). Most of the sampling effort was concentrated in the hour before sunrise as well as in the early morning hours when bird activity is highest. The survey effort per 'time window' of 30 min was about twice as high during periods of peak activity than during quieter late morning and late afternoon hours.

#### Data collection in transect-mapping surveys

In the pioneer study described here I mapped the position of each bird with the help of the 25-m distance markers, differentiating between observations within the main belts of 25 m on each side of the transect and those in the unlimited supplementary belts at distances > 25 m from the paths. This sample design was inspired by the two-belt method proposed by Järvinen & Väisänen (1975). However, the two-belt approach is not the optimal one for transect-mapping surveys (p. 103f, Guidelines for an optimized transect-mapping protocol for rapid assessments).

All records were noted on preprepared transect map forms that reproduced the actual transect schematically, including the distance markers, the two main belts (left and right), and the far belts. I used unique 6-letter codes for each species to save time while taking notes (Appendices 4 and 5). For each record I noted additional encoded information, such as the number of individuals encountered, the sex and age of birds seen, and the type of observation (visual or auditory and type of vocalizations heard). For species moving in family groups or flocks exact numbers of individuals often remain uncertain. When appropriate I estimated the number of vocalizing individuals according to the experience I had with group and flock sizes of each species.

If I could not identify the source of a distinct vocalization, I tape-recorded the call or song of the unidentified species together with additional information, such as the distance on the transect and a current code (e.g., BIRD 05), which I also registered in the transect map form. Sometimes I tried to call in the unknown bird by broadcasting its taped song. However, in this study playback was exclusively used for identification purposes, and not to test the presence of a certain species. When aural stimulus failed, it was often possible to identify the species subsequently through comparison with sound archives or the help of other ornithologists.

A slow-moving observer runs the risk of counting some individuals repeatedly within the same sample.

Terborgh *et al.* (1990) faced the same problem in their spot-mapping surveys in Amazonian Peru, and took the position that, for territorial species, successive registrations > 50 m apart represented different territory holders. In my experience this assumption does not always hold, especially in the case of species accompanying fast-moving foraging flocks. Therefore I put special emphasis on marking counter-singing territory neighbors, simultaneously displaying males at leks, and records of intra-specific territory disputes in the transect map forms (p. 104-106, Guidelines for an optimized transect-mapping protocol for rapid assessments; cf. Thiollay (1994b) and Robinson *et al.* (2000)). The challenges caused in this context by non-territorial species, trap-lining hummingbirds, and far-ranging foraging flocks (e.g., parrots, toucans, and others) will be addressed in Chapter 5.

In addition to the information already mentioned, the time was noted at each x-hundred meter distance marker. The weather conditions were recorded at the beginning and end of each sample. If the actual weather conditions (e.g., drizzle, rain, wind) had an obvious negative impact on bird activity, the survey was stopped for an appropriate period and then continued (e.g., after the rain stopped), or cancelled and repeated on another day.

#### Dates and effort of surveys

Between Feb. 1997 and Jan. 1998 I surveyed the 18 transects at least twice according to the MTW protocol. All in all I carried out 44 MTW surveys with 262 samples (Appendix 3). The total time effort in the MTW study was 507.6 h, with an average sampling effort of  $52.9 \pm 4.9$  min per 100-m transect and complete survey.

Transects MNT1 and MNT2 were surveyed four times according to the MTW protocol (Appendix 3). The intervals between samples within complete MTW surveys were 14, 3, 4, and 3 days for MNT1, whereas they varied between 3 and 5 days for MNT2. The average study time for one complete MTW survey was  $349.3 \pm 24.4$  min for MNT1 and  $318.0 \pm 21.3$  min for MNT2, corresponding to  $55.9 \pm 3.9$  min and  $57.8 \pm 3.9$  min per 100-m transect, respectively.

#### Non-standardized observation hours

Between Apr. 1995 and Nov. 2000 I visited Playa de Oro 28 times and spent a total of 484 days within the community area. Consequently, apart from the



survey efforts of the standardized mist-netting and MTW studies, I accumulated a considerable but unknown number of non-standardized observation hours. Several species of birds were recorded exclusively during unsystematic sampling.

The non-standardized observation time for MNT2 was perhaps twice as high as for MNT1. For this reason, the species list for MNT2 (Appendix 12b) is likely more complete than for MNT1 (Appendix 12a), although the absolute number of species recorded was identical for both sites.

#### Bird species identification and taxonomy

When I started my systematic field work in Playa de Oro in Aug. 1995, I had only a poor knowledge of the local avifauna. 'The Birds of Ecuador' (Ridgely & Greenfield 2001a,b) was not yet published, but it was by good fortune that 'The Birds of Colombia' (Hilty & Brown 1986) covered most Chocoan species, and that remaining identification questions could usually be clarified with the help of the 'Birds of South America', volumes I and II (Ridgely & Tudor 1989, 1994). Only in a few cases did I have to consult the bird collection of the Museo Ecuatoriano de Ciencias Naturales, Quito.

In the mist-netting study I documented species identification by photos, body measurements, and in some cases (e.g., hummingbirds) also with a few samples of the rectrices and tail-coverts.

Because only about 5% of commonly heard bird vocalizations were commercially available at the time when I prepared myself for the field work, I started to intensively tape-record bird sounds during free hours on the mist-netting project. During the transect-mapping study I tried to obtain voucher recordings of as many bird vocalizations as possible, in order to document the presence of the species, their sound repertoire at the study site, and my identifications (Jahn *et al.* 2002, 2008). P. Coopmans, P. Mena V., and R.S. Ridgely subsequently identified some of the vocalizations I was unfamiliar with.

For practical reasons, I follow Ridgely & Greenfield (2001b) for taxonomy, family and species order, and English names. However, I implemented recent gender agreements (David & Gosselin 2002a,b) and changes at the level of genera (e.g., Banks *et al.* 2003). Important inconsistencies between Ridgely & Greenfield (2001b) and the taxonomy proposed by other authors, as well as more recent changes (e.g., Banks *et al.* 2008, Renssen *et al.* 2011), are addressed in Appendix 5.

#### Data analysis

To assess the effectiveness of species detectability and accumulation in the mist-netting and line transect surveys, I included in the analysis all landbird species recorded by standardized as well as non-standardized sampling between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (Appendix 12a) and MNT2 (Appendix 12b). Some waterbirds, like frigatebirds, cormorants, ducks, herons, and gulls, followed the course of the Río Santiago on passage. I ignored these species because trees and shrubs obstructed the view of the river from any position in the transects. However, all aquatic bird species recorded at least once from within the transect routes were included. The latter group embraces breeding residents, like kingfishers and Striated Heron *Butorides striata*, as well as long-distance migrants like Osprey *Pandion haliaetus* and Spotted Sandpiper *Actitis macularius*.

In MTW surveys it is basically not possible to distinguish between individuals, and thus many birds are recorded repeatedly in different samples. In fact, the method aims at the generation of grouped registrations for the determination of the number of territories (p. 110-115, Estimation of population densities on the basis of transect-mapping data). However, in the pilot study I tried to avoid repeated registrations within one sample. In contrast to audio-visual surveys, individuals can be identified in mist-netting studies once they are permanently marked. Repeated netting of the same individuals results in a higher probability of the corresponding species being recorded, which is why samples that include recaptures are more comparable with the MTW data. Thus I included them in the analysis; see also Blake & Loiselle (2001) for a similar justification for using total captures in comparisons between mist-netting and point-counting data. Here, only birds recaptured within 2 h of the preceding trapping were excluded, since there was a high probability that these individuals flew more or less straight away into the nets after they were released.

I analyze the effectiveness of species detectability and species accumulation at different levels. First, I present the species accumulation graphs for individual surveys as well as for the complete standardized mist-netting project and MTW study. To illustrate the time efficiency of both methods, I also show the species accumulation during the study time. Furthermore, I compare the species richness determined in each survey to the total number of species recorded during standardized and non-standardized sampling

and to the total obtained exclusively in the standardized studies (see Chapter 5 for additional aspects of species richness and species accumulation). Finally, I analyze species detectability with regard to the following factors:

*Influence of taxonomic affinities.* – Species with a close phylogenetic relationship often share certain characteristics (behavioral, ecological, etc.) that influence their detectability in surveys. To uncover the impact of taxonomic relationships on the results of the study, I analyze the detectability at different phylogenetic levels. As some bird families were represented by only a single or a few species, I decided to lump certain groups when they have at least some characteristics in common (Appendices 13a-13c).

*Influence of body size.* – The mesh width of the nets largely influences the size-class distribution of birds in mist-netting samples (Heimerdinger & Lebermann 1966, Pardieck & Waide 1992). Body size may also influence the conspicuousness of birds in audiovisual surveys. For the analysis I decided to use the mean body mass (Appendices 18a and 19a), not the total length of the birds. In accordance with Terborgh *et al.* (1990), I selected a logarithmic ( $\log_2$ ) scale for the definition of the 'body mass classes' (Appendices 14a-14c).

*Influence of breeding/non-breeding status and territory/home-range size.* – I defined as breeding species all those taxa that apparently reproduced within 100 m of the transects during the study period. By this definition the transect areas of MNT1 (Fig. 5) and MNT2 (Fig. 8) were c. 15.6 ha and c. 14.1 ha, respectively. Species that likely bred outside the transect areas were also counted as breeding species when their territories or home ranges obviously occupied a part of these areas (e.g., larger species). For the analysis I distinguish between breeding taxa and non-breeding visitors (Appendices 12a and 12b), and then further subdivide these groups. Note that some species that bred in the transect area of MNT1 were non-breeding visitors in the area of MNT2 and vice versa. In the combined analysis of the two transects (Appendix 15c), species presumably breeding within or close to at least one of the transect areas were regarded as 'breeding species'. The non-breeding visitors were subdivided into non-territorial dispersing taxa (i.e., floaters, stragglers, and elevational migrants), non-territorial latitudinal migrants (i.e., Nearctic-Neotropical migrants and intra-Neotropical migrants), and long-distance migrants regularly establishing temporary feeding territories (Appendix 9).

Territorial breeding residents were grouped according to the estimated size of their territories. The assignation of a species to a certain territory size category was based on the capture/recapture data and, especially, on the results of the MTW study (Appendices 18b and 19b), taking into account the information presented for the same species or sister taxa by other researchers (e.g., Willis 1974, Thiollay 1989b, 1994b; Terborgh *et al.* 1990, Robinson *et al.* 2000). In doubtful cases, and when the approximate territory size was close to the defined limits, I placed the species in the larger size class. For taxa that do not defend territories against members of their own species, I opted to estimate their home ranges instead. The males of some species (e.g., some hummingbirds, tyrannids, cotingas, and others), which do not form pairs or family groups, establish display territories to attract females. In contrast to leks, only one male usually occupies these locations. In some hummingbird taxa (e.g., *Amazilia tzacatl*) belonging to this group, both sexes apparently also occupy temporary feeding territories, which they defend intensely. These species were combined in a separate cohort of 'occupants of display territories or foraging territories' (Appendices 15a-15c), without further differentiating between size classes of the area occupied. Another category was used for lek-forming species (e.g., some hummingbirds, manakins, and cotingas). However, the limits between this and the former group are not always precise, as some display-territory-forming species also tend to gather in loose courtship assemblies (e.g., *Mionectes* flycatchers and *Laniocera* cotingas), whereas displaying males of lek-forming species may sometimes be found away from leks (e.g., *Eutoxeres* and *Androdon* hummingbirds).

*Influence of habitat.* – To enable a brief analysis of species detectability in different habitat types, I assigned each taxon to one of seven general habitat classes (Appendices 16a-16c): forest, forest edge, open country, river, river edge, settlements, and no preferences (Appendix 8). For species with a rather broad spectrum of habitat use, I selected the habitat class where they occurred with the greatest frequency and usually also in their greatest abundance. The assignment was based mainly on my own observations of the habitat preferences in the study area and is not automatically congruent with the habitat descriptions of the same species for other regions.

*Influence of main survey stratum.* – Many species use a wide range of strata during their life cycle for foraging, courtship display, collection of nesting ma-

terial, nesting, and dispersal (Appendix 9). For the analysis (Appendices 17a-17c) I assigned each taxon to just one 'main survey stratum', which corresponds to the stratum where most records were, or might be, obtained in audiovisual surveys. In general, it is the stratum where birds most frequently vocalize and, in the case of rather silent species, where they are most commonly observed. It often, but not necessarily, coincides with one of the main foraging strata of the species (e.g., the Pallid Dove *Leptotila pallida* feeds on the ground, but sings more often from a low perch in thick undergrowth). The assignment to a main survey stratum was based on my own observations and, for rarely encountered taxa, mostly on the information presented in Hilty & Brown (1986), Stiles & Skutch (1989), del Hoyo *et al.* (1992, 1994, 1996, 1997, 1999, 2001, 2002, 2003), and Ridgely & Greenfield (2001a,b).

It should be emphasized that, in some cases, the assignment to certain groups, categories, or guilds is somewhat arbitrary. This is less a problem in the case of body mass classes, but it is prevalent in the context of lumping taxonomic groups as well as defining the main habitat, breeding/non-breeding status, territory size, and main survey stratum. Of course the same problem also exists in the assignment of abundance ranks (Appendices 6 and 8), main foraging strata, and main foraging guilds (Appendix 9), which are discussed in later chapters.

*Statistical analysis.* – For descriptive statistics and the generation of graphics I employed Microsoft Excel (Microsoft 2001), and for all other statistics SPSS software (SPSS 2003). I used Chi-squared statistics (Fowler & Cohen 1986) to test for differences in proportions of species between the results for transects and survey methods, as well as categories of taxonomic groups, body masses, status, habitat, and strata. The corresponding degrees of freedom were stated as subscripted numbers (e.g.,  $\chi^2_6$ ). For the combined data sets of both transects, differences in species detectability between the mist-netting surveys ( $n = 6$ ) and MTW surveys ( $n = 8$ ) were tested with pair-wise (Mann-Whitney) U-tests (Fowler & Cohen 1986). In all tests, differences were regarded significant at a probability level of  $P < 0.05$ .

## Results

### Mist-netting study

In the standardized mist-netting study of MNT1, I obtained 1199 captures, representing 117 species and

including 31% recaptures (Appendix 12a). The average number of birds trapped in the complete surveys, MNT1/I to MNT1/III, was  $400 \pm 50$ , including  $16.3 \pm 5.3\%$  recaptures. In the latter percent value, only individuals repeatedly trapped within each survey were considered 'recaptures'. A mean of  $85 \pm 4$  species were recorded per survey, corresponding to  $0.016 \pm 0.001$  new species per minute and  $72.4 \pm 3.6\%$  of the species captured during the complete standardized study of the transect. For MNT2 the number of captures was 1527, representing 96 species and including 35% recaptures (Appendix 12b). I trapped an average of  $509 \pm 54$  birds per complete survey, MNT2/I to MNT2/III, including  $20.3 \pm 0.3\%$  recaptures (see comment above). The samples contained a mean of  $69 \pm 4$  species per survey, corresponding to  $0.013 \pm 0.001$  new species per minute and  $71.9 \pm 4.2\%$  of the species obtained during the complete standardized mist netting of the transect. Considering MNT1 and MNT2 together, I netted a total of 135 species in the standardized study, 78 (57.8%) of which were captured at both sites.

Species richness in the complete surveys showed no clear pattern in the course of the study (Figs. 17a and 17b). By contrast, the number of captures tended to decrease from survey to survey, with the exception of MNT2/III. Furthermore, the final three quarters of the accumulation curves had the general tendency to be located above the curves of the preceding samples, suggesting that additional species were obtained with proportionally less captures in each new netting session.

Taking into account standardized as well as non-standardized sampling, I obtained a total of 3458 captures, representing c. 2283 individuals and 146 species (Appendix 1). Species accumulation in the complete sample is described well by a power function, when the data are sorted chronologically (Fig. 18). The recapture rate of the complete mist-netting study was about 34%, though it is probable that it was slightly higher due to the fact that not all birds and species could be marked permanently. Only two individuals (0.09%) were captured at both transects. The birds involved were an immature *Mionectes oleagineus*, banded at MNT2 on 2 Mar. 1996 and recaptured at MNT1 on 21 Apr. of the same year, and a female-colored, likely immature *Oryzoborus angolensis*, banded at Playa Rica on 1 Mar. 1996 and re-trapped ten days later in the outskirts of the village. In addition, it is possible that a few individual hummingbirds of common hermit species like *Threnetes*

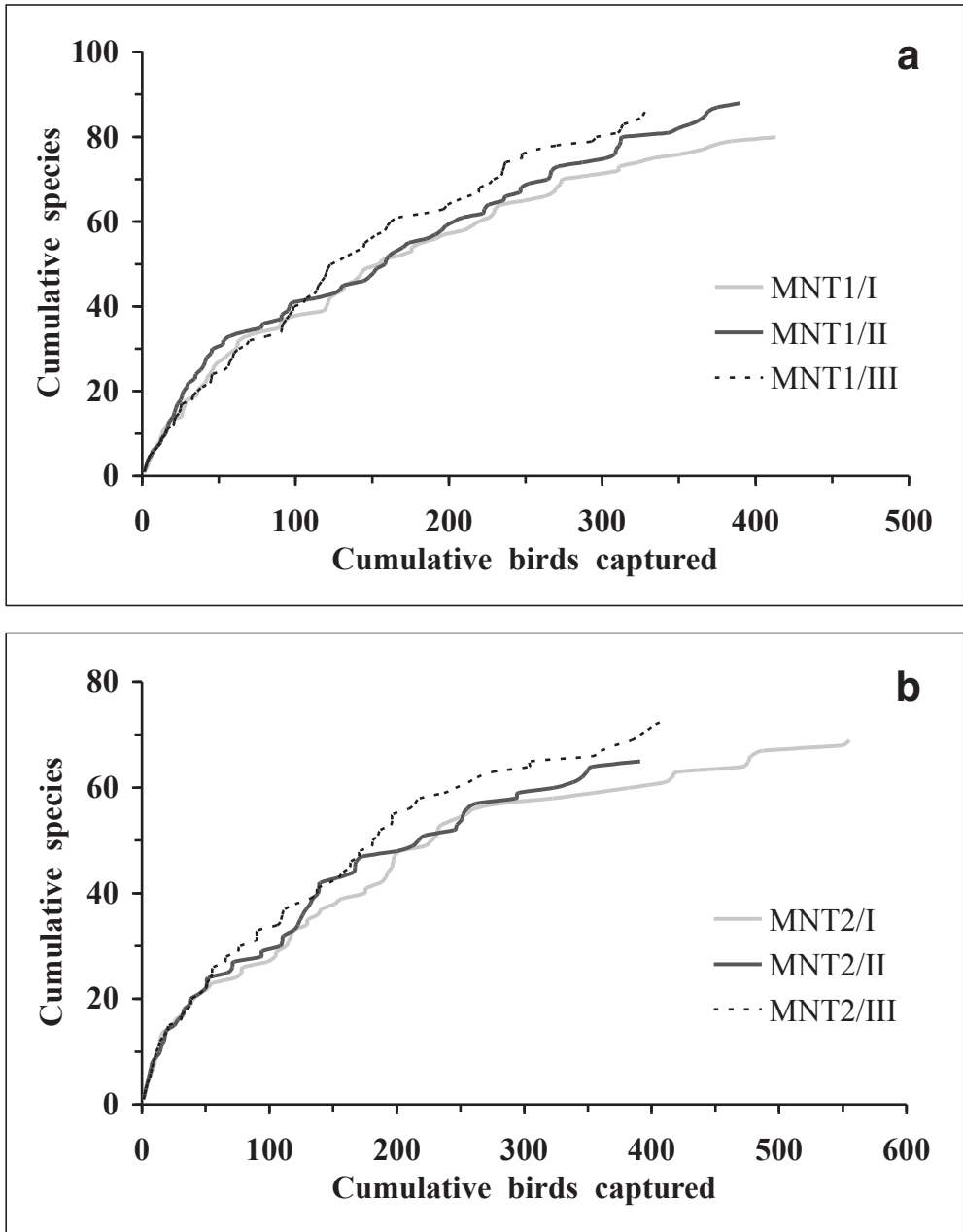


FIG. 17. Species accumulation in the standardized mist-netting study in three complete surveys (a) at MNT1 and (b) at MNT2. The data sets follow the order of the transect sections (A to D) and, within each sample, the chronological sequence of captures, as outlined in Appendix 2. Recaptures were included to facilitate the comparison with the transect-mapping data. The final point of each curve coincides with the last new species netted, and does not necessarily represent the last individual trapped within the surveys; see Appendices 12a and 12b for the number of captures and first captures obtained per species, as well as for totals.

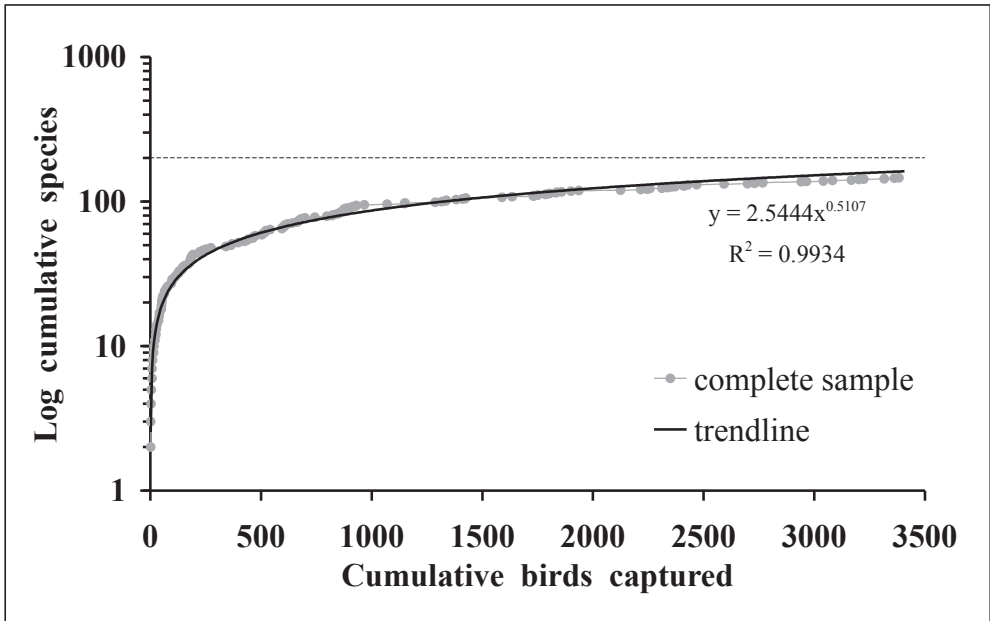


FIG. 18. Species accumulation in the complete non-standardized mist-netting study. Log of cumulative number of species ( $n = 146$ ) versus birds captured ( $n = 3458$ ) at four sites in Playa de Oro. The data were sorted strictly chronologically, as outlined in Appendix 1. Recaptures are included. In contrast to the trendlines shown in Fig. 22, the power function fits much better than the corresponding log normal curve ( $y = 22.607\ln(x) - 63.25$ ;  $R^2 = 0.8658$ ), likely due to the use of cumulative captures instead of study time as well as to the different sequence of the data. The dashed line indicates 200 species and was arbitrarily chosen. This number of species could be expected after roughly 6000 captures if the study would have been continued.

*ruckeri* and *Phaethornis yaruqui* were captured at both transects. The Trochilidae belonged to the bird groups I could not permanently mark, and thus the very few cases when I suspected possible movements of a hummingbird between transects could not be confirmed with certainty. At MNT2 I also captured one territorial adult *Automolus rubiginosus* marked by other banders. Most likely it was the individual reported by Benítez & Matheus (1997), which was banded in Nov. 1994 in the Estero Angostura area, about 2.8 km east of Playa Rica.

#### Transect-mapping study

##### Transect-mapping study of MNT1 and MNT2

In the standardized transect-mapping study of MNT1, I recorded 3569 birds, representing 162 species, with 2223 separate observations (Appendices 3 and 12a). On average I noted  $892 \pm 234$  birds with  $556 \pm 112$  separate records in the complete surveys,

MNT1/1 to MNT1/4. These samples contained a mean of  $116 \pm 9$  species, corresponding to  $0.33 \pm 0.1$  new species per survey minute and  $71 \pm 6\%$  of the species recorded during the entire MTW study of the transect. At MNT2 I recorded 2797 birds, representing 144 species, with a total of 1814 separate records (Appendices 3 and 12b). In the complete surveys, MNT2/1 to MNT2/4, I noted  $699 \pm 125$  individuals with  $454 \pm 55$  separate observations. Each of these samples contained a mean of  $99 \pm 12$  species, corresponding to  $0.31 \pm 0.05$  new species per minute and  $69 \pm 9\%$  of the species recorded during the entire MTW study of the transect. For MNT1 and MNT2 together I noted 187 species in the mapping study, 119 (63.6%) of which were recorded at both sites.

Species richness in the complete surveys at MNT1 and MNT2 tended to increase in the course of the study (Figs. 19a and 19b), with the exception

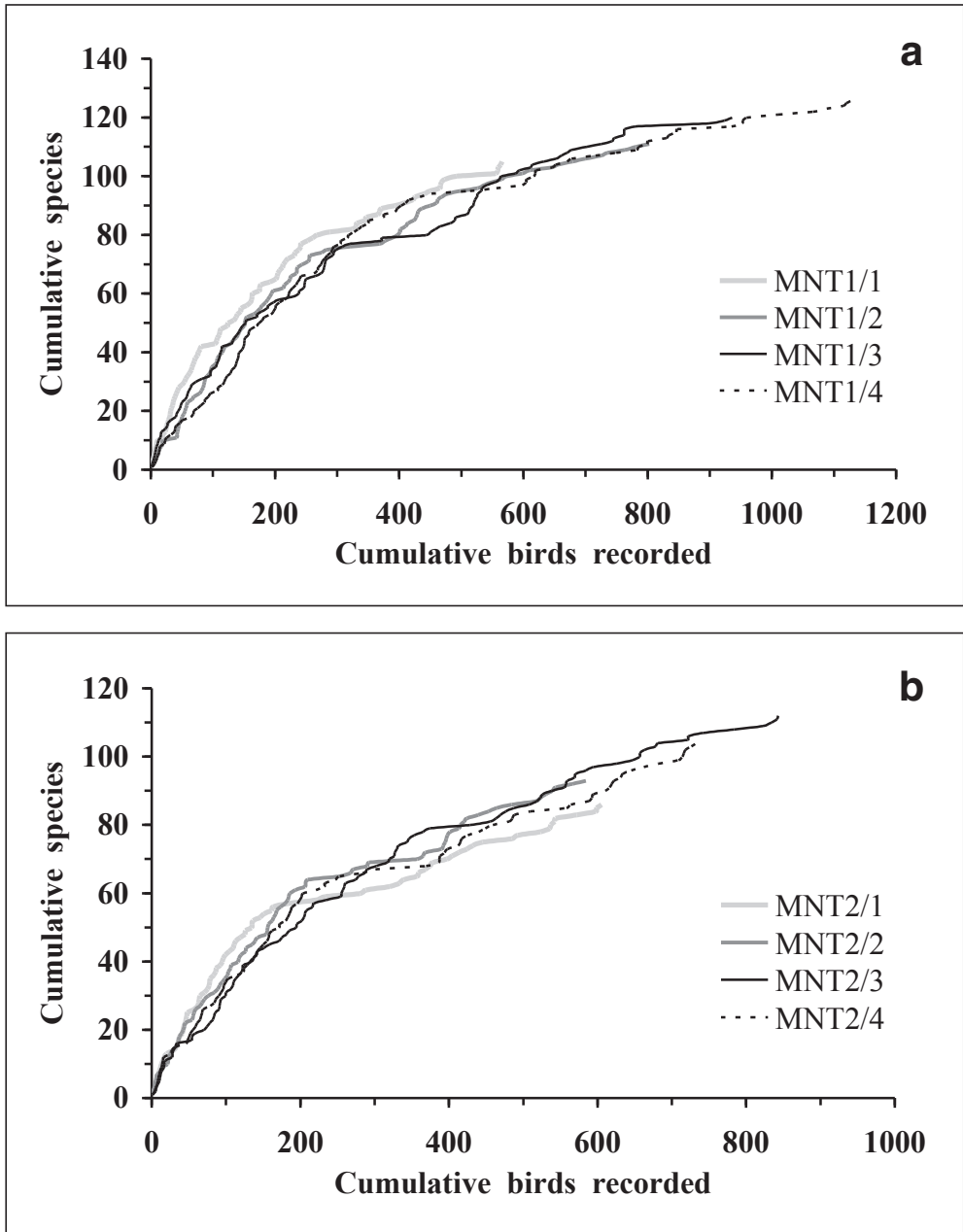


FIG. 19. Species accumulation in four complete MTW surveys of the transect-mapping study (a) at MNT1 and (b) at MNT2. The data sets follow the order of the samples (1A to 3B) and, within each sample, the chronological sequence of the observations, as outlined in Appendix 3. They contain an unknown number of repeated records of some individuals. The final point of each curve coincides with the last new species noted, and does not necessarily represent the last individual observed within the surveys; see Appendices 12a and 12b for the number of birds recorded per species as well as for totals.



of MNT2/4 ( $n = 104$ ), which resulted in less species than the preceding survey ( $n = 112$ ). At MNT1 the number of records, as well as observed birds, increased substantially from survey to survey, whereas no clear pattern was perceptible for MNT2. The variation between surveys was mostly due to my improved identification skills and practice with the MTW technique rather than to real changes in abundance or species richness.

The average number of records as well as species obtained per sample (1A to 3B) largely depended on the bird activity during the corresponding periods of the day (Fig. 20a), and was lowest for predawn (1A) and after-dusk (3B) periods. The differences in medians for samples 1B through 2B, corresponding to periods of high activity during morning hours, were not significant in the corresponding pair-wise U-tests, neither for the number of observations nor for species richness. By contrast, the differences between the former three data sets and 1A, 3A, and 3B were significant in all cases of pair-wise comparisons ( $U = 6.0$  to  $< 0.001$ ,  $P < 0.01$  to  $< 0.001$ ,  $n = 8$  per sample). Of course, the differences between late afternoon visits 3A and the twilight hour samples 1A and 3B were also significant ( $U < 0.001$ ,  $P < 0.001$ , in both cases), whereas no significant differences existed between the latter two data sets. Pronounced differences between samples were also found in the proportion of the 'types of record' (i.e., visual or acoustical), which led to species identification (Fig. 20b). These differences were significant in a Chi-squared test ( $\chi^2_{15} = 167.2$ ,  $P < 0.001$ ). In 8.8% of all records ( $n = 4037$ ) the birds were seen, but in only half of these cases was species identification not also supported by sounds (= exclusively visual).

The type of record followed the general pattern of bird activity as well as light intensity. The proportion of visual records was lowest for twilight hour visits (1A: 2.1%; 3B: 3.0%) and highest for late afternoon samples (3A: 18.3%). Regarding acoustical records, the proportion of songs and calls shifted in the course of the day, with songs being more important than calls in predawn and early morning samples (46.1 to 51.5% vs. 37.3 to 41.2%) and the opposite being the case in late morning, afternoon, and after-dusk visits (31.0 to 43.4% vs. 45.1 to 50.5%). Surprisingly, in the Chi-squared test, differences in the proportion of record categories were statistically significant also between early-morning samples 1B and 2A ( $\chi^2_3 = 17.2$ ,  $P = 0.001$ ), which were carried out in the same time schedules but in opposite direc-

tions. This indicates that the type of record shifts quickly between habitats within the first morning hour.

#### Complete MTW study of the transect network

In the standardized MTW study of all 18 transects (including MNT1 and MNT2), I sampled about 53 400 birds with c. 34 550 separate records (Appendix 3). This database contains information on more than 250 species, corresponding to an arithmetic mean of 140 separate observations per species, and to about 75% of all 336 species recorded until Nov. 2004 in the area of Playa de Oro (Appendix 6).

#### Standardized and non-standardized surveys

Taking into account all standardized and non-standardized mist-netting and audiovisual surveys, I recorded 231 species each in the transect areas of MNT1 and MNT2 (Appendices 12a and 12b). For MNT1 and MNT2 together I recorded a total of 268 species, 194 (72.4%) of which were shared by both sites.

#### Comparative aspects

##### Species richness and species accumulation

In the standardized mist-netting and transect-mapping studies, I recorded 212 (79.1%) of the 268 species known to occur at both transects together (Appendix 13c; see Appendices 13a and 13b for the results of the individual transects MNT1 and MNT2). I trapped 50.4% ( $n = 135$ ) of all taxa in the six mist-netting surveys, with  $28.7 \pm 3.5\%$  ( $n = 77 \pm 9$ ) on average. In the eight complete MTW surveys, I obtained 69.8% ( $n = 187$ ) of the total species richness, and the mean per survey was  $40.0 \pm 4.9\%$  ( $n = 107 \pm 13$ ). The difference in medians of detected species per survey was significant between sampling methods in the corresponding U-test ( $U = 1.5$ ,  $P = 0.004$ ,  $n_{MN} = 6$ ,  $n_{MTW} = 8$ ). Of the species recorded by standardized sampling at both transects, 25 were exclusively detected by mist netting and 77 exclusively by MTW.

Comparing species accumulation curves between transects and methods (Figs. 21a and 21b), species richness was lower at MNT2 (MN:  $n = 96$ ; MTW:  $n = 144$ ) than at MNT1 (MN:  $n = 117$ ; MTW:  $n = 162$ ) with both survey techniques. On the other hand, it is striking that in the mist-netting study the number of captures at MNT2 ( $n = 1527$ ) was considerably greater than at MNT1 ( $n = 1199$ ), whereas

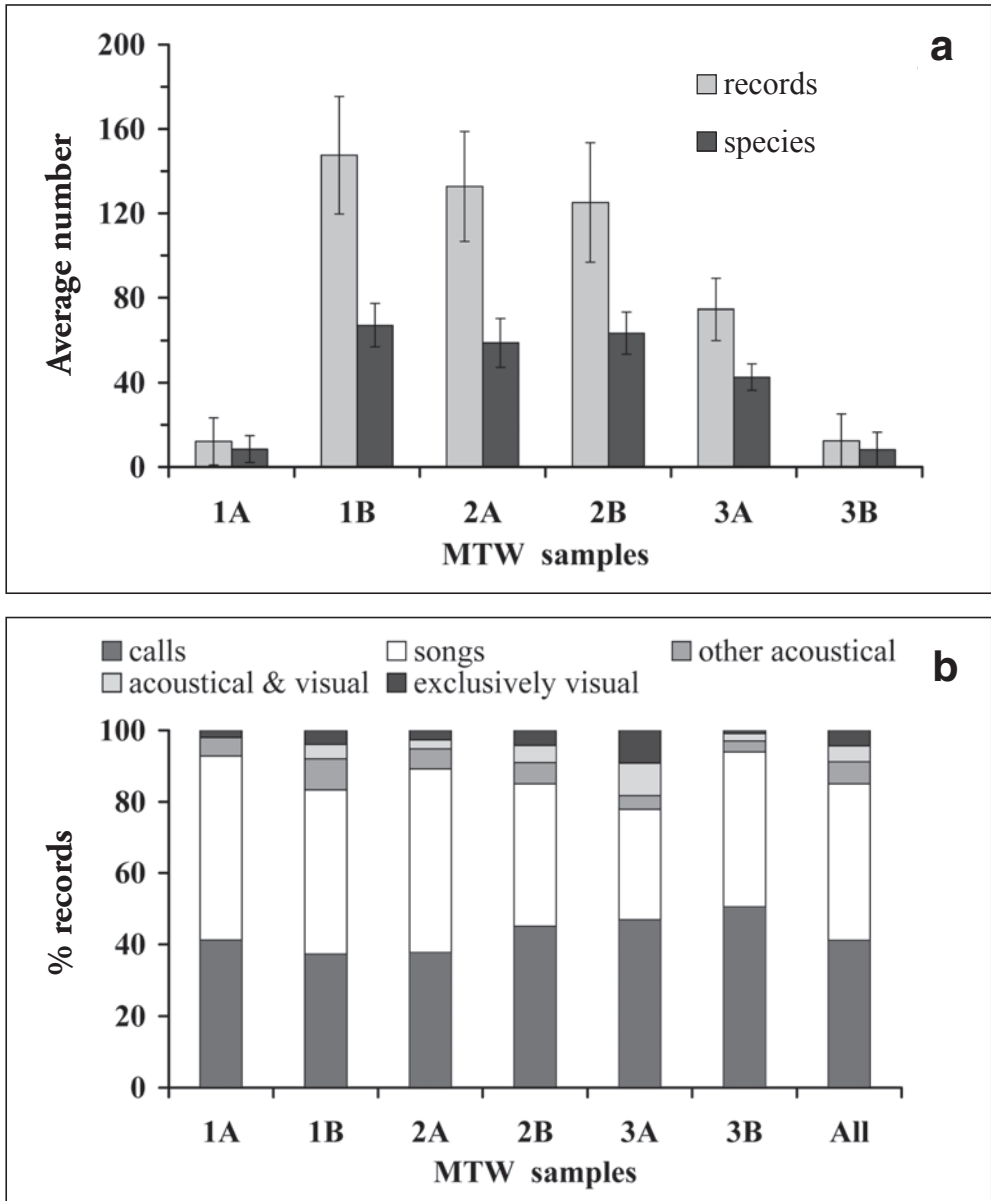


FIG. 20. Results of the transect-mapping study of MNT1 and MNT2, (a) average number of records and species per sample, and (b) proportion of the most important 'types of record' in each sample and in all samples pooled together ( $n = 4037$ ). The categories 'calls,' 'songs,' and 'other acoustical' records combined constitute the exclusively acoustical observations, which add up to 91.2% ( $n = 3683$ ) of all cases. The category 'other acoustical' records embraces a number of identifications based on species-specific mechanical sounds (e.g., drums of woodpeckers, wing noises produced by *Manacus manacus*, and others), as well as cases where songs and calls were heard simultaneously. 'Exclusively visual' and 'acoustical & visual' records had to be lumped for the Chi-squared test to avoid the expected count of some cells in the contingency table being less than five. The combined category is referred to as 'visual' observations in the text.

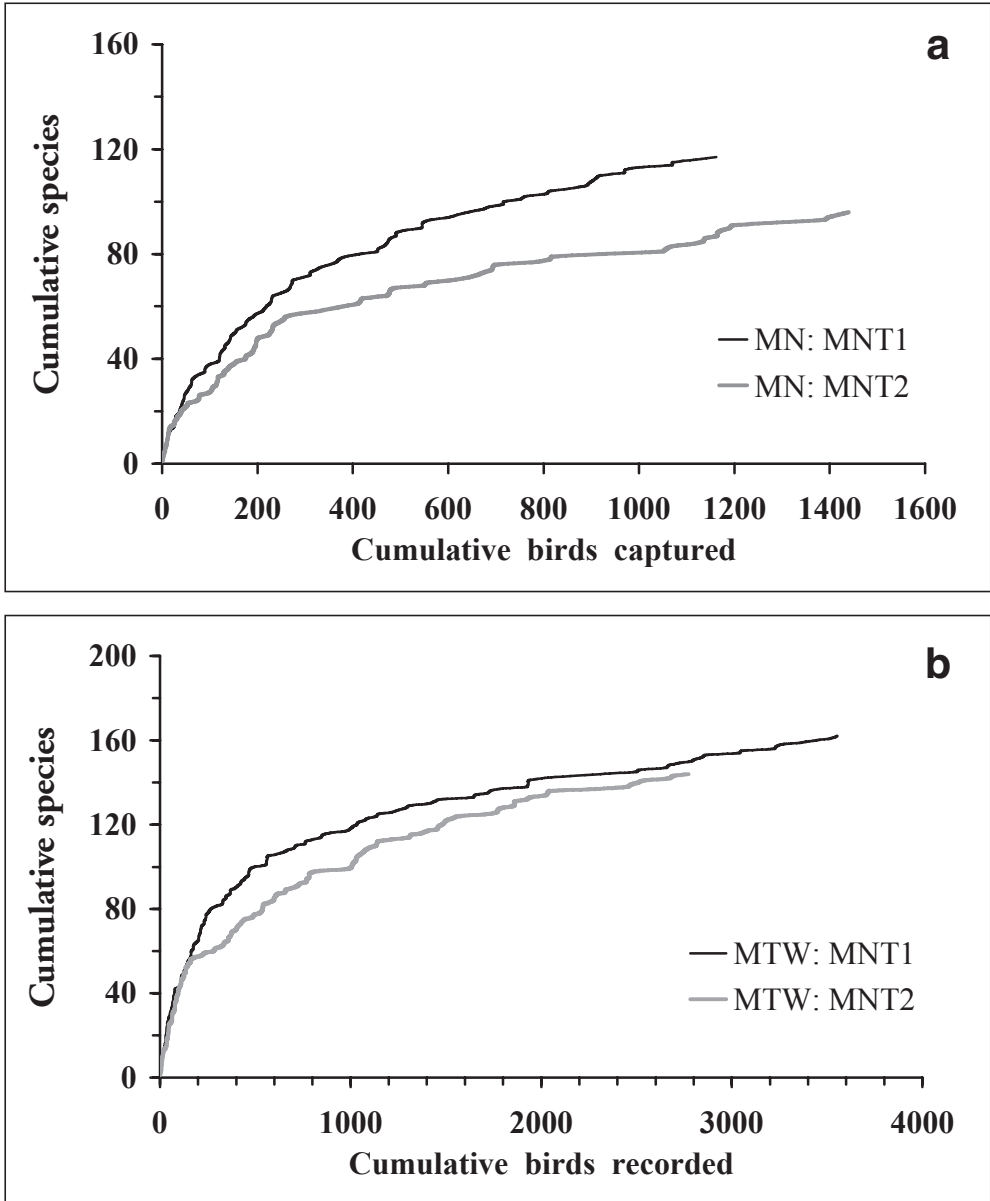


FIG. 21. Comparison of species accumulation during standardized sampling at MNT1 and MNT2 (a) in the mist-netting (MN) project and (b) in the transect-mapping (MTW) study. The data in (a) were sorted according to surveys (I to III), sections (A to D), and, within each sample, according to the chronological sequence of captures, as outlined in Appendix 2. In (b) the data follow the order of surveys (1 to 4), samples (1A to 3B), and, within each sample, the chronological sequence of observations, as outlined in Appendix 3.

in the transect-mapping study the situation was just the opposite, with many more birds recorded at MNT1 ( $n = 3569$ ) than at MNT2 ( $n = 2797$ ). Thus, judging by the netting data, bird diversity was much lower at MNT2 than at MNT1, as indicated by the position and divergence of the accumulation curves. By contrast, in the MTW study the accumulation curves kept relatively close together, implying that diversity was only slightly lower at MNT2 than at MNT1.

The true time efficiency and effectiveness of the MTW technique in comparison with the mist-netting method is revealed when the study effort is taken into account. For both transects together, I noted in 8.2% ( $n = 44.5$  h) of the time effort 38.5% ( $n = 52$ ) more species in the standardized audiovisual surveys than by mist netting ( $n = 544$  h). It is also striking that the species accumulation curve of the transect-mapping study has not stabilized yet (Fig. 22),

meaning that many more species would have been recorded with additional effort. According to the trendline of the species accumulation curve, we could expect c. 285 species, that is 150 (111%) more than captured in total, if the MTW surveys had been continued for the same time period as the standardized mist-netting project. This aspect has to be taken into account when we compare the completeness of the bird inventories between survey methods.

#### Influence of taxonomic affinities

Taking both transects together, non-passerines contributed 38.8% ( $n = 104$ ), suboscine passerines 31.7% ( $n = 85$ ), and oscine passerines 29.5% ( $n = 79$ ) to the 268 species recorded during standardized and non-standardized sampling (Fig. 23; Appendix 13c). For the individual transects these proportions varied only slightly (Appendices 13a and 13b), with differences not being significant in a Chi-squared test.

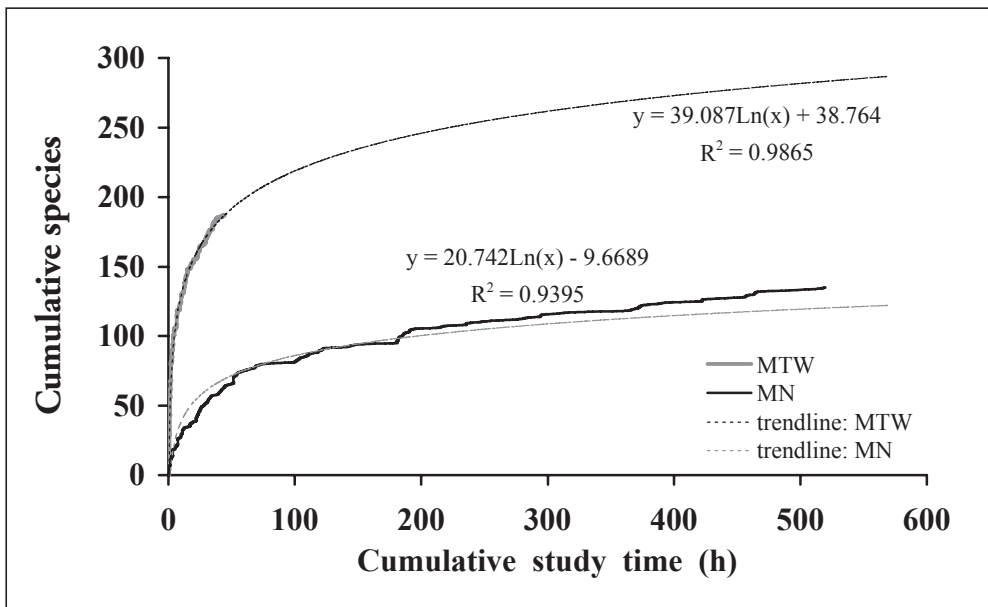


FIG. 22. Comparative time-efficiency and effectiveness of species accumulation in the standardized mist-netting (MN) and transect-mapping (MTW) projects at MNT1 and MNT2. In the mist-netting study, 135 species were captured with an effort of 544 h (= 173 400 NSMH = 4817 MNH), whereas 187 species were recorded in only 44.5 h in the MTW study. Note that the accumulation curve of the MTW study has not stabilized yet. The mist-netting data were alternated between transects, starting with MNT1, and sorted according to the surveys (I to III), sections (A to D), and, within each sample, according to the chronological sequence of captures. Likewise, the MTW data were also alternated between transects, and follow the order of surveys (1 to 4), samples (1A to 3B), and, within each sample, the chronological sequence of observations.

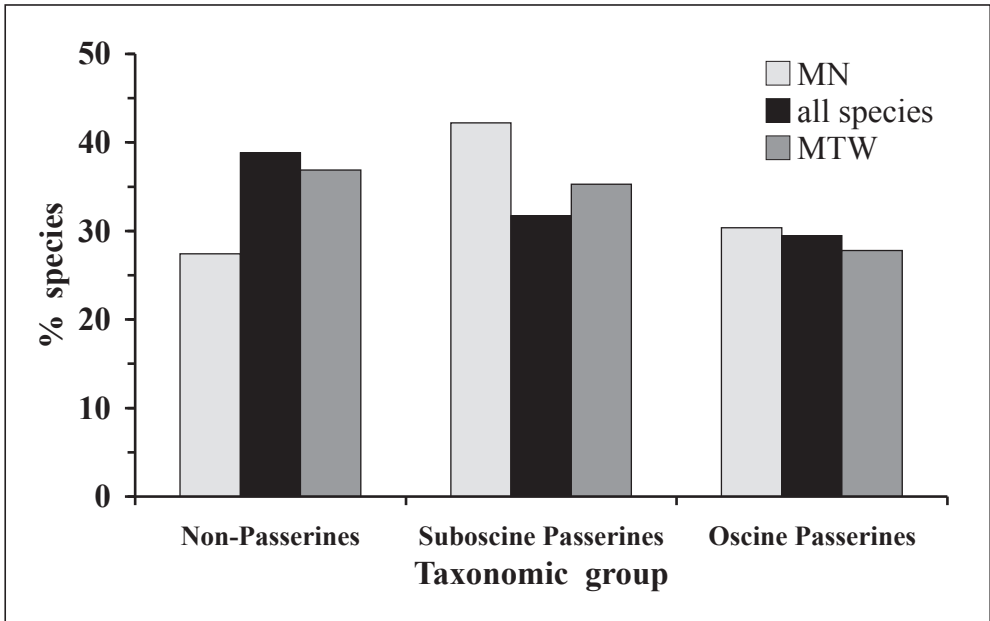


FIG. 23. Proportion of species per major taxonomic group in data sets gathered by standardized and non-standardized sampling (all species:  $n = 268$ ), mist netting (MN:  $n = 135$ ), and transect mapping (MTW:  $n = 187$ ) at MNT1 and MNT2.

Regarding the standardized mist-netting study, the proportions found for the three major taxonomic groups were significantly different from those stated above ( $\chi^2_2 = 18.648$ ,  $P < 0.001$ ). By contrast, no significant differences were found for the proportions within the taxa observed in the MTW study when compared with the complete set of species ( $\chi^2_2 = 3.663$ ,  $P = 0.160$ ).

In the standardized mist-netting study, non-passerines were considerably underrepresented, with 35.6% ( $n_{\text{observed}} = 37$ ,  $n_{\text{expected}} = 52$ ) of all species captured in total. The mean for the netting surveys at MNT1 (25.0%) was considerably higher than at MNT2 (14.9%), probably because more species of larger non-passerines were present at the latter transect (Appendices 12a and 12b). The percentage of non-passerines recorded in the MTW study was almost twice as high as in the mist-netting project, with 66.4% ( $n_{\text{obs}} = 69$ ,  $n_{\text{exp}} = 73$ ) in the complete study. The difference in medians of detected taxa per survey was significant between sampling methods in the U-test ( $U < 0.001$ ,  $P = 0.002$ ). Regarding the non-passerine species recorded by standardized sampling, 8 were exclusively recorded by mist netting

whereas 40 were only detected by transect mapping.

The detection rate varied widely among different non-passerine groups. In the mist-netting project it was greatest for hummingbirds (Trochilidae), with all species ( $n = 15$ ) captured in the course of the study. Capture rates were moderate for groups like Columbidae, Trogonidae, Coraciiformes (Alcedinidae, Momotidae), Galbuliformes (Galbulidae, Bucconidae), and Piciformes (Capitonidae, Ramphastidae, Picidae), with 41.7 to 69.2% netted. All other families of non-passerines showed a much lower detectability, and some bird families were not captured at all in the standardized surveys, namely the Tinamidae, Cathartidae, Accipitridae, Falconidae, Cracidae, Psittacidae, Nyctibiidae, Caprimulgidae, and Apodidae. By contrast, species of almost all bird families were recorded in the transect-mapping project, the exceptions being *Butorides striata* (Ardeidae) and *Actitis macularius* (Scolopacidae), which were recorded in neither the mist-netting samples nor the MTW surveys. Bird groups with high detection rates in the MTW study were the Psittacidae, nocturnal birds (Strigidae, Nyctibiidae, Caprimulgidae), Trochilidae, and Piciformes, with 83.3 to 100% of all species known to

occur. The lowest detectability was found for the combined group of Cathartidae, Accipitridae, and Falconidae, as well as for the Cuculidae. Regarding the bird groups detected by both sampling methods, the medians of species recorded per survey were significantly higher in the MTW study than in the mist-netting project for the lumped group of Tinnamidae, Cracidae, Odontophoridae, and Rallidae ( $U < 0.001$ ,  $P = 0.002$ ), as well as for the Columbidae ( $U = 4.5$ ,  $P = 0.01$ ), the combined group of Trogonidae through Bucconidae ( $U = 30$ ,  $P = 0.005$ ), and Piciformes ( $U < 0.001$ ,  $P = 0.002$ ). No significant differences were found for Cuculidae and Trochilidae.

Of the suboscine passerines, 67.1% ( $n_{\text{obs}} = 57$ ,  $n_{\text{exp}} = 43$ ) were trapped in the standardized netting study. MTW sampling detected 77.6% ( $n_{\text{obs}} = 66$ ,  $n_{\text{exp}} = 59$ ) of the taxa. In the U-test the medians of recorded species per survey were significantly higher in the transect-mapping study than in the mist-netting project ( $U = 5.0$ ,  $P = 0.013$ ). Of the suboscine species recorded by standardized sampling, 8 were only recorded by mist netting, whereas 17 were exclusively detected by transect mapping.

With the exception of the Cotingidae, all suboscine families were trapped in the standardized mist-netting project. The highest capture rates were obtained for the combined groups of ovenbirds (Furnariidae) and woodcreepers (Dendrocolaptidae), with 84.6% ( $n = 11$ ), and antbirds (Thamnophilidae) and antpittas (Formicariidae), with 80.0% ( $n = 16$ ) of all species in the course of the study. The lowest overall trapping rate was found for the 'tyrannid complex', composed of Tyrannidae, Pipridae, and Cotingidae (57.7%;  $n = 30$ ). Within this group the manakins were much more completely represented than members of the other two families. Transect mapping detected all suboscine families. Of the combined group of Furnariidae and Dendrocolaptidae, all species ( $n = 13$ ) were recorded in the course of the study, with an average of 67.3% per survey. With 75.6% the mean observation rate was even higher for antbirds and antpittas, but one rare altitudinal migrant species, *Myrmotherula schisticolor*, was not recorded in any MTW sample. The taxa of the 'tyrannid complex' totaled 65.4% ( $n = 34$ ) in the complete study, but the average per survey was only 35.8% ( $n = 19$ ). The medians of species recorded per survey were significantly higher in the MTW study than in the mist-netting project for the lumped groups of ovenbirds and woodcreepers ( $U = 6.5$ ,  $P = 0.02$ ) as well as for antbirds and antpittas

( $U = 1.0$ ,  $P = 0.003$ ), whereas no significant difference was found for the 'tyrannid complex'.

In the case of the oscine passerine species, 51.9% ( $n_{\text{obs}} = 41$ ,  $n_{\text{exp}} = 40$ ) were captured in the course of the standardized study. MTW sampling revealed 65.8% ( $n_{\text{obs}} = 52$ ,  $n_{\text{exp}} = 55$ ) of all taxa. However, the difference between sampling methods in medians of species detected per survey was not significant in a U-test ( $U = 10.5$ ,  $P = 0.079$ ). Looking at the oscine passerine species recorded during standardized surveys, 9 were exclusively recorded by mist netting and 20 only by transect mapping.

Both methods detected all oscine passerine families in the standardized studies at MNT1 and MNT2. Total capture rates were highest for the combined group of vireos and thrushes (80%) and lowest for swallows (25%,  $n = 2$ ). Intermediate rates were found for Troglodytidae and Polioptilidae together, as well as for the combined group of Parulidae, Thraupidae, Cardinalidae, Emberizidae, and Icteridae, with 54.5% ( $n = 6$ ) and 52.7% ( $n = 29$ ), respectively. With transect mapping the detection rate was highest for the lumped group of wrens and gnatcatchers, with 81.8% ( $n = 9$ ). For the combined group of Parulidae through Icteridae, 69.1% ( $n = 38$ ) of all taxa were noted. Only 25% ( $n = 2$ ) of all swallows and 60% ( $n = 3$ ) of the Vireonidae and Turdidae together were recorded by transect mapping. In the U-tests, none of the oscine passerine groups considered here showed significant differences in the median of species detected per survey between the mist-netting project and the MTW study.

#### Influence of body size

The 268 species recorded during standardized and non-standardized sampling at MNT1 and MNT2 showed a positively skewed distribution over the body mass classes (Fig. 24). However, species weighing 17–32 g seem to be oddly underrepresented (16.8%;  $n = 45$ ). Only 3 of the 11 recognized body size categories contained more than 10% of all species (Appendix 14c). Bird taxa weighing 9–16 g were most numerous, representing 25% ( $n = 67$ ) of the community's species. Second most important was the group of 33–64 g with 21.3% ( $n = 57$ ). The proportions were very similar for the individual transects, with the general tendency that the number of larger taxa ( $> 257$  g) was slightly greater at MNT2 in comparison with MNT1 (Appendices 14a and 14b). In the standardized mist-netting study the proportions found were significantly different from those expected



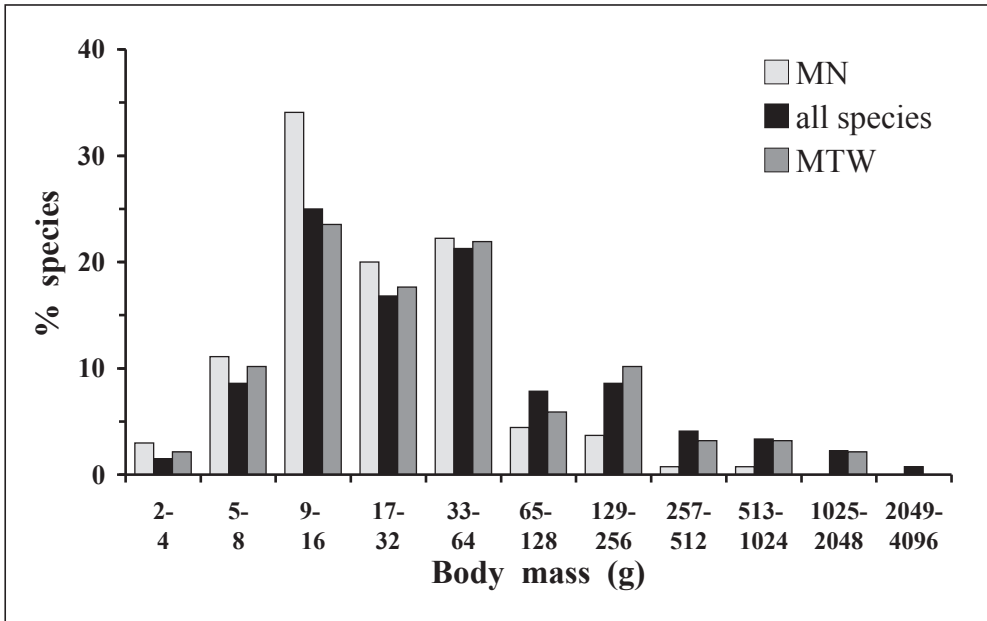


FIG. 24. Proportion of species per body mass class in data sets gathered by standardized and non-standardized sampling (all species:  $n = 268$ ), mist netting (MN:  $n = 135$ ), and transect mapping (MTW:  $n = 187$ ) at MNT1 and MNT2. The log2 scale for the mass categories was selected in accordance with Terborgh *et al.* (1990: 225). For the Chi-squared test I used the following combined groups in order to avoid the expected count of some cells in the contingency table being less than five: 2-8 g, 129-512 g, 513-4096 g (see text for details).

( $\chi^2_6 = 47.083$ ,  $P < 0.001$ ). By contrast, no significant differences were found for the proportions within MTW data when compared with the complete set of species ( $\chi^2_6 = 8.178$ ,  $P = 0.225$ ).

The mist-netting surveys were strongly selective for smaller birds, as expected. Only species of the five lightest body mass categories ( $\leq 64$  g) were well represented, reaching capture rates  $> 50\%$  of all taxa in the course of the study. Species weighing 9-16 g were oddly overrepresented in the data set. On the other hand, the representation of taxa  $> 64$  g decreased continuously with increasing weight, and birds  $> 1025$  g were not captured at all. By contrast, species detection in the MTW study was basically independent of body size, and at least 50% of the species present were recorded in all categories, the only exception being species  $> 2049$  g. The latter group embraced only two rare non-breeding visitors, *Sarcoramphus papa* and *Coragyps atratus* (Appendix 6). For six of the nine body size groups detected by both methods, the medians of species recorded per

survey were significantly greater in the MTW study than in the mist-netting project: 17-32 g ( $U = 6.0$ ,  $P = 0.018$ ), 33-64 g ( $U = 2.0$ ,  $P = 0.004$ ), 65-128 g ( $U < 0.001$ ,  $P = 0.002$ ), 129-256 g ( $U < 0.001$ ,  $P = 0.002$ ), 257-512 g ( $U = 0.5$ ,  $P = 0.002$ ), and 513-1024 g ( $U = 4.0$ ,  $P = 0.007$ ). The difference between sampling methods for the lightest three body mass classes was not significant, not even for species of 9-16 g ( $U = 11.0$ ,  $P = 0.092$ ).

#### Influence of breeding/non-breeding status and territory/home-range size

Breeding species accounted for 75.4% ( $n = 202$ ) of the 268 species recorded at MNT1 and MNT2 (Appendix 15c). The remaining taxa were composed of various kinds of feeding visitors, dispersing species, and migrants. The number of breeding residents representing the four recognized territory size classes decreased sharply with increasing territory area (Fig. 25), from 38.8% ( $n = 104$ ) of all species for small ones to 1.5% ( $n = 4$ ) for very large ones. Pronounced

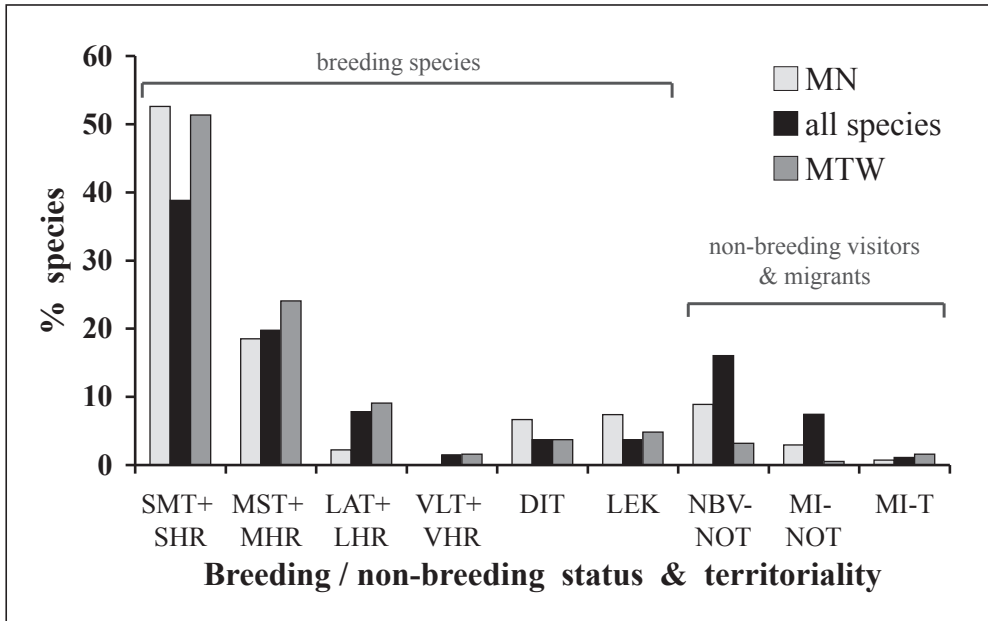


FIG. 25. Proportion of species per breeding/non-breeding status category in data sets gathered by standardized and non-standardized sampling (all species:  $n = 268$ ), mist netting (MN:  $n = 135$ ), and transect mapping (MTW:  $n = 187$ ) at MNT1 and MNT2. Taxa presumably breeding within or close to at least one of the transect areas were regarded as 'breeding species'. Each breeding taxon was assigned to a 'category of territoriality'. For pair- or family-clan-forming species, which advertise and actively defend breeding and/or foraging territories, I estimated the size class of the territories. However, for taxa not defending territories against conspecifics, I opted to estimate the size of their home ranges (Appendix 9). Abbreviations used: SMT + SHR = small territory or home range ( $\leq 10$  ha); MST + MHR = medium-sized territory or home range (11-30 ha); LAT + LHR = large territory or home range (31-90 ha); VLT + VHR = very large territory or home range ( $\geq 91$  ha); DIT = display territory; usually small territories established by males of some species to attract females, also including feeding territories, which are established by some species belonging in this category; LEK = lek; aggregation of several to many males at a communal courtship display site, where they attract females; NBV-NOT = non-territorial non-breeding visitor; dispersing species, like stragglers, floaters, and elevational migrants; MI-NOT = long-distance migrants recorded predominantly on passage; MI-T = long-distance migrants of which at least some individuals temporarily establish feeding territories. Note: For the Chi-squared test I combined the categories 'LAT + LHR' with 'VLT + VHR,' as well as 'DIT' with 'LEK' and 'MI-T', in order to avoid the expected count of some cells in the contingency table being less than five (see text for details).

differences between individual transects in the proportion of breeding and non-breeding species as well as in their distribution over the status categories are evident (Appendices 15a and 15b). Transect MNT2 had, compared with MNT1, a lower percentage of breeding residents, with 73.6% ( $n = 170$ ) versus 79.2% ( $n = 183$ ). Statistically significant differences in the proportion of breeding/non-breeding status categories were found between the data of the stan-

dardized studies and the complete set of species recorded at MNT1 and MNT2 (mist netting:  $\chi^2_5 = 56.643$ ,  $P < 0.001$ ; MTW:  $\chi^2_5 = 137.154$ ,  $P < 0.001$ ). In general, dispersing species and migrants were underrepresented in data gathered by both methods, but this tendency was more pronounced in the case of transect mapping.

In the mist-netting study, 58.4% ( $n_{\text{obs}} = 118$ ,  $n_{\text{exp}} = 102$ ) of all breeding species were trapped.

The results were heavily distorted towards species occupying small territories ( $n_{\text{obs}} = 71$ ,  $n_{\text{exp}} = 52$ ) as well as those occupying display territories and leks (the latter two together:  $n_{\text{obs}} = 19$ ,  $n_{\text{exp}} = 10$ ), with 68.3 to 100% of all species captured per group in the course of the study. On the other hand, 47.2% of occupants of medium-sized territories ( $n_{\text{obs}} = 25$ ,  $n_{\text{exp}} = 27$ ) and 14.3% of those holding large territories were netted, while taxa inhabiting very large territories were not trapped at all (the latter two together:  $n_{\text{obs}} = 3$ ,  $n_{\text{exp}} = 13$ ). The detection rates in the transect-mapping study were much more consistent for the entire range of breeding resident categories. Occupants of small territories were recorded at 87.6% ( $n_{\text{obs}} = 96$ ,  $n_{\text{exp}} = 73$ ), of mid-sized territories at 84.9% ( $n_{\text{obs}} = 45$ ,  $n_{\text{exp}} = 37$ ), of large and very large territories at 81% and 75%, respectively (the latter two together:  $n_{\text{obs}} = 20$ ,  $n_{\text{exp}} = 17$ ), and species establishing display territories and leks at 70% and 90% (the latter two together:  $n_{\text{obs}} = 16$ ,  $n_{\text{exp}} = 14$ ). Not surprisingly, for all categories of breeding species together, the median number of taxa recorded per complete survey was significantly greater in the MTW study than in the mist-netting project ( $U = 1.5$ ,  $P = 0.004$ ). The same was true for all categories of breeding-territory-establishing species ( $U < 0.001$ ,  $P = 0.002$ ; for small territories, medium-sized territories, and large territories). However, the situation was distinct for lek-forming species ( $U = 2.0$ ,  $P = 0.003$ ) and display-territory-establishing taxa ( $U = 6.0$ ,  $P = 0.013$ ), where the median number of detected taxa per survey was significantly greater in the mist-netting study. Regarding the breeding species recorded during standardized surveys, 11 were only recorded by mist netting and 70 exclusively by transect mapping.

Capture rates of non-breeding visitors and migrants together were 25.8% ( $n_{\text{obs}} = 17$ ,  $n_{\text{exp}} = 33$ ) and were slightly higher for dispersing species (stragglers, floaters, and short-distance migrants) with 27.9% ( $n_{\text{obs}} = 12$ ,  $n_{\text{exp}} = 21$ ) than for non-territorial latitudinal migrants (20%;  $n_{\text{obs}} = 4$ ,  $n_{\text{exp}} = 10$ ). In the transect-mapping study only 15.2% ( $n_{\text{obs}} = 10$ ,  $n_{\text{exp}} = 46$ ) of the combined group of non-breeding visitors and migrants were noted. Again, dispersing species were detected with a higher rate than non-territorial latitudinal migrants, with 14% ( $n_{\text{obs}} = 6$ ,  $n_{\text{exp}} = 30$ ) and 5.0% ( $n_{\text{obs}} = 1$ ,  $n_{\text{exp}} = 14$ ), respectively. However, I should stress that all three long-distance migrant species (*Empidonax virescens*, *Tyrannus niveigularis*, and *Piranga rubra*) that regularly estab-

lish temporary feeding territories in the area were recorded in the MTW surveys. Comparing sampling methods, the median number of species detected per survey was significantly greater in the mist-netting project than in the MTW study for non-territorial latitudinal migrants ( $U = 8.0$ ,  $P = 0.023$ ). However, no significant differences were found for dispersing species and long-distance migrants establishing feeding territories, or the combined group of non-breeding visitors and migrants. Of the non-breeding visitors and migrants recorded during standardized surveys, 14 (58.3%) were exclusively recorded by mist netting and 7 (29.2%) by transect mapping only.

Not less than 56% of the 25 taxa recorded exclusively by standardized mist netting were non-breeding visitors in the transect areas (Table 10). Furthermore, for seven breeding resident species recorded by both methods, the medians of individuals detected per complete survey were significantly greater in the mist-netting project than in the MTW study. For at least two additional species (*Myiobius atricaudus* and *M. sulphureipygius*) in the same status category, significant differences in favor of the mist-netting method would likely be obtained with a larger sample size.

#### Influence of habitat

Forest-dwelling species formed the largest group in the transect areas of MNT1 and MNT2, contributing 47.0% ( $n = 126$ ) to the total species richness (Fig. 26a; Appendix 16c). Forest edges and open country were the main habitats for 23.5% ( $n = 63$ ) and 20.5% ( $n = 55$ ) of the bird community, whereas river-edge-inhabiting birds as well as species with no habitat preferences were less numerous. The proportions differed somewhat between transects (Appendices 16a and 16b). In the standardized mist-netting study the proportions of species per main habitat type were not different from those of all species recorded at MNT1 and MNT2. By contrast, a significant difference was found between the proportions within the MTW data and the complete species inventory ( $\chi^2_3 = 11.934$ ,  $P = 0.008$ ). Since this latter finding is potentially unsupportive of the effectiveness of species detection in transect-mapping surveys, I also tested a subset of data containing only breeding species (Fig. 26b). Here, any significant differences between sampling methods and the complete data set disappeared, implying that, in audiovisual surveys, the detectability of non-breeding visitors and

TABLE 10. List of species that in the standardized studies at MNT1 and MNT2 had a better detectability in the mist-netting surveys than in MTW sampling. Abbreviations used (cf. Appendices 12a and 12b): (a) status: br = breeding resident, nbv = non-breeding visitor; (b) exclusively mist-netted: species not detected in MTW surveys are marked with a plus sign; (c) U-test: differences between sampling methods regarding the median of individuals detected per survey where tested with a Mann-Whitney test ( $n_{MN} = 6$ ,  $n_{MTW} = 8$ ); (d) small sample size: species for which the number of individuals detected in the MTW surveys was too small to give a statistically significant result in the U-test due to the high number of tied ranks, were marked with a plus sign; the corresponding P-values are written in brackets.

Species	Status <sup>a</sup>	Exclusively mist-netted <sup>b</sup>	U-test <sup>c</sup>		Small sample size <sup>d</sup>
			U-value	P-value	
<i>Neocrex colombiana</i>	br	+			
<i>Geotrygon montana</i>	br	+			
<i>Phaethornis yaruqui</i>	br		7.5	0.033	
<i>Thalunania fannyi</i>	br	+			
<i>Amazilia amabilis</i>	nbv	+			
<i>Trogon rufus</i>	br	+			
<i>Chloroceryle americana</i>	br	+			
<i>Chloroceryle inda</i>	br	+			
<i>Chloroceryle aenea</i>	br	+			
<i>Malacoptila panamensis</i>	br		< 0.001	0.012	
<i>Xenops minutus</i>	br		3.5	0.019	
<i>Glyphorhynchus spirurus</i>	br		3.5	0.008	
<i>Myrmotherula schisticolor</i>	nbv	+			
<i>Myiopagis viridicata</i>	nbv	+			
<i>Mionectes olivaceus</i>	br		0.5	0.014	
<i>Mionectes oleagineus</i>	br	+			
<i>Terenotriccus erythrurus</i>	br		< 0.001	0.007	
<i>Myiobius atricaudus</i>	br		2.5	(0.085)	+
<i>Myiobius sulphureipygius</i>	br		< 0.001	(0.13)	+
<i>Pachyrhamphus albogriseus</i>	nbv	+			
<i>Platypsaris homochrous</i>	nbv	+			
<i>Machaeropterus deliciosus</i>	nbv	+			
<i>Chloropipo holochlora</i>	br	+			
<i>Schiffornis turdina</i>	nbv	+			
<i>Vireo olivaceus</i>	nbv	+			
<i>Catharus ustulatus</i>	nbv	+			
<i>Cyphorhinus phaeocephalus</i>	nbv	+			
<i>Geothlypis auricularis</i>	br	+			
<i>Oporornis agilis</i>	nbv	+			
<i>Pheucticus ludovicianus</i>	nbv	+			
<i>Rhodospingus cruentus</i>	nbv	+			
<i>Volatinia jacarina</i>	nbv	+			
<i>Tiaris obscurus</i>	br	+			
<i>Oryzoborus angolensis</i>	br		1.0	0.034	

migrants was not equal for all habitat categories.

Taking both transects together, capture rates were almost equal for species inhabiting forest (53.2%;  $n = 67$ ) and open country (54.5%;  $n = 30$ ), and

were only slightly lower for forest-edge-dwelling species (47.6%;  $n = 30$ ) and for taxa found along river and stream edges (42.1%;  $n = 8$ ). Species with no clear habitat preferences were not trapped in the

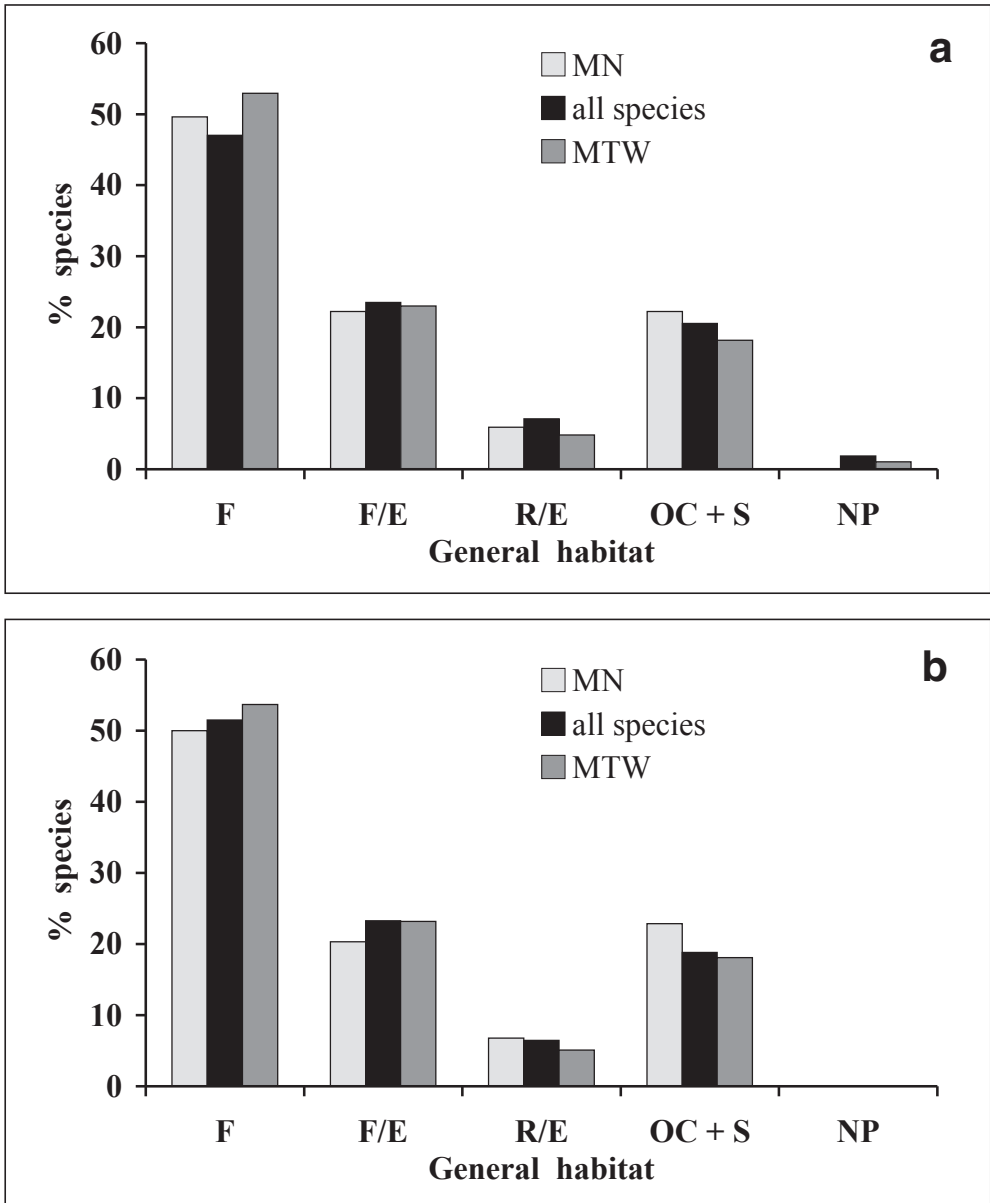


FIG. 26. Proportion of species per habitat class in data sets gathered by standardized and non-standardized sampling (all species), mist netting (MN), and transect mapping (MTW) at MNT1 and MNT2, (a) for the complete set of data (all species:  $n = 268$ ; MN:  $n = 135$ ; MTW:  $n = 187$ ) and (b) exclusively for breeding taxa (all species:  $n = 202$ ; MN:  $n = 118$ ; MTW:  $n = 177$ ). Abbreviations used (cf. Appendix 8): F = forest; F/E = forest edge; R/E = river or stream edge; OC = open country and semi-open country; S = settlements (lumped here with OC because only one species, *Troglodytes aedon*, belonged in this category); NP = no preference. Note: For the Chi-squared test of (a) I combined the categories 'OC + S' with 'NP' and for (b) 'OC + S' with 'R/E', in order to avoid the expected count of some cells in the contingency table being less than five (see text for details).

standardized mist-netting project. Detection rates in the transect-mapping study were higher for all general habitat types, and highest for forest-dwelling species at 78.6% ( $n = 99$ ). Taxa found at forest edges were recorded at 68.3% ( $n = 23$ ), birds of river and stream edges at 47.4% ( $n = 9$ ), and open-country species at 61.8% ( $n = 34$ ). Two of five species without clear habitat preferences were also observed. Regarding the four bird groups recorded by both standardized methods, the medians of species detected per survey were significantly higher in the MTW study than in the mist-netting project for forest-dwelling species ( $U < 0.001$ ,  $P = 0.002$ ). However, no significant differences were found for forest-edge-inhabiting species, open-country-dwelling species, as well as species predominantly found at river edges.

#### Influence of main survey stratum

Undergrowth-dwelling species formed the largest group in the transect areas of MNT1 and MNT2, contributing 26.9% ( $n = 72$ ) to the total species richness (Fig. 27a; Appendix 17c). The canopy was the main census stratum for 16.8% ( $n = 45$ ) of the taxa, followed by understory- and subcanopy-inhabiting species, with 14.6% ( $n = 39$ ) each. The remaining categories, ground, airspace, and treetops and outer foliage, contained fewer species. The proportions differed only slightly between transects (Appendices 17a and 17b). Nevertheless, the number of species per stratum in the data sets gathered by standardized sampling differed significantly from the proportions found for all species (MN:  $\chi^2_6 = 85.809$ ,  $P < 0.001$ ; MTW:  $\chi^2_6 = 28.713$ ,  $P < 0.001$ ). The result for the MTW study stood, of course, in contradiction to my expectations. Thus I also tested the subset of data containing exclusively the breeding species (Fig. 27b). Once non-breeding visitors and migrants were eliminated, no significant differences in proportions of taxa per stratum were found between the MTW study and the complete set of reproductive species ( $\chi^2_2 = 1.991$ ,  $P = 0.37$ ). However, the difference between the latter sample and the mist-netting data remained significant ( $\chi^2_2 = 32.105$ ,  $P < 0.001$ ).

Evidently the mist-netting technique is highly selective for undergrowth- and understory-inhabiting species, with, respectively, 84.7% ( $n_{\text{obs}} = 61$ ,  $n_{\text{exp}} = 36$ ) and 76.9% ( $n_{\text{obs}} = 30$ ,  $n_{\text{exp}} = 20$ ) of all species trapped in the course of the study. However, it should be emphasized that the average capture rate per com-

plete survey was much lower for understory species (44.4%,  $n = 17$ ) than for undergrowth-dwelling taxa (62.3%,  $n = 45$ ). Ground-living species were also relatively well represented, with 45.5% ( $n_{\text{obs}} = 10$ ,  $n_{\text{exp}} = 11$ ) captured during the study, and a mean of 23.5% ( $n = 5$ ) per survey. But netting rates for taxa inhabiting the upper vegetation strata, outer foliage, or airspace were considerably lower. By contrast, bird detection in the transect-mapping study was good for all strata, perhaps with the exceptions of species usually recorded on treetops, bare snags, and outer foliage (together 42.1%,  $n = 8$ ), as well as for taxa recorded mostly in the airspace (40.6%,  $n = 13$ ). These categories evidently contained many non-breeding visitors and migrants (Figs. 27a and 27b). Species of all other strata had detection rates of between 63.6 and 84.4%. However, the mean rate per survey was somewhat lower for species living in the subcanopy (37.5%) and in the canopy (37.8%) than for taxa found in the lower strata (41.5–52.5%).

In the pair-wise U-tests, medians of species detected per survey were significantly higher in the MTW study than in the mist-netting project for species living on the ground ( $U = 1.5$ ,  $P = 0.003$ ) or in the subcanopy, canopy, and airspace (each:  $U < 0.001$ ,  $P = 0.002$ ). However, no significant differences were found for understory-inhabiting species as well as for taxa predominantly encountered on treetops, dead snags, or the outer foliage of bushes and trees. For undergrowth-dwelling species, medians of detection rates were significantly higher in mist-netting surveys than in the transect-mapping study ( $U = 0.5$ ,  $P = 0.002$ ).

#### Discussion

Comparative effectiveness and efficiency of mist-netting and audiovisual surveys

##### Species richness and species accumulation

The correct identification of species is one of the most critical points in any study of tropical bird communities, independent of the method applied. According to advocates of mist netting, one of the method's principal advantages over audiovisual surveys is the minimization of observer variability; only a moderate training is necessary for the identification of hand-held birds, so that even inexperienced banders are able to produce accurate data on bird communities as no familiarity with vocalizations and field marks are required (Karr 1981a,b; Stotz *et al.* 1996).



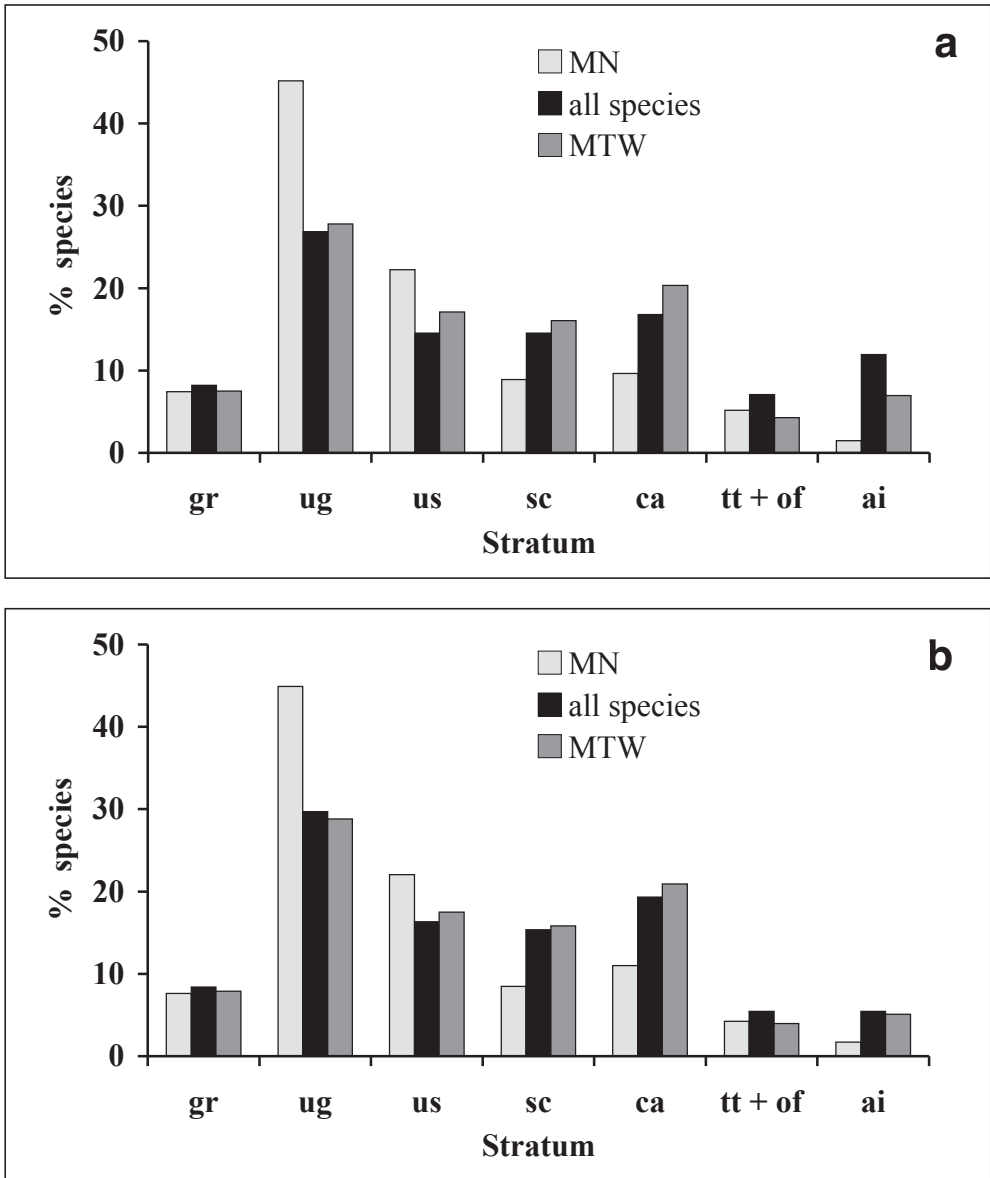


FIG. 27. Proportion of species per main survey stratum in data sets gathered by standardized and non-standardized sampling (all species), mist netting (MN), and transect mapping (MTW) at MNT1 and MNT2, (a) for the complete set of data (all species:  $n = 268$ ; MN:  $n = 135$ ; MTW:  $n = 187$ ), and (b) exclusively for breeding taxa (all species:  $n = 202$ ; MN:  $n = 118$ ; MTW:  $n = 177$ ). Abbreviations used (cf. Appendix 9): gr = ground level; ug = undergrowth ( $0$  to  $4 \pm 1$  m); us = understory ( $4 \pm 1$  m to c.  $15$  m); sc = subcanopy (c.  $15$ - $25$  m); ca = canopy; used for species feeding at or near the foliage-air interface of canopy trees and emergent trees ( $>20 \pm 5$  m); of = outer foliage; tt = treetops and bare or dead snags; ai = airspace. Note: For the Chi-squared test of (b) I combined the categories 'gr' with 'ug,' 'us' with 'sc,' as well as 'ca' and 'tt + of' with 'ai', in order to avoid the expected count of some cells in the contingency table being less than five. No lumping of stratum categories was necessary in (a); see text for details.

This may be true when the researchers rigorously document the captures through detailed morphometric measurements, voucher specimens, and photos, but undoubtedly not all workers have the discipline, permission, or sufficient funds to do this and, consequently, even this advantage of mist netting has been disputed (Remsen & Good 1996). Stiles & Rosselli (1998) also challenged the former argument, emphasizing that the effectiveness of bird inventories based on mist netting increases considerably with the experience of workers (e.g., regarding the selection of appropriate sites, rapid setting and proper management of nets, safe and fast handling of captures, and correct identification). Nevertheless, it is evident that the number of species netted in constant-time-effort samples is strongly independent of observer training. Comparing the numbers of taxa trapped per complete survey at MNT1 and MNT2 (Appendices 12a and 12b), this argument also holds true in the study presented here. No clear pattern is perceptible and so variability of species richness was determined by a number of stochastic factors (e.g., presence/absence of certain food resources close to the nets) as well as by season (e.g., presence/absence of dispersing and migratory species), rather than by the experience of the bander. By contrast, my improving identification skills were responsible for the steadily increasing number of species recorded per survey in the transect-mapping study (exception: survey MNT2/4). However, both survey methods corresponded in showing that species richness was greater at MNT1 than at MNT2 (MN: 21.9%,  $n = 21$ ; MTW: 12.5%,  $n = 18$ ).

One interesting difference in results between survey methods was that in the mist-netting project c. 27% more captures were obtained at MNT2 than at MNT1, but in the MTW study c. 28% more birds were recorded at MNT1 than at MNT2. Various factors were responsible for this pronounced discrepancy. Foremost, dispersing individuals, such as immatures and non-breeding adults, were much more numerous at Playa Rica than on the outskirts of the village, as confirmed by mark-recapture data (not shown). Of certain forest species, such as *Eutoxeres aquila*, *Mionectes olivaceus*, *Pipra mentalis*, *Lepidothrix coronata*, *Turdus daguae*, and others, I mist-netted twice to six times as many individuals at MNT2 than at MNT1. One important reason for this was the high abundance of some bird-pollinated and bird-dispersed plant taxa in the MNT2 area (e.g., *Besleria* and *Miconia* within forest; *Heliconia* and *Clibadium*

at forest edges and in the clearing). These food resources not only maintained a considerable breeding population of the nectarivores and frugivores mentioned above, but also attracted large numbers of conspecific feeding visitors. Although the same plant genera were present at MNT1, food resources were not as abundant and concentrated there. Local landscape formation may have also played an important role. The small clearing at MNT2 was surrounded by medium-age forest to the north and west, and by the Río Santiago and Estero Playa Rica to the east and south (Fig. 8). In general, proximity to old-growth forest is regarded as an important prerequisite for the presence of forest-dwelling birds in young second-growth habitats (Robinson & Terborgh 1997, Blake & Loiselle 2001). Furthermore, the river and stream formed natural barriers for many of the smaller forest-undergrowth-dwelling birds, and thus redirected the movements of dispersing individuals to the clearing of transect section A. In the case of MNT1, such concentrating effects of ecotones were much weaker, at least for most forest species. Consequently, the number of forest birds trapped in the semi-open floodplain of MNT1 was distinctly lower. Dispersing individuals mostly go undetected in transect-mapping surveys (Fig. 25) because they rarely vocalize (Hutto *et al.* 1986, Gram & Faaborg 1997). Thus the high abundance of floaters recorded in the mist-netting surveys at MNT2 was not noted in the MTW study. Furthermore, semi-open habitats were much more extensive and diverse at MNT1 (Fig. 5) than at MNT2 (Fig. 8), sustaining larger populations of territorial open-country and forest-edge species (e.g., *Crypturellus soui*, *Patagioenas speciosa*, *Amazilia tzacatl*, *Synallaxis brachyura*, *Taraba major*, *Myrmotherula pacifica*, *Thraupis episcopus*, *Ramphocelus icteronotus*, and *Saltator maximus*). Mean territory size of open-country-inhabiting taxa tends to be considerably smaller than that of forest species of similar body size (Robinson & Terborgh 1990). Thus taking into account the high detectability of most breeding residents in transect-mapping surveys (Fig. 25), it is not surprising that the number of birds recorded in the MTW study was higher at MNT1 than at MNT2, and that the situation was just the opposite regarding numbers of captures. Alternatively, it seems possible that bird abundance at MNT1 and MNT2 really changed from 1995/96 to 1997 due to the strong El Niño event starting in 1997. At least the results for some short-distance migrants were apparently affected by the climatic anomaly.

*Myiopagis viridicata* and *Platypsaris homochrous*, for instance, which breed in the drier life zones of western Ecuador, were regularly mist-netted and observed at both transects in the dry seasons of 1995 and 1996. In the same period in 1997, which was more humid between July and December than in normal years, both species were apparently absent, or at least considerably rarer in the transect areas, and were not detected during MTW surveys. Furthermore, Loiselle & Blake (1992) reported that in Costa Rica use of second-growth habitats by elevational migrants varies between years. However, both transects were equally affected by El Niño, and so I suspect that the observed divergence of results was in fact caused by the difference in bird detectability between survey methods.

Acquired net avoidance by some species and individuals are important disadvantages of the mist-netting technique (MacArthur & MacArthur 1974, Karr 1981b), leading to linearly decreasing capture rates of permanent residents in long-term studies (Bierregaard 1990b, Salaman 2001). Although this factor was not analyzed here in detail, it is clearly reflected in the decreasing number of captures in each new survey (exception: MNT2/III). Furthermore, it is also the likely cause why the steepness of species accumulation curves tended to increase from survey to survey (Figs. 17a and 17b), indicating that new species were obtained with less captures, namely in the forested transect sections B to D. The fact that feeding visitors and dispersing birds were much more common at MNT2 than at MNT1, especially in section A, may explain why the three accumulation curves separated somewhat later at the former transect (after about 50 vs. 10 captures). At Playa Rica the acquisition of net shyness by territorial birds was probably partly overlapped by the constant flux of transients and floaters.

Species accumulation in the MTW study followed different rules, and my improving capacity to detect more birds as well as species per survey was particularly evident at MNT1. Of course, such variability in survey results is an important point of critique used by supporters of mist netting (Karr 1981a). However, this was a pioneer project carried out in a species-rich area, and therefore it should be no surprise that I steadily learned to identify more types of bird sounds and to estimate group and flock sizes more accurately. It is well known that the quality and consistency of audiovisual survey data may improve considerably with training of observers (Faanes &

Bystrak 1981, Kepler & Scott 1981, Erwin 1982, Bibby *et al.* 1998, Nichols *et al.* 2000). The fact that species identification in the transect-mapping study was based in only 8.8% of the cases on visual observations (Fig. 20b) explains why intense preparation is so important. Moreover, it was obviously not enough to learn only the primary songs of the local avifauna, since territorial, alarm, contact, and other calls led to identification in 37-51% of all records, depending on the time of day. This constitutes a considerable challenge, taking into account that many species emit a wide spectrum of vocalizations and sometimes even specific mechanical sounds, which may vary in frequency range, intensity, duration, and quality between individuals, seasons, or according to the degree of agitation. Often they are also very similar to sounds emitted by other species. I estimate that an observer who wants to identify 95% of the entire repertoire of the bird species of Playa de Oro would have to learn about 3500 different types of sounds, probably more. Fortunately, most species use some vocalization types much more frequently than others, so that a worker knowing only about 20-30% of the species' repertoire may produce acceptable and consistent results in standardized audiovisual surveys. Of course, it is then critical to rigorously document the identification of bird sounds with voucher recordings.

Several studies on tropical bird communities have complemented mist-netting samples with audiovisual surveys and vice versa (p. 63f, Introduction). Some of these comparative studies focused on Nearctic-Neotropical migrants (e.g., Wallace *et al.* 1996, Gram & Faaborg 1997, Rappole *et al.* 1998), and thus will be discussed below. Although also concentrating on Nearctic migrants, Lynch (1989) apparently published the first comparative study that considered the effectiveness of mist netting and point counting in surveys of Neotropical birds. On the Yucatán Peninsula, Mexico, he recorded a total of 212 taxa (excluding all aerial foragers, unless they were seen perched, and six transient Nearctic migrants), 205 of which were detected by audiovisual methods (effort: 976 counts of 10 to 12 min each, using aural stimuli for migrants), and 141 by trapping (effort 11 562 MNH). No less than 71 taxa were detected only by point counting, whereas only 7 were exclusively mist-netted. Similarly conclusive results were obtained by Whitman *et al.* (1997), who compared mist-netting and point-counting data collected at the same study plots in a mature sub-

tropical forest in Belize. Each point ( $n = 60$ ) was surveyed for three consecutive days with one technique, then subsequently the alternative method was used for the same time period. In comparison with a checklist gathered in 896 person-days and containing 203 bird taxa, only 29% ( $n = 58$ ) of total species richness was detected by mist netting (field effort: c. 150 person-hours) but 59% ( $n = 119$ ) by point counts (c. 45 person-hours). Only six of the species detected during standardized sampling were recorded exclusively by mist netting. Stiles & Rosselli (1998) compared the effectiveness of mist netting with non-standardized audiovisual observations, which were used to inventory the birds in a 15-ha study plot of montane forest in the Eastern Cordillera of the high Andes of Colombia. Along trails of about 3000 m in length, observers noted all birds detected by audiovisual methods for 2-3 days each during 11 visits, while simultaneously collecting phenological data on flowers and fruits. Subsequently, they mist-netted for two mornings per visit on the same transects (effort: 1596 MNH). Of 102 species recorded in total, 101 were observed and 50 trapped, leaving only one to be exclusively detected through mist netting. However, the differences found between mist-netting and point-counting data gathered in a long-term study at La Selva, Costa Rica (Blake & Loiselle 2001), were much less pronounced than in the previous examples. There, 196 species ( $n = 10\,019$  captures) were mist-netted (effort: 36\,408 MNH), representing 62% of 317 terrestrial taxa present (all aquatic and predominantly aerial species were excluded), and 215 species ( $n = 15\,577$  observations) were recorded during point counts (number of 10-min counts not provided), corresponding to 68% of all landbirds. During standardized sampling, 53 species were exclusively detected by point counting and 34 species only by mist netting. More taxa were observed than captured in old-growth forest but not in young successional vegetation. Unfortunately, the authors provided no information on the field effort (in absolute hours or person-hours) for either method, so that it is impossible to compare their time-efficiency. Furthermore, it is unclear in how far netting and audiovisual surveys really covered a comparable area, in contrast to the designs employed by Whitman *et al.* (1997) and in the present study, thus also making direct comparisons of the effectiveness of species accumulation difficult. Two other extreme examples of the low degree of completeness of mist-netting samples were reported for Amazonian

*terra firme* forest. (1) Over a five-year period ( $n = 1353$  birds banded), Thiollay (1994b) captured only 39.9% ( $n = 99$ ) of all species known to occur at his 100-ha study plot at Nouragues, French Guiana, and (2), after seven years of banding ( $n = 24\,957$  captures) and an effort of 136\,000 MNH, merely 41% ( $n = 143$ ) of all species known to occur at a study site north of Manaus, Brazil, were trapped (Bierregaard 1990b). These percentage values were even lower than the 50.4% of total species richness recorded with standardized netting at transects MNT1 and MNT2 in Playa de Oro. Of course, the divergence is principally due to the fact that my study as well as that of Blake & Loiselle (2001) included young second-growth habitats, whereas in French Guiana and Brazil only primary forests were sampled.

Apart from the time efficiency and effectiveness of species accumulation, another equally important aspect has to be considered for the selection of a rapid assessment method for tropical bird communities: How well do survey results represent the real proportions of certain groups or guilds within the complete bird assemblages of the study areas? In the following paragraphs I will discuss how some of these factors affected the species composition in data sets gathered by mist netting, transect mapping, and other survey methods.

#### Influence of taxonomic affinities

The distorted proportions I found in the mist-netting data for major taxonomic groups (non-passerines, suboscine passerines, and oscine passerines; Fig. 23) are mainly due to the method's selectivity for small to medium-sized birds (Fig. 24). The higher percentage of larger species in many non-passerine families explains why the group as a whole was underrepresented in netting samples. In addition, some families inhabit the upper strata and airspace and therefore are only rarely trapped in undergrowth nets (e.g., Psittacidae and Apodidae). The hummingbirds were the only group that had a high probability of being captured, due to their small size, the presence of several undergrowth-dwelling species, and the fact that some canopy species breed in the lower growth and sometimes show considerable flexibility regarding strata selection in the presence of appropriate or abundant food resources. Remarkable is also that three out of four kingfisher species (Alcedinidae) were exclusively recorded through trapping (see below). However, most other non-passerine families were not accurately represented in mist-netting samples (Appendi-

ces 13a-13c). By contrast, transect-mapping data reflected the real composition of the bird community much better than mist-netting samples. The superiority of MTW is demonstrated by the fact that 52% of all non-passerine taxa recorded during standardized sampling at MNT1 and MNT2 were exclusively recorded by transect mapping. The corresponding rate for the mist-netting study was just 10%.

Surprisingly, Whitman *et al.* (1997) reported that their mist-netting and point-counting data sets from Belize had similar proportions of species in groupings based on families ( $\chi^2_{35} = 34.6$ ,  $P = 0.45$ ). In my opinion this result is doubtful, among other things because according to the data presented (Appendix 1 in Whitman *et al.* 1997) no less than 11 families (Tinamidae, Ardeidae, Accipitridae, Falconidae, Psittacidae, Cuculidae, Apodidae, Trogonidae, Cotingidae, Corvidae, and Icteridae) were exclusively recorded by point counting in their standardized study. I suspect their Chi-squared test result may be in error due to the small number of species in many families, pushing the expected count of several cells in the contingency table below the critical value of five and so distorting the analysis. For just this reason, I have not used a Chi-squared test at the family level. However, regarding the three major taxonomic groups, my mist-netting and transect-mapping data sets had very different proportions of species ( $n = 212$ ;  $\chi^2_2 = 12.335$ ,  $P = 0.002$ ), confirming the results presented above (p. 80-82, Influence of taxonomic affinities). In fact, comparing the data of Whitman *et al.* (1997) with the results reported here, many parallels are evident. Firstly, in both studies most of the families exclusively recorded by audiovisual surveys belonged to the non-passerines. If we consider only standardized sampling, 8 of 11 families not trapped by Whitman *et al.* (1997) and 9 of 10 not mist-netted in Playa de Oro were non-passerine. Similarly, 6 of 8 families exclusively point-counted in Mexico's Yucatán Peninsula belonged to the non-passerines (Lynch 1989). Considering that the latter study excluded the Cathartidae and Apodidae, the true relationship was more likely 8 of 10. On the other hand, hummingbirds were relatively well represented in mist-netting samples. Stiles & Rosselli (1998) also confirmed this general pattern for a high-Andean forest in Colombia. The poor representation of medium-sized to large non-passerine taxa in mist-netting samples is especially problematic for conservation-related studies (p. 213-215, Birds as indicators of environmental change).

In transect-mapping data, even those non-passerine families usually overlooked in traditional line transect censuses and point counts (e.g., Whitman *et al.* 1997), such as crepuscular and night-active species (e.g., Strigidae, Nyctibiidae, and Caprimulgidae) as well as rails (Rallidae), were well represented. However, for various reasons mean detection rates per MTW survey were low for diurnal raptors (Cathartidae, Accipitridae, and Falconidae), cuckoos (Cuculidae), and swifts (Apodidae). In the case of the cuckoos, only two (*Piaya cayana* and *P. minuta*) out of six species probably bred at both transects, *Taepora naevia* occurred only in the initial section of MNT1, and the three remaining species were vagrants in the transect areas. Similarly, only one (*Chaetura spinicaudus*) out of six swift species was a breeding resident in the transect areas, whereas the others were dispersing species and elevational and longitudinal migrants, so that the accumulated detection rate of 66.7% for this group seems not too bad after all. On the other hand, diurnal raptors are one of the most difficult groups because most taxa occur at low densities, occupy large territories, and have unobtrusive or even secretive behavior. Thiollay (1989a) employed no less than four distinct methods for an accurate survey of tropical raptors in French Guiana, including mapping of movements of soaring territorial pairs (e.g., *Ictinia plumbea*, *Accipiter* spp., *Falco ruficularis*), extrapolation of the mean number of individuals soaring over a given area (e.g., *Sarcoramphus papa* and *Cathartes* spp.), mapping of birds seen or heard in the forest understory (e.g., *Leucopternis* spp. and *Daptrius* spp.), and estimation of mean density from strip transect censuses (e.g., *Harpagus bidentatus*, *Leptodon cayanensis*, *Micrastur* spp.). Although the transect-mapping technique is intended to combine these methods, only 30% of the diurnal raptors present were recorded by MTW sampling at MNT1 and MNT2. I assume that the following factors were responsible for the poor result: (a) the areas covered by the mist-netting transects were small in relation to the size of the territories of most diurnal raptor species, diminishing the probability of detection; (b) the transects being so short, the time windows covered by surveys 2B (MNT1: c. 75 min; MNT2: c. 66 min) were too limited to sufficiently include mid- to late-morning hours, a critical period for species soaring above the canopy or performing display flights; (c) the populations of some species were diminished due to hunting by local people. For some diurnal raptors, detection rates were consider-

ably higher at longer transects (data not shown), but others were notoriously overlooked or underestimated in MTW surveys, namely *Accipiter superciliosus*, *A. bicolor*, *Leucopternis semiplumbeus*, and most species of *Micrastur* forest-falcons with the exception of *M. semitorquatus*. For some of these species it might be necessary to use aural stimuli (playback) to improve detection (p. 174f, Guidelines for the use of transect mapping (MTW) in monitoring studies).

The proportion of suboscine passerines was overestimated by both survey methods, but the data gathered by transect mapping were much closer to reality. For ovenbirds (Furnariidae), woodcreepers (Dendrocolaptidae), antbirds (Thamnophilidae), and antpittas (Formicariidae) together no less than 32 out of 33 taxa were recorded in the course of the MTW study, and with 72% the mean per complete survey was also very high. In contradiction to the data presented here, Blake & Loiselle (2001) reported that the Furnariidae belonged to those families at La Selva which were better detected by mist netting than audiovisual surveys, perhaps indicating a possible weakness of point counting in comparison with transect mapping. The exceptional detection rates for these families were based on the many but nevertheless distinct calls and songs most species have, combined with a higher level of vocal activity (perhaps with the exception of some woodcreepers; cf. Terborgh *et al.* 1990), facilitating their discovery and identification. This finding has potential importance for environmental assessment and monitoring studies (p. 210-213, Birds as indicators of environmental change). Although members of these families were well represented in mist-netting samples too, some subcanopy-dwelling species remained untrapped (e.g., *Thamnistes anabatinus* and *Myrmotherula ignota*) or under-recorded (e.g., *Dendrocolaptes sanctithomae*, *Xiphorhynchus lachrymosus*, and *Microrhopias quixensis*). Even three rare inhabitants of lower forest growth, *Sclerurus mexicanus*, *Campylorhamphus pusillus*, and *Phaenostictus mcleannani*, were observed but never mist-netted. By contrast, observation rates for the families of the 'tyrannid complex' (Tyrannidae, Cotingidae, and Pipridae) were markedly lower for both methods. In the case of transect mapping this was probably because this group embraced some rare, silent, and unobtrusive species (see below) as well as various dispersive and migratory taxa. On the other hand, netting missed most of the canopy and subcanopy species. Not surprisingly, the only sub-

oscine family not recorded by mist netting, neither in Playa de Oro nor in Belize, was the Cotingidae. In the lowlands of northwestern Ecuador, the group includes predominantly subcanopy- and canopy-dwelling species, with the exception of *Laniocera rufescens*, an uncommon cotingid of the forest understory, which was not present at MNT1 and MNT2. The same species was only recorded during non-standardized observations in Belize as well (Appendix 2 in Whitman *et al.* 1997). However, all suboscine families, including the Cotingidae, were captured in the long-term study at La Selva (Appendix 1 in Blake & Loiselle 2001; note that *L. rufescens* and *Lipaugus unirufus* are regarded here as being cotingids).

The proportions of oscine passerines in the data sets gathered by both methods were quite similar to those calculated for the entire bird community. Swallows had the lowest detection rates in both cases, mainly because only two out of eight species were resident in the transect areas. Together, wrens (Troglodytidae) and gnatcatchers (Poliopitidae) had the highest observation rates of any oscine family in the transect-mapping study. Wrens especially are very vocal and active birds, and are thus more easily detected compared with most other oscine passerines. Because many of these species also belong to the group of ground- to understory-dwelling insectivores, they are potentially important indicators of anthropogenic alterations in the forest structure. For various reasons, the average detection rates for the combined group of Parulidae, Thraupidae, Cardinalidae, Emberizidae, and Icteridae were considerably lower. The New World warblers contain many long-distance migrant species, which often remain undetected in MTW surveys. Furthermore, some species of tanagers and honeycreepers, as well as emberizine finches, have rather unobtrusive and sometimes similar vocalizations and thus are easily overlooked. The Parulidae and Emberizidae were also among the families underestimated by point counting in Costa Rica (Blake & Loiselle 2001). On the other hand, with each new MTW survey the number of new species increased, so that 69.1% of all taxa were recorded in the course of the study. Due to the fact that many species of the Thraupidae inhabit subcanopy and canopy levels, the trapping rates were rather low. Nevertheless, all oscine families were captured in Playa de Oro. By contrast, during standardized sampling in Belize, two oscine families were exclusively recorded by point counting. Of these, the Corvidae are not present in the Chocóan lowlands of Ecuador, whereas



the other (Icteridae) were also trapped in Belize, but during non-standardized mist-netting surveys (Appendix 2 in Whitman *et al.* 1997). Likewise, the Corvidae were the only oscine family not captured at La Selva (Blake & Loiselle 2001).

#### Influence of body size

The selectivity of mist nets for certain bird size categories is one of the most important drawbacks of the method (e.g., Karr 1979, 1981b; Remsen & Parker 1983, Remsen & Good 1996). In the present study, all body mass classes  $\leq 64$  g were overrepresented in mist-netting samples, most conspicuously the category between 9 and 16 g (Fig. 24). On the other hand, all weight classes  $\geq 65$  g were greatly underestimated. Using slightly different body mass categories, Stiles & Rosselli (1998) got a very similar result, with species  $\leq 50$  g overrepresented and heavier taxa underrepresented in mist-netting data. However, in a Kolmogorov-Smirnov test they did not find a significantly different distribution over size categories between species observed and captured. Surprisingly, Whitman *et al.* (1997) also did not find significant differences in proportions of species between their mist-netting and point-counting data in a Chi-squared test using three size categories from small to large species. By contrast, significantly different proportions between standardized mist-netting and MTW samples were found in Playa de Oro ( $\chi^2_6$  23.544,  $P = 0.001$ ,  $n_{\text{spp}} = 212$ ; group combinations as described in Fig. 24). One possible explanation for these contradictory results might be the differences in mesh sizes used by different workers. Comparative studies employing mesh sizes of 30 mm (HTX) and 36 mm (ATX) have shown that the proportions of birds caught in different categories of band sizes (Heimerdinger & Lebermann 1966) as well as body masses (Pardieck & Waide 1992), were significantly different. Particularly, the proportion of birds caught in weight classes  $\leq 25$  g was greater in 30-mm mesh nets, but for birds in the categories  $\geq 26$  g greater for 36-mm nets. Stiles & Rosselli (1998) used both net types, Whitman *et al.* (1997) employed 36-mm mesh nets, whereas the mesh size used in Playa de Oro was only c. 18 mm. Thus size selectivity in the present study was shifted to the smallest size classes. Even species in the 2–4 g group were overrepresented in my netting data, although on various occasions I witnessed that small hummingbirds slipped through the nets (e.g., *Phaethornis striigularis* and *Popelairia conversii*). However, in 36-mm nets, birds less than

5 to 8 g are not efficiently captured, nor are birds  $> 100$  g (Karr 1979, Karr 1981b), but note that Blake & Loiselle (2001), on a very few occasions, even trapped large species like *Ortalis cinereiceps*, *Penelope purpurascens*, and *Crax rubra* with such nets. Differences in mesh sizes certainly affect the comparability between mist-netting studies.

#### Influence of breeding/non-breeding status and territory/home-range size

The fact that in the transect-mapping study 91% of all identifications were exclusively based on acoustical records (Fig. 20b) explains why the method is highly selective for breeding and territorial species (Fig. 25; Appendices 15a–15c). Dispersing individuals as well as migrants on passage rarely vocalize (Blake & Loiselle 2001). Thus they are more likely to be overlooked in audiovisual surveys than breeding residents actively defending territories or attracting females through courtship displays at leks, and migrants occupying temporary feeding territories. Consequently, the MTW method is rather unsuitable for surveying non-resident taxa. This characteristic of MTW has to be kept in mind when planning the objectives of a rapid assessment or monitoring study. In most cases, breeding residents are much more important than migrants and other transients for a meaningful assessment of habitat quality and conservation value of tropical landscapes (Poulsen *et al.* 1997). However, seasonal movements between habitats and, especially, the elevational migrations of many Neotropical birds have recently gained importance in the design of protected areas, because the survival of the species involved might depend greatly on unbroken connections between breeding and non-breeding habitats (Stiles 1988, Stiles & Clark 1989, Loiselle & Blake 1991b, 1992; Levey & Stiles 1992, Nosedal 1994, Powell & Bjork 1994, 2004; Rosselli 1994). Furthermore, continuing declines of some Nearctic-Neotropical migrants (e.g., Terborgh 1980, 1989; Askins *et al.* 1990, Rappole & McDonald 1994) have stimulated research on their status and ecology on the wintering grounds (e.g., Keast & Morton 1980, Hagan & Johnston 1992, Morton *et al.* 1994, Martin & Finch 1995). Some workers compared the effectiveness of point counting and mist netting in studies on the habitat selection of wintering Nearctic-Neotropical migrants (e.g., Lynch 1989, Wallace *et al.* 1996, Gram & Faaborg 1997, Rappole *et al.* 1999, Blake & Loiselle 2001). In accordance with the results of the present study, audiovisual surveys

detected significantly lower numbers of migrant species and individuals than mist netting in winter surveys in three regions of Cuba, whereas point counting recorded more species of residents (Wallace *et al.* 1996). Mist netting underestimated the proportion of migrant species by 26.3% and point counting by 53.3%. Surprisingly, Gram & Faaborg (1997) recorded more resident as well as migrant species by mist netting ( $n_{\text{total}} = 100$ ,  $n_{\text{migrants}} = 26$ ) than by point counting ( $n_{\text{total}} = 89$ ,  $n_{\text{migrants}} = 20$ ), of a total of 134 landbird species in four habitats in the Sierra Madre Oriental in northeastern Mexico. However, four migrant species were exclusively observed in audiovisual surveys, whereas eight were only detected with mist nets. By contrast, of 43 latitudinal migrants recorded during standardized sampling on the Yucatán Peninsula, Lynch (1989) detected 10 species only by point counting (using aural stimuli), whereas 5 were only mist-netted. Rappole *et al.* (1998) stressed that, due to differences in the use of strata, vocal activity, and timidity, either method underestimated or missed whole categories of wintering migrants in southern Mexico. Consequently, the authors proposed to combine both survey procedures to ensure more accurate assessments of habitat use by Nearctic-Neotropical migrants in the non-breeding season. Blake & Loiselle (2001) came to a similar conclusion, emphasizing that the two methods provide rather different perspectives on the importance of resident and migrant species as well as trophic groups. That is to say, if a study concerns seasonal movements of Neotropical species or the status and habitat selection of long-distance migrants, rather than communities of breeding residents, then it is certainly not appropriate to use audiovisual techniques as the single survey method. Instead, transect mapping or point counting should be used in combination with mist netting.

Considering residents only, one important flaw of mist netting is the underestimation of species that occupy territories > 30 ha (Fig. 25), most of which are large-bodied. Some forest species that require large areas for survival are more vulnerable to habitat alterations and hunting pressure than taxa occupying small territories (p. 213-215, Birds as indicators of environmental change). Although Blake & Loiselle (2001) found no significant differences between the number of threatened species recorded by point counting and mist netting, I have to emphasize that for most conservation projects it is prohibitive to carry out comprehensive trapping studies due to time

restraints and low budgets. Economically it is simply not sustainable to record one *Crax rubra* per 10 000 birds captured over a period of roughly 10 years, as in the study at La Selva (Blake & Loiselle 2001), whereas a line transect method generated 9 sightings and 19 aural detections in a study time of just 3 weeks in the same area (Jiménez *et al.* 2003). Thus mist-netting data may not provide critical information on the presence as well as abundance of many threatened species.

Those breeding residents which during standardized sampling efforts were exclusively trapped ( $n = 11$ ) or detected with a much higher probability ( $n = 9$ ) in mist-netting than in MTW surveys are, of course, critical for the evaluation of the effectiveness of the transect-mapping method (Table 10). Some of these taxa were likely overlooked or underestimated because they mostly occurred at the periphery of the transect areas (e.g., *Trogon rufus*, *Oryzoborus angolensis*). In a few other cases it is rather doubtful whether they really bred in the transect areas in the year when the mapping study was carried out (e.g., *Mionectes oleagineus*, *Geothlypis auricularis*, *Tiaris obscurus*). However, the likely reasons for my failure to satisfactorily detect some other species should be analyzed in more detail.

*Neocrex colombiana*, one of three rail species known to breed in the MNT1 transect area, was exclusively trapped during standardized sampling. Although I tape-recorded the grunting alarm and distress calls of one mist-netted immature, other important calls (e.g., contact calls) and the song remain unknown. Note that the song description in Ridgely & Greenfield (2001a: 124) is erroneous – my fault; see remarks under *Amblycercus holosericeus* in Appendix 6 for details. Until the rail's vocalizations are better documented, it is uncertain whether this species can be reliably surveyed with audiovisual methods or not.

Easily overlooked in transect-mapping surveys were also the quail-doves *Geotrygon montana* and *G. veraguensis*, which for reasons unknown almost never sang in Playa de Oro. By contrast, *G. purpurata*, a species inhabiting the foothill zone, was more regularly heard singing. The song of *G. montana* was noted on a very few occasions, but the taxon remained undetected in audiovisual surveys at MNT1 and MNT2. Similar problems in the acoustical detection of this species were also reported for Costa Rica (Blake & Loiselle 2001) and Belize (Whitman *et al.* 1997). Even more extreme, all records of *G. veraguensis*

sis in Playa de Oro, apart from the mist-netted birds, were visual observations. However, this quail-dove does not belong in the group of more frequently mist-netted birds because it was regularly seen feeding on seeds and small fruits at the transects.

The hummingbirds are also challenging, in most cases due to their wide repertoire of high-pitched vocalizations, which are sometimes very similar between species of different genera. Furthermore, many taxa show an extremely complex and poorly understood pattern of local and regional song dialects (Kroodsma *et al.* 1996; pers. obs.). Although *Thalurania fannyi* was rare in mist-netting samples too, I principally blame my poor knowledge of the species's vocalizations for failing to detect it during MTW surveys at MNT1 and MNT2. Conversely, *Phaethornis yaruqui* was well represented in mapping data, considering that no leks of this hermit were present in the transect areas and most records related to dispersing or trap-lining individuals. The median number of birds mist-netted was simply higher due to the much longer survey effort, increasing the number of individuals traversing the sampled transect sections. The latter interpretation is supported by the fact that recapture rates were low for this species (7.6% during standardized sampling).

The case of *Chloroceryle* kingfishers was very distinct. These species can be reasonably well detected by an observer moving along streams and rivers, but are usually missed from transects that do not permit frequent and free views onto the vegetation at their edges. Smaller kingfishers sometimes also fly through the forest undergrowth, usually to cross from one stream to another or because they breed at some distance from water, but unfortunately rarely call when doing so. Consequently, within forest mist netting was more effective in detecting them than MTW.

Most vocalizations of *Malacoptila panamensis* are only audible at a short distance, and thus mist netting revealed higher median numbers per survey. However, a sufficient number of MTW samples might permit reliable estimations of the population density for this puffbird.

Somewhat similar was the situation for *Xenops minutus* and *Glyphorhynchus spirurus*, the only ovenbird and woodcreeper, respectively, which were more often detected by mist netting than by transect mapping. Both species vocalize less frequently than most other members of their families and so true population density is easily underestimated in MTW rapid assessment surveys.

In audiovisual surveys, the detection of *Mionectes* flycatchers as well as of some manakin taxa, such as *Pipra mentalis*, *Lepidothrix coronata*, and *Manacus manacus*, greatly depended on the presence and general activity of displaying males in the transect areas. Feeding individuals were only rarely spotted. *Mionectes oleagineus* and *M. olivaceus* were mist-netted at both transects, and the latter was the most frequently captured species at MNT2. I failed to detect *M. oleagineus* in the MTW surveys because the species did not establish display territories at the mist-netting transects. In fact, it remains unclear whether the taxon bred there at all in 1997. Similarly, *M. olivaceus* was not observed in the MNT1 area. However, the species was recorded in all mapping surveys at MNT2, where up to four singing males were present. Even more problematic was the sampling of *Terenotriccus erythrurus*, *Myiobius atricaudus*, and *M. sulphureipygius* (Tyrannidae), as well as of *Chloropipo holochlora* (Pipridae). All four were common in mist-netting samples, but rarely noted in transect-mapping surveys. Of these, *T. erythrurus* was the most vocal taxon and the relatively low number of records might be partly due to the presence of non-territorial individuals (recapture rate in the standardized study: 37%). By contrast, most individuals of *M. atricaudus*, *M. sulphureipygius*, and *C. holochlora* were sedentary (recapture rates: 58–64%), so that their low detection rates in the MTW surveys must be due to the fact that these species were mostly silent. *Chloropipo holochlora* is one of the most inconspicuous bird species in the study area and I doubt that its breeding population can ever be reliably assessed with an audiovisual survey method. However, I presume that, at least in the case of the *Myiobius* flycatchers, the number of registrations would have been significantly higher if I had used more of the survey time for active searching rather than for tape recording. Both species accompany mixed-species flocks, *M. atricaudus* sometimes and *M. sulphureipygius* rather regularly. Of course, even with the flexible speed survey regimen according to the MTW protocol, it is often impossible to identify all members of mixed-species flocks, especially if a great chunk of time is used for documenting their vocalizations. In this context it is important to remember that for winter-flocking insectivores in Middle America, King & Rappole (2000) required c. 1.5 h on average, and up to 4 h, to identify all taxa within a single flock ( $n = 333$  flocks), depending on flock size and habitat conditions. Although in this example the flocks contained many

Nearctic-Neotropical migrants, many of which are not very vocal during winter months, it is obvious that the situation is comparable when we consider silent and unobtrusive flock members like *Myiobius* flycatchers.

#### Influence of habitat

When compared with the complete set of species, the proportions of taxa observed per habitat class in the MTW study were distorted due to the selectivity of the method for breeding species (Figs. 26a and 26b). On the wintering grounds many Nearctic-Neotropical migrants prefer second-growth habitats (Petit *et al.* 1995, Wallace *et al.* 1996, Robinson & Terborgh 1997), as do various intra-Neotropical migrants, e.g., *Myiopagis viridicata*, *Platypsaris homochrous*, and others (pers. obs.). Thus it is no surprise that, compared with the complete bird list, the proportion of species inhabiting open country was underestimated by transect mapping, whereas the proportion of forest-dwelling birds was overestimated. Consequently, the differences were no longer significant after excluding migrants and non-breeding visitors from the analysis ( $n_{\text{residents}} = 202$ ). Interestingly, the proportions in the mist-netting data were different from neither the complete set of species ( $n = 268$ ) nor the MTW results when only taxa detected during standardized sampling ( $n = 212$ ) were taken into account ( $\chi^2_3 = 1.14$ ,  $P = 0.767$ ). Because mist nets cover a higher percentage of total vegetation height in young successional vegetation than in high canopy forest, more open-country species and less forest-inhabiting taxa had been expected. This paradox was possibly due to the proximity of forest. Subcanopy- and canopy-dwelling species, such as *Zimmerius chrysops*, *Ornithion brunneicapillus*, *Dacnis berlepschi*, or *Tangara lavinia*, sometimes descended to shrub level at forest edges (pers. obs.; cf. Karr 1990, Blake & Loiselle 2001) and thus improved the representation of forest birds in mist-netting samples. Interestingly, unlike the results reported by other researchers (e.g., Gram & Faaborg 1997, Rappole *et al.* 1998, Blake & Loiselle 2001), the number of open-country species recorded in Playa de Oro by mist netting ( $n = 30$ ) was not higher than that detected by audiovisual surveys ( $n = 34$ ). However, the margin was indeed relatively thin. Thus, in comparison with Central American study sites, lower species richness as well as abundance of Nearctic-Neotropical migrants in the Ecuadorian Chocó (p. 155f, Comparison with other

Neotropical sites) might have affected the outcome in favor of MTW sampling.

The differences in proportions of open-country and forest-dwelling species at MNT1 compared with MNT2 were probably caused by the relative extent of the corresponding habitat types at each site (Figs. 7 and 11). The number of open-country species noted at MNT1 was higher than at MNT2, because the semi-open areas at the former were part of a larger system of abandoned and cultivated plantations, covering a sufficient area for the presence of many taxa that were absent or occurred only infrequently in the small clearing at Playa Rica (e.g., *Buteo magnirostris*, *Crotophaga ani*, *Tapera naevia*, *Veniliornis callinotus*, *Lepidocolaptes souleyetii*, *Taraba major*, *Phylloscopus griseiceps*, *Tyrannulus elatus*, *Myiophobus fasciatus*, *Myiarchus tuberculifer*, *Myiozetetes granadensis*, *Tyrannus melancholicus*, *Polioptila plumbea*, *Geothlypis auricularis*, *Euphonia lanirostris*, *Tangara cyanicollis*, *Molothrus bonariensis*, and *M. oryzivorus*).

#### Influence of main survey stratum

Species-specific differences in the use of strata heavily affect the likelihood of capture (Figs. 27a and 27b), limiting the meaningfulness of mist-netting data in community-wide studies (Remsen & Good 1996, Robinson & Terborgh 1997). Furthermore, variations in vegetation structure and height considerably bias capture frequencies of single species as well as the composition of netting samples (Lynch 1989, Petit *et al.* 1992, Remsen & Good 1996, Blake & Loiselle 2001). In the present study, the only stratum where mist netting had a higher effectiveness, but not efficiency, than transect mapping was the undergrowth (Appendix 17c). Average capture rates for ground as well as understory-dwelling taxa were much lower, and several netting sessions had to be carried out to obtain a representative accumulation of species. Transect mapping was more effective for both strata.

Of course, in audiovisual surveys the detectability of a given taxon may also be affected by strata preference as well as vegetation structure and habitat type (e.g., Dawson 1981, Oelke 1981a, Richards 1981, Verner 1985, Schieck 1997); for instance, the likelihood of observing canopy-dwelling birds might be reduced due to the difficulties of spotting smaller species high in the canopy from ground level (Blake & Loiselle 2001), as well as by sound attenuation of calls and songs (Waide & Narins 1988). However, in the transect-mapping study, detection of breeding species was not biased by strata preference (Fig. 27b).

Although the average number of subcanopy and canopy species detected per survey was slightly lower than for other vegetation strata (exception 'outer foliage and treetops'), they accumulated quickly with growing numbers of MTW surveys, and their proportion in the complete study was, in fact, higher than expected. Important reasons for the slightly delayed accumulation of canopy species might be simple effects of scale and patchiness. Terborgh *et al.* (1990) reported that canopy flocks on average occupied > 20 ha of floodplain forest at Cocha Cashu, Peru, whereas understory flocks defended only c. 5 ha. Furthermore, canopy flocks covered only about two-thirds of the study plot, likely avoiding areas with frequent tree-fall gaps and other openings (Munn 1985), while understory flocks blanket the entire area. Another factor was the low sampling effort during mid- to late-morning, as most canopy-dwelling birds reach their activity maximum later in the morning than understory species (Blake 1992).

Species mostly recorded in the airspace (e.g., Cathartidae, some Accipitridae, swifts, and swallows) were well represented in transect-mapping data, when non-breeding taxa were excluded from analysis. Thus the flexible observer speeds permitted by the MTW protocol might have a considerable advantage over the rigid census periods of point-counting methods.

#### Comparison of MTW with other potential rapid assessment methods

It must be emphasized that Multi Time-Window Transect Mapping (MTW) is not the first method in combining the accuracy of territory mapping with the efficiency of transect techniques. A much older approach in the same direction was 'plot mapping' (Emlen 1977), developed to spot-map territorial breeding bird species in plots or along trails (typically 500 m in length) with fixed or species-specific variable boundaries, in order to estimate their absolute population densities (Christman 1984). Interestingly, only a few researchers ever used this method (e.g., Thompson *et al.* 1992, Martin 2001), perhaps because most bird studies concentrate on only one or a few species that can be more accurately surveyed by distance sampling (see below). Thompson *et al.* (1992) employed a variant of plot mapping that resembles the MTW protocols in many aspects, particularly the marking of trails every 25 m and the execution of eight counts in different time schedules in a 10-day period. However, plot mapping is 'tradi-

tional' by using constant observer speeds of 1 km/h and censusing birds exclusively during early morning hours (typically between 05:30 h and 09:30 h). Thus the method does not solve many of the challenges a researcher might face when surveying entire tropical bird communities (p. 66f, Reasoning for the selection of the survey method, and p. 67-70, The transect-mapping (MTW) protocol of the pilot-study). In consequence, for rapid assessments in tropical latitudes, plot mapping might not have many advantages over traditional line transect techniques.

The fact, that a single observer was able to detect almost 40% more bird species in only 8% of the time with MTW transect mapping than by mist netting, demonstrates the method's effectiveness and efficiency in rapid assessments (Fig. 22). The average detection rate per complete MTW survey at transects MNT1 and MNT2 was 0.31 to 0.33 new species per minute, and thus 19 to 25 times as high as the mean rate of 0.013 to 0.016 species per minute in a complete mist-netting survey. Economic calculations are quite complex and would be beyond the scope of this work, but for 1500-m transects the costs of a transect-mapping study were approximately only 5% of a comparable mist-netting project, with simultaneously greater accuracy and relevance of the data (Jahn 2001). As a result, mist netting is inadequate for most rapid-assessment tasks (Table 11). Nevertheless, some researchers have applied mist netting, together with observation and tape recording, as a rapid inventory technique. Employing such a combined method, Salaman & Donegan (in prep., cited in Salaman 2001) detected an average of 55% of all bird species known to occur at seven sites in the Serranía de los Churumbelos, Colombia, during 5- to 7-day periods each. Assuming that these inventories were carried out by at least two experienced researchers (plus assistants), we could expect that a comparable transect-mapping survey, according to the enhanced protocol (see next subchapter), would reveal c. 70% of the total bird species richness and 80 to 90% of all breeding residents present in the transect areas.

As mentioned above (p. 67f, Reasoning for the selection of the survey method), territory- or spot-mapping techniques may be useful for detailed studies on bird communities in small areas where appropriate maps and a dense system of trails are available, for instance around some tourist facilities or scientific stations (e.g., Terborgh *et al.* 1990, Thiollay 1994b, Robinson *et al.* 2000), but their poor time-efficiency and inadequacy for surveys in rugged ter-



TABLE 11. Comparative suitability of survey methods for rapid assessments and monitoring studies of species-rich tropical bird communities. The evaluation assumes that surveys are carried out by well-trained and skilled observers. Abbreviations used: UG = undergrowth- and ground-dwelling species; US = understory-dwelling species; UL = species inhabiting upper levels (subcanopy, canopy, and airspace). Notes: a = undergrowth-level mist netting, employing a capture-recapture design; b = standard methods without nest search (e.g., International Bird Census Committee 1969, 1970; Bibby *et al.* 1992, 2000); c = refers to sampling designs that allow a crude estimation of avian density; e.g., fixed-radius point counts (e.g., Hutto *et al.* 1986) or variable circular-plot methods (e.g., Reynolds *et al.* 1980), but not to unlimited-radius point counts (e.g., Lynch 1995, Blake & Loisele 2001) permitting merely the calculation of an index of relative abundance; techniques based on precise distance measurement are included in distance-sampling methods (see note 'e'); d = refers to sampling designs that allow a crude estimation of avian density; e.g., two-belt transects (e.g., Jarvinen & Väisänen 1975) or variable strip transects (e.g., Emlen 1971), but not to unlimited transect counts merely permitting the calculation of an index of relative abundance; techniques based on precise distance measurement are included in distance-sampling methods (see note 'e'); e = line transect and point transect sampling with accurate distance measurement for every individual or group (e.g., Buckland *et al.* 1993, 2001); f = random walk surveys used in combination with 5-, 10- or 20-species lists (Fjeldså 1999, Herzog *et al.* 2002); g = transect mapping according to the enhanced multi-belt protocol for rapid assessments (Table 12) and monitoring studies (Tables 42 and 43); h = suitability of data for environmental impact assessments, design of protected areas, and landscape-planning purposes; i = identification skills, proper design of surveys and use of sampling methods, accurate data analysis, etc.; j = for personnel not involved in species identification; k = either absolute number of days, person-hours, or days spent in the field; l = includes equipment (e.g., GPS, mist nets, tape recorders, directional microphones, and batteries) and maps, as well as the establishment, marking, and maintenance of trails; m = rapid assessments of entire bird communities for conservation purposes; n = e.g., number of birds or territories recorded per kilometer transect or per point; birds captured per 100 MNH; records per 5-, 10-, or 20-species lists; o = bird abundance (index, relative, or absolute) observed in base line year is set arbitrarily to a reference value (e.g., 100); population changes are monitored by comparing data of subsequent surveys (same localities, methods, and effort) with the reference value; p = includes breeding and non-breeding birds.

Criteria	Mist netting <sup>a</sup>	Territory & spot mapping <sup>b</sup>	Point counting <sup>c</sup>	Line transect sampling <sup>d</sup>	Distance sampling <sup>e</sup>	Random walking <sup>f</sup>	Transect mapping <sup>g</sup>
A. Suitability as rapid assessment method							
1. Completeness of bird inventories:							
a) resident species	UG/US: high; UL: low	high	moderate-high	moderate	moderate	moderate-high	high
b) migrants and dispersing species	UG/US: high; UL: low	low-moderate	low-moderate	low-moderate	low-moderate	low-moderate	low-moderate
2. Accuracy of estimates:							
a) species richness	low	high	moderate-high	moderate	moderate	moderate-high	high
b) diversity indices	low-moderate	high	moderate	low-moderate	low-moderate	low	moderate-high
3. Detectability of problematic bird groups:							
a) rare and threatened species	UG/US: high; UL: low	high	moderate	moderate	moderate	moderate-high	moderate-high
b) crepuscular and nocturnal taxa	low	moderate	moderate	moderate	moderate	moderate-high	moderate-high
c) occupants of large territories and home ranges	low	moderate	low	low	low	low-moderate	moderate
d) secretive and non-vocal species	UG/US: high; UL: low	low-moderate	low	low	low	low-moderate	low-moderate
e) hummingbirds	UG/US: high; UL: low	moderate-high	moderate	low-moderate	low-moderate	moderate-high	moderate-high
f) canopy-dwelling species	low	high	moderate	moderate	moderate	high	high
g) migrants and dispersing species	UG/US: high; UL: low	low-moderate	low-moderate	low-moderate	low-moderate	low-moderate	low-moderate



TABLE 11. Continued.

Criteria	Mist netting <sup>a</sup>	Territory & spot mapping <sup>b</sup>	Point counting <sup>c</sup>	Line transect sampling <sup>d</sup>	Distance sampling <sup>e</sup>	Random walking <sup>f</sup>	Transect mapping <sup>g</sup>
4. Study-area-related suitability:							
a) large areas	unsuitable	unsuitable	good	good	good	good	good
b) remote areas	moderate	bad-moderate	good	good	good	good	good
c) rough terrain	unsuitable	unsuitable	moderate-good	bad	unsuitable	moderate	moderate
d) homogeneous habitats	good	good	good	good	good	good	good
e) habitat gradients	good	bad-moderate	good	good	good	good	good
f) habitat mosaics	good	good	excellent	moderate	moderate	good	moderate
5. Suitability for conservation purposes <sup>h</sup>	moderate	excellent	moderate-good	moderate	moderate	moderate	excellent
6. Effort and related aspects:							
a) training of researchers <sup>i</sup>	moderate	high	high	high	high	high	high
b) training of field assistants <sup>j</sup>	moderate	low	low	low	moderate	low	low
c) number of field assistants required	high	low	low	low	very high	very low	low
d) time effort for field work <sup>k</sup>	very high	high	low	low	high	very low	low
e) time efficiency of field work	very low	low	high	very high	moderate	very high	high
f) logistical and technical effort <sup>l</sup>	high	moderate-high	low	low	moderate	very low	low
g) data analysis	moderate	high	moderate-high	moderate-high	moderate-high	moderate	high
7. Survey Costs	very high	high	low	low	high	low	low
8. Synoptic evaluation: rapid assessments <sup>m</sup>	unsuitable	unsuitable	moderate-good	moderate	unsuitable	moderate	good
B. Suitability as monitoring method							
1. Suitability for obtaining estimations of							
a) abundance indices <sup>n</sup>	UG/US; moderate; UL: bad	(not used)	moderate	moderate	moderate	moderate	moderate-good
b) relative abundance	UG/US; good; UL: bad	good	moderate	moderate	moderate	moderate	moderate-good
c) absolute abundance / population density	bad-moderate	good	bad-moderate	bad-moderate	excellent	unsuitable	moderate-good
d) population indices <sup>o</sup>	UG/US; good; UL: bad	good	moderate	moderate	excellent	moderate	moderate-good
e) population size	UG/US; good; UL: bad	good	bad-moderate	bad-moderate	excellent	unsuitable	moderate-good
2. Suitability for monitoring of population changes							
a) breeding residents	UG/US; good; UL: bad	good	moderate	moderate	good	moderate	good
b) latitudinal and elevational migrants	UG/US; good; UL: bad	bad-moderate	bad-moderate	bad-moderate	bad-moderate	bad-moderate	bad-moderate
c) seasonal changes in community composition <sup>p</sup>	UG/US; excellent; UL: bad	bad-moderate	bad-moderate	bad-moderate	bad-moderate	bad-moderate	bad-moderate
3. Magnitude of bias	UG/US; moderate	moderate	large	large	moderate-small	very large	moderate-large
4. Synoptic evaluation: population monitoring							
a) entire bird communities	unsuitable	unsuitable-good	moderate	bad-moderate	unsuitable	bad-moderate	moderate-good
b) one to several appropriate species	excellent-good	unsuitable-good	moderate-good	moderate	excellent	bad-moderate	moderate-good

rain or large areas disqualify them for use in rapid assessments. In recent years, a simplified territory-mapping method (dubbed 'line mapping' in Germany) has been of growing popularity in 'common bird surveys' in Europe (e.g., Schmid *et al.* 2001, Schmid *et al.* 2004, Südbeck *et al.* 2005), both in the context of bird atlas projects and monitoring programs of common breeding birds (e.g., Gedeon *et al.* 2007, Mitschke *et al.* 2007). In grid cells of 100 ha, birds are recorded on both sides of trails that are 3–6 km long and ideally circular in form. However, due to the fact that detailed maps (scale 1:5000) are prerequisites, this approach has the same principal disadvantage for bird surveys in tropical latitudes as the original territory-mapping technique, besides being less precise than the latter due to the lower number of samples that are carried out per year (only two to four samples, depending on the country and altitude). Likewise, distance-sampling methods (Buckland *et al.* 1993, 2001) are unsuitable for rapid assessments of entire species-rich avian communities because it is impossible to accurately measure the distances of all birds heard and seen. In addition, most taxa are too rare to obtain the sample size needed for the calculation of population densities ( $n_{\min} \approx 60$ –80 observations; Buckland *et al.* 1993: 296). Even in transect-mapping surveys experienced observers should use multi-belt mapping forms with at least four to eight distance intervals at each side of the transect line (see next subchapter), which might represent a potential alternative for continuous distance measurements (e.g., Rosenstock *et al.* 2002). However, whenever feasible, distance sampling is certainly the best choice for obtaining robust estimates of population densities for single or a few species in monitoring studies. Even in transect-mapping surveys, experienced observers should use multi-belt mapping forms with at least four to eight distance intervals at each side of the transect line (see next subchapter), which might represent a potential alternative for continuous distance measurements (e.g., Rosenstock *et al.* 2002).

Traditional line transect censuses, e.g., in the form of variable strip (Emlen 1971) or two-belt methods (Järvinen & Väisänen 1975), are suitable in extensive, open, homogeneous, and species-poor habitats (Bibby *et al.* 1992), but produce rather poor results in bio-diverse tropical forests. By contrast, forest birds, including canopy-dwelling taxa, were well represented in the MTW data (Figs. 26a and 26b), demonstrating that this method works even in structurally

complex and species-rich habitats. In tropical forests point counting may detect rare, secretive, and silent taxa better than traditional line transect censuses, as the observer is stationary during counting periods. However, valuable observation time is lost in traveling between counting points (p. 66f, Reasoning for the selection of the survey method). In addition, to ensure that the birds readjust their behavior after being disturbed by the observer while approaching the counting station, it is appropriate to wait several minutes prior to taking data (Buckland *et al.* 1993). These factors considerably reduce the time efficiency of point-count surveys. For example, Lynch (1995) recorded on average one new species per minute in 10-minute counts carried out in the first hour after sunrise at Quintana Roo, Mexico, using unlimited-radius points without aural stimuli. Taking into account a mean travel time of 5 min (Lynch 1995), the time efficiency is reduced to 0.67 new species per minute. In other words, travel time reduced mean efficiency of point counting by one third. In comparison, I recorded on average 0.84 new species per minute in early morning samples at MNT1 and MNT2 (samples 1B and 2A; mean duration: 74.9 min;  $n = 16$ ), which were also carried out roughly in the first daylight hour. Thus, the time efficiency of transect mapping was surprisingly high, considering that the detection rate refers to the entire time span of an early morning sample, and not just to an average 10-min count period. It is certain that in Lynch's study the mean detection rate for five point counts together (5 counts of 10 min plus 5 travel periods of 5 min = 75 min) was much lower than 0.67 new species per minute because some of the species found at each new point had already been observed at previous stations.

The main advantage of transect mapping over point counting is that birds are detected and mapped over the entire length of the transect route, whereas the latter method provides accurate data only for a few spots along the same trail. Because most tropical forest species are not evenly distributed over an area, even in rather homogeneous habitat (e.g., Terborgh *et al.* 1990, Thiollay 1994b, 2002a; Robinson *et al.* 2000), some taxa may appear exclusively or mostly between counting stations, and thus would be lost for analysis. This could be particularly important in conservation-related studies, where information on the local distribution pattern of threatened and other indicator species might be critical for the zoning of community reserves or planning of mitigating meas-

ures (Jahn 2001; Chapter 7). Furthermore, the flexible observer speeds used in MTW surveys ensure that mixed-species-flock members can be identified more accurately than in any method with a rigid regime of constant travel speed or counting time. Not surprisingly, some of the bird groups and species regarded as poorly recorded in point-counting studies (e.g., Whitman *et al.* 1997, Blake & Loiselle 2001), like hummingbirds, ovenbirds, some woodcreepers, and canopy species, had high detection rates in transect-mapping surveys. Flexible travel times also allow the use of transect mapping in rugged terrain (e.g., Jahn 2008), where point counting traditionally was the only audiovisual method that produced consistent results (Dawson 1981). Nevertheless, in some circumstances point counting also has some important advantages over transect mapping. It might be the best survey method for habitat mosaics and small forest fragments (e.g., Anderson & Ohmart 1981, Aleixo 1999, Petit & Petit 2003, Ribon *et al.* 2003; but see Stratford & Stouffer 1999). Furthermore, the calculation of population densities on the basis of point-counting data is well established and tested (e.g., Bibby *et al.* 1992, 2000), whereas some work remains to be done in this respect for transect-mapping data (p. 110-115, Estimation of population densities on the basis of transect-mapping data).

The most time efficient of all rapid assessment methods may be the recently proposed random walk approach, which allows the estimation of species richness as well as relative abundance when used in combination with 5-, 10- or 20-species lists (Fjeldså 1999, Herzog *et al.* 2002). The method relates species richness to the number of observations, rather than time or area, thereby allowing comparison of data gathered by different observers and under varying field conditions, as long as certain assumptions are met (Herzog *et al.* 2002). No marking of trails or stations is necessary, in contrast to other methods. Furthermore, the observer is independent of any constant traveling speed or counting time regime, so that he/she may tape-record or track down unknown vocalizations without interfering with the survey protocol. In addition, the entire daylight period may be used to collect data. Comparing these features with the MTW protocol, it is obvious that transect mapping is similar regarding the rather flexible observer speed and extensive survey schedule, which includes different periods of the day. However, the random walk approach has severe shortcomings in the context of conservation-related studies. For ex-

ample, Herzog *et al.* (2002) proposed excluding all species recorded at distances >50 m from analysis. As a consequence, some information on rare species, especially those with large territories or home ranges, might be lost. This is not desirable for the reasons mentioned in the previous subchapters. Furthermore, this survey method only produces species lists, as well as crude estimates of total species richness and relative abundance, and does not provide information on species distribution patterns along the surveyed trails. However, species richness by itself is a rather poor predictor of conservation value, at least at local and regional levels (p. 216f, Assessing conservation value at the local level). By contrast, transect-mapping data result not only in species lists but also in detailed maps of the distribution pattern of the birds along the transect routes. Employing an enhanced MTW technique, absolute population densities can be estimated (p. 169-175, Guidelines for the use of transect mapping (MTW) in monitoring studies). All observations can easily be referenced with Geographic Information Systems (GIS), as long as the orientation of transects was accurately measured and the coordinates of starting points were determined. Although in theory coordinates of very important localities, such as display sites or nesting trees of globally threatened species, could also be collected with Global Positioning System (GPS) equipment in random walk surveys, this would be very time consuming within forest, and certainly would affect the method's efficiency. In addition, the method is unsuitable for tasks like monitoring and impact studies, where it is important to survey exactly the same sites (plots, points, or transects) at the same periods of the day, and with similar time effort to assure comparability of data sets. Therefore, I recommend using transect mapping in most circumstances and point-counting methods in irregular small-patched habitat mosaics, both of which provide much more detailed information in rapid assessment surveys as well as monitoring studies than the random walk approach (Table 11).

#### Guidelines for an optimized transect-mapping protocol for rapid assessments

Although the original transect-mapping protocol (p. 67-70, The transect-mapping (MTW) protocol of the pilot study) was very effective and time efficient in bird surveys, it still had some shortcomings that make methodological improvements necessary. As discussed earlier, in comparison with other bird

groups, the detection rates for diurnal raptors were rather low in MTW surveys (p. 92-95, Influence of taxonomic affinities). This had a number of reasons, but the most important was probably the inappropriate sampling of mid- to late-morning hours, when some of the overlooked species tend to soar or perform flight displays above the canopy. In addition, canopy birds reach their activity maximum later in the morning than species inhabiting lower strata (Blake 1992). As the mean number of species detected per complete MTW survey was lower for the subcanopy, canopy, treetops, and outer foliage than for other vegetation strata (Appendices 17a-17c), this is another argument in favor of a higher sampling effort in the corresponding time period. Fortunately, two additional samples that cover late morning hours can be introduced into the original MTW time schedule, without increasing the number of days necessary to perform a complete survey. Thus, according to the optimized MTW protocol, one complete rapid assessment survey consists of eight (instead of six) samples that can be carried out within two days under optimal conditions (Table 12). However, if the aim of a study is rather the determination of population densities or a long-term monitoring of bird communities, then an even more comprehensive transect-mapping protocol should be used (p. 169-175, Guidelines for the use of transect mapping (MTW) in monitoring studies).

Another serious source of bias was the two-belt approach applied in the pilot study. By mapping the birds only within or beyond the 25-m main belt, I unnecessarily reduced the resolution of information to a degree that may have affected the determination of the number of territories for some species. Although this aspect seems to be more relevant for monitoring studies than rapid assessment surveys, it should be emphasized that in conservation projects it is often very important to know the location of territories or leks of threatened species as precisely as possible (Chapter 7). Furthermore, some of the information collected in rapid assessment surveys might also be of indirect importance for the analysis of monitoring data obtained at other transects (see below). Considering that the additional effort is minimal, there is certainly no reason not to map birds at a higher resolution in rapid assessments as well. To achieve this, I propose a multi-belt transect-mapping form in which the birds are recorded in four strips at distances of 0-25, 25-50, 50-100, and >100 m on each side of the transect. Well-trained observers should use additional

bands, e.g., intervals bounded at 10, 25, 50, 100, 200, and > 200 m (cf. Rosenstock *et al.* 2002). The latter approach might facilitate data analysis with the program DISTANCE (Thomas *et al.* 2002b), as long as certain key assumptions are met, which in field practice is a challenge on its own (p. 110f, Estimation of population densities on the basis of transect-mapping data). However, using too many intervals makes distance estimation more time-consuming and error-prone, particularly when less experienced observers are involved in the study. For birds detected in the far belts (> 100 m or > 200 m, depending on the number of intervals used), the true distances should always be estimated and noted (i.e., the perpendicular distance between bird and transect line). This will be helpful for the determination of the approximate position of the bird and the delimitation of territories on the maps. For all species that are more regularly seen than heard, distances should also be estimated as precisely as possible. With a sufficient number of observations, this might eventually provide more accurate estimates of visual detection threshold distances, which at the moment are quite imprecise.

In addition to the multi-belt approach I also propose mapping the position of the birds more precisely beyond the transect ends. This would considerably extend the area covered by the transects, especially for species with loud and far-carrying vocalizations. To achieve this, a grid showing the continuation of the trail as well as the perpendicular distances of 0-10, 10-25, 25-50, 50-100 etc. beyond the transect ends should be included in the mapping forms. Of course, the observer stops at the transect ends, but while he/she is taking a brief rest before starting the next sample, the birds can be mapped at the ends and beyond with the same resolution as along the transect line.

Very important for the determination of the number of territories is a rigorous assessment of simultaneously vocalizing territory neighbors. Although this detail was already mentioned in the description of the original MTW method, it is necessary to introduce a consistent system for the registration of this information. Conspecific individuals that represent distinct territories should be noted with different subscripted capital letters, whereas each group of territory neighbors recorded simultaneously should be marked with superscripted numbers, for instance THMZEX<sub>A</sub><sup>1</sup>, THMZEX<sub>B</sub><sup>1</sup>, and THMZEX<sub>C</sub><sup>1</sup> when three individuals of *Myrmeciza exsul* representing different territories were recorded at the same time,

TABLE 12. Idealized time schedules and minutes surveyed per time window of 30 min in rapid assessments according to the improved transect-mapping method. In contrast to the original MTW protocol (cf. Table 9), two additional samples (M1C and M1D) are carried out during late morning hours with an observer speed of c. 9 min/100 m. The aim is to optimize the use of time during the survey period and, especially, to improve the inventory of canopy-dwelling species as well as soaring or flight-displaying raptors, which were undetected by the original protocol. Thereby, the average minimum observer effort increases to 71 (instead of 53) min per 100-m transect section for complete surveys. However, various factors might result in a higher time effort in MTW surveys (see text for details). Due to the fact that bird activity is often low from late morning through early afternoon hours, the 'optimal' transect length for MTW surveys according to the new time schedule is 1200 m. The times of sunrise and sunset were arbitrarily chosen. Those times in bold, either for the start or the end of samples, exclusively depend on the times of sunrise (M1A, M1B, and M2A) or sunset (A1A and A1B), and thus are independent of the transect lengths (cf. Table 9). It must be emphasized that observers should aim to reach the corresponding transect markers roughly at the time indicated in the schedules to witness the bird chorus at dawn and dusk. For later morning samples (M1C, M1D, and M2B) start times and travel speeds are much more flexible. However, for transect lengths shorter than 1200 m, samples M1C and M2B should be started between about 140 and 170 min after sunrise (between 8:30 h and 9:00 h). See Tables 42 and 43 for an enhanced transect-mapping protocol for monitoring studies and additional notes on the adaptation of survey schedules to the particular conditions of the habitat and latitude of study areas outside the Ecuadorian Chocó region.

Transect length 1200 m:			Minutes surveyed in time windows of 30 min																												
Sample	Effort (min/ 100 m)	Start relative to sunrise/ sunset (min)	Start	End	Sunrise	Sunset	before sunrise			after sunrise								before sunset			after sunset										
							-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	-5	-4	-3	-2	-1	1	2			
M1A →	4	48	05:02	05:50	06:10	18:15	8	30	10																						
M1B ←	12	144	05:50	08:14	06:10	18:15			20	30	30	30	30	4																	
M1C →	9	108	08:14	10:02	06:10	18:15									26	30	30	22													
M1D ←	9	108	10:02	11:50	06:10	18:15											8	30	30	10											
M2A →	12	144	05:50	08:14	06:10	18:15			20	30	30	30	30	4																	
M2B ←	12	144	08:14	10:38	06:10	18:15									26	30	30	30	28												
A1A →	9	108	16:07	17:55	06:10	18:15																	8	30	30	30	10				
A1B ←	4	48	17:55	18:43	06:10	18:15																					20	28			
Sum	71	852					8	30	50	60	60	60	60	60	60	60	60	60	58	30	30	10	8	30	30	30	30	28	0		

and THMZEX<sub>A</sub><sup>1</sup>, THMZEX<sub>B</sub><sup>1/2</sup>, and THMZEX<sub>C</sub><sup>2</sup> when first territory neighbors A and B were heard together and then territory holders B and C. Individuals and groups without simultaneous observations of conspecific territory neighbors are usually recorded without subscripted characters and superscripted numbers, an exception being mates or clan members of larger species vocalizing simultaneously at some distance from each other. These should be recorded separately in the following manner: FAMISE<sub>A</sub><sup>1</sup>1,0 (male *Micrastur semitorquatus*) and FAMISE<sub>A</sub><sup>1</sup>0,1 (female) if their sexes are known or FAMISE<sub>A1</sub><sup>1</sup> and FAMISE<sub>A2</sub><sup>1</sup> if this is not the case. On the other hand, it should be emphasized that pairs or family groups of smaller species should always be recorded in the same grid cell of the transect-mapping form (e.g., THMZEX 1,1; one male and one female), even if they sing in neighboring ones. Only if a movement > 50 m was observed for the same individual(s) should it be noted in the transect-mapping form through repetitive annotation, using roman numerals after the subscripted large capitals, e.g., THMZEX<sub>DI</sub>1,1 for the first record of a pair of *M. exsul* and THMZEX<sub>DII</sub>1,1 for the second observation of the same birds.

The observer speeds shown in Table 12 should be interpreted as minimum average effort per 100-m transect section. The real travel time is often longer, particularly in areas with high avian species richness and abundance, like mosaic landscapes in the floodplain of tropical rivers. Examples for other factors that might slow down the average observer speed are transects in rugged terrain demanding much concentration for trail navigation, unstable climatic conditions, extremely high bird activity (e.g., numerous mixed-species flocks), extensive documentation of bird sounds while sampling the transect, prolonged observation periods at certain spots (e.g., to track down unknown sounds), or poor knowledge of the local avifauna. That is to say, in transect-mapping surveys travel speeds should be adapted to the specific conditions of the study transects, particularly the activity patterns of the local avifauna and the individual skills and habits of the observer. However, in any case the observer should aim to be at the markers indicated in the schedules during the dawn and dusk periods (20 min before sunrise and 20 min before sunset; cf. Tables 12, 42, and 43). Furthermore, the observer should record the time at each 25-m marker to facilitate an analysis of real survey effort per transect section.

The design of rapid assessment studies largely depends on their specific aims. One important aspect is that a single two-day MTW survey according to the improved protocol presented here (minimum effort of c. 14 h) will not provide complete bird inventories of a transect or a study area, as demonstrated by the species accumulation graph for transects MNT1 and MNT2 (Fig. 22). In continuous Chocoan *terra firme* forest, species accumulation begins to stabilize after c. 25 h (c. 2000 'birds recorded') for a single 1200-m transect and after c. 50 h (c. 4000 'birds recorded') for two transects together (pers. obs.), when surveyed according to the MTW monitoring protocol (Tables 42 and 43). Stabilization of accumulation curves might take even longer in heterogeneous habitat. Thus, if complete species lists are needed for rather small areas (< 100 ha), I recommend to use the more comprehensive six-day monitoring scheme instead of the two-day protocol. However, if rather large areas have to be inventoried in just a few days, the MTW rapid assessment method should be used. In this case a minimum of four to six 1200-m transects should be surveyed per 500 ha. However, more transects might be needed in the same area if the development of adaptive management strategies is the aim of the study (p. 229-238, Transect mapping as a tool for adaptive management).

## Conclusion

Multi Time-Window Transect Mapping (MTW) allows the detection of bird species that have their activity peaks at different periods of the day. In rapid assessments following the optimized protocol, each transect is surveyed with a set of eight samples, which are carried out from pre-dawn to after-dusk periods, with highest effort during early morning hours. For each sample period the mean observer speed is adapted to the activity level of the birds and is about three times higher for pre-dawn and after-dusk samples than for samples during early morning hours. Certain characteristics of the transect routes (e.g., topography and habitat), weather conditions, as well as observer skills and habits may also influence the average travel time during MTW surveys. For optimal efficiency, transects are sampled on the way out as well as on the way back. Under good weather conditions, a complete rapid assessment survey of transects of up to 1200 m can be carried out in two days. In contrast to traditional line transect methods, MTW permits observers to stop or move very slowly



for an appropriate time span, in order to identify mixed-species-flock members or to make audio recordings of poorly known bird vocalizations. Thus the method is highly effective even in structurally complex and biodiverse tropical forests. Furthermore, the position of each bird is mapped with the help of 25-m distance markers, revealing the distribution pattern of species and flocks along the transect route. In humid tropical forests, a single worker can accurately assess the distribution pattern of threatened and other bird species in an area of c. 2000 ha per year, when he/she is supported by at least three field assistants, who establish transects and field camps. Observers must also be in good physical shape, be able and motivated to concentrate on bird identification for extended time periods (about seven to twelve hours per day), and of course need an excellent knowledge of the sound repertoire and other field characters of the local avifauna to produce accurate data.

Even the original method, composed of only six samples per complete MTW survey, was highly effective in detecting breeding species in all territory size classes, taxa that establish display territories or leks, as well as latitudinal migrants that defend temporary feeding territories. However, dispersing birds, floaters, long-distance migrants on passage, as well as extremely silent breeding residents (e.g., *Geotrygon* quail-doves, *Myiobius* flycatchers, *Chloropipo* manakins) were overlooked or underestimated. Proportions found in MTW data sets for major taxonomic groups (non-passerines, suboscines, and oscines), body mass classes, as well as habitat and stratum categories, are similar to those found in the complete breeding bird communities of the study areas. By contrast, mist-netting data are heavily biased towards small (< 64 g) and mobile species inhabiting the lower vegetation strata. With the exception of hummingbirds, most non-passerine families are underrepresented in mist-netting samples. Furthermore, the use of different mesh sizes also affects the comparability between mist-netting studies. High costs, low time efficiency, as well as inaccurate representation of entire bird groups make the use of mist netting prohibitive for most survey tasks, unless seasonal movements of Neotropical species or the status and

habitat selection of latitudinal migrants are of concern. However, mist netting is the only standard technique allowing to study the demography and survival rates of song bird populations, which is why integrated monitoring programs, like 'Constant Effort Site Ringing' (CES) in Europe (European Union for Bird Ringing 2008) and 'Monitoring Avian Productivity and Survivorship' (MAPS) in North America (The Institute for Bird Populations 2008a), have gained importance in recent decades. For the same reason, The Institute for Bird Populations (2008b) established in 2002/03 the Monitoring Overwintering Survival (MoSI = Monitoreo de Sobrevivencia Invernal) Program for Nearctic-Neotropical migrant birds in Central America and northern South America.

In comparison with point counting, transect mapping might be more effective for crepuscular taxa, hummingbirds, ovenbirds, some woodcreepers, canopy-dwelling species, as well as species with large territories or home ranges. Transect mapping is also more time efficient than point counting, avoiding any unused travel time on the transect routes. On the other hand, point counting might produce more reliable results in habitat mosaics that are composed of small and irregularly distributed patches. However, comparative studies have to be carried out at the same localities before differences in effectiveness, efficiency, and applicability can be quantified and statistically tested.

In rapid assessments, transect mapping might be slightly less time efficient than the random walk approach due to the necessity of putting up distance markers and determining the orientation of transects. However, the detailed information generated through mapping clearly outstrips that of random walk surveys, which merely provide species lists as well as rough estimates of total species richness and relative abundance for areas of poorly defined extent. MTW survey data can be georeferenced with minimal effort, and so provide valuable information for conservation-related objectives, like the zoning of strategies and the intensity of management options (e.g., forest management, hunting, recreational activities), as well as the design of protected areas and biological corridors at local and regional levels.



## 5. STRUCTURE AND ORGANIZATION OF THE BIRD COMMUNITY

### Introduction

Humid Neotropical forests sustain the world's most diverse avian communities (Pearson 1977, Stotz *et al.* 1996), with up to 400 or more taxa at individual localities in western Amazonia (Haffer 1990). Taking non-forest birds and migrants into account, species richness may locally exceed 500 taxa in areas of only a few square kilometers (Robinson *et al.* 1990, Robinson & Terborgh 1990, Rahbek & Graves 2001). The coexistence of so many bird species has been explained by a complex array of historical, environmental, and stochastic factors, as well as ecological and behavioral interactions (Blackburn & Gaston 1996, Rahbek & Graves 2001; see also Gaston (2000) for a recent, but general, review on global patterns of biodiversity).

Historical factors have shaped the existing regional species pools from which modern communities have developed (Thiollay 1990c). They probably include Milankovitch cycles, large-scale astronomical oscillations attributable to slight changes in the Earth's solar orbit and tilt of the equator, which may have caused periodic changes in the world climate throughout the history of the planet (Haffer 1993). During the Pleistocene, glacial advances in northern latitudes made the Neotropics periodically cooler and drier (Haffer 1987, Colinvaux 1989). As a consequence, the distribution of ecosystems and life zones shifted repeatedly and continuous tropical forest probably underwent phases of shrinkage and fragmentation. Populations inhabiting different forest remnants became geographically isolated from one another, promoting rapid speciation (and subspeciation). Secondary contacts between populations were reestablished through forest expansion in humid and warm interglacial periods (Haffer 1969, 1974; Nores 1992). Paleogeographic changes, such as the uplift of the northern Andes, periodic marine transgressions, and changes in major river systems, are other historical factors that may have caused vicariance events, accelerating speciation (Cracraft 1985, Cracraft & Prum 1988). Long- and short-term geological processes have shaped the local and regional topography as well as the distribution pattern of soil types (Brown & Prance 1987), which, together with climatic conditions, determine the taxonomic composition of modern plant and animal communities. In addition,

dynamic natural disturbance processes like tree-fall gaps, watercourses, storms, and fires create a complex vertical heterogeneity of successional habitats, each of which supports its own assemblage of bird species (Schemske & Brokaw 1981, Remsen & Parker 1983, Sanford *et al.* 1985, Terborgh 1985, Boucher 1990, Haffer 1991, Waide 1991).

The most important environmental factors promoting and sustaining high species diversity in tropical forests are the fairly constant but moderately high temperatures, which together with a regular but not excessive supply of solar radiation and, especially, high atmospheric humidity, ensure elevated levels of primary productivity (Bourlière & Harmelin-Vivien 1988, Raich *et al.* 1991). These factors permit more species to be accommodated due to a steady availability of a wide and diverse array of food resources (May 1988, Wilson 1992) through, e.g., staggered flowering and fruiting phenologies of competing bird-pollinated and bird-dispersed plant species (Snow 1966, Stiles 1975, 1977). Other ecological consequences of high year-round productivity are an increased foliage complexity (Karr & Roth 1971, Pearson 1975) and foraging substrate diversity (Karr 1975, Remsen & Parker 1984, Rosenberg 1990b, Stotz *et al.* 1996), including vines, epiphytes, bamboo stands, and clusters of dry leaves, which create additional space and potential food resources for birds. Nevertheless, availability of food may often be irregular in space and time, especially in mature forests, due to high diversity, low density, and patchy distribution of potential animal prey and food plant species, as well as seasonal or interannual fluctuations (Davis 1945, Karr 1976a, Willis 1976, Smythe 1982, Thiollay 1988, 1990b; Boinski & Fowler 1989, Loiselle & Blake 1990, 1991a,b; Blake *et al.* 1992). Together with interspecific competition (Terborgh & Weske 1975, Diamond 1980, Sherry 1984) and high levels of predation (Snow 1962, Willis 1967, 1972; Gaddis 1980, Skutch 1985), these factors promote highly specialized ecological, behavioral, and social adaptations, such as niche segregation (Pearson 1980, Traylor & Fitzpatrick 1982, Terborgh 1985, Cody 2000), mixed-species flocks (Munn & Terborgh 1979, Munn 1985, Powell 1985, Graves & Gotelli 1993, Naka 2004), obligate army-ant-following birds (Willis & Oniki 1978), small

clutch size (Cody 1966, Skutch 1985, Kulesza 1990), asynchronous breeding (Skutch 1950, Ricklefs 1966, Wyndham 1986, Fleischer *et al.* 1997, Stutchbury 1998), and seasonal movements between habitats and life zones (Stiles 1988, Levey & Stiles 1992, Loiselle & Blake 1992, Nosedal 1994, Powell & Bjork 1994, 2004; Rosselli 1994).

This complex network of evolutionary processes, environmental factors, ecological interactions, and behavioral traits not only shape the composition and dynamics of bird communities, but also influence their vulnerability in the face of anthropogenic habitat alteration and persecution. Therefore, basic information on bird community characteristics is very important for the design of site-specific conservation strategies.

Very little is known about the structure and organization of avian communities in the Chocó biogeographic region (Salaman 1994, 2001). Although Benítez & Matheus (1997) published the first bird list for Playa de Oro, with only 146 species it was too incomplete to be conclusive (Appendices 5 and 6). Here I provide a much more extensive, though still preliminary, bird inventory for the site and probably also the first comprehensive analysis of any bird assemblages found in the Ecuadorian Chocó lowlands and lowermost foothills. First, I focus on a variety of aspects relating to species richness, composition, and ecology of the entire bird community of Playa de Oro. In a second step, I present detailed data on species richness and diversity, species abundance and body size relationships, available area per territory, and estimates for the biomass density of two human-influenced habitat mosaics in the Río Santiago floodplain and adjacent *terra firme* areas. To facilitate direct comparisons with the bird communities of other Neotropical forests, I also analyze a 1000-capture sample for *terra firme* forest. Furthermore, I propose an enhanced protocol for the use of 'Multi Time-Window Transect Mapping' (MTW) in monitoring studies, which may help to generate accurate data on tropical bird communities in the shortest time possible.

## Methods

### Bird survey methods

The methods used for the bird surveys are described in the previous chapter and include mist netting, transect mapping, and non-standardized observation hours (p. 66-71, Methods).

### Data analysis

#### Characterization of the bird community of Playa de Oro

The analysis regarding confirmation status, taxonomic affinities, breeding/non-breeding taxa, resident/migrant status, core/non-core species sensu Remsen (1994), general habitat selection, main foraging stratum, foraging guilds, diet, and flocking behavior was principally based on the data compiled in Appendices 5, 6, 8, and 9; the sources used are stated in each Appendix. The reader should keep in mind my comments on the potential arbitrariness regarding the assignation of species to certain groups, categories, or guilds (p. 71-73, Data analysis).

#### Estimation of population densities on the basis of transect-mapping data

For a correct interpretation of data gathered according to the MTW protocol (p. 66-71, Methods), it is important to clarify the rules and limitations of the survey technique and to identify potential sources of bias.

The calculation of bird densities from data collected in conventional line transect surveys is based on a series of assumptions (e.g., Bibby *et al.* 1992, 1998, 2000; Buckland *et al.* 1993, 2001), which are often difficult to fulfill (e.g., Bart *et al.* 2004), particularly when sampling tropical forest birds. Of course, some of these rules are also violated in MTW surveys, and others are intentionally circumvented. Thus, I want to emphasize that the very nature of transect-mapping data is different from that of data collected with other sampling protocols. In the following, I discuss the idealized assumptions of traditional transect methods and clarify how far MTW surveys comply with them or not:

#### (1) *Birds directly on the transect line are always detected.*

– A critical prerequisite for density estimations based on statistical models that may be met only by ground- and undergrowth-dwelling species. However, birds perching motionless in dense vegetation above the transect (some Accipitridae, Strigidae, Nyctibiidae, Bucconidae, Trogonidae, Tyrannidae, and others) might be regularly overlooked unless they vocalize. Of course, this problem is especially prevalent in surveys carried out around dawn and dusk. Because an observer moves slower in periods of peak activity in MTW surveys, the probability of detecting cryptic species perched above the transect should be higher than in conventional transect censuses.

(2) *Birds are detected at their initial location, prior to movements in response to the approaching observer.* – An assumption that is violated rather frequently, especially for silent birds sitting or moving close to the transect line (see also next paragraph).

(3) *Distances are accurately determined.* – This step is extremely labor-intensive and thus feasible only in studies that focus on one or a few species (e.g., Casagrande & Beissinger 1997, Martínez-Morales 1999, Rappole *et al.* 2003) or that can count on an army of collaborators and field assistance (e.g., Cresswell *et al.* 1999). Accurate measurement of perpendicular distances is certainly not an option when a single observer gathers data for an entire species-rich bird community at a mean rate of c. 1.5 records per minute, with > 90% of the birds detected not seen, as was the case in the study presented here. To avoid time-consuming distance determination, Järvinen & Väisänen (1975) developed the two-belt method, which is widely used in Finland (Järvinen & Väisänen 1983a,b; Järvinen *et al.* 1991). Birds are either noted in the near belt, when detected at distances < 25 m from the transect line, or in the far belt. Relative densities are then calculated from the relationship between the number of birds noted in each belt on the basis of linear, exponential, or half-normal functions, which have been shown to give similar density estimates (Bibby *et al.* 1992). My original idea was to use this simple but effective method in Playa de Oro as well. However, many birds were detected well ahead, up to several hundred meters for species with loud songs, like *Tinamus major*, *Herpetotheres cachinnans*, *Odontophorus erythrops*, *Amazona farinosa*, and *Ramphastos swainsonii*. Under these circumstances it was usually not possible to know at which distances on the transect and in which belts the birds actually sang. Thus, I regularly corrected my annotations as soon as I approached the birds close enough to confirm their position, violating the second assumption and distorting the true numeric relationship between near and far belt records.

(4) *Individuals are counted only once.* – The risk of double-counting individual birds within the same sample is clearly elevated in MTW surveys due to slow observer speed. At least for species that establish territories, such errors are usually eliminated when putting the observations on a map for analysis, because simultaneously singing, conspecific territory neighbors are particularly marked on the survey forms (p. 104-106, Guidelines for an optimized transect-mapping protocol for rapid assessments).

Furthermore, contrary to conventional methods, transect mapping also aims to track bird movements of more than 50 m whenever feasible. However, repeated counting might sometimes occur for non-territorial species, such as *Cathartes aura*, trap-lining hummingbirds, and certain flock-forming taxa like parrots, swifts, and swallows, especially if they tend to move back and forth in relatively large areas.

(5) *Individuals are detected independently.* – An assumption that is difficult to comply with in audio-visual surveys. Songs or calls of certain species often stimulate their territory neighbors to reveal their own positions (e.g., *Tinamidae*, *Odontophoridae*, *Rallidae*, *Thryothorus* wrens, and *Lipaugus unirufus*), a phenomenon that depends on the population density, among other factors (Diehl 1981, Bibby *et al.* 1992). In MTW surveys, counter-singing territory holders facilitate the determination of the number of territories present along transect lines. However, problems may arise when the same species vocalize only rarely when their densities are low. In other cases, like those of lekking males, records are not by definition independent of one another.

Comparing traditional line transect methods with transect mapping, the most important difference between them is that the data collected with the former are assumed to be independent within and between samples, whereas the data gathered in a set of six (or more) MTW samples are not independent of each other. Thus, to obtain meaningful population parameters, MTW data have to be analyzed at the level of complete surveys, not individual samples. MTW circumvents the assumptions of conventional line transect sampling insofar as the exact measurement of perpendicular distances of individuals is avoided. Instead, the number of territories located along the transects is determined by repeated registrations of the same territory holders, resulting in clusters of registrations when projected on a map. Of course, a sufficient number of samples is an important prerequisite for this procedure. For non-territorial breeding residents I determined the maximum number of individuals present per sample. Absolute population densities are then estimated on the basis of effectively surveyed areas, which can be calculated with the help of species-specific and habitat-specific 'detection threshold distances' (DTDs).

DTDs were first introduced by Emlen & DeJong (1981), who defined them as the distance at which a bird song becomes inaudible for an experienced observer with full normal hearing capacity. They

determined the DTD for primary vocalizations of 12 common bird species in homogeneous deciduous forests in southern Wisconsin, using portable two-way radios for communication between observers. DeJong & Emlen (1985) presented theoretical and experimental evidence “that auditory detection approximates a constant function out to a maximum detection distance where it rather abruptly decreases to zero, rather than declining gradually [...]” (cf. Figure 1, model B in DeJong & Emlen 1985). However, empirical curves based on bird surveys using subjective estimates as well as measurements of visual and aural detection distances typically show a gradual decline for a number of reasons (Eberhardt 1968, 1978; Emlen 1971, Järvinen & Väisänen 1975, Emlen & DeJong 1981, DeJong & Emlen 1985). For any given bird species and habitat, the maximum detection distance is influenced by various factors that include, among others, heterogeneities in vegetation structure and topography, background noise levels, height and orientation of the vocalizing birds in relation to the observer, the level of observer concentration, as well as simple laws of geometry. The latter means that birds near the periphery of the detection field around the moving observer are within detection distance for a shorter time than birds closer to the transect line (cf. Fig. 2 in Emlen & DeJong 1981). Thus, empirical detection functions rarely follow an idealized ‘all-or-none’ curve, and the ‘average DTD’ of a species is usually much shorter than the ‘maximum DTD’ proposed by Emlen & DeJong (1981) (cf. DeJong & Emlen 1985). Sophisticated and flexible models, like those used in the Distance 4.0 program (Thomas *et al.* 2002b), therefore work with preselected parametric ‘key’ functions (e.g., uniform, half-normal, negative exponential, and ‘hazard-rate’ models), and if they fail to provide an adequate description of the observed detection function, polynomial or cosine series adjustments are added until a satisfactory fit is achieved (Buckland *et al.* 1993, 1998, 2001; Thomas *et al.* 2002a). Independently of the exact form of the detection function, the average DTD of a particular species can be defined as the perpendicular distance from the transect at which as many individuals are detected beyond as are missed within. Under this definition, the average DTD is identical to the effective strip half-width  $\mu$  used in distance-sampling methods according to Buckland *et al.* (1998) and Thomas *et al.* (2002a), whereas the maximum DTD sensu Emlen & DeJong (1981) corresponds rather to  $w$ ,

which is the maximum perpendicular distance at which objects were recorded in distance-sampling studies.

I estimated the average DTD for the main habitat of each species ( $n = 268$ ) recorded at the mist-netting transects (Appendices 18a and 19a) on the basis of my field experience regarding the most frequent species-specific as well as observer-specific method of detection and associated distances. That is to say, I first differentiated between species mostly or exclusively recorded visually and those mainly detected by sound. In a second step, I estimated the average maximum distance at which the species were (or might be) detected in their preferred habitat. In the case of vocal species, I based the estimates on the most commonly heard loud vocalizations (songs and calls). For visually detected species I took into account the vegetation structure of their preferred habitat, the main survey stratum, as well as their general conspicuousness. To obtain more accurate estimates, I used a spreadsheet showing the assumed average DTD together with the corresponding minimum ( $-33\%$ ) and maximum ( $+33\%$ ) values. I continued to alter the average DTD to the point that I felt the minimum and maximum values covered a realistic range. Subsequently, all estimates were rechecked and, when necessary, corrected together with Patricio Mena V., who has considerable experience in audiovisual bird identification gathered during many years of field work (1995–2001) and dozens of MTW surveys in the Ecuadorian Chocó, including the Playa de Oro area (cf. Fig. 39). Naturally, the accuracy of these estimates is unknown and certainly varies between species. I assume that, within the main habitat (e.g., tropical wet forest) and in areas with regular topography (flat to slightly rolling), the error of most average DTD estimates is considerably less than  $\pm 33\%$ . However, for bird taxa mainly recorded by sight the values might be less precise, since the vegetation structure was so variable even in transect sections within ‘homogeneous’ habitat. For large and silent species that were mainly seen in flight (e.g., *Cathartes aura*), I averaged the estimates over the entire transect length. Here, I used smaller average DTDs at MNT2 than at MNT1 (150 m vs. 200 m) because the smaller proportion of semi-open habitats at the former transect made the observation of these birds less likely. For all other species I employed identical average DTDs for MNT1 and MNT2.

Taking breeding/non-breeding status and other natural history traits into account, I calculated den-



sity indices, absolute densities, and biomass densities for each species as follows (Appendices 18a and 19a):

(a) *Territorial breeding species.* – The number of territories was determined based on four complete MTW surveys (= 24 samples, according to the original rapid assessment protocol) per mist-netting transect (Appendices 3, 12a, and 12b). Each record was noted in the corresponding position on a map, one per taxon and transect, specifying the survey and sample, as well as the number of individuals, type of vocalization, and other relevant details when available (sex, age, etc.). Regarding perpendicular distances, problems arose in some cases while transferring the observations onto the maps, because the original two-belt design of the MTW surveys only showed at which side of the transect line the birds were recorded and whether they were within or beyond the 25-m near belts. As a result, one peripheral territory or another may have been erroneously lumped with a better-documented territory covering the near belts. To eliminate this problem in future studies, I propose a multi-belt mapping form in the improved guidelines for rapid assessment surveys (p. 104, Guidelines for an optimized transect-mapping protocol for rapid assessments) and monitoring studies (p. 169-175, Guidelines for the use of transect mapping (MTW) in monitoring studies).

For species thought or known to breed in the transect areas, a single record of one adult bird was regarded as sufficient to assume the presence of a territory. This sometimes occurred for taxa that were difficult to detect and, especially, for peripheral territories. However, single records obtained during different samples or surveys were lumped into one territory when the distance between them seemed reasonable in relation to the expected average size of the species's territories. Likewise, records of fast-moving and far-ranging taxa obtained during the same sample were usually regarded as belonging to the same territory (potential double counts) as long as the field data did not indicate otherwise, e.g., through simultaneous observations of different territory holders or clumped registrations obtained during various samples, confirming the existence of additional territories. Hypothetical borders of the presumed territories were drawn on the maps using similar areas within species and for both transects. As a general rule, I tried to reduce the number of territories to the smallest number possible. Whenever possible I consulted the capture/recapture data to clarify doubtful cases. Territories located at the ends

of the transects were counted as quarter-fractions (e.g., 0.25, 0.5, or 0.75) of one territory, depending on their overlap with the transects as well as their presumed total size. All other territories were fully counted, including peripheral ones, as long as they were not located at the ends of the transects. After I had determined the number of territories, I calculated a density index as 'territories per kilometer transect'.

For the calculation of absolute densities it has to be taken into account that, due to the laws of geometry, peripheral territories have a much lower probability of being noted than those crossed by the transect line. As a consequence, the number of detected marginal territories increases with each new survey. The detection of large territories may follow similar rules. Therefore, the 'effective detection area' increases with repeated sampling, and the total number of territories determined by a single MTW survey is not directly comparable to the number based on multiple surveys. In the case of transects MNT1 and MNT2, the total number of territories recorded in the four MTW surveys together was respectively 43.9% and 44.8% higher than the mean number of territories detected in single MTW surveys. However, this difference was only partially attributable to an increase in the number of detected peripheral territories because not all core territories were recorded during all surveys. Unfortunately, the resolution of the mapping was not high enough to accurately determine the proportion of central and marginal territories (p. 104, Guidelines for an optimized transect-mapping protocol for rapid assessments), but I estimated that overlooked core territories were responsible for roughly one third of the difference between the average number of territories detected per MTW survey and the study totals. Thus I decided to use the percentage values by which the mean number of detected territories per MTW survey was smaller than the total number of territories. For MNT1 and MNT2 this was 30.5% and 30.9%, respectively. For territorial breeding species I added the corresponding values to the 'average DTD' in order to estimate the 'effective DTD' for each taxon and transect. Subsequently, I obtained the effective detection area as the product of twice the effective DTD and the transect length, and the absolute territory density by dividing the number of territories by the effective detection area. Finally, I estimated the absolute population density by multiplying the territory density by the presumed mean number of birds per territory. For socially monogamous species I used a factor of 2.5 as

an approximation, corresponding to one male and female per territory and a year-round mean presence of one juvenile or immature per two territories; see Terborgh *et al.* (1990: 222) for the reasoning. For species regularly forming extended family groups (e.g., *Odontophorus*, *Pteroglossus*, *Ramphastos*, *Querula*, and *Campylorhynchus*), I chose a higher factor, depending on the estimated mean number of individuals per group (Appendices 18a and 19a).

(b) *Lek and display-territory-establishing species.* – With the exception of the hummingbirds (see below), I used the maximum number of displaying males recorded at the lek sites or in transect sections containing display territories. All records of females, juveniles, and immatures were ignored. Lekking males are not recorded independently of each other and display activity changes with time of day and season (e.g., Snow 1968, Endler & Théry 1996). Thus I used the maximum number obtained in any of the MTW samples carried out in the course of the study. Because their number was determined on the basis of four complete MTW surveys, I assumed that the relationship between average DTD and effective DTD would be as in territorial breeding residents. Consequently, I augmented the average DTDs in the corresponding percentage values in order to transform them into the effective DTDs (see above). Then I calculated the absolute density of displaying males per square kilometer. To obtain an estimate for absolute population density I used a hypothetical factor of 2.5, assuming equal sex ratio and a year-round average of one juvenile/immature individual per four adult birds. It may turn out that this relationship is not the correct one for this group.

(c) *Small inconspicuous suboscine passerines that do not form permanent pairs.* – For these rarely vocalizing breeding species (e.g., *Terenotriccus erythrurus*, *Myiobius* spp., and *Pipra mentalis* at transects without leks), which were chronically underdetected in MTW surveys, I based the calculation of population densities on the maximum number of unsexed and unaged individuals recorded in the course of the study. For this purpose, I transferred all observations onto a map and then used either the maximum number of individuals recorded during a single sample or, when single records were sufficiently distant, the accumulated number obtained from various samples. Subsequently, I calculated the effective detection area and the absolute population density on the basis of the average DTD. However, this would probably

not be the correct course if more survey time had been spent in active visual searching for these inconspicuous taxa, and less time in tape recording of bird sounds (p. 172, Guidelines for the use of transect mapping (MTW) in monitoring studies).

(d) *Other species that could not be analyzed in units of territories or displaying males.* – For the following bird groups I based the calculation of population densities on the average maximum number of unsexed and unaged individuals recorded per survey: (1) mostly silent species with large home ranges that might form foraging aggregations (e.g., Cathartidae); (2) hummingbirds, because they are fast moving, often erratic in occurrence, do not form permanent pairs, and in most species both sexes vocalize rather frequently, males at leks and display territories and both sexes at feeding territories or while traplining; (3) species that frequently participate in fast or erratically moving foraging flocks (e.g., swifts, parrots, swallows, and a few tanager species); (4) non-breeding visitors not always present in the transect areas (i.e., floaters and migrants). These bird groups have in common that males, females, juveniles, and immatures have a similar probability of being detected in audiovisual surveys because they vocalize with similar frequency and intensity. Furthermore, their number in the transect areas might vary considerably between seasons or with availability of food resources (e.g., carrion, flowering and fruiting trees). Average maximum numbers of individuals are non-cumulative, which is why I calculated the effective detection area and the absolute population density directly on the basis of the average DTD.

For all species I finally calculated the biomass density for the habitat mosaic by multiplying the estimated number of individuals per square kilometer by their mean body masses (Appendices 18a and 19a). Furthermore, I also estimated the population density within the appropriate habitat and, for territorial species, the available area per territory (Appendices 18b and 19b). For this purpose I first multiplied the within-habitat transect length by twice the average or effective DTD (see above), in order to obtain the effective detection area. I estimated the transect length within appropriate habitat from my field observations as well as mist-netting data. For species of which ecotones may form part of their territories, I counted edges as within habitat. The within-habitat transect length was equal to the total transect length for taxa that occupy a broad spectrum of habitats, e.g., open country as well as forest. The

number of individuals per square kilometer was then calculated, using the procedures described above. The available area per territory was calculated directly from the estimated number of territories per square kilometer. The resulting area is usually larger than the average territory size because most species occupy only a part of the available area, even in seemingly homogeneous habitat (Terborgh *et al.* 1990, Thiollay 1994b, 2002a; Robinson *et al.* 2000). Only for species that occupied all of the appropriate habitat within a detection area would the available area per territory equal territory size.

All data on population density, biomass density, and available area per territory presented here have to be regarded as preliminary, because estimates are based on only two relatively short transects and for most species also on a rather low number of observed individuals or territories.

#### Species richness estimators

To evaluate the question of how accurately species richness estimators can predict the total number of species in the transect areas of MNT1 and MNT2, based on the observed species richness and abundance of the mist-netting and transect-mapping surveys, I used EstimateS 6.0b (Colwell 2000; also see Colwell & Coddington 1994) and compared the results with those obtained through standardized and non-standardized sampling. Following Herzog *et al.* (2002: 752), I computed seven nonparametric estimators (ACE [Abundance-based Coverage Estimator]: Chao *et al.* 1993, Chazdon *et al.* 1998; ICE [Incidence-based Coverage Estimator]: Lee & Chao 1994, Chazdon *et al.* 1998; Chao 1: Chao 1984, 1987; Chao 2: Chao 1984, 1987; Jackknife 1: Burnham & Overton 1978, 1979; Heltshe & Forrester 1983, Smith & van Belle 1984; Jackknife 2: Burnham & Overton 1978, 1979; Smith & van Belle 1984, Palmer 1991; Bootstrap: Smith & van Belle 1984) and two Michaelis-Menten (MM) statistics that extrapolate species accumulation curves (MMRuns and MMMean: Raaijmakers 1987). ACE and Chao 1 are abundance-based models, whereas all other nonparametric estimators are based on the presence/absence (incidence) of species in the samples; see Colwell (2001) for equations and further details. The equations for the Michaelis-Menten richness estimators are stated in Raaijmakers (1987): MMRuns computes estimates for each pooling level of each randomization run, and then averages over randomization runs, whereas MMMean calculates

estimators only once for the mean species accumulation curve (Colwell 2001); see Colwell & Coddington (1994) and Keating & Quinn (1998) for discussions and evaluations of these methods.

I used the following settings to compute the statistics with EstimateS: (a) number of sample order randomizations = 50; (b) arbitrarily chosen random seed = 42 (allows the user to obtain precisely the same results when repeating the procedure for the same data sets); (c) randomize samples without replacement (ensures that the final value for the averaged, random-order species accumulation curve precisely matches the total number of observed species); (d) Chao 1 and Chao 2 bias correction 'on'; see Colwell (2000) for details; (e) upper abundance limit for rare or infrequent species (needed for coverage-based estimators, i.e., ACE and ICE) = 10 (recommended default); (f) individual shuffling 'off' (this experimental tool allows the removal of effects of distribution patchiness, which was not an objective of my analysis).

I analyzed the data of the standardized surveys at various levels (Tables 26 to 29). In the case of mist netting, I used first captures ( $MN_{fc}$ ), first captures for each complete survey ( $MN_{cap1}$ ), and all kinds of captures ( $MN_{cap2}$ ). For transect mapping I considered the raw data of each survey ( $MTW_c$ ) as well as the modeled population data for areas of one square kilometer (= 100 ha) per transect ( $MTW_{pop}$ ). The estimators were computed for each complete survey, for combinations of all surveys per transect, and for pooled data sets of both transects. However, at least two samples are required for the calculation of incidence-based estimators, in contrast to abundance-based statistics. As a result, only ACE and Chao 1 could be computed for all data sets.

For the assessment of performance of the species richness estimators I compared the results for each data set with the number of the core species known to occur at the corresponding transect or the combined transects. Here, the term 'core taxon' refers to the species's status in the 'universe' of Playa de Oro and not to the transect areas (Appendix 6). Bird communities are dynamic and it would be presumptuous to judge which of the non-breeding visitors were core and which non-core, also because, among other things, non-breeding species were principally underdetected in the bird surveys. Although all mist-netting samples contained some non-core taxa, their actual number was so low that I decided to include them in the data sets used for the computation of the

estimators and to compare the results with the known numbers of core species. The most important reason for this was the fact that the total number of species at the transects was based on an observation period of at least two-and-one-half years, whereas the standardized mist-netting study covered only 13 months in total.

It is important to clarify that not all of the data sets fully comply with the characteristics of 'valid' samples assumed by the statistics computed with EstimateS. In general there are two alternative approaches in species richness assessment protocols, an individual-based one and a sample-based one (Gotelli & Colwell 2001). Examples for valid individual-based samples are the data sets containing only first captures of each complete mist-netting survey ( $MN_{cap1}$ ) or the pooled data set of first captures per transect ( $MN_{fc}$ ). Likewise, a valid sample-based approach is the joint analysis of the two first-capture data sets obtained at MNT1 and MNT2. In the case of transect mapping, the population data per square kilometer ( $MTW_{pop}$ ) for MNT1 or MNT2 are also individual-based samples, and a sample-based approach is followed when we analyze them together. However, the latter data sets were obtained through extrapolations of unknown accuracy and were not based on complete counts, thus representing modeled bird communities and not randomly drawn samples.

Obviously, samples containing all captures ( $MN_{cap2}$ ) or raw data of the transect-mapping surveys ( $MTW_c$ ) are not 'valid' samples in the sense of statistical models, as they contain repeatedly recorded individuals. Thus any abundance-based estimations of species richness, diversity indices, or similarity coefficients are in fact computed for 'pseudo-abundance' data. However, at least in mist-netting studies, 'all-capture' samples have been widely used to generate and compare species accumulation curves and species abundance-rank plots (e.g., Bierregaard 1990b, Karr 1990, Karr *et al.* 1990, Robinson & Terborgh 1990; see also Figs. 17a,b, 18, 21, and 38 in the present work). Some authors provided arguments as to why they preferred to analyze samples of all captures and not exclusively first captures (e.g., Karr 1981b, Blake & Loiselle 2001), although without presenting any systematic comparative analysis of the problem. Another kind of bias is introduced when we analyze replicated samples of the same plot, e.g., the three complete mist-netting surveys or four MTW surveys per transect, which are certainly not com-

pletely comparable to independent random samples obtained in a finite area. As in the case of all-capture samples vs. first-capture samples, the consequences of study designs and data analysis are rarely addressed in the relevant publications. Therefore, it seems to be valid to take a closer look here at the effects of including recaptures or repeatedly observed individuals in samples used for the computation of species richness estimators and other community data.

#### Species-abundance relationship, species diversity, and similarity coefficients

Diversity is traditionally studied in relation to four main models: the geometric series, Fisher's logarithmic series, truncated lognormal, and MacArthur's broken stick (Magurran 1988, Gotelli & Graves 1996). Rank abundance plots of the mist-netting and transect-mapping data were used to obtain a first assessment of the species abundance distributions. The geometric series could be excluded as a possible species abundance model, whereas mathematical fit had to be tested formally with Chi-squared statistics for the log series, truncated lognormal, and broken stick. In all three cases I employed the fitting procedures described in Magurran (1988: 132-141). However, in the first steps of fitting the truncated lognormal distributions, I followed Cohen (1959, 1961) and Kempton & Taylor (1974) [all three articles cited in Krebs (1989)] in using the 'sample variance'  $s^2$  of the log abundances instead of their 'population variance'  $\sigma^2$ , since the observed data represent samples of populations, not the entire populations themselves. The parametric diversity index  $\lambda$  (lambda) was calculated as  $\lambda = \hat{S}_T / \hat{\sigma} = \hat{S}_T / \sqrt{\hat{\sigma}^2}$  (Kempton & Taylor 1974), with  $\hat{S}_T$  being the estimated total number of species in the community, including those to the left of the veil line, and  $\hat{\sigma}^2$  the estimate of true variance of the lognormal. Note that the estimate of true variance of the lognormal  $\hat{\sigma}^2$  is often considerably larger than the 'population variance'  $\sigma^2$ , and thus the diversity index  $\lambda$  is overestimated when  $\sigma$ , instead of  $\hat{\sigma}$ , is accidentally used in the denominator of the formula stated above.

Other diversity indices, like Fisher's  $\alpha$ , Shannon's  $H'$ , and Simpson's  $D$ , were computed using EstimateS 6.0b (Colwell 2000) according to the equations stated in Magurran (1988) and Hayek & Buzas (1996); see Colwell (2001) for details. The Shannon evenness  $EH'$  was subsequently calculated according to Magurran (1988: equation 2.22). For Simpson's  $D$  I also computed the natural logarithm, for the reasons stated

by Rosenzweig (1995). To assess whether the bird diversity of transects MNT1 and MNT2 can be unambiguously compared, I also plotted percentage cumulative abundance against log species rank (k-dominance curves; Platt *et al.* 1984) for the mist-netting and transect-mapping data. For the interpretation of the diversity indices it also has to be taken into account that MNT1 and MNT2 were located in a mosaic of semi-open country, young successional forest, and medium-aged forest. Thus we are not analyzing within-habitat  $\alpha$  (alpha) diversity here, but in fact landscape-level  $\gamma$  (gamma) diversity.

For the comparison of bird diversity between transects MNT1 and MNT2, I also computed four similarity indices, two qualitative (incidence-based), indices (Jaccard and Sørensen I), and two quantitative (abundance-based) indices (Sørensen II and Morisita-Horn), according to the equations in Magurran (1988: 95), using EstimateS 6.0b (Colwell 2001). The same software also calculates a coverage-based estimator for shared species (Chen *et al.* 1995, Chao *et al.* 2000); equations shown in Appendix B of Colwell (2001). Again, it has to be remembered that, in the present case, the similarity indices do not refer to between-habitat  $\beta$  (beta) diversity, but rather to between-landscape  $\delta$  (delta) diversity. The latter is defined as the change in species composition and abundance between areas of  $\gamma$  diversity that occur within an area of regional  $\nu$  (epsilon) diversity (Whittaker 1960, 1977; Magurran 1988). Of course, most authors simply apply the term 'β diversity' to any study that compares the differences in species composition between samples, habitats, or communities (Southwood 1978). Consequently, as the similarity indices used here are employed for the assessment of between-transect diversity, the differentiation between  $\beta$  and  $\delta$  diversity might be merely academic.

#### Other statistical methods

For descriptive statistics, PivotTable reports, and the generation of graphics, I employed Microsoft Excel (Microsoft 2001), and for all other statistics SPSS software (SPSS 2003). I used Chi-squared tests (Fowler & Cohen 1986) to compare proportions of species in body mass classes, between different status and habitat categories, and between transects. The corresponding degrees of freedom were given as subscripted numbers (e.g.,  $\chi^2_6$ ). Assumed correlations between the body size of the birds and the available area per breeding territory were analyzed with the nonparametric Spearman's rank test. These tests were

one-tailed, as a strong positive correlation between variables was anticipated. In all tests, differences were regarded as significant at a probability level of  $P < 0.05$ .

#### 1000-capture sample for *terra firme* forest

Karr *et al.* (1990) compared 1000-capture samples for upland forest of four Neotropical areas, and Salaman (2001) added equally standardized samples for three forest types in the Río Nambí drainage. Because the complete mist-netting samples gathered at transects MNT1 and MNT2 contained birds of different habitats, I exclusively used captures obtained in section D of MNT1 and sections C and D of MNT2 (Table 4). These transect sections were located within *terra firme* forest and the closest forest borders were at a distance of c. 55-109 m and 64-182 m from the net lines, respectively (Figs. 7 and 11). For each of the three mist-netting surveys carried out per section, I took the first  $111.1 \pm 2.8$  (range 108 to 115) trapped birds to obtain the 1000-capture sample for selectively logged medium-aged forest.

#### Results

##### The bird community of Playa de Oro

##### Species richness and confirmation status

Between Jun. 1993 and Nov. 2000 a total of 336 bird species (Appendix 5) were recorded in Playa de Oro at elevations of c. 50 to 450 m (pers. obs.; P. Mena V., pers. comm.; Benítez & Matheus 1997; and other observers mentioned in Appendix 6). Since the first submission of the present work in Nov. 2004, I confirmed the presence of eight additional species that could not be included in the analysis, two of which, *Lurocalis semitorquatus* and *Cypseloides cherriei*, were identified on the basis of tape recordings made before the year 1998. Five were observed during a short field trip in Nov. 2005 (*Ardea herodias*, *Oroaetus isidori*, *Hylocharis humboldtii*, *Pachyrhamphus spodiurus*, and *Cinclus leucocephalus*) and one other was heard in Jul. 2009 (*Sporophila schistacea*).

Until Nov. 2004, the identification of 264 (79.5%) species has been fully documented and confirmed, either by tape recordings of their vocalizations or by photos of mist-netted birds (Appendix 6). The vocalizations of an additional seven species are also documented by recordings, which, however, should be confirmed by other experts. Two of these species (*Spizastur melanoleucus*, *Micrastur mirandollei*) are very likely present, whereas the other



five taxa certainly occur in Playa de Oro (sight records), even if the identifications of the corresponding recordings should turn out not to be correct. For 57 species there are only unconfirmable observations or undocumented mist-netting records (without photos); see Appendix 6 for details of these records. All in all, the observations of eight species were regarded as 'uncertain records' because the species involved are difficult to identify under field conditions (*Chaetura cinereiventris*, *Progne subis*), were seen or heard too briefly to be absolutely certain about the identification (*Pyrhura melanura*, *Coccyzus euleri*, *Xenerpestes minlosi*), or were reported exclusively by local hunters and/or Benítez & Matheus (1997) with incomplete documentation (*Amazona autumnalis*, *Aulacorhynchus haematopygus*, *Myiobius villosus*). These eight species were included only because they very likely do occur regularly or seasonally in Playa de Oro, judging by their known elevational and life zone distribution and migration routes (pers. obs.; Ridgely & Greenfield 2001b). However, the area's total of 344 species does not contain six of the species reported by Benítez & Matheus (1997) because I regard them as 'very likely misidentified' (Appendix 7).

Only eight species were exclusively mist-netted: *Myiobius villosus*, *Masius chrysopterus*, *Myadestes raloides*, *Seiurus noveboracensis*, *Oporornis philadelphia*,

*O. agilis*, *Pheucticus ludovicianus*, and *Rhodospingus cruentus*, the first three by Benítez & Matheus (1997) and the last five by myself. These species belong in the group of altitudinal or latitudinal migrants. All other taxa were noted predominantly, or exclusively, by audiovisual methods (Appendix 6).

#### Taxonomic affinities

The 336 bird species included in the analysis belong to 48 families and 243 genera (Appendix 5). The number of families present increases to 50 if recent taxonomic changes are taken into account, i.e., the placement of *Sapayoa aenigma* into its own monotypic family Sapayoidae and the transfer of the genera *Chlorophonia* and *Euphonia* from the Thraupidae to the Fringillidae (Banks *et al.* 2003, Remsen *et al.* 2004). Most genera were represented by only one ( $n = 134$ ) or two ( $n = 38$ ) species. The most species-rich genera were *Tangara* and *Myrmotherula*, with eight and five species, respectively.

At a higher taxonomic level, the non-passerines ( $n = 137$ ) were more species-rich than the suboscine (102) and oscine (97) passerines. The Accipitridae (16), Trochilidae (15), and Picidae (10) were the largest non-passerine families. The most species-rich bird family was the Tyrannidae with 49 taxa. The Thamnophilidae (19) was the only other suboscine

TABLE 13. Distribution of species between various status categories and major taxonomic groups (cf. Appendix 6).

Status	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
A) Breeding				
Breeding confirmed or very likely	101	87	67	255
Breeding possible	11	3	7	21
Sum breeding	112	90	74	276
B) Non-breeding visitors and transients				
Nearctic-Neotropical migrants	6	3	16	25
Intra-Neotropical migrants	1	1	1	3
Altitudinal migrants (foothills → down)	6	4	4	14
Altitudinal migrants (lowlands → up)	12	4	2	18
Sum non-breeding	25	12	23	60
C) All migratory spp. (incl. those breeding)				
Latitudinal	9	5	17	31
Altitudinal	24	13	15	52
Sum migrants	33	18	32	83
D) Importance (regularity of occurrence)				
Core	122	94	75	291
Non-core (vagrant, transient, or irregular)	15	8	22	45
All species	137	102	97	336



TABLE 14. Distribution of species between habitats and major taxonomic groups (cf. Appendix 8).

Habitat	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
A) Non-forest (incl. water and airspace)				
Large river	12			12
Fast-flowing streams and rivers	1	2		3
Pastures and/or open fields (e.g., sugar cane, corn, rice)	7		17	24
Mixed-culture plantations and/or young successional vegetation	8	17	16	41
Settlements			1	1
Airspace (aerial feeders without habitat preference)	4		1	5
Sum non-forest	32	19	35	86
B) Forest				
Primary and (old) second growth	57	44	35	136
Forest interior	12	17	5	34
Forest streams	2			2
Forest/open country edge	30	22	17	69
Forest/river edge	4		5	9
Sum forest	105	83	62	250
All species	137	102	97	336

family represented by more than 10 species. The Thraupidae (36), Parulidae (10), and Emberizidae (10) were the largest oscine passerine families.

#### Breeding/non-breeding status, seasonal movements, and related aspects

I estimate that c. 82% of the species considered here certainly or possibly breed in Playa de Oro (Table 13). With 23.7%, the proportion of non-breeding visitors and transients was twice as high for oscine than for suboscine passerines (11.8%). The non-passerines were intermediate with 18.3%. If those taxa that probably breed are also included in the analysis then 62.7% of all migratory species were known or suspected to perform seasonal movements between life zones within western Ecuador. I regard 86.6% of the entire bird community as core species and 13.4% as non-core taxa, according to the concept of Remsen (1994); see Appendix 6 for details.

#### General habitat selection

I count 74.4% ( $n = 250$ ) of the species considered here as forest or forest-edge-inhabiting taxa (Table 14), 89.6% of which certainly or possibly breed in the area (Table 15). Forty-two families, or 44 after recent taxonomic changes, include at least one forest species (Table 39). The number of 'forest genera' in Playa de

Oro is 186, when forest-edge species are included (see Appendix 8 for detailed accounts on the habitat selection of each species).

Of the forest species, 31.2% were most frequently encountered at forest edges and thus usually thrive with moderate levels of anthropogenic forest fragmentation. Another 54.4% of the forest species do not necessarily avoid edges, but may depend mostly on continuous primary forest or advanced second growth. At least 13.6% are forest-interior species and might be highly sensitive even to moderate levels of forest fragmentation (p. 210-213, *Birds as indicators of environmental change*).

Non-breeding visitors were almost four times as frequent among non-forest species (39.5%) than among forest taxa (10.4%). Of the 31 latitudinal migrants recorded, 54.8% were non-forest species. Forest edges were the single most important habitat for latitudinal migrants (29%), followed by pastures and open fields (22.6%), whereas primary and secondary forest were the most important habitat for altitudinal migrants (42.3%).

#### Main foraging strata

Non-passerines used the widest spectrum of foraging strata, from water to open airspace (Table 16). None of the passerines recorded until Nov. 2004 were aquatic. On the other hand, the airspace-feeding

TABLE 15. Distribution of species between habitats and various status categories (cf. Appendices 6 and 8).

Habitat	Reproductive status		Migrants			Importance		All species
	breeding	non-breeding	altitudinal	latitudinal	all	core	non-core	
A) Non-forest								
Large river	3	9	5	4	9	8	4	12
Fast-flowing streams/ivers	2	1	1		1	2	1	3
Pastures and/or open fields	11	13	8	7	15	13	11	24
Mixed-culture plantations / young successional vegetation	35	6	4	3	7	36	5	41
Settlements	1					1		1
Airspace (aerial feeders without habitat preference)		5	2	3	5	3	2	5
Sum non-forest	52	34	20	17	37	63	23	86
B) Forest								
Primary and (old) second-growth forest	123	13	22	4	26	124	12	136
Forest interior	34					34		34
Forest streams	2					2		2
Forest/open country edge	58	11	9	9	18	60	9	69
Forest/river edge	7	2	1	1	2	8	1	9
Sum forest	224	26	32	14	46	228	22	250
All species	276	60	52	31	83	291	45	336

group was similarly represented in the oscine passerines (Hirundinidae) and in the non-passerines (Apodidae). The suboscine passerines were entirely restricted to the five 'terrestrial' vegetation strata (ground to canopy levels). The distribution of species over the five vegetation strata was much more even for non-passerines, with 14.6 to 19.0% per stratum, than for passerines. The suboscines preferably foraged in the undergrowth (37.3%) and the oscines in the canopy (33%). For breeding species, the undergrowth (27.2%) and canopy (25.4%) were the predominant foraging strata, whereas non-breeders were much more evenly distributed between the foraging strata (Table 17).

#### Foraging guilds and diet

Most species were either insectivorous (38.7%) or omnivorous (28.3% ; but see Appendix 9 regarding the rather broad definition of 'omnivore' used here). With the exception of the arboreal dead-leaf-searching insectivores and stem-feeding granivores, non-passerines were represented in all other foraging guilds considered (Table 18). Insectivores (24.1%) were the most species-rich foraging guild of the non-passerines, but closely followed by carnivores (22.6%). Suboscine passerines were also predominantly insectivorous (61.8%), and within this group arboreal gleaners and arboreal sallying taxa were most numerous. However (but see note above), for oscine

TABLE 16. Distribution of species between main foraging strata and major taxonomic groups (cf. Appendix 9).

Main foraging stratum	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
Water	15			15
Ground	23	7	7	37
Undergrowth	20	38	25	83
Understory	22	17	16	55
Subcanopy	26	14	8	48
Canopy	23	26	32	81
Airspace	8		9	17
All species	137	102	97	336

TABLE 17. Distribution of species between main foraging strata and various status and habitat categories (cf. Appendices 6 and 9).

Main foraging stratum	Reproductive status		Migrants			Importance		Habitat		All species
	breeding	non-breeding	altitudinal	latitudinal	all	core	non-core	forest	non-forest	
Water	6	9	5	4	9	11	4	2	13	15
Ground	29	8	7	3	10	30	7	23	14	37
Undergrowth	75	8	9	4	13	77	6	61	22	83
Understory	48	7	8	2	10	49	6	45	10	55
Subcanopy	42	6	4	3	7	44	4	47	1	48
Canopy	70	11	14	8	22	70	11	67	14	81
Air space	6	11	5	7	12	10	7	5	12	17
All species	276	60	52	31	83	291	45	250	86	336

TABLE 18. Distribution of species between foraging guilds and major taxonomic groups (cf. Appendix 9).

Foraging guild	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
A) Aquatic (piscivores and others)	15			15
B) Carnivore				
Carion feeder	3			3
Terrestrial & arboreal raptor	17			17
Arboreal raptor	7			7
Aerial raptor	4			4
Sum carnivore	31			31
C) Insectivore				
Terrestrial gleaning insectivore	4	5	5	14
Terrestrial sallying insectivore	2	1		3
Bark-climbing surface-feeding insectivore	1	8		9
Bark-climbing in-trunk-interior-feeding insectivore	8			8
Arboreal gleaning insectivore	4	22	19	45
Arboreal dead-leaf-searching insectivore		5	1	6
Arboreal sallying insectivore	8	22		30
Aerial insectivore	6		9	15
Sum insectivore	33	63	34	130
D) Nectarivore	15			15
E) Frugivore				
Terrestrial frugivore	4			4
Arboreal frugivore	9	10	9	28
Sum frugivore	13	10	9	32
F) Granivore				
Terrestrial granivore	2		2	4
Stem-feeding granivore			6	6
Arboreal granivore	8			8
Sum granivore	10		8	18
G) Omnivore				
Terrestrial omnivore	8		1	9
Arboreal gleaning omnivore	6	1	44	51
Arboreal sallying omnivore	6	28	1	35
Sum omnivore	20	29	46	95
All species	137	102	97	336

TABLE 19. Distribution of species between foraging guilds and various status and habitat categories (cf. Appendices 6 and 9).

Foraging guild	Reproductive status			Migrants			Importance			Habitat	
	breeding	non-breeding		altitudinal	latitudinal	all	core	non-core		forest	non-forest
A) Aquatic (piscivores and others)	6	9		5	4	9	11	4		2	13
B) Carnivore											
Carrion feeder	2	1		2		2	2	1		2	1
Terrestrial & arboreal raptor	17						17			16	1
Arboreal raptor	7			1		1	6	1		7	
Aerial raptor	3	1			3	3	3	1		3	1
Sum carnivore	29	2		3	3	6	28	3		28	3
C) Insectivore											
Terrestrial gleaning insectivore	10	4		2	2	4	11	3		10	4
Terrestrial sallying insectivore	2	1		1		1	2	1		1	2
Bark-climbing surface-feeding insectivore	9						9			7	2
Bark-climbing in-trunk-interior-feeding insectivore	8						8			7	1
Arboreal gleaning insectivore	39	6		2	5	7	38	7		34	11
Arboreal dead-leaf-searching insectivore	5	1		1		1	5	1		6	
Arboreal sallying insectivore	27	3		1	2	3	29	1		26	4
Aerial insectivore	5	10		5	6	11	9	6		4	11
Sum insectivore	105	25		12	15	27	111	19		95	35
D) Nectarivore	14	1		4		4	15			12	3
E) Frugivore											
Terrestrial frugivore	4						4			4	
Arboreal frugivore	23	5		8	1	9	25	3		27	1
Sum frugivore	27	5		8	1	9	29	3		31	1
F) Granivore											
Terrestrial granivore	2	2		2	1	3	2	2		2	2
Stem-feeding granivore	4	2		2		2	4	2			6
Arboreal granivore	5	3		4		4	5	3		8	
Sum granivore	11	7		8	1	9	11	7		10	8
G) Omnivore											
Terrestrial omnivore	9						9			5	4
Arboreal gleaning omnivore	46	5		5	4	9	46	5		40	11
Arboreal sallying omnivore	29	6		7	3	10	31	4		27	8
Sum omnivore	84	11		12	7	19	86	9		72	23
All species	276	60		52	31	83	291	45		250	86

TABLE 20. Distribution of species between diet categories and major taxonomic groups (cf. Appendix 9).

Diet	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
A) Aquatic				
Aquatic plant matter (and some invertebrates)	1			1
Aquatic vertebrates and/or invertebrates	14			14
B) Carnivore				
Carion	3			3
Vertebrates	10			10
Vertebrates and large insects	18			18
C) Insectivore				
Small insects (and/or other invertebrates)	14	45	31	90
Large insects (and/or other invertebrates/small vertebrates)	19	18	3	40
D) Nectarivore				
Nectar (and some arthropods)	15			15
E) Frugivore and/or granivore				
Fruits and/or seeds	23	10	17	50
F) Omnivore				
Fruits and/or seeds + invertebrates and/or small vertebrates	17		2	19
Small insects + fruits	1	16	41	58
Large insects + fruits	2	13	3	18
All species	137	102	97	336

passerines omnivorous species (47.4%) were more numerous than any other guild. The main foraging technique of almost all oscines was gleaning. In stark contrast, c. 50% of the suboscines belonged in the group of 'sallying' species.

The highly specialized arboreal dead-leaf-searching insectivores were represented by at least six species, five suboscines (*Cranioleuca erythropis*, *Hyloctistes virgatus*, *Automolus ochrolaemus*, *A. rubiginosus*, *Myrmotherula fulviventris*) and one oscine passerine (*Amblycercus holosericeus*), all of which are either forest or forest-edge species (Table 19). Other foraging guilds exclusively represented by forest taxa were the arboreal raptors (some Accipitridae, *Micrastur mirandollei*, *Glaucidium griseiceps*), arboreal granivores (Psittacidae), and terrestrial frugivores (*Crax rubra*, *Geotrygon* spp.). Stem-feeding granivores (i.e., *Tiaris obscurus*, *Oryzoborus angolensis*, *Sporophila* spp.) were the only group exclusively represented by oscines and restricted to non-forest habitats.

Latitudinal migrants were mostly insectivorous (48.4%) or omnivorous (22.6%). In the case of altitudinal migrants these categories were also the most species-rich. However, other foraging guilds were also important, like frugivores and granivores.

Considering the entire bird community (Table 20), the most important food resources were

small insects and other small invertebrates (26.8%), small insects and fruits (17.3%), and fruits and/or seeds (14.9%). For insectivorous non-passerines, large insects, including other large invertebrates and small vertebrates, were more important in their diet than small insects, with 57.6% vs. 42.4%, respectively. For latitudinal migrants, small insects (45.2%) were the predominant diet category (Table 21), whereas it was fruits and/or seeds for altitudinal migrants (30.8%).

#### Body size relationship

The 336 species considered here show a positively skewed distribution over the logarithmic body mass classes (Figs. 28a,b, and 29). Curiously, species in the category 17-32 g seem to be underrepresented, a pattern that was also found for the subset ( $n = 268$ ) of taxa recorded at transects MNT1 and MNT2 (p. 82 f, Influence of body size). The suspicion that this result might be biased by disproportional distribution of species over certain status and/or habitat categories had to be rejected. Chi-squared tests revealed that differences in the proportions of breeding and non-breeding species ( $\chi^2_5 = 6.693$ ,  $P = 0.245$ ), core and non-core taxa ( $\chi^2_4 = 1.445$ ,  $P = 0.836$ ), and forest and non-forest species

TABLE 21. Distribution of species between diet groups and various status and habitat categories (Appendices 6 and 9).

Diet	Reproductive status		Migrants		Importance		Habitat		All species
	breeding	non-breeding	altitudinal	latitudinal	all	core	non-core	forest	
A) Aquatic									
Aquatic plant matter (and some invertebrates)		1		1	1		1		1
Aquatic vertebrates and/or invertebrates	6	8	5	3	8	11	3	2	14
B) Carnivore									
Carrion	2	1	2		2	2	1	2	3
Vertebrates	9	1	1	1	2	8	2	9	10
Vertebrates and large insects	18			2	2	18		17	18
C) Insectivore									
Small insects (and/or other invertebrates)	69	21	9	14	23	74	16	61	90
Large insects (and/or other invertebrates/small vertebrates)	36	4	3	1	4	37	3	34	40
D) Nectarivore									
Nectar (and some arthropods)	14	1	4		4	15		12	15
E) Frugivore and/or granivore									
Fruits and/or seeds	38	12	16	2	18	40	10	41	50
F) Omnivore									
Fruits and/or seeds + invertebrates and/or small vertebrates	18	1	2		2	18	1	16	3
Small insects + fruits	52	6	8	5	13	52	6	42	58
Large insects + fruits	14	4	2	2	4	16	2	14	4
All species	276	60	52	31	83	291	45	250	336



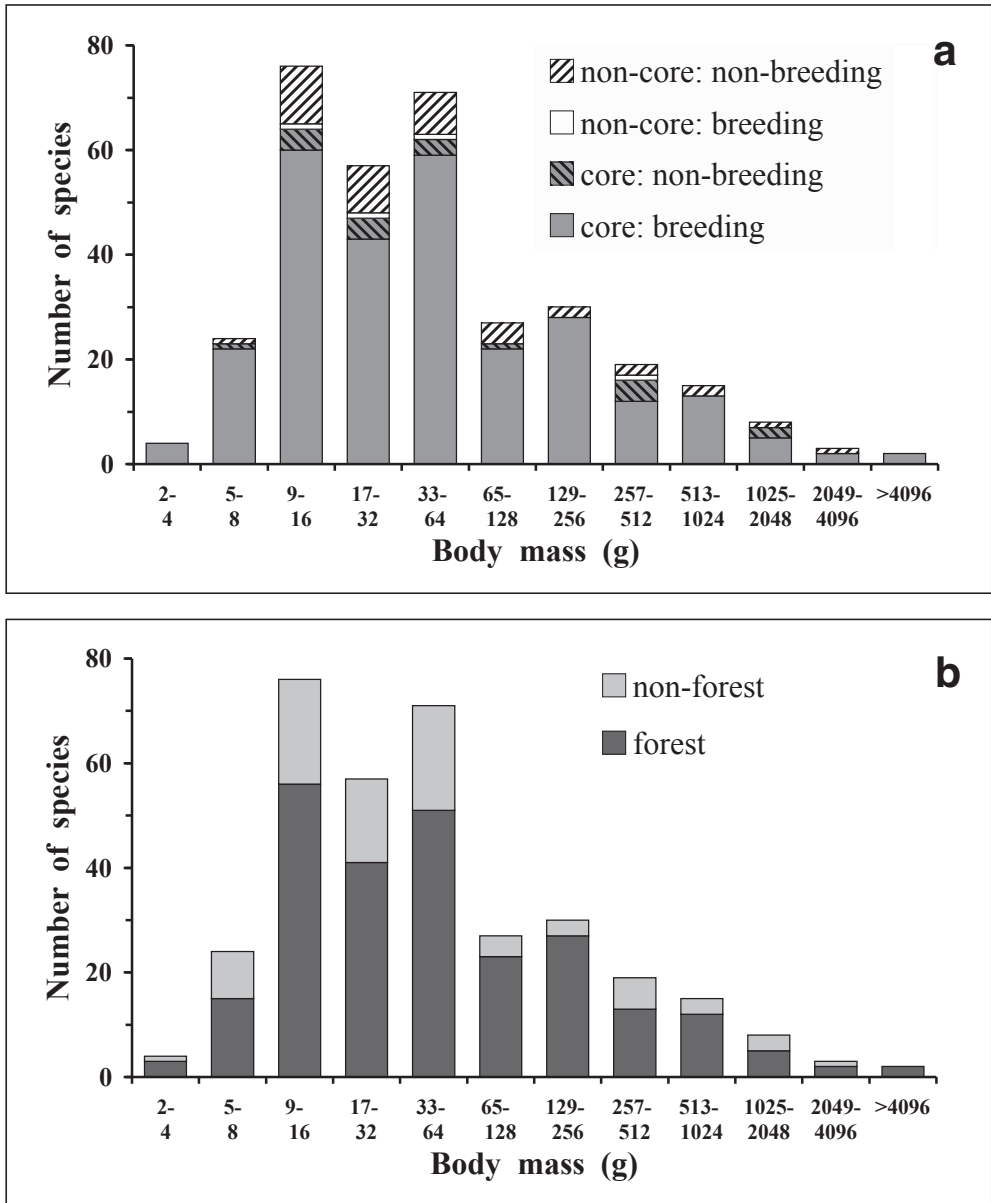


FIG. 28. Proportion of species per body mass class (log2 scale) in the bird community of Playa de Oro ( $n = 336$ ), (a) breeding/non-breeding and core/non-core species (sensu Remsen 1994; Appendix 6), (b) forest/non-forest species (Appendix 8). Non-core breeding taxa presumably do not breed regularly in Playa de Oro because the area lies outside their normal distribution range and does not cover their main habitats or life zones. However, some non-core species were probably just underrecorded and might, in fact, be core taxa. Note: For the Chi-squared test I used the following combined body mass categories to avoid the expected count of some cells in the contingency table being less than five: (a) breeding/non-breeding species: 2-8 g, 65-256 g, and  $\geq 257$  g; core/non-core taxa: 2-16 g, 65-256 g, and  $\geq 257$  g; and (b) forest/non-forest species: 2-8 g, 129-512 g, and  $\geq 513$  g.

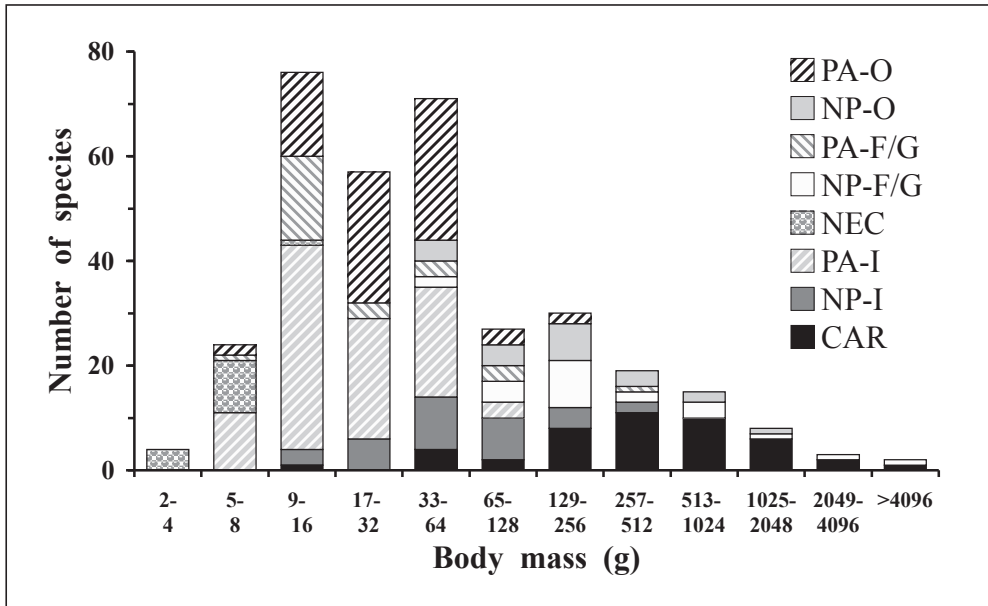


FIG. 29. Proportion of species per body mass class (log2 scale) and broad foraging guild in the bird community of Playa de Oro ( $n = 336$ ). Abbreviations used: PA-O = passerine omnivore; NP-O = non-passerine omnivore; PA-F/G = passerine frugivore and/or granivore; NP-F/G = non-passerine frugivore and/or granivore; NEC = nectarivore; PA-I = passerine insectivore; NP-I = non-passerine insectivore; CAR = carnivore; includes here, apart from scavengers, diurnal raptors and nocturnal raptors as well as piscivores.

( $\chi^2_6 = 4.954$ ,  $P = 0.55$ ) were not significant. Thus the unexpectedly low number of birds weighing 17–32 g seems to be a genuine characteristic of the bird community and independent of broad habitat or status categories.

The mean body size of core species differed drastically among foraging guilds (Fig. 29). The nectarivorous Trochilidae are uniformly small, ranging from only 2 to 12.5 g ( $\bar{x}_{core} = 5.5 \pm 2.2$ ; core species only). In general, passerines tend to be considerably smaller than non-passerines belonging to the same foraging guild; e.g., insectivorous passerines ( $\bar{x}_{core} = 23.3 \pm 18.1$  g) are on average almost four times lighter than their non-passerine counterparts ( $\bar{x}_{core} = 91.9 \pm 94.5$  g), frugivorous and granivorous passerines ( $\bar{x}_{core} = 42.1 \pm 75.0$  g) are almost 15 times smaller than non-passerines ( $\bar{x}_{core} = 626.2 \pm 991.2$  g) in the same guilds, and for omnivorous taxa the relationship between mean body masses of passerines ( $\bar{x}_{core} = 33.5 \pm 30.3$  g) and non-passerines ( $\bar{x}_{core} = 241.5 \pm 255.9$  g) is about one to seven. Note that these numbers are not easily comparable with other

studies because I have used a much broader definition of ‘omnivores’ than most authors. The smallest taxon of the bird community was *Phaethornis striigularis* (Trochilidae) with only  $c. 2.6 \pm 0.3$  g, and the largest *Harpia harpyja* (Accipitridae) with 4000–9000 g (Appendices 9 and 11).

#### Foraging flocks and foraging associations

No less than 231 (68.8%) of the 336 bird species taken into account may participate in foraging flocks (Table 22), and at least 26.5% (89) of all species can be encountered in various flock types (Table 24). Non-passerines (48.2%) are less gregarious than suboscines (76.5%) and oscines (89.7%). Almost all suboscine passerines that attend flocks do so in mixed-species flocks (93.6%), whereas about 44.8% of the oscines form single-species groups or join single-species as well as mixed-species flocks. The tendency to participate in flocks was slightly greater for non-breeding taxa (76.7%) than for breeding species (67.0%) (Table 23). Forest species (72.4%) forage more frequently in flocks than non-forest

species (58.1%). The proportion of altitudinal migrants (80.8%) attending flocks is slightly higher than that of latitudinal migrants (71%).

Army-ant-following flocks are one of the most conspicuous types of foraging associations to be found in Neotropical forest. Only three obligate army-ant followers, after the definition of Willis & Oniki (1978), occur in the lowlands of the Ecuadorian Chocó, viz. *Hylophylax naevioides*, *Gymnopathys leucaspis*, and *Phaenostictus mcleannani*. However, 34 other species recorded in Playa de Oro reportedly follow army ants at least occasionally, and *Dendrocincla fuliginosa*, *Dendrocolaptes sanctithomae*, and *Myrmeciza immaculata* regularly do so (Tables 24 and 25).

Undergrowth-to-understory mixed-species flocks, subsequently referred to as 'mixed understory flocks', are usually more diverse than ant-following flocks. In the lowlands of Playa de Oro, five suboscines, viz. *Hyloctistes virgatus*, *Dysithamnus puncticeps*, *Myrmotherula fulviventris*, *M. axillaris*, and *Sapayoa aenigma*, as well as three oscines, viz. *Hylophilus ochraceiceps*,

*Thryothorus leucopogon*, and *Chlorothraupis olivacea*, are the core members of these flocks and thus are almost always present. The noisy *C. olivacea* is usually the flock leader. In addition, there are seven taxa that can be frequently observed either in understory or in canopy flocks, and thus are referred to as stratum-switching mixed-flock attendants. These species are five suboscines, viz. *Xenops minutus*, *Xiphorhynchus lachrymosus*, *X. erythropygius*, *Thamnistes anabatinus*, and *Tolmomyias flavotectus*, and two oscines, viz. *H. decurtatus* and *Euphonia xanthogaster*. All in all, no less than 77 species reportedly accompany mixed understory flocks at least occasionally, only 7 of them being non-breeding visitors.

Mixed-species canopy flocks also tend to be very species-rich. Core species of these flocks are the tyrannid *Conopias albobittatus* and four oscine passerines, viz. *Vireolanius leucotis*, *Cyanerpes caeruleus*, *Tangara palmeri*, and *Heterospingus xanthopygius*. However, *V. leucotis* is usually missing below elevations of c. 150 m. Many other species regularly accompany

TABLE 22. Distribution of species between categories of participation in foraging flocks and major taxonomic groups (cf. Appendix 9). Note: The categories of participation exclusively refer to the frequency of flocking from the perspective of the species and not to their 'abundance rank'; e.g., *Neomorphus radiolosus* is presumably a regular army-ant follower (e.g., Ridgely & Greenfield 2001b) and consequently is listed here as a regular attendant of mixed-species flocks, but the species is so rare and cautious that it is observed only with extreme luck.

Flocking behavior	Non-passerines	Suboscine Passerines	Oscine Passerines	All species
A) Flocking species				
Participants in single-species flocks				
- Permanently or frequently flocking	16		5	21
- Regularly or seasonally flocking	9	1	7	17
- Occasionally or rarely flocking		1	2	3
Sum participants in single-species flocks	25	2	14	41
Participants in single-species & mixed-species flocks				
- Permanently or frequently flocking	6	1	7	14
- Regularly flocking	7		16	23
- Occasionally or rarely flocking	1	2	2	5
Sum participants in single-species & mixed-species flocks	14	3	25	42
Participants in mixed-species flocks				
- Core members		14	8	22
- Regular attendants	6	28	27	61
- Occasional or rare attendants	21	31	13	65
Sum participants in mixed-species flocks	27	73	48	148
Sum flocking species (all)	66	78	87	231
B) Non-flocking species	71	24	10	105
All species	137	102	97	336

TABLE 23. Distribution of species between categories of participation in foraging flocks and various status and habitat categories (cf. Appendix 9).

Flocking behavior	Reproductive status			Migrants			Importance		Habitat	
	breeding	non-breeding	altitudinal	latitudinal	all		core	non-core	forest	non-forest
A) Flocking species										
Participants in single-species flocks										
- Permanently or frequently flocking	14	7	6	3	9		16	5	13	8
- Regularly or seasonally flocking	9	8	7	5	12		11	6	11	6
- Occasionally or rarely flocking		3		3	3		3	3	3	3
Sum participants in single-species flocks	23	18	13	11	24		27	14	27	14
Participants in single-species & mixed-species flocks										
- Permanently or frequently flocking	9	5	4	1	5		12	2	10	4
- Regularly flocking	13	10	9	4	13		15	8	7	16
- Occasionally or rarely flocking	4	1	1	1	2		4	1	4	1
Sum participants in single-species & mixed-species flocks	26	16	14	6	20		31	11	21	21
Participants in mixed-species flocks										
- Core members	22						22		22	
- Regular attendants	56	5	5	3	8		56	5	54	7
- Occasional or rare attendants	58	7	10	2	12		61	4	57	8
Sum participants in mixed-species flocks	136	12	15	5	20		139	9	133	15
Sum flocking species (all)	185	46	42	22	64		197	34	181	50
B) Non-flocking species										
	91	14	10	9	19		94	11	69	36
All species	276	60	52	31	83		291	45	250	86

TABLE 24. Participants in foraging flocks per major taxonomic group (cf. Appendix 9). In contrast to Table 22, species that participate in various flock types were counted repeatedly. Notes: (a) species that either participate in understory or canopy flocks and regularly or frequently switch between them; (b) some Cracidae and Odontophoridae; (c) e.g., some Cathartidae, Ardeidae, and others; (d) Apodidae and Hirundinidae, including migratory species; (e) without Apodidae and Hirundinidae.

Type of foraging flock or foraging aggregation	Non-passerines	Suboscine Passerines	Oscine Passerines	Grand total
A) Forest and forest-edge flocks				
Ant-following flocks				
- Obligate attendants		3		3
- Regular attendants	1	3		4
- Occasional or rare attendants	12	11	7	30
Sum ant-following flocks	13	17	7	37
Mixed-species undergrowth-to-understory flocks				
- Core members		5	3	8
- Regular attendants		8	4	12
- Occasional or rare attendants	4	14	5	23
Sum mixed-species undergrowth-to-understory flocks	4	27	12	43
Stratum-switching mixed-species flock attendants <sup>a</sup>				
- Core members		5	2	7
- Regular attendants	2	7	4	13
- Occasional or rare attendants	9	3	2	14
Sum stratum-switching mixed-species flock attendants	11	15	8	34
Mixed-species canopy flocks				
- Core members		1	4	5
- Regular attendants	2	8	15	25
- Occasional or rare attendants		1	5	6
Sum mixed-species canopy flocks	2	10	24	36
Single-species ground-dwelling flocks <sup>b</sup>				
- Regularly or seasonally flocking	3			3
Single-species undergrowth-to-understory flocks				
- Permanently or frequently flocking	1		2	3
Single-species canopy flocks				
- Permanently or frequently flocking	9	1	2	12
- Regularly or seasonally flocking	5	1	5	11
- Occasionally or rarely flocking		1		1
Sum single-species canopy flocks	14	3	7	24
Mixed-species forest-edge flocks				
- Core members			1	1
- Regular attendants	1	5	13	19
- Occasional or rare attendants	1	14	7	22
Sum mixed-species forest-edge flocks	2	19	21	42
Single-species forest-edge flocks				
- Permanently or frequently flocking			3	3
- Regularly or seasonally flocking			5	5
- Occasionally or rarely flocking		1	2	3
Sum single-species forest-edge flocks		1	10	11
B) Non-forest flocks				
Non-passerine non-forest foraging associations <sup>c</sup>				
- Permanently or frequently flocking	2			2
- Regularly or seasonally flocking	5			5
- Occasionally or rarely flocking	1			1
Sum non-passerine non-forest foraging associations	8			8

TABLE 24. Continued.

Type of foraging flock or foraging aggregation	Non-passerines	Suboscine Passerines	Oscine Passerines	Grand total
Mixed-species grassland flocks				
- Regularly or seasonally flocking			8	8
- Occasionally or rarely flocking			1	1
Sum mixed-species grassland flocks			9	9
Single-species grassland flocks				
- Permanently or frequently flocking	2		1	3
- Regularly or seasonally flocking			8	8
Sum single-species grassland flocks	2		9	11
Aerial foraging flocks <sup>d</sup>				
- Permanently or frequently flocking	5		3	8
- Regularly or seasonally flocking	1		6	7
Sum aerial foraging flocks	6		9	15
Migration flocks <sup>e</sup>				
- Permanently or frequently flocking	3			3
- Regularly or seasonally flocking	2		1	3
- Occasionally or rarely flocking		1	4	5
Sum migration flocks	5	1	5	11
C) Non-flocking species	71	24	10	105
Grand total	142	117	133	392

canopy flocks, namely thrupids of the genera *Dacnis* and *Tangara* as well as *Euphonia* and several small tyrannids. Together with the stratum-switching mixed-flock attendants, about 70 species reportedly accompany canopy flocks at least occasionally, only five of which are non-breeding visitors.

The flocking behavior of *Tachyphonus delatrii*, one of the commonest thrupids of the Chocoan lowland forest, is also very interesting. This species is usually encountered in noisy monospecific foraging flocks of 4 to 20 or more individuals, which quickly move through the forest undergrowth and understory, sometimes flying up into fruiting canopy trees for brief periods of time. Furthermore, groups of *T. delatrii* regularly join mixed understory flocks and sometimes may function even as the nucleus of their formation.

Some non-passerine taxa, especially Psittacidae and Ramphastidae, regularly form single-species canopy flocks. Frequency of flocking as well as flock size may vary considerably with season and are usually greatest in the non-breeding periods. Sometimes different species may gather in the same fruiting trees, but they usually keep themselves separate. Only one suboscine passerine, viz. *Querula purpurata*, regularly forms monospecific canopy flocks of three to eight individuals, which may represent extended family

groups. The colonially breeding icterids *Cacicus microrhynchus* and *Zarhynchus wagleri* are permanently-flocking oscines. In Playa de Oro both are usually encountered in single-species groups, but sometimes they flock together and may also attend mixed canopy or understory flocks.

The composition of mixed forest-edge flocks is considerably less well defined than that of mixed understory and canopy flocks. In Playa de Oro only one species, *Hylophilus decurtatus*, which is also a core species of mixed canopy flocks, was present in almost all forest-edge flocks. Regular attendants include more oscine than suboscine taxa, such as *Tangara* and *Thraupis* tanagers as well as cardinalids like *Saltator*. Apart from *H. decurtatus*, some forest birds, typically canopy-dwelling species, were also present in most forest-edge flocks.

*Mitrospingus cassinii*, an oscine with uncertain taxonomic relationship (Appendix 5), permanently lives in monospecific groups. The taxon inhabits the undergrowth of forest edges along rivers and streams and is one of the most conspicuous species in this habitat. However, like many other single-species flock-forming taxa, they also regularly attend mixed-species flocks.

In Playa de Oro, non-forest foraging associations are much less conspicuous and less important than



TABLE 25. Participants in foraging flocks in various status and habitat categories (cf. Appendix 9). In contrast to Table 23, species that participate in various flock types were counted repeatedly. Notes: see Table 24.

Type of foraging flock or foraging aggregation	Reproductive status		Migrants		Importance		Habitat	
	breeding	non-breeding	altitudinal	latitudinal	core	non-core	forest	non-forest
A) Forest and forest-edge flocks								
Ant-following flocks								
- Obligate attendants	3				3		3	3
- Regular attendants	4				4		4	4
- Occasional or rare attendants	29	1	1	1	30		30	30
Sum ant-following flocks	36	1	1	1	37		37	37
Mixed-species undergrowth-to-understory flocks								
- Core members	8				8		8	8
- Regular attendants	12		1		12		12	12
- Occasional or rare attendants	19	4	5	2	20	3	23	23
Sum mixed-species undergrowth-to-understory flocks	39	4	6	2	40	3	43	43
Stratum-switching mixed-species flock attendants <sup>a</sup>								
- Core members	7				7		7	7
- Regular attendants	11	2	2	1	10	3	13	13
- Occasional or rare attendants	13	1	2	2	14		14	14
Sum stratum-switching mixed-species flock attendants	31	3	4	1	31	3	34	34
Mixed-species canopy flocks								
- Core members	5				5		5	5
- Regular attendants	23	2	2	1	23	2	25	25
- Occasional or rare attendants	6		1	1	6		5	1
Sum mixed-species canopy flocks	34	2	3	1	34	2	35	1
Single-species ground-dwelling flocks <sup>b</sup>								
- Regularly or seasonally flocking	3				3		3	3
Single-species undergrowth-to-understory flocks								
- Permanently or frequently flocking	3				3		3	3
Single-species canopy flocks								
- Permanently or frequently flocking	10	2	2		10	2	12	12
- Regularly or seasonally flocking	8	3	7		9	2	11	11
- Occasionally or rarely flocking	1				1		1	1
Sum single-species canopy flocks	19	5	9		20	4	24	24

TABLE 25. Continued.

Type of foraging flock or foraging aggregation	Reproductive status		Migrants		Importance		Habitat	
	breeding	non-breeding	altitudinal	latitudinal	core	non-core	forest	non-forest
Mixed-species forest-edge flocks								
- Core members	1				1		1	1
- Regular attendants	17	2	1	2	3	18	11	8
- Occasional or rare attendants	18	4	4	1	5	20	12	10
Sum mixed-species forest-edge flocks	36	6	5	3	8	39	24	18
Single-species forest-edge flocks								
- Permanently or frequently flocking	3		1		1	3	3	3
- Regularly or seasonally flocking	5					5	1	4
- Occasionally or rarely flocking	2	1		1	1	2	2	1
Sum single-species forest-edge flocks	10	1	1	1	2	10	6	5
B) Non-forest flocks								
Non-passerine non-forest foraging associations <sup>c</sup>								
- Permanently or frequently flocking		2	2		2	1		2
- Regularly or seasonally flocking	1	4	4		4	3	1	4
- Occasionally or rarely flocking	1		1		1	1	1	1
Sum non-passerine non-forest foraging associations	2	6	7		7	5	2	6
Mixed-species grassland flocks								
- Regularly or seasonally flocking	4	4	3	2	5	4		8
- Occasionally or rarely flocking	1					1		1
Sum mixed-species grassland flocks	5	4	3	2	5	5		9
Single-species grassland flocks								
- Permanently or frequently flocking	2	1	1		1	2	1	3
- Regularly or seasonally flocking	4	4	3	2	5	4	1	7
Sum single-species grassland flocks	6	5	4	2	6	6	1	10
Aerial foraging flocks								
- Permanently or frequently flocking	3	5	3	2	5	6	3	5
- Regularly or seasonally flocking	2	5	2	4	6	3	1	6
Sum aerial foraging flocks	5	10	5	6	11	9	4	11
Migration flocks <sup>c</sup>								
- Permanently or frequently flocking	1	2	1	2	3	2	1	2
- Regularly or seasonally flocking	1	2		3	3	1	1	2
- Occasionally or rarely flocking		5		5	5	5	5	5
Sum migration flocks	2	9	1	10	11	3	7	4
C) Non-flocking species	91	14	10	9	19	94	69	36
Grand total	322	70	59	38	97	339	292	100
						53		392

TABLE 26. Observed and estimated species richness, and number of individuals recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. Abbreviations used: (a) data set:  $MN_{cap1}$  = mist-netting data; included are first captures and recaptures trapped for the first time in the corresponding surveys, I to III (Appendices 12a and 12b);  $MN_{ic}$  = first captures only;  $MTW_{pop}$  = number of individuals and species per 100 ha calculated on the basis of the transect-mapping data (Appendices 18a and 19a); (b) field data:  $N_{ds}$  = number of data sets used for the calculation of the species richness estimators;  $S_{obs}$  = number of species observed;  $N_{ind/b}$  = number of individuals in the sample ( $MTW_{pop}$ ,  $MN_{ic}$ , and  $MN_{cap1}$  for single surveys) or birds captured ( $MN_{cap1}$  for combined data sets, which also include recaptures obtained during different surveys); (c) species richness estimator: shown are the absolute estimates; see Methods for details (p. 115f, Species richness estimators). The gray cells indicate incidence-based estimations that were also obtained with the corresponding data sets containing all recaptures ( $MN_{cap2}$ ) or the crude number of birds recorded ( $MTW_c$ ); see Table 28.

Data set <sup>a</sup>	Field data <sup>b</sup>			Species richness estimator <sup>c</sup> (absolute value)								
	N <sub>ds</sub>	S <sub>obs</sub>	N <sub>ind/b</sub>	ACE	ICE	Chao 1	Chao 2	Jackknife 1	Jackknife 2	Bootstrap	MMRuns	MMMean
MN <sub>cap1</sub> : MNT1/I	1	80	350	102.3	—	100.4 ±11.6	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT1/II	1	88	354	109.4	—	110.0 ±12.3	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT1/III	1	86	296	122.9	—	110.4 ±11.8	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT1/I-III	3	117	1000	133.5	142.9	127.1 ±6.1	135.7 ±9.0	139.7 ±2.4	146.2	128.2	144.5	144.1
MN <sub>ic</sub> : MNT1/I-III	1	117	827	131.9	—	126.8 ±5.9	—	—	—	—	—	—
MTW <sub>pop</sub> : MNT1	1	162	5307	162.3	—	162.0 ±0.4	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT2/I	1	69	452	82.6	—	83.0 ±10.0	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT2/II	1	65	367	72.8	—	69.4 ±4.0	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT2/III	1	73	398	105.3	—	100.1 ±15.2	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT2/I-III	3	96	1217	118.2	128.3	126.1 ±19.0	145.7 ±26.3	119.3 ±4.7	129.2	106.8	116.4	115.9
MN <sub>ic</sub> : MNT2/I-III	1	96	992	120.4	—	121.1 ±14.7	—	—	—	—	—	—
MTW <sub>pop</sub> : MNT2	1	144	4817	145.5	—	144.9 ±1.9	—	—	—	—	—	—
MN <sub>cap1</sub> : MNT1&MNT2	6	135	2217	158.7	165.0	154.9 ±10.8	168.7 ±15.3	167.5 ±3.4	182.3	150.1	154.1	152.9
MN <sub>ic</sub> : MNT1&MNT2	2	135	1819	157.6	205.2	153.9 ±10.2	155.2 ±7.5	163.5 ±10.5	163.5	149.3	192.1	183.1
MTW <sub>pop</sub> : MNT1&MNT2	2	187	10124	188.0	259.9	187.5 ±1.3	206.0 ±6.7	221.0 ±9.0	221.0	204.0	243.0	239.5

TABLE 27. Accuracy of estimated and observed species richness as percentage of the known number of core species, and number of individuals recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. The number of core species was 217 at MNT1, 214 at MNT2, and 243 at both transects together. Abbreviations used: (a) data set; see Table 26; (b) field data:  $N_{dk}$  = number of data sets used for the calculation of the species richness estimators;  $S_{obs}$  (%) = relative number of species observed;  $N_{ind/b}$  = number of individuals/birds in the sample; see Table 26; (c) species richness estimator (% of core species): shown are the relative estimates; see Methods for details (p. 115f, Species richness estimators). The gray cells indicate incidence-based estimations that were also obtained with the corresponding data sets containing all recaptures ( $MN_{cap2}$ ) or the crude number of birds recorded ( $MTW_{cr}$ ); see Table 29.

Data set <sup>a</sup>	Field data <sup>b</sup>			Species richness estimator <sup>c</sup> (% of core species)							
	$N_{dk}$	$S_{obs}$ (%)	$N_{ind/b}$	ACE	ICE	Chao 1	Chao 2	Jackknife 1	Jackknife 2	Bootstrap	MMRuns
$MN_{cap1}$ : MNT1/I	1	36.9	350	47.1	—	46.3 $\pm$ 5.3	—	—	—	—	—
$MN_{cap1}$ : MNT1/II	1	40.6	354	50.4	—	50.7 $\pm$ 5.7	—	—	—	—	—
$MN_{cap1}$ : MNT1/III	1	39.6	296	56.6	—	50.9 $\pm$ 5.4	—	—	—	—	—
$MN_{cap1}$ : MNT1/I-III	3	53.9	1000	61.5	65.9	58.6 $\pm$ 2.8	62.5 $\pm$ 4.1	64.4 $\pm$ 1.1	67.4	59.1	66.6
$MN_{fc}$ : MNT1/I-III	1	53.9	827	60.8	—	58.4 $\pm$ 2.7	—	—	—	—	—
$MTW_{pop}$ : MNT1	1	74.7	5307	74.8	—	74.7 $\pm$ 0.2	—	—	—	—	—
$MN_{cap1}$ : MNT2/I	1	32.2	452	38.6	—	38.8 $\pm$ 4.7	—	—	—	—	—
$MN_{cap1}$ : MNT2/II	1	30.4	367	34.0	—	32.4 $\pm$ 1.9	—	—	—	—	—
$MN_{cap1}$ : MNT2/III	1	34.1	398	49.2	—	46.8 $\pm$ 7.1	—	—	—	—	—
$MN_{cap1}$ : MNT2/I-III	3	44.9	1217	55.2	60.0	58.9 $\pm$ 8.9	68.1 $\pm$ 12.3	55.7 $\pm$ 2.2	60.4	49.9	54.4
$MN_{fc}$ : MNT2/I-III	1	44.9	992	56.3	—	56.6 $\pm$ 6.9	—	—	—	—	—
$MTW_{pop}$ : MNT2	1	67.3	4817	68.0	—	67.7 $\pm$ 0.9	—	—	—	—	—
$MN_{cap1}$ : MNT1&MNT2	6	55.6	2217	65.3	67.9	63.7 $\pm$ 4.4	69.4 $\pm$ 6.3	68.9 $\pm$ 1.4	75.0	61.8	63.4
$MN_{fc}$ : MNT1&MNT2	2	55.6	1819	64.9	84.4	63.3 $\pm$ 4.2	63.9 $\pm$ 3.1	67.3 $\pm$ 4.3	67.3	61.4	79.1
$MTW_{pop}$ : MNT1&MNT2	2	77.0	10124	77.4	107.0	77.2 $\pm$ 0.5	84.8 $\pm$ 2.8	90.9 $\pm$ 3.7	90.9	84.0	100.0

forest flocks, due to the small extent of open habitats. However, aerial flocks of swifts or swallows more often draw attention when they forage above rivers or clearings.

#### The bird community of human-influenced habitat mosaics

##### Observed and estimated species richness

Of the 231 species recorded by standardized and non-standardized sampling at MNT1, 217 (93.9%) were core species (see Appendix 6 for the definition of core species). At the same transect, two non-core latitudinal migrants (*Catharus ustulatus* and *Oporornis agilis*) were trapped during standardized mist-netting surveys, in addition to 115 (98.3%) core species. By contrast, exclusively core taxa ( $n = 162$ ) were detected by transect mapping. At MNT2, 214 (92.6%) taxa out of a total of 231 observed during standardized and non-standardized sampling were core species. Four non-core species (*Pachyrhamphus albogriseus*, *C. ustulatus*, *Pheucticus ludovicianus*, and *Rhodospingus cruentus*) were captured among 92 (95.8%) core taxa. Again, only core species (144) were recorded by MTW sampling. For both transects together, 243 (90.7%) taxa out of a total of 268 noted during standardized and non-standardized sampling were core species. Five non-core taxa (see above) were mist-netted among 130 (96.3%) core species, and out of a total of 187 species recorded by transect mapping not even one taxon was non-core.

For all species richness statistics tested, the estimates were sensitive to sample size as well as completeness of the species inventories (Tables 26 and 28). In general, higher numbers of species and individuals per taxon in the samples led to higher estimates of total species richness, i.e., data sets of the transect-mapping study in comparison with the less complete mist-netting samples. However, there were exceptions for samples with similar numbers of species and individuals as well as between richness estimators, and thus no clear-cut rules are discernible. For instance, in mist-netting survey MNT2/III, fewer species ( $n_{\text{sp}} = 73$ ) and 'individuals' ( $n_b = 501$ ;  $MN_{\text{cap}2}$ ) were recorded than in transect-mapping survey MNT2/I ( $n_{\text{sp}} = 86$ ,  $n_b = 614$ ), but abundance-based estimators ACE and Chao 1 computed higher richness values for the former sample. Furthermore, no clear tendency was discernible regarding the estimated total species richness when comparing abundance-based statistics between mist-netting data

sets containing only first captures ( $MN_{\text{fc}}$ ), first captures of each survey ( $MN_{\text{cap}1}$ ), and all types of recaptures ( $MN_{\text{cap}2}$ ).

In contrast to abundance-based statistics, incidence-based estimators always led to the same results, as long as the number and composition of species per sample is constant, because calculations are made with presence/absence matrixes. Although only abundance-based statistics can be computed for single data sets, it seems that they are not suitable for an accurate estimation of the total number of species based on mist-netting or transect-mapping data. Both ACE and Chao 1 notoriously underestimated species richness (Tables 27 and 29), and for combined data sets they produced identical results, so long as species abundance is constant (Table 28).

The highest and most accurate values were obtained with incidence-based statistics, namely ICE, MMRuns, MMMean, Jackknife 2, and Chao 2. Nevertheless, it is obvious that estimates based on mist-netting data do not reveal the true species richness of the transect areas, especially when single surveys were analyzed. Estimations computed for data sets of the complete mist-netting study (MNT1/I-III and MNT2/I-III) still underestimated total richness of core species by at least 32%. Better estimates were obtained only when both transects were analyzed together. When all species captured in the course of the standardized study were combined within one data set per transect, ICE estimated the total richness of core species at MNT1 and MNT2 with an accuracy of 84.4%.

In the case of transect mapping, estimations of total species richness should not be based on single rapid assessment surveys either (Table 29). However, accuracy increases rapidly with a rising number of surveys and reaches 77.0 to 97.7% (ICE) when computed on the basis of only two complete MTW surveys. The lower values correspond to earlier transect-mapping samples, reflecting my insufficient experience and identification skills in the start phase of the study. When analyzing the data of both transects together, Jackknife 2 predicted 87.6% of the species richness, resulting when the eight complete surveys were regarded as separate samples, and MMRuns estimated 90.6% for four samples in which, for each transect, surveys 1 and 2 as well as 3 and 4 had been combined. Finally, for one accumulated sample per transect, each containing all species of surveys 1 to 4, ICE overestimated the total number of core species by 7%. Estimations calculated for the latter data set

TABLE 28. Observed and estimated species richness, and number of birds captured/recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. Abbreviations used: (a) data set (cf. Appendices 12a and 12b);  $MN_{cap2}$  = mist-netting data; all types of captures and recaptures obtained in the corresponding surveys, I to III, are included;  $MTW_c$  = transect-mapping data; all birds are included, even those repeatedly recorded in the corresponding surveys, I to 4; (b) field data:  $N_{ds}$  = number of data sets used for the calculation of the species richness estimators;  $S_{obs}$  = number of species observed;  $N_b$  = number of birds captured/recorded (includes recaptures or repeatedly observed individuals); (c) species richness estimator: shown are the absolute estimates; see Methods for details (p. 115 f. Species richness estimators). The gray cells indicate incidence-based estimations that were also obtained with the corresponding data sets containing only the first captures for each survey ( $MN_{cap1}$ ) or the modeled population data for 100 ha ( $MTW_{pop}$ ); see Table 26.

Data set <sup>a</sup>	Field data <sup>b</sup>			Species richness estimator <sup>c</sup> (absolute values)								
	N <sub>ds</sub>	S <sub>obs</sub>	N <sub>b</sub>	ACE	ICE	Chao 1	Chao 2	Jackknife 1	Jackknife 2	Bootstrap	MMRuns	MMMean
MN <sub>cap2</sub> : MNT1/I	1	80	449	100.4	—	99.8 ±11.9	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT1/II	1	88	401	105.0	—	109.5 ±12.7	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT1/III	1	86	349	113.6	—	106.8 ±10.7	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT1/I-III	3	117	1199	134.2	142.9	128.5 ±6.9	135.7 ±9.0	139.7 ±2.4	146.2	128.2	144.5	144.1
MTW <sub>c</sub> : MNT1/I	1	105	609	122.7	—	118.7 ±7.8	—	—	—	—	—	—
MTW <sub>c</sub> : MNT1/2	1	111	803	123.4	—	120.6 ±6.0	—	—	—	—	—	—
MTW <sub>c</sub> : MNT1/3	1	120	1021	150.0	—	159.7 ±20.0	—	—	—	—	—	—
MTW <sub>c</sub> : MNT1/4	1	126	1136	140.6	—	147.3 ±13.0	—	—	—	—	—	—
MTW <sub>c</sub> : MNT1/I&2	2	130	1412	139.6	174.51	138.6 ±5.8	140.9 ±4.9	152.0 ±3.0	152.0	141.0	164.0	163.5
MTW <sub>c</sub> : MNT1/3&4	2	151	2157	165.4	212.0	165.6 ±8.5	167.0 ±6.2	179.0 ±3.0	179.0	165.0	196.3	195.8
MTW <sub>c</sub> : MNT1/I+2&3+4	2	162	3569	169.6	199.0	174.4 ±9.2	169.5 ±3.7	183.5 ±10.5	183.5	172.8	195.6	192.1
MTW <sub>c</sub> : MNT1/I-4	4	162	3569	169.6	179.0	174.4 ±9.2	178.1 ±8.1	185.3 ±10.3	191.4	173.7	188.4	187.4
MN <sub>cap2</sub> : MNT2/I	1	69	567	78.5	—	77.3 ±6.8	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT2/II	1	65	459	72.3	—	69.7 ±4.3	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT2/III	1	73	501	100.8	—	105.6 ±20.3	—	—	—	—	—	—
MN <sub>cap2</sub> : MNT2/I-III	3	96	1527	119.6	128.3	126.8 ±20.4	145.7 ±26.3	119.3 ±4.7	129.2	106.8	116.4	115.9
MTW <sub>c</sub> : MNT2/I	1	86	614	94.4	—	93.5 ±5.9	—	—	—	—	—	—
MTW <sub>c</sub> : MNT2/2	1	93	587	111.5	—	108.9 ±9.6	—	—	—	—	—	—
MTW <sub>c</sub> : MNT2/3	1	112	858	131.0	—	130.8 ±10.9	—	—	—	—	—	—
MTW <sub>c</sub> : MNT2/4	1	104	738	121.0	—	127.2 ±13.8	—	—	—	—	—	—
MTW <sub>c</sub> : MNT2/1&2	2	112	1201	128.2	164.7	127.9 ±9.6	126.6 ±6.2	134.5 ±3.5	134.5	123.3	151.0	150.0
MTW <sub>c</sub> : MNT2/3&4	2	132	1596	150.1	183.4	150.8 ±10.9	145.3 ±5.6	156.0 ±4.0	156.0	144.0	170.3	169.3
MTW <sub>c</sub> : MNT2/1+2&3+4	2	144	2797	155.3	185.4	154.7 ±7.2	153.4 ±4.4	166.0 ±10.0	166.0	155.0	180.9	176.5
MTW <sub>c</sub> : MNT2/I-4	4	144	2797	155.3	159.6	154.7 ±7.2	152.2 ±4.7	164.3 ±5.3	163.8	155.2	173.9	171.6
MN <sub>cap2</sub> : MNT1&MNT2	6	135	2726	158.1	165.0	156.0 ±11.4	168.7 ±15.3	167.5 ±3.4	182.3	150.1	154.1	152.9
MN <sub>cap2</sub> : MNT1&MNT2	2	135	2726	158.1	205.2	156.0 ±11.4	155.2 ±7.5	163.5 ±10.5	163.5	149.3	192.1	183.1
MTW <sub>c</sub> : MNT1&MNT2	8	187	6366	196.1	199.2	201.0 ±10.0	199.5 ±7.2	208.9 ±5.5	212.8	198.5	211.6	210.3
MTW <sub>c</sub> : MNT1&MNT2	4	187	6366	196.1	205.7	201.0 ±10.0	199.5 ±6.1	212.5 ±7.2	214.8	200.6	220.2	217.6
MTW <sub>c</sub> : MNT1&MNT2	2	187	6366	196.1	259.9	201.0 ±10.0	206.0 ±6.7	221.0 ±9.0	221.0	204.0	243.0	239.5



TABLE 29. Accuracy of estimated and observed species richness as percentage of the known number of core species, and number of individuals recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. The number of core species was 217 at MNT1, 214 at MNT2, and 243 at both transects together. Abbreviations used: (a) data set: see Table 28; (b) field data:  $N_{ds}$  = number of data sets used for the calculation of the species richness estimators;  $S_{obs}\%$  = relative number of species observed;  $N_b$  = number of birds captured/recorded; (c) species richness estimator (% of core species): shown are the relative estimates; see Methods for details (p. 115f; Species richness estimators). The gray cells indicate incidence-based estimations that were also obtained with the corresponding data sets containing only the first captures for each survey ( $MN_{cap1}$ ) or the modeled population data for 100 ha ( $MTW_{pop}$ ); see Table 27.

Data set <sup>a</sup>	Field data <sup>b</sup>			Species richness estimator <sup>c</sup> (% of core species)									
	$N_{ds}$	$S_{obs}\%$	$N_b$	ACE	ICE	Chao 1	Chao 2	Jackknife 1	Jackknife 2	Bootstrap	MMRuns	MMMean	
$MN_{cap2}$ : MNT1/I	1	36.9	449	46.3	—	46.0 $\pm$ 5.5	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT1/II	1	40.6	401	48.4	—	50.5 $\pm$ 5.9	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT1/III	1	39.6	349	52.4	—	49.2 $\pm$ 4.9	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT1/I-III	3	53.9	1199	61.8	65.9	59.2 $\pm$ 3.2	62.5 $\pm$ 4.1	64.4 $\pm$ 1.1	67.4	59.1	66.6	66.4	66.4
$MTW_c$ : MNT1/I	1	48.4	609	56.5	—	54.7 $\pm$ 3.6	—	—	—	—	—	—	—
$MTW_c$ : MNT1/2	1	51.2	803	56.9	—	55.6 $\pm$ 2.8	—	—	—	—	—	—	—
$MTW_c$ : MNT1/3	1	55.3	1021	69.1	—	73.6 $\pm$ 9.2	—	—	—	—	—	—	—
$MTW_c$ : MNT1/4	1	58.1	1136	64.8	—	67.9 $\pm$ 6.0	—	—	—	—	—	—	—
$MTW_c$ : MNT1/1&2	2	59.9	1412	64.3	80.4	63.9 $\pm$ 2.7	64.9 $\pm$ 2.3	70.0 $\pm$ 1.4	70.0	65.0	75.6	75.3	75.3
$MTW_c$ : MNT1/3&4	2	69.6	2157	76.2	97.7	76.3 $\pm$ 3.9	77.0 $\pm$ 2.9	82.5 $\pm$ 1.4	82.5	76.0	90.5	90.2	90.2
$MTW_c$ : MNT1/1+2&3+4	2	74.7	3569	78.2	91.7	80.4 $\pm$ 4.2	78.1 $\pm$ 1.7	84.6 $\pm$ 4.8	84.6	79.6	90.1	88.5	88.5
$MTW_c$ : MNT1/1-4	4	74.7	3569	78.2	82.5	80.4 $\pm$ 4.2	82.1 $\pm$ 3.7	85.4 $\pm$ 4.7	88.2	80.0	86.8	86.4	86.4
$MN_{cap2}$ : MNT2/I	1	32.2	567	36.7	—	36.1 $\pm$ 3.2	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT2/II	1	30.4	459	33.8	—	32.6 $\pm$ 2.0	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT2/III	1	34.1	501	47.1	—	49.3 $\pm$ 9.5	—	—	—	—	—	—	—
$MN_{cap2}$ : MNT2/I-III	3	44.9	1527	55.9	60.0	59.3 $\pm$ 9.5	68.1 $\pm$ 12.3	55.7 $\pm$ 2.2	60.4	49.9	54.4	54.2	54.2
$MTW_c$ : MNT2/I	1	40.2	614	44.1	—	43.7 $\pm$ 2.8	—	—	—	—	—	—	—
$MTW_c$ : MNT2/2	1	43.5	587	52.1	—	50.9 $\pm$ 4.5	—	—	—	—	—	—	—
$MTW_c$ : MNT2/3	1	52.3	858	61.2	—	61.1 $\pm$ 5.1	—	—	—	—	—	—	—
$MTW_c$ : MNT2/4	1	48.6	738	56.5	—	59.4 $\pm$ 6.4	—	—	—	—	—	—	—
$MTW_c$ : MNT2/1&2	2	52.3	1201	59.9	77.0	59.8 $\pm$ 4.5	59.2 $\pm$ 2.9	62.9 $\pm$ 1.6	62.9	57.6	70.6	70.1	70.1
$MTW_c$ : MNT2/3&4	2	61.7	1596	70.1	85.7	70.5 $\pm$ 5.1	67.9 $\pm$ 2.6	72.9 $\pm$ 1.9	72.9	67.3	79.6	79.1	79.1
$MTW_c$ : MNT2/1+2&3+4	2	67.3	2797	72.6	86.6	72.3 $\pm$ 3.4	71.7 $\pm$ 2.1	77.6 $\pm$ 4.7	77.6	72.4	84.5	82.5	82.5
$MTW_c$ : MNT2/1-4	4	67.3	2797	72.6	74.6	72.3 $\pm$ 3.4	71.1 $\pm$ 2.2	76.8 $\pm$ 2.5	76.5	72.5	81.3	80.2	80.2
$MN_{cap2}$ : MNT1&MNT2	6	55.6	2726	65.1	67.9	64.2 $\pm$ 4.7	69.4 $\pm$ 6.3	68.9 $\pm$ 1.4	75.0	61.8	63.4	62.9	62.9
$MN_{cap2}$ : MNT1&MNT2	2	55.6	2726	65.1	84.4	64.2 $\pm$ 4.7	63.9 $\pm$ 3.1	67.3 $\pm$ 4.3	67.3	61.4	79.1	75.3	75.3
$MTW_c$ : MNT1&MNT2	8	77.0	6366	80.7	82.0	82.7 $\pm$ 4.1	82.1 $\pm$ 3.0	86.0 $\pm$ 2.3	87.6	81.7	87.1	86.5	86.5
$MTW_c$ : MNT1&MNT2	4	77.0	6366	80.7	84.7	82.7 $\pm$ 4.1	82.1 $\pm$ 2.5	87.4 $\pm$ 3.0	88.4	82.6	90.6	89.5	89.5
$MTW_c$ : MNT1&MNT2	2	77.0	6366	80.7	107.0	82.7 $\pm$ 4.1	84.8 $\pm$ 2.8	90.9 $\pm$ 3.7	90.9	84.0	100.0	98.6	98.6

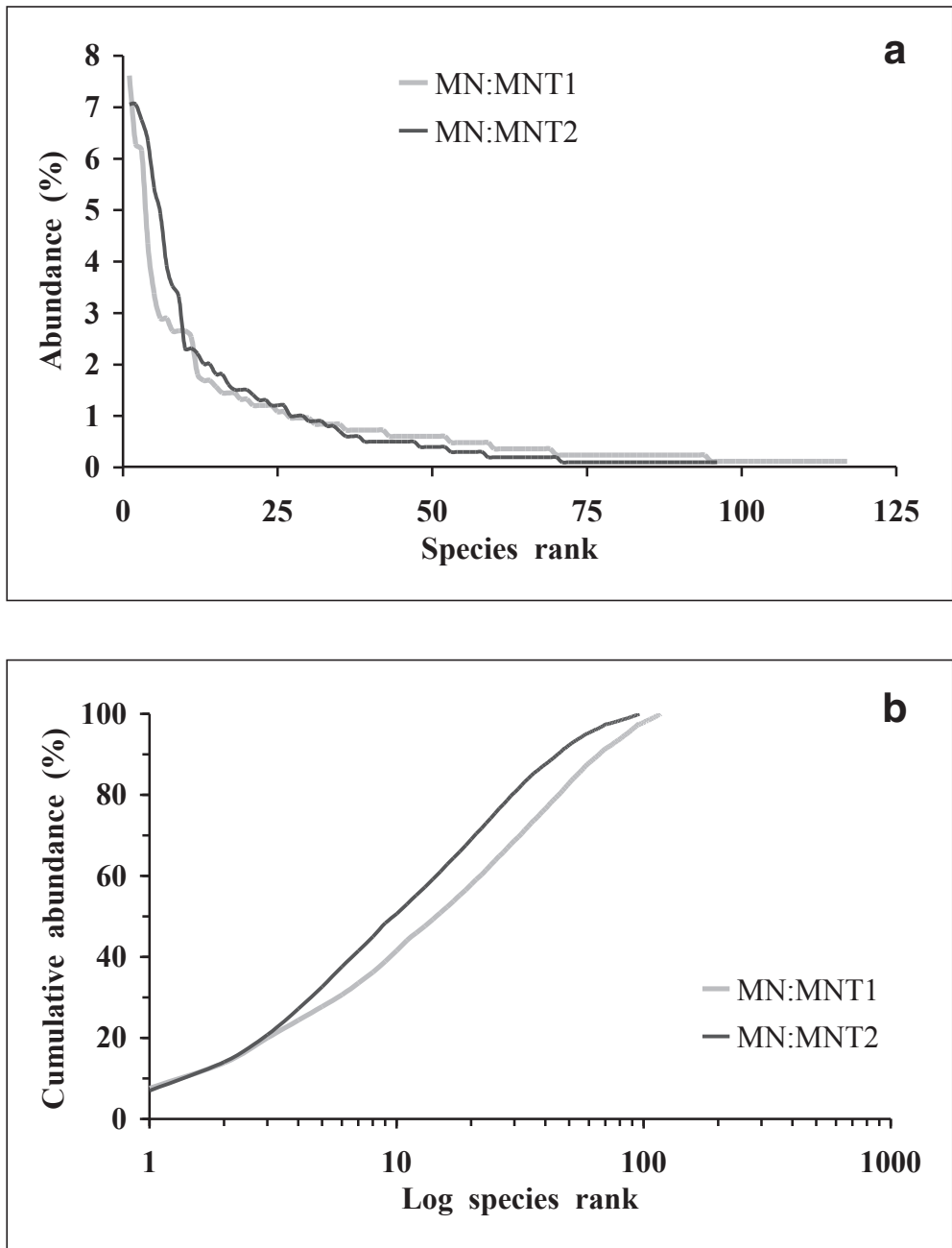


FIG. 30. Rank-abundance plots of the undergrowth avifauna at MNT1 and MNT2, based on first captures obtained during the standardized mist-netting study (Appendices 12a and 12b), (a) relative abundance versus species sequence, (b) k-dominance plot in which cumulative relative abundance is plotted against the log of species sequence. Note that for (a) the relative abundance was not plotted on a logarithmic scale (as in Fig. 31a) because the resulting stair-like pattern does not permit any meaningful interpretation.

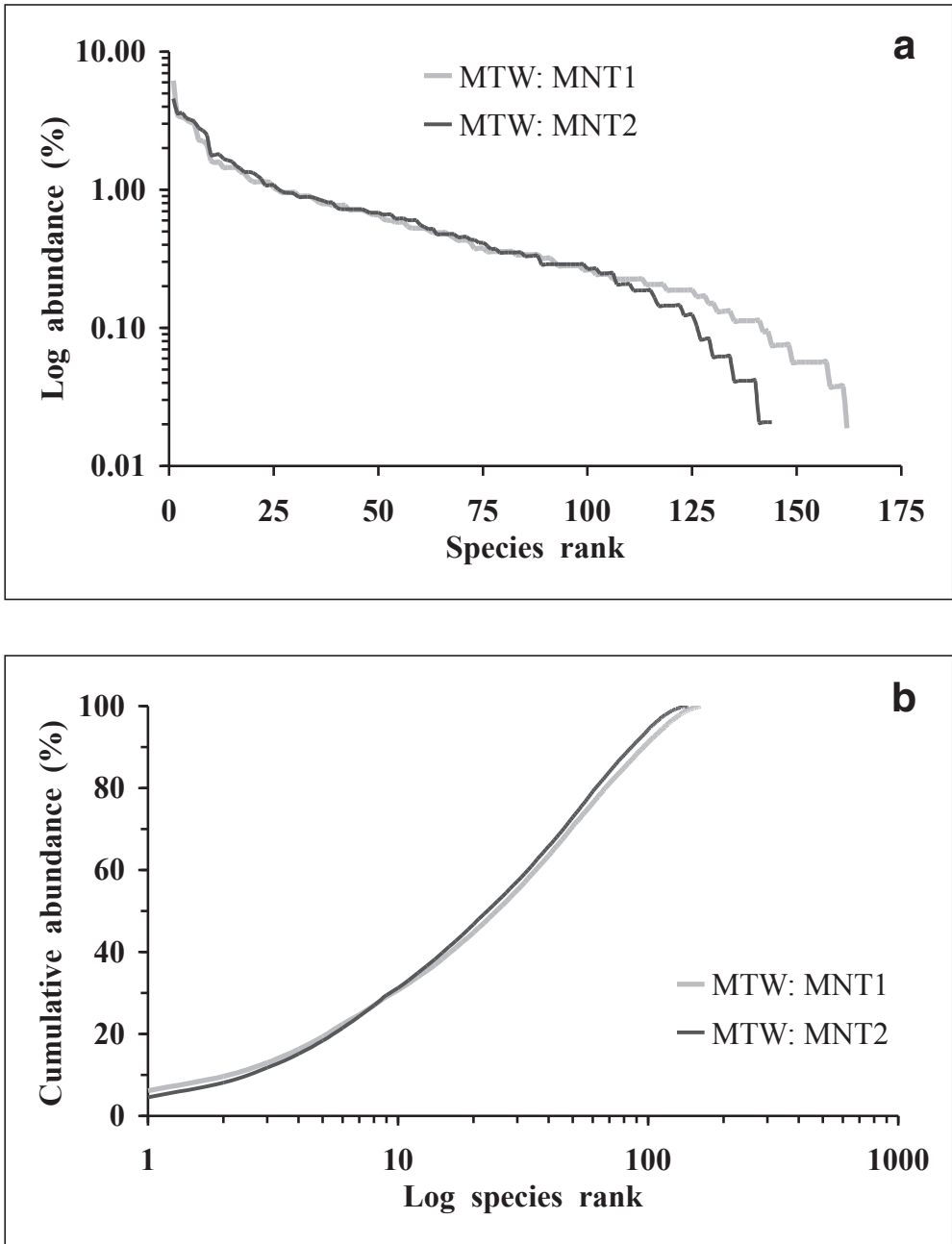


FIG. 31. Rank-abundance plots of the bird communities at MNT1 and MNT2, based on extrapolated transect-mapping (MTW) data for an area of 100 ha each (Appendices 18a and 19a), (a) log of relative abundance versus species sequence, (b) k-dominance plot in which cumulative relative abundance is plotted against the log of species sequence.

had an accuracy of 100% with MMRuns and 98.6% with MMMean. For incidence-based estimators these results were, of course, identical when estimations were founded on the extrapolated population data ( $MTW_{pop}$ ) of the transects (Table 27). By contrast, with abundance-based estimators ACE and Chao 1 it is evidently not possible to obtain meaningful richness estimations with data sets of modeled communities, since their richness estimates are almost identical to the observed number of species (Table 26).

#### Species-abundance relationship

Considering first captures exclusively, the abundance distribution of the undergrowth-dwelling avifauna was very similar at both sites, showing the typical pattern of natural communities (e.g., Magurran 1988, Tokeshi 1993), with few species being relatively common, some showing medium abundance, and most being rare (Fig. 30a). Fewer uncommon and rare taxa were captured at MNT2 than at MNT1. As a consequence, the graph of MNT2 is situated above that of MNT1 in the k-dominance plot (Fig. 30b), indicating unambiguously that the former transect had a more dominant and, hence, less diverse undergrowth bird assemblage (Platt *et al.* 1984).

Raw transect-mapping data contain an unknown number of repeatedly recorded individuals and thus are not suitable for a meaningful assessment of species-abundance relationships. However, it is possible to extrapolate species abundance as well as population density based on MTW data (Appendices 18a and 19a). According to the modeled bird community, the abundance distribution at both sites was almost identical up to rank 107, after which the number of rare taxa was lower at MNT2 than at MNT1 (Fig. 31). In both cases the sigmoid shape of the curves fits a (truncated) lognormal distribution as well as the broken-stick model (cf. Magurran 1988: 14). In the corresponding k-dominance plot, the curves of MNT1 and MNT2 do intersect, illustrating a shift in dominance relative to that of species richness.

Rank-abundance plots are not fail-safe for the assessment of which species abundance model provides the best description of community data (Magurran 1988), and thus mathematical fit was also tested formally (Figs. 32a to 34b; Table 30). For first captures the distribution of species over the abundance categories was very similar for both transects, but the higher number of common and lower num-

ber of uncommon to rare species at MNT2 is clearly illustrated. In both cases logarithmic series as well truncated lognormal models fit the observed distribution. However, p-values in the corresponding Chi-squared tests were higher for the log series. This tendency was even more extreme when recaptures ( $MN_{cap2}$ ) were included in the analysis for comparative reasons.

In order to assess whether the species abundance distributions of the modeled bird communities ( $MTW_{pop}$ ) are similar to the observed 'pseudo-abundance' of the crude transect-mapping data ( $MTW_c$ ), I analyzed both sets of data for MNT1 as well as for MNT2. Curiously, the observed distribution at MNT1 (Fig. 33a) was rather distinct from the one at MNT2 (Fig. 34a). The pattern for the raw MTW data of MNT1 was almost perfectly matched by the truncated lognormal model, whereas none of the three abundance models considered satisfactorily described the distribution found at MNT2 (Table 30). However, this unusual pattern observed for the latter transect did not at all impede the extrapolated abundance data fitting common abundance models. The abundance distributions of the modeled bird communities matched the truncated lognormal as well as broken-stick models (Figs. 33b and 34b). In the case of MNT1, p-values of Chi-squared tests were higher for the truncated lognormal model than for the broken stick, while the opposite was true for MNT2.

The fact that the broken-stick model can describe the abundance distribution of the modeled communities indicates that their evenness was relatively high (Magurran 1988). This is also demonstrated by the cumulative relative abundance of the 10 commonest species in the corresponding data sets (Tables 31 and 32). For example, in the modeled community of MNT1, the 10 commonest species together had a relative abundance of merely 30.8%, whereas the corresponding values in the mist-netting samples as well as in the raw transect-mapping data set were c. 11% higher. For MNT2 this difference was even more pronounced.

As expected, the composition of the 10 commonest species was identical between neither data sets gathered with different methods at the same transects, nor data sets collected with the same method at different transects. For both transects, mist-netting samples of first captures shared eight of the commonest species with those data sets containing all captures (including recaptures) from the

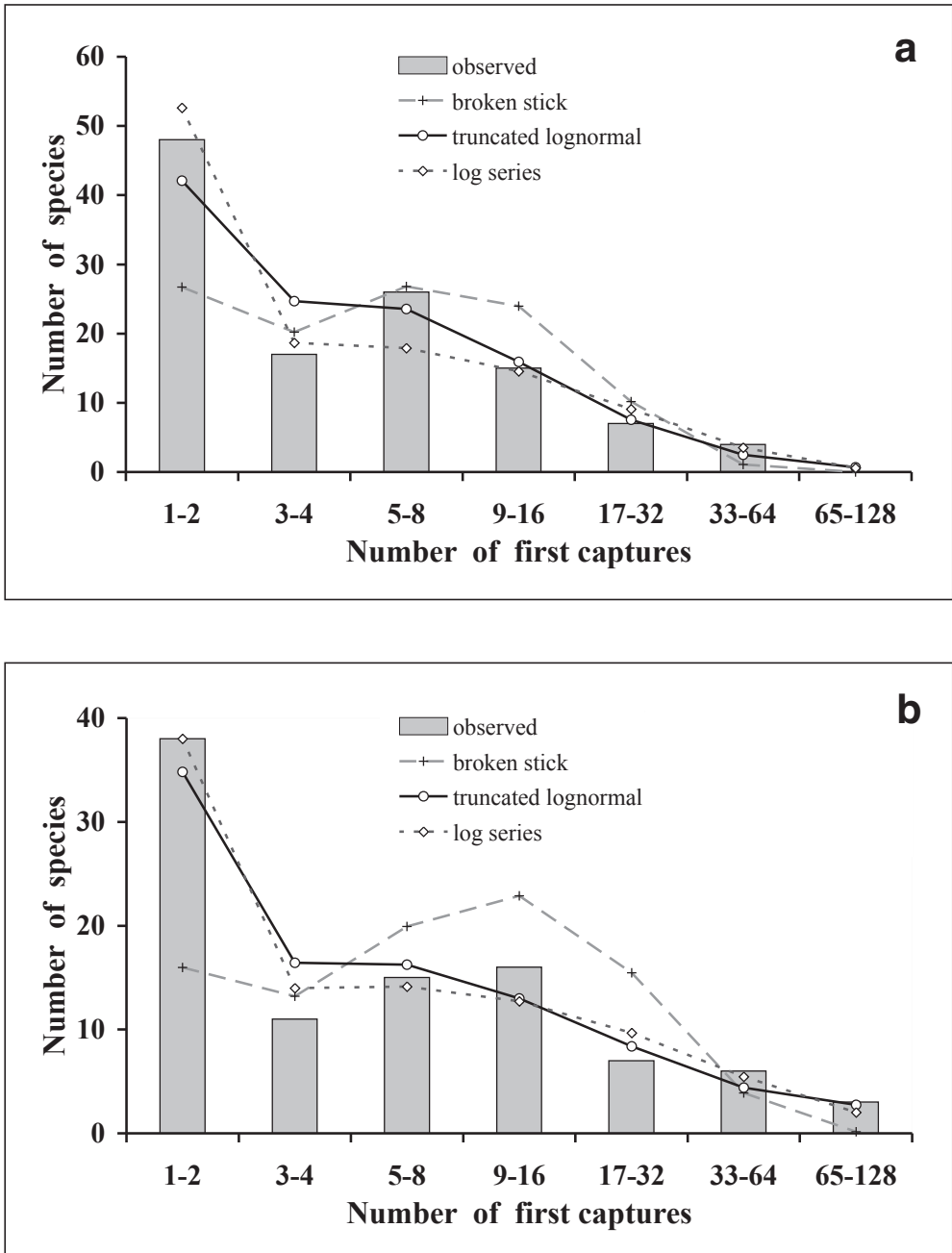


FIG. 32. Observed number of species per abundance class (log2 scale) and expected distribution according to three abundance models, fitted by using the methods described in Magurran (1988: 132-141), of first captures obtained in the standardized mist-netting study (a) at MNT1 and (b) at MNT2. See Table 30 for the corresponding Chi-squared test results.

TABLE 30. Fit of three commonly used abundance models to the observed species richness and number of birds captured/recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. Abbreviations used: (a) data set: see Tables 26 and 28; (b) field data:  $S_{\text{obs}}$  = number of species observed;  $N_{\text{b/ind}}$  = number of birds captured/recorded ( $MN_{\text{cap2}}$  and  $MTW_{\text{c}}$ ) or number of individuals ( $MN_{\text{fc}}$  and  $MTW_{\text{pop}}$ ); (c) abundance model: d.f. = degrees of freedom; P-value = probability; values indicating that the fitted abundance distributions are not significantly different from the observed ones are highlighted in gray; see Methods for details (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients); cf. Figs. 32 to 34.

Data set <sup>a</sup>	Field data <sup>b</sup>		Log series <sup>c</sup>			Truncated lognormal <sup>c</sup>			Broken stick <sup>c</sup>		
	$S_{\text{obs}}$	$N_{\text{b/ind}}$	d.f.	$\chi^2$	P-value	d.f.	$\chi^2$	P-value	d.f.	$\chi^2$	P-value
$MN_{\text{cap2}}$ : MNT1/I-III	117	1199	5	2.38	0.7941	3	5.09	0.1652	5	37.55	<0.0001
$MN_{\text{fc}}$ : MNT1/I-III	117	827	4	4.60	0.3305	2	3.54	0.1703	4	24.45	0.0001
$MTW_{\text{c}}$ : MNT1/I-4	162	3569	7	25.33	0.0007	4	0.38	0.9841	6	31.88	<0.0001
$MTW_{\text{pop}}$ : MNT1	162	5307	7	98.38	<0.0001	5	5.03	0.4128	7	12.43	0.0874
$MN_{\text{cap2}}$ : MNT2/I-III	96	1527	6	2.46	0.8727	4	5.11	0.2765	5	53.52	<0.0001
$MN_{\text{fc}}$ : MNT2/I-III	96	992	5	2.59	0.7622	3	3.59	0.3088	5	38.70	<0.0001
$MTW_{\text{c}}$ : MNT2/I-4	144	2797	6	13.86	0.0313	4	10.35	0.0349	6	49.88	<0.0001
$MTW_{\text{pop}}$ : MNT2	144	4817	7	78.13	<0.0001	5	9.44	0.0929	7	7.86	0.3454

same transect. By contrast, the crude  $MTW$  data sets shared only six and four of the commonest species at MNT1 and MNT2, respectively, with the corresponding modeled population data. The latter finding is interesting because at MNT2 the sample of first captures shared no less than seven of the commonest species with the data for the extrapolated population. For MNT1 the corresponding number of shared species was six.

Naturally, not only the composition of the commonest species was different between data sets, but also the sequence of those taxa shared between them. At MNT1, for instance, *Manacus manacus* was the most abundant species according to population estimates, but by first captures it was only the third most common species. At MNT2 the situation was just the opposite, with *M. manacus*, together with *Phaethornis yaruqui*, representing the most frequent first captures, whereas in the modeled population *M. manacus* shared rank 2.5 with *Mionectes olivaceus*. Three and four of the most commonly captured taxa at MNT1 and MNT2, respectively, were hummingbirds. In the extrapolated population data of MNT1 only one (*Threnetes ruckeri*) and at MNT2 two of them (*T. ruckeri*, *Amazilia rosenbergi*) appeared among the commonest taxa.

#### Species diversity

Fisher's  $\alpha$  of mist-netting samples gathered at MNT1 were unambiguously higher than those of MNT2

(Tables 33 and 34), and this was true for data sets containing only first captures ( $MN_{\text{fc}}$ ), first captures of each survey ( $MN_{\text{cap1}}$ ), and all types of recaptures ( $MN_{\text{cap2}}$ ). This result was already expected given the  $k$ -dominance plot (Fig. 30b) and was mostly confirmed by other indices as well, like  $\lambda$ , Shannon's  $H'$ , and Simpson's  $D$ . Furthermore,  $\alpha$  increased from survey to survey, likely because additional species were obtained with proportionally less captures in the course of the standardized mist-netting study, a conclusion that was already drawn from the shifting position of the species accumulation curves (Figs. 17a,b). However, this pattern of increasing diversity was not confirmed by other indices, for which the second mist-netting surveys at MNT1 and MNT2 produced the highest diversity values, independently of the type of captures considered in the analysis.

Diversity values tended to decrease with increasing proportion of recaptures in the corresponding samples (Tables 33 and 34). Only samples  $MN_{\text{cap1}}$  have slightly higher Simpson's  $D$  values than corresponding data sets  $MN_{\text{fc}}$ .

For  $\lambda$  as well as for Shannon's  $H'$ , the means of the three complete mist-netting surveys were smaller than the corresponding values of the combined data sets, demonstrating moderate sensitivity of these indices to sample size. At MNT1, for example, the means of  $\lambda$  ( $209.7 \pm 18.96$ ) and Shannon's  $H'$  ( $3.99 \pm 0.08$ ) were considerably lower than the correspond-



ing values of the combined data set for first captures ( $\lambda = 245.35$ ;  $H' = 4.14$ ). The survey averages for other diversity indices tended to be much more similar to the values of the combined data sets, with the exception of Shannon's evenness  $EH'$ , which was slightly higher for survey means. The same patterns were also seen for mist-netting data sets containing all types of captures.

Comparing the combined raw data sets of the four transect-mapping surveys per transect, the values of all diversity indices were slightly ( $\alpha$ ,  $H'$ , and  $D$ ) to considerably ( $\lambda$ ) higher at MNT1 than at MNT2, with the exception of Shannon's evenness  $EH'$ , which was slightly higher at MNT2. Comparing the averages of the complete MTW surveys with the results for the combined data sets of the same transects, most diversity statistics computed slightly higher values for the latter samples, with differences being most pronounced for  $\lambda$ . However, as in the case of the mist-netting samples,  $\alpha$  was less sensitive to sample size than other indices and Shannon's evenness  $EH'$  was higher for survey means than for the combined data sets of the same transects.

Interestingly, there were striking differences between diversity estimates for MNT1 and MNT2 when comparing the results for the complete studies between mist-netting and transect-mapping data. For MNT1, the combined MTW data set revealed only slightly higher diversity values than the sample of first captures ( $MN_{fc}$ ), with the difference being greatest for  $\lambda$ , but evenness was higher for the mist-netting data. By contrast, for MNT2 all indices had considerably higher values in the MTW sample than in the mist-netting data set.

For the modeled bird communities ( $MTW_{pop}$ ), most diversity statistics calculated considerably higher values than for any other samples, the only exception being  $\alpha$ , for which the pattern was much more complex. For MNT1,  $\alpha$  was smaller for the extrapolated population data than for almost all other samples. In the case of MNT2,  $\alpha$  was larger for the modeled community than for all mist-netting samples, but smaller than for almost all raw data sets of the transect-mapping study. When comparing results for the modeled data with those of first captures,  $\alpha$  was also the only index that returned almost identical values for the combined data sets of both transects together. Values for the extrapolated bird population were very similar for both transects, with the exception of the parametric statistics, which attested

considerably higher diversity for MNT1 than for MNT2.

#### Similarity between transects MNT1 and MNT2

For the interpretation of similarity coefficients obtained in comparisons between samples of MNT1 and MNT2, it is important to first analyze the corresponding coefficients for repeated surveys at each transect, in order to assess the conclusiveness of the results. Mean similarity between samples of first captures of each survey ( $MN_{cap1}$ ) was surprisingly low, for MNT1 as well as for MNT2 (Table 35). For all coefficients considered, similarity was lower on average at MNT1 than at MNT2. The incidence-based Jaccard's coefficient returned the lowest values, whereas the abundance-based Morisita-Horn produced the highest estimates for similarity between surveys. Comparing mean similarity of all possible between-transect combinations of surveys to the within-transect results, it is obvious that incidence-based coefficients, like Jaccard and Sørensen I (= qualitative variant), were only insignificantly lower between samples of MNT1 and MNT2 than between data sets obtained through resampling of the same transects. Differences were more pronounced for the quantitative (abundance-based) coefficients Sørensen II and Morisita-Horn. However, when similarity estimates were based exclusively on samples of first captures ( $MN_{fc}$ ) for each transect, the differences to within-transect means were very small, between only 0.02 (Jaccard, MNT1) and 0.15 points (Morisita-Horn, MNT2). For samples containing all types of captures ( $MN_{cap2}$ ; Table 36), the patterns of similarity were very close to those for samples of first captures of each survey ( $MN_{cap1}$ ).

Looking at the raw data of transect-mapping surveys, mean within-transect similarity was slightly higher for MNT1 than for MNT2 in the case of incidence-based coefficients, but the situation was just the opposite for abundance-based coefficients (Table 37). Average values of  $\delta$  diversity were considerably lower than mean within-transect similarities, though for qualitative coefficients these differences disappeared when comparisons were based on the combined MTW data sets of each transect. Only for quantitative coefficients were the  $\delta$  diversity values insignificantly lower, with 0.04-0.08 (Sørensen II) and 0.02-0.07 points (Morisita-Horn), than the within-transect survey averages. If similarity be-

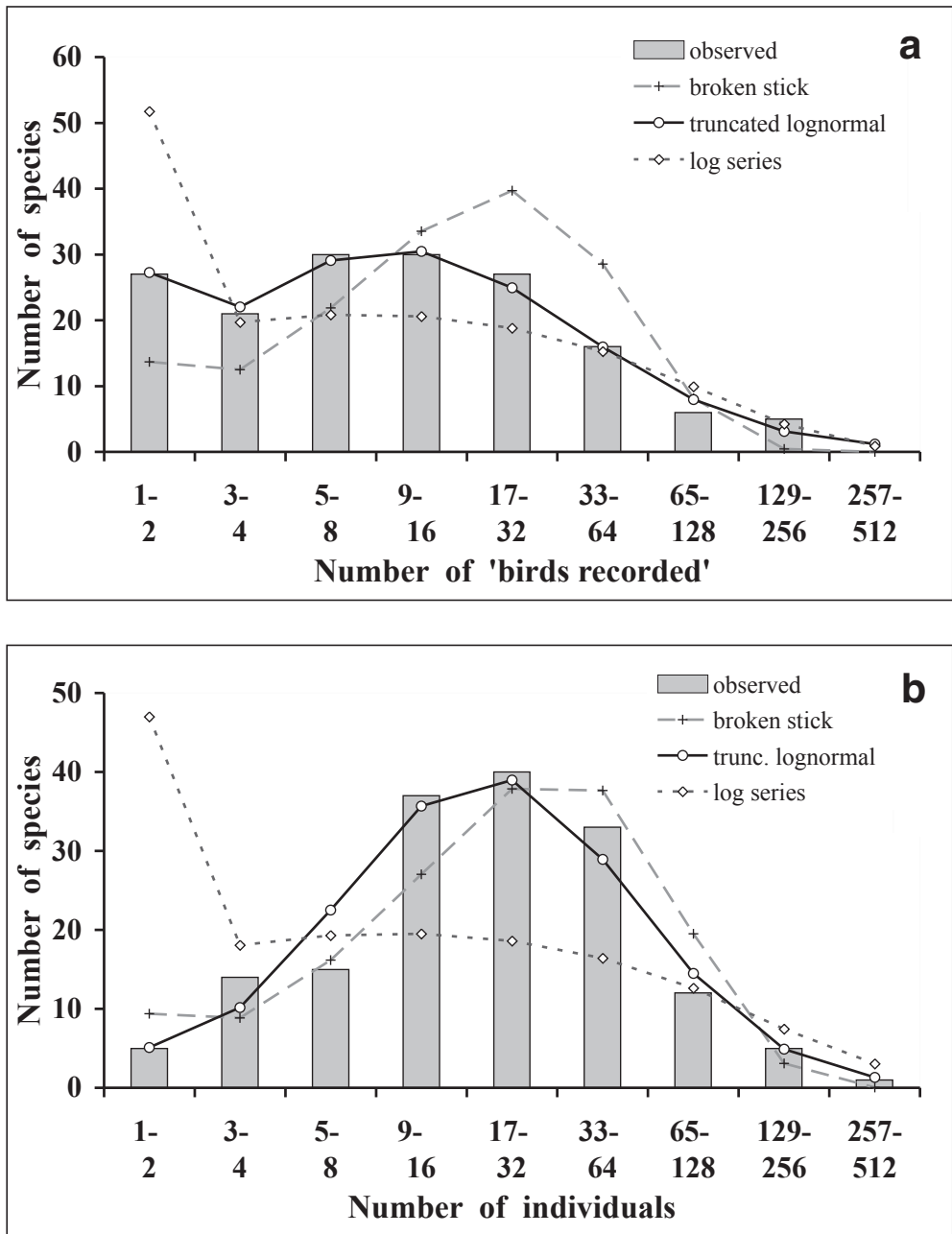


FIG. 33. Observed number of species per abundance class (log<sub>2</sub> scale) and expected distribution according to three abundance models, based on (a) all birds recorded (MTW<sub>c</sub>) during the transect-mapping surveys at MNT1 (includes an unknown number of repeated observations of some individuals) and (b) the modeled bird population of an area of 100 ha at the same transect (MTW<sub>pop</sub>; Appendix 18a). See Table 30 for the corresponding Chi-squared test results.

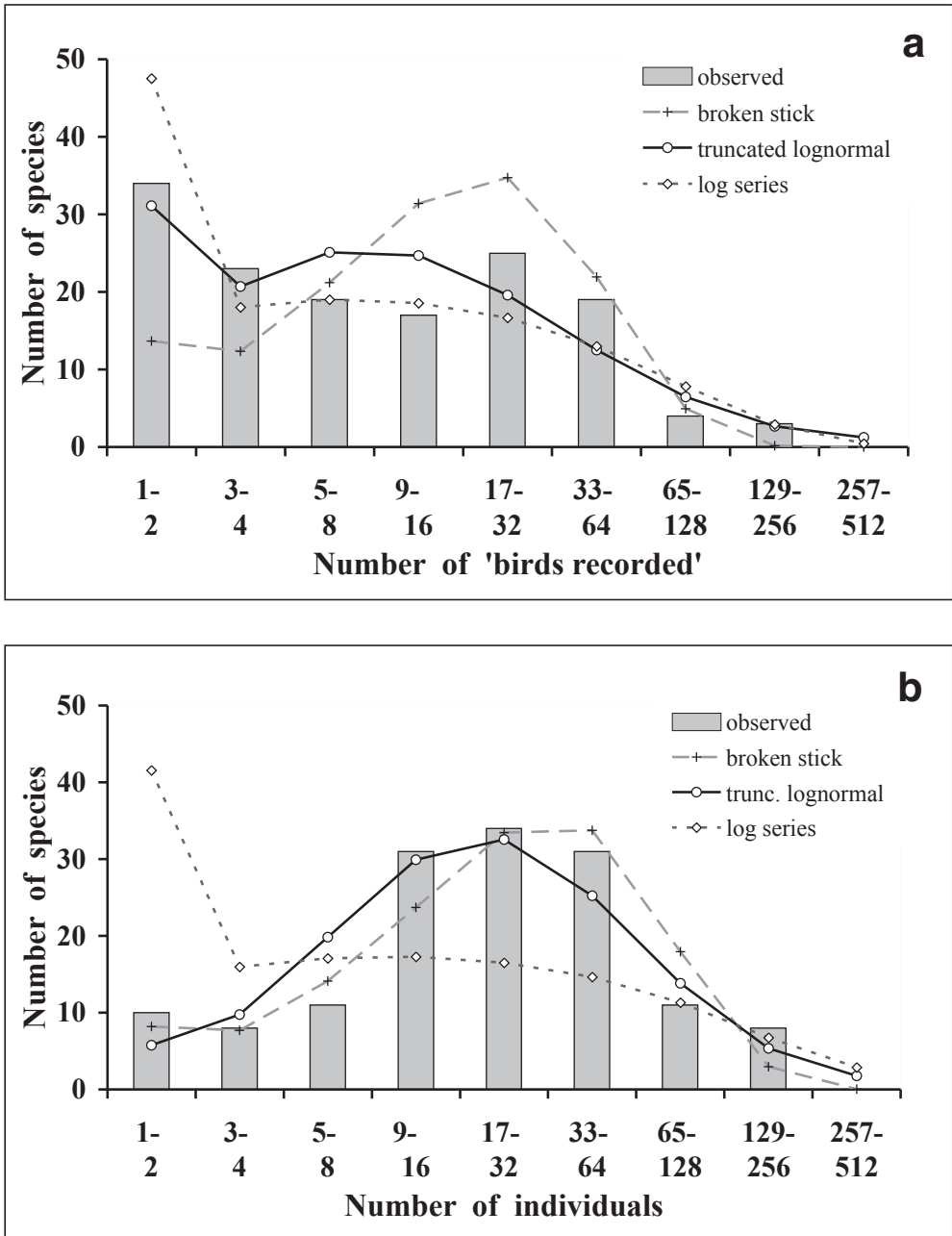


FIG. 34. Observed number of species per abundance class (log<sub>2</sub> scale) and expected distribution according to three abundance models, based on (a) all birds recorded (MTW<sub>c</sub>) during the transect-mapping surveys at MNT2 (includes an unknown number of repeated observations of some individuals) and (b) the modeled bird population of an area of 100 ha at the same transect (MTW<sub>pop</sub>; Appendix 19a). See Table 30 for the corresponding Chi-squared test results.

TABLE 31. Ten commonest species in the standardized mist-netting (MN) and transect-mapping (MTW) studies at MNT1 (cf. Appendices 12a and 18a). The three commonest taxa are highlighted in gray; intensity increases with abundance. For valid 'top 10' species with equal abundance I assigned tied ranks according to the rules of nonparametric statistics.

MNT1	Undergrowth-dwelling species (MN)				Entire bird community (MTW)			
	Individuals (first captures)		All captures		Extrapolated population		'Birds recorded'	
	Relative abundance		Relative abundance		Relative abundance		Relative abundance	
	(%)	Rank	(%)	Rank	(%)	Rank	(%)	Rank
<i>Crypturellus soui</i>	—	—	—	—	(0.5)	(61)	2.6	9
<i>Leptotila pallida</i>	(0.5)	(59)	(0.4)	(59)	1.6	10	(1.1)	(19)
<i>Chaetura spinicaudus</i>	—	—	—	—	3.1	5	(2.4)	(11)
<i>Threnetes ruckeri</i>	7.6	1	5.5	3	2.3	7	2.5	10
<i>Phaethornis yaruqui</i>	6.3	2	4.8	4	(0.7)	(50)	(1.1)	(21)
<i>Amazilia rosenbergi</i>	4.4	4	3.0	7	(1.6)	(12)	(1.6)	(13)
<i>Synallaxis brachyura</i>	2.7	9	(2.5)	(11)	3.4	3	4.8	4
<i>Glyphorynchus spirurus</i>	(2.5)	(11)	3.0	7	(1.2)	(19)	(0.6)	(46)
<i>Myrmotherula pacifica</i>	(1.1)	(26)	(1.0)	(29)	(1.1)	(22)	2.7	8
<i>Cercomacra tyrannina</i>	3.4	5	4.1	5	2.1	9	5.2	3
<i>Myrmeciza exsul</i>	(1.6)	(15)	(1.6)	(19)	(1.1)	(21)	3.9	5
<i>Mionectes olivaceus</i>	2.7	9	3.0	7	—	—	—	—
<i>Myiobius atricaudus</i>	(1.5)	(17)	(1.9)	(13)	2.3	8	(0.1)	(106)
<i>Myiobius sulphureipygius</i>	(1.2)	(22)	2.8	9.5	—	—	—	—
<i>Manacus manacus</i>	6.2	3	6.7	1	6.2	1	3.3	6
<i>Coereba flaveola</i>	(1.8)	(12)	(1.7)	(15)	3.5	2	(1.8)	(12)
<i>Ramphocelus icteronotus</i>	(0.7)	(36)	(0.5)	(50)	3.3	4	6.9	1
<i>Tachyphonus delatrii</i>	2.9	6.5	6.5	2	3.0	6	6.6	2
<i>Saltator maximus</i>	2.9	6.5	2.8	9.5	(1.1)	(20)	2.8	7
<i>Sporophila corvina</i>	2.7	9	(2.4)	(12)	(0.9)	(34)	(0.5)	(54)
Sum (10 commonest spp.)	41.6		42.0		30.8		41.3	
Count 'valid' ranks		10		10		10		10

tween modeled bird assemblages is compared with the MTW survey averages of MNT1 and MNT2, it is evident that only the Morisita-Horn coefficient is sufficiently smaller (0.11-0.16 points) to indicate potential differences between transects.

#### Body size relationship and guild structure

In the transect-mapping data sets the distribution of species over the logarithmic body mass categories was very similar for MNT1 and MNT2 ( $\chi^2_6 = 3.015$ ,  $P = 0.807$ ), and both showed the typical positive skew (Figs. 35a,b) also observed for the entire bird community (Figs. 28a,b, and 29). In addition to the underrepresentation of birds weighing 17-32 g, which I already mentioned in the context of other samples (p. 123-126, Body size relationship), the body mass class of 65-128 g also contained conspicuously few

species in the MTW samples. Comparing the two data sets, only 8 species > 257 g were recorded at MNT1, whereas almost twice as many ( $n = 15$ ) were detected in these size categories at MNT2. The latter sample included three species (*Tinamus major*, *Cathartes aura*, *Ara ambiguus*) in the category 1025-2048 g and one (*Penelope purpurascens*) > 2049 g. By contrast, only one taxon (*C. aura*) represented the categories > 1025 g at MNT1.

The representation of foraging guilds within the body mass categories was rather similar for both MTW samples. However, carnivores were greatly underrepresented at MNT1. The same tendency was found for non-passerine frugivores/granivores, which were represented in five size classes at MNT2, but only in three at MNT1. The only other important difference was the absence of non-passerine insec-

TABLE 32. Ten commonest species in the standardized mist-netting (MN) and transect-mapping (MTW) studies at MNT2 (Appendices 12b and 19a). The three commonest taxa are highlighted in gray; intensity increases with abundance. For valid 'top 10' species with equal abundance I assigned tied ranks according to the rules of nonparametric statistics.

MNT2	Undergrowth-dwelling species (MN)				Entire bird community (MTW)			
	Individuals (first captures)		All captures		Extrapolated population		'Birds recorded'	
	Relative abundance		Relative abundance		Relative abundance		Relative abundance	
	(%)	Rank	(%)	Rank	(%)	Rank	(%)	Rank
<i>Geotrygon veraguensis</i>	(0.3)	(58)	(0.2)	(64)	1.8	11	(0.1)	(98)
<i>Threnetes ruckeri</i>	4.9	6	4.1	6	2.8	7	3.0	6
<i>Phaethornis yaruqui</i>	7.1	1.5	4.9	5	(1.3)	(20)	2.1	8
<i>Eutoxeres aquila</i>	3.9	7	3.6	7	(0.7)	(50)	(0.4)	(56)
<i>Amazilia rosenbergi</i>	3.5	8	(2.3)	(13)	2.5	9	2.1	10
<i>Synallaxis brachyura</i>	(0.3)	(55)	(0.2)	(61)	1.8	11	(1.4)	(24)
<i>Glyphorynchus spirurus</i>	(1.3)	(22)	(2.0)	(17)	1.8	11	(0.2)	(85)
<i>Cercomacra tyrannina</i>	(1.5)	(19)	(2.2)	(14)	(1.7)	(13)	4.3	4
<i>Myrmeciza exsul</i>	2.3	10.5	(2.2)	(16)	(1.6)	(14)	4.8	3
<i>Gymnophis leucaspis</i>	(2.0)	(14)	3.3	8.5	(1.0)	(26)	(1.5)	(17)
<i>Hylopezus perspicillatus</i>	(0.3)	(54)	(0.3)	(54)	(0.6)	(54)	2.1	10
<i>Mionectes olivaceus</i>	6.4	4	7.5	2	3.6	2.5	(0.8)	(38)
<i>Myiobius sulphureipygus</i>	(2.0)	(13)	2.9	10	(0.9)	(30)	(<0.1)	(133)
<i>Pipra mentalis</i>	6.8	3	5.7	4	3.2	5	(0.9)	(35)
<i>Lepidothrix coronata</i>	3.3	9	3.3	8.5	4.6	1	(1.6)	(16)
<i>Manacus manacus</i>	7.1	1.5	6.9	3	3.6	2.5	(0.9)	(33)
<i>Turdus daguae</i>	2.3	10.5	(2.2)	(15)	(0.4)	(81)	(1.1)	(28)
<i>Thryothorus leucopogon</i>	(0.4)	(49)	(0.4)	(45)	(0.9)	(35)	2.9	7
<i>Microbates cinereiventris</i>	(1.8)	(15)	(2.0)	(18)	(1.3)	(21)	2.1	10
<i>Ramphocelus icteronotus</i>	(1.2)	(24)	(0.8)	(32)	3.1	6	5.6	2
<i>Tachyphonus delatrii</i>	5.4	5	7.8	1	3.3	4	8.3	1
<i>Arremon aurantirostris</i>	(0.9)	(30)	(1.0)	(27)	2.7	8	(1.3)	(25)
<i>Cacicus microrhynchus</i>	(0.1)	(71)	(0.1)	(73)	(1.1)	(23)	3.2	5
Sum (10 commonest spp.)	50.7		50.1		31.3		38.5	
Count 'valid' ranks		11		10		12		11

tivores in the body mass category 17-32 g in the transect-mapping data of MNT2. This group was represented by four species (*Chaetura pelagica*, *Panyptila cayennensis*, *Galbula ruficauda*, *Veniliornis calzonotus*) in the data set of MNT1.

#### Population density and biomass

Based on the MTW data, I modeled the bird communities for habitat mosaics of 100 ha each per transect area (Appendices 18a and 19a). Apart from the reproductive population, the extrapolated population data also include juveniles, immatures, and some of the non-breeding visitors (core species only). Although some clear differences existed between the

sites regarding species richness as well as species composition, the biomass density was almost identical for MNT1 and MNT2 (Table 38). However, the number of individuals per 100 ha was considerably lower ( $\Delta = 494$ ) at the latter site than at the former. Consequently, the mean body mass per species as well as per individual was lower at MNT1 ( $\bar{x}_{\text{spp}} = 73.0$  g;  $\bar{x}_{\text{ind}} = 36.4$  g) than at MNT2 ( $\bar{x}_{\text{spp}} = 125.5$  g;  $\bar{x}_{\text{ind}} = 41.1$  g).

Regarding population density, the three most individual-rich guilds at MNT1 were arboreal gleaning omnivores, arboreal gleaning insectivores, and arboreal frugivores. Although arboreal gleaning omnivores were also the most important group regarding

TABLE 33. Diversity indices according to the observed species richness and number of individuals recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. Values represent  $\gamma$  (*gamma*) diversity as each transect covered various habitat types. Abbreviations used: (a) data set: see Table 26; (b) field data:  $S_{\text{obs}}$  = number of species observed;  $N_{\text{ind/b}}$  = number of individuals captured/recorded (MTW<sub>pop</sub>, MN<sub>fc</sub>, and MN<sub>cap1</sub> for single surveys) or birds captured (MN<sub>cap1</sub> for combined data sets, which also include recaptures obtained during different surveys); (c) diversity index: see Methods (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients).

Data set <sup>a</sup>	Field data <sup>b</sup>		Diversity index <sup>c</sup>				
			(log series)	(lognormal)	Shannon		Simpson
	$S_{\text{obs}}$	$N_{\text{ind/b}}$	$\alpha \pm \text{SD}$	$\lambda$	$H'$	$EH'$	$D$ $\ln D$
MN <sub>cap1</sub> : MNT1/I	80	350	32.42 $\pm$ 2.77	188.15	3.91	0.89	37.77   3.63
MN <sub>cap1</sub> : MNT1/II	88	354	37.53 $\pm$ 3.17	223.84	4.07	0.91	46.77   3.85
MN <sub>cap1</sub> : MNT1/III	86	296	40.70 $\pm$ 3.75	217.11	4.00	0.90	42.51   3.75
MN <sub>cap1</sub> : MNT1/I-III	117	1000	34.37 $\pm$ 1.93	224.48	4.13	0.87	42.01   3.74
MN <sub>fc</sub> : MNT1/I-III	117	827	37.19 $\pm$ 2.21	245.35	4.14	0.87	40.37   3.70
MTW <sub>pop</sub> : MNT1	162	5307	31.58 $\pm$ 1.12	343.55	4.56	0.90	62.32   4.13
MN <sub>cap1</sub> : MNT2/I	69	452	22.69 $\pm$ 1.80	141.05	3.69	0.87	29.03   3.37
MN <sub>cap1</sub> : MNT2/II	65	367	22.94 $\pm$ 1.97	152.46	3.74	0.90	33.46   3.51
MN <sub>cap1</sub> : MNT2/III	73	398	26.23 $\pm$ 2.16	146.92	3.66	0.85	27.48   3.31
MN <sub>cap1</sub> : MNT2/I-III	96	1217	24.44 $\pm$ 1.37	152.66	3.79	0.83	30.23   3.41
MN <sub>fc</sub> : MNT2/I-III	96	992	26.24 $\pm$ 1.54	162.31	3.81	0.83	30.19   3.41
MTW <sub>pop</sub> : MNT2	144	4817	27.93 $\pm$ 1.05	285.40	4.48	0.90	62.56   4.14
MN <sub>cap1</sub> : MNT1&MNT2	135	2217	31.67 $\pm$ 1.41	208.05	4.06	0.83	37.69   3.63
MN <sub>fc</sub> : MNT1&MNT2	135	1819	33.69 $\pm$ 1.57	218.29	4.08	0.83	37.17   3.62
MTW <sub>pop</sub> : MNT1&MNT2	187	10124	32.56 $\pm$ 1.00	337.80	4.67	0.89	71.73   4.27

biomass density, the sequence changed in the second and third positions, with arboreal frugivores having greater values than arboreal gleaning insectivores. The latter guild was closely followed by the terrestrial omnivores. As regards population density, the same guilds were also the most important ones at MNT2. However, the sequence was slightly different, with arboreal gleaning insectivores being the most individual-rich category, followed by arboreal gleaning omnivores and arboreal frugivores. Biomass density was highest for arboreal gleaning omnivores, as it was at MNT1, but in contrast to the former transect the second most important group at MNT2 was terrestrial omnivores, followed by arboreal frugivores.

Pronounced differences existed for several foraging guilds. Although biomass density of carnivores was twice as high at MNT1 than at MNT2, 85% of the biomass at the former site was concentrated in a single species, the scavenger *Cathartes aura*, whereas only 24.1% were accounted for by this vulture at MNT2. Thus the biomass density of diurnal and nocturnal raptors was in fact 2.5 times higher at the latter transect than at MNT1. However, the number

of individuals per 100 ha belonging to the carnivore guild was similar at both sites, with 20 at MNT1 and 24 at MNT2. Other interesting differences existed for terrestrial gleaning insectivores (e.g., *Sclerurus mexicanus*, Formicariidae, *Microcerculus marginatus*, *Basileuterus fulvicauda*), for which the number of individuals and biomass at MNT2 were more than double of that at MNT1. Arboreal sallying insectivores (e.g., jacamars, puffbirds, some tyrannids) and aerial insectivores (swifts, swallows) had a considerably higher biomass density at MNT1 than at MNT2. Biomass density of arboreal granivores (Psittacidae) was twice as high at MNT2 than at MNT1. Terrestrial omnivores, composed mainly of tinamous, wood-quails, and rails, were another important guild for which the biomass density was about 1.5 times higher in the area of Playa Rica than at the outskirts of the village, although their population density was actually lower at MNT2 than at MNT1. This apparent paradox can be explained by the presence of the large-bodied *Tinamus major* as well as higher population densities of other relatively heavy species, like *Odontophorus erythrops* and *Amaurolimnas con-*



color at the former site (Appendices 18a and 19a). Population densities of hummingbirds were very high at both transects.

#### Available area per breeding territory

Unfortunately it is not possible to determine precise territory sizes based on transect-mapping data. However, it is possible to estimate the available area per breeding territory within appropriate habitat (Appendices 18b and 19b).

About 77.5% of the 187 species recorded by transect mapping at MNT1 and MNT2 were assumed to have established breeding territories at one or both transects (Fig. 36). The mean area per territory was considerably smaller for 29 non-forest taxa

( $\bar{x} = 11.2 \pm 16.9$  ha) than for 116 forest species ( $\bar{x} = 26.0 \pm 41.7$  ha), as was their mean body mass ( $\bar{x} = 48.1 \pm 78.5$  g vs.  $\bar{x} = 117.3 \pm 254.8$  g). Most non-forest birds ( $n = 11$ ; 37.9%) had an available area of 2–4 ha per territory, whereas for forest taxa it was 9–16 ha ( $n = 33$ ; 28.5%). Chi-squared tests confirmed that the proportions of forest and non-forest taxa in the area size classes were very distinct ( $\chi^2_3 = 13.6$ ,  $P = 0.004$ ). On the other hand, one-tailed Spearman's rank tests demonstrated that the available area per territory is positively correlated with the body mass of the species, this being the case for non-forest ( $r_s = 0.589$ ,  $P < 0.001$ ) as well as forest-inhabiting birds ( $r_s = 0.627$ ,  $P < 0.001$ ). The relationship between the body size of birds and the available area

TABLE 34. Diversity indices according to the observed species richness and number of birds captured/recorded during standardized mist-netting and transect-mapping surveys at MNT1 and MNT2. Values represent  $\gamma$  (gamma) diversity as each transect covered various habitat types. Abbreviations used: (a) data set: see Table 28; (b) field data:  $S_{\text{obs}}$  = number of species observed;  $N_b$  = number of birds captured/recorded; (c) diversity index: see Methods (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients).

Data set <sup>a</sup>	Field data <sup>b</sup>		Diversity index <sup>c</sup>					
			(log series)	(lognormal)	Shannon		Simpson	
	$S_{\text{obs}}$	$N_b$	$\alpha \pm \text{SD}$	$\lambda$	$H'$	$EH'$	$D$	$\ln D$
MN <sub>cap2</sub> : MNT1/I	80	449	28.32 $\pm$ 2.20	169.79	3.81	0.87	31.02	3.43
MN <sub>cap2</sub> : MNT1/II	88	401	34.83 $\pm$ 2.79	213.94	4.06	0.91	45.54	3.82
MN <sub>cap2</sub> : MNT1/III	86	349	36.47 $\pm$ 3.11	203.48	3.98	0.89	42.05	3.74
MN <sub>cap2</sub> : MNT1/I-III	117	1199	32.08 $\pm$ 1.71	210.17	4.08	0.86	39.43	3.67
MTW <sub>c</sub> : MNT1/I	105	609	36.58 $\pm$ 2.45	231.92	4.05	0.87	36.44	3.60
MTW <sub>c</sub> : MNT1/2	111	803	34.93 $\pm$ 2.12	232.99	3.97	0.84	29.24	3.38
MTW <sub>c</sub> : MNT1/3	120	1021	35.31 $\pm$ 1.96	216.15	4.09	0.85	39.65	3.68
MTW <sub>c</sub> : MNT1/4	126	1136	36.24 $\pm$ 1.93	247.62	4.22	0.87	45.21	3.81
MTW <sub>c</sub> : MNT1/1&2	130	1412	34.90 $\pm$ 1.74	251.39	4.09	0.84	32.78	3.49
MTW <sub>c</sub> : MNT1/3&4	151	2157	36.98 $\pm$ 1.60	257.98	4.26	0.85	45.15	3.81
MTW <sub>c</sub> : MNT1/1-4	162	3569	34.94 $\pm$ 1.34	274.31	4.27	0.84	41.50	3.73
MN <sub>cap2</sub> : MNT2/I	69	567	20.59 $\pm$ 1.52	135.61	3.62	0.85	25.43	3.24
MN <sub>cap2</sub> : MNT2/II	65	459	20.67 $\pm$ 1.65	138.19	3.71	0.89	32.29	3.47
MN <sub>cap2</sub> : MNT2/III	73	501	23.51 $\pm$ 1.79	135.25	3.63	0.85	27.12	3.30
MN <sub>cap2</sub> : MNT2/I-III	96	1527	22.74 $\pm$ 1.21	143.32	3.75	0.82	28.97	3.37
MTW <sub>c</sub> : MNT2/I	86	614	27.22 $\pm$ 1.88	189.54	3.93	0.88	35.13	3.56
MTW <sub>c</sub> : MNT2/2	93	587	31.11 $\pm$ 2.15	194.97	3.96	0.87	33.57	3.51
MTW <sub>c</sub> : MNT2/3	112	858	34.40 $\pm$ 2.04	222.28	4.13	0.88	42.18	3.74
MTW <sub>c</sub> : MNT2/4	104	738	33.00 $\pm$ 2.08	214.17	4.14	0.89	46.13	3.83
MTW <sub>c</sub> : MNT2/1&2	112	1201	30.21 $\pm$ 1.63	198.93	4.03	0.85	35.78	3.58
MTW <sub>c</sub> : MNT2/3&4	132	1596	34.15 $\pm$ 1.65	231.01	4.22	0.86	44.39	3.79
MTW <sub>c</sub> : MNT2/1-4	144	2797	32.17 $\pm$ 1.34	230.17	4.20	0.85	41.13	3.72
MN <sub>cap2</sub> : MNT1&MNT2	135	2726	29.83 $\pm$ 1.27	192.56	4.00	0.82	35.44	3.57
MTW <sub>c</sub> : MNT1&MNT2	187	6366	36.12 $\pm$ 1.19	283.77	4.37	0.84	45.02	3.81

TABLE 35. Similarity coefficients comparing diversity between different surveys of MNT1 and MNT2, between transects, and different surveys of each transect. Based mainly on ‘first captures’ ( $MN_{cap1}$ ) of the standardized mist-netting surveys. Values for comparisons between sites represent between-landscape ( $\delta$ , *delta*) diversity rather than between-habitat ( $\beta$ , *beta*) diversity, as each transect covered various habitat types. By contrast, comparisons between different surveys of the same transect merely describe the variability in results, and are included as control. Abbreviations used: (a) data set (survey): see Table 26;  $MTW_{pop}$  was included for comparative reasons; (b) field data:  $S_{obs}$  = number of species observed in sample 1 and 2; shared  $S_{obs}$  1&2 = number of species shared; (c) shared  $S_{est}$  1&2: coverage-based estimator for shared species; see Methods for details (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients); (d) similarity coefficients: see Methods for details.

Data set (survey) <sup>a</sup>		Field data <sup>b</sup>				Similarity coefficient <sup>d</sup>			
				shared	shared	(qualitative)		(quantitative)	
		$S_{obs}$ 1	$S_{obs}$ 2	$S_{obs}$ 1&2	$S_{est}$ 1&2 <sup>c</sup>	Jaccard	Sørensen I	Sørensen II	Morisita-Horn
A) $MN_{cap1}$									
MNT1/I	MNT1/II	80	88	64	81.0	0.62	0.76	0.74	0.91
MNT1/I	MNT1/III	80	86	61	81.6	0.58	0.73	0.70	0.90
MNT1/II	MNT1/III	88	86	66	92.6	0.61	0.76	0.69	0.86
	Mean	82.7	86.7	63.7	85.1	0.60	0.75	0.71	0.89
	± SD	4.6	1.2	2.5	6.5	0.02	0.02	0.03	0.03
MNT2/I	MNT2/II	69	65	54	65.0	0.68	0.81	0.75	0.92
MNT2/I	MNT2/III	69	73	54	66.2	0.61	0.76	0.76	0.91
MNT2/II	MNT2/III	65	73	53	63.7	0.62	0.77	0.76	0.89
	Mean	67.7	70.3	53.7	65.0	0.64	0.78	0.76	0.91
	± SD	2.3	4.6	0.6	1.2	0.04	0.03	0.01	0.02
MNT1/I	MNT2/I	80	69	55	63.6	0.59	0.74	0.62	0.78
MNT1/I	MNT2/II	80	65	51	58.9	0.54	0.70	0.64	0.82
MNT1/I	MNT2/III	80	73	52	67.1	0.51	0.68	0.63	0.75
MNT1/II	MNT2/I	88	69	59	69.4	0.60	0.75	0.56	0.69
MNT1/II	MNT2/II	88	65	54	62.2	0.55	0.71	0.60	0.76
MNT1/II	MNT2/III	88	73	59	83.5	0.58	0.73	0.59	0.71
MNT1/III	MNT2/I	86	69	56	75.3	0.57	0.72	0.55	0.76
MNT1/III	MNT2/II	86	65	51	66.1	0.51	0.68	0.58	0.79
MNT1/III	MNT2/III	86	73	58	90.6	0.57	0.73	0.56	0.74
	Mean	84.7	69.0	55.0	70.7	0.56	0.72	0.59	0.76
	± SD	3.6	3.5	3.2	10.5	0.03	0.03	0.03	0.04
B) $MN_{fc}$									
MNT1/I-III	MNT2/I-III	117	96	78	91.1	0.58	0.73	0.63	0.80
C) $MTW_{pop}$									
MNT1	MNT2	162	144	119	119.4	0.64	0.78	0.65	0.73

per breeding territory is best described by power functions (Fig. 37). The slightly flatter slope of the trendline for non-forest species indicates that, on average, their area per territory is smaller than that of forest taxa of the same size.

1000-capture sample for *terra firme* forest  
The 1000-capture sample of MNT1 and MNT2

(Table 4) embraced 68 species (Table 40). Only one species, the tanager *Tachyphonus delatrii*, was represented by more than 100 captures. The second most commonly trapped species was the flycatcher *Mionectes olivaceus*, followed by the hummingbird *Phaethornis yaruqui*. The 10 commonest species together added up to 52.3% of all captures (Tables 40 and 41).

## Discussion

### Comparability of relative abundance values in bird studies

Due to the intrinsic difficulties of computing absolute population densities for tropical birds, many authors opted for describing their community composition through relative abundances. This is the rule for mist-netting studies (e.g., Lovejoy 1974, Bierregaard 1990b, Poulsen 1994), but it has sometimes also been done for comprehensive datasets gathered with audiovisual methods (e.g., Blake 2007). However, one important lesson to be learned from this work is that researchers must assure comparability of

data sets before analyzing bird abundances at regional levels. The pronounced differences in relative abundances and ranks of the commonest species between methods (mist netting vs. transect mapping) and data sets (first captures vs. all captures and extrapolated populations vs. birds recorded) demonstrate the importance of standardization (Tables 31 and 32). For mist-netting data this is done by comparing 1000-capture samples, including recaptures, although even then some sources of bias persist (see p. 157f, Comparison with other Neotropical sites). However, it is evident that relative abundances calculated from crude counts are principally not comparable with proportions derived from absolute po-

TABLE 36. Similarity coefficients comparing diversity between different surveys of MNT1 and MNT2, between transects, and different surveys of each transect. Based on 'all captures' ( $MN_{cap2}$ ) of the standardized mist-netting surveys. See Table 35 for further details. Abbreviations used: (a) data set (survey): see Table 28; (b) field data:  $S_{obs}$  = number of species observed in sample 1 and 2; shared  $S_{obs}$  1&2 = number of species shared; (c) shared  $S_{est}$  1&2: coverage-based estimator for shared species; see Methods for details (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients); (d) similarity coefficients: see Methods for details.

Data set (survey) <sup>a</sup>		Field data <sup>b</sup>				Similarity coefficient <sup>d</sup>			
				shared	shared	(qualitative)		(quantitative)	
1	2	$S_{obs}$ 1	$S_{obs}$ 2	$S_{obs}$ 1&2	$S_{est}$ 1&2 <sup>c</sup>	Jaccard	Sørensen I	Sørensen II	Morisita-Horn
A) $MN_{cap2}$									
MNT1/I	MNT1/II	80	88	64	75.8	0.62	0.76	0.72	0.86
MNT1/I	MNT1/III	80	86	61	79.3	0.58	0.73	0.66	0.86
MNT1/II	MNT1/III	88	86	66	85.3	0.61	0.76	0.69	0.87
	Mean	82.7	86.7	63.7	80.1	0.60	0.75	0.69	0.86
	± SD	4.6	1.2	2.5	4.8	0.02	0.02	0.03	0.01
MNT2/I	MNT2/II	69	65	54	63.4	0.68	0.81	0.70	0.87
MNT2/I	MNT2/III	69	73	54	62.7	0.61	0.76	0.77	0.91
MNT2/II	MNT2/III	65	73	53	61.1	0.62	0.77	0.77	0.89
	Mean	67.7	70.3	53.7	62.4	0.64	0.78	0.75	0.89
	± SD	2.3	4.6	0.6	1.2	0.04	0.03	0.04	0.02
MNT1/I	MNT2/I	80	69	55	64.1	0.59	0.74	0.65	0.84
MNT1/I	MNT2/II	80	65	51	56.9	0.54	0.70	0.65	0.79
MNT1/I	MNT2/III	80	73	52	68.6	0.51	0.68	0.61	0.74
MNT1/II	MNT2/I	88	69	59	68.4	0.60	0.75	0.55	0.70
MNT1/II	MNT2/II	88	65	54	60.1	0.55	0.71	0.59	0.75
MNT1/II	MNT2/III	88	73	59	77.2	0.58	0.73	0.57	0.71
MNT1/III	MNT2/I	86	69	56	68.6	0.57	0.72	0.53	0.76
MNT1/III	MNT2/II	86	65	51	58.8	0.51	0.68	0.58	0.77
MNT1/III	MNT2/III	86	73	58	90.9	0.57	0.73	0.55	0.74
	Mean	84.7	69.0	55.0	68.2	0.56	0.72	0.59	0.76
	± SD	3.6	3.5	3.2	10.6	0.03	0.03	0.04	0.04
MNT1/I-III	MNT2/I-III	117	96	78	95.2	0.58	0.73	0.65	0.83

TABLE 37. Similarity coefficients comparing diversity between different surveys of MNT1 and MNT2, between transects, and different surveys of each transect. Based on 'birds recorded' during transect-mapping surveys (raw MTW data) and the extrapolated bird populations. Abbreviations used: (a) data set (survey):  $MTW_c$  = see Table 28;  $MTW_{pop}$  = see Table 26; (b) field data:  $S_{obs}$  = number of species observed in samples 1 and 2; shared  $S_{obs}$  1&2 = number of species shared; (c) shared  $S_{est}$  1&2: coverage-based estimator for shared species; see Methods for details (p. 116f, Species-abundance relationship, species diversity, and similarity coefficients); (d) similarity coefficients: see Methods for details.

Data set (survey) <sup>a</sup>		Field data <sup>b</sup>				Similarity coefficient <sup>d</sup>			
				shared	shared	(qualitative)		(quantitative)	
		$S_{obs}$ 1	$S_{obs}$ 2	$S_{obs}$ 1&2	$S_{est}$ 1&2 <sup>c</sup>	Jaccard	Sørensen I	Sørensen II	Morisita-Horn
A) $MTW_c$									
MNT1/1	MNT1/2	105	111	86	101.7	0.66	0.80	0.70	0.91
MNT1/1	MNT1/3	105	120	87	115.9	0.63	0.77	0.60	0.80
MNT1/1	MNT1/4	105	126	83	100.6	0.56	0.72	0.59	0.86
MNT1/2	MNT1/3	111	120	94	117.4	0.69	0.81	0.72	0.81
MNT1/2	MNT1/4	111	126	90	101.8	0.61	0.76	0.66	0.82
MNT1/3	MNT1/4	120	126	95	122.8	0.63	0.77	0.70	0.85
	Mean	109.5	121.5	89.2	110.0	0.63	0.77	0.66	0.84
	± SD	5.9	5.9	4.7	9.8	0.04	0.03	0.06	0.04
MNT2/1	MNT2/2	86	93	67	75.9	0.60	0.75	0.71	0.87
MNT2/1	MNT2/3	86	112	73	81.0	0.58	0.74	0.69	0.89
MNT2/1	MNT2/4	86	104	71	76.8	0.60	0.75	0.70	0.89
MNT2/2	MNT2/3	93	112	78	98.5	0.61	0.76	0.69	0.88
MNT2/2	MNT2/4	93	104	71	80.1	0.56	0.72	0.68	0.86
MNT2/3	MNT2/4	112	104	84	97.8	0.64	0.78	0.74	0.93
	Mean	92.7	104.8	74.0	85.0	0.60	0.75	0.70	0.89
	± SD	10.1	7.0	6.1	10.3	0.03	0.02	0.02	0.02
MNT1/1	MNT2/1	105	86	59	64.7	0.45	0.62	0.55	0.76
MNT1/1	MNT2/2	105	93	63	78.6	0.47	0.64	0.50	0.73
MNT1/1	MNT2/3	105	112	69	88.7	0.47	0.64	0.51	0.76
MNT1/1	MNT2/4	105	104	63	72.3	0.43	0.60	0.53	0.76
MNT1/2	MNT2/1	111	86	64	71.2	0.48	0.65	0.55	0.76
MNT1/2	MNT2/2	111	93	67	77.3	0.49	0.66	0.52	0.68
MNT1/2	MNT2/3	111	112	75	95.2	0.51	0.67	0.54	0.71
MNT1/2	MNT2/4	111	104	68	80.6	0.46	0.63	0.53	0.73
MNT1/3	MNT1/4	120	126	95	122.8	0.63	0.77	0.70	0.85
MNT1/3	MNT2/1	120	86	63	66.9	0.44	0.61	0.52	0.69
MNT1/3	MNT2/2	120	93	69	80.8	0.48	0.65	0.47	0.63
MNT1/3	MNT2/3	120	112	83	97.5	0.56	0.72	0.57	0.72
MNT1/3	MNT2/4	120	104	74	88.2	0.49	0.66	0.56	0.72
MNT1/4	MNT2/1	126	86	67	73.7	0.46	0.63	0.51	0.77
MNT1/4	MNT2/2	126	93	73	88.2	0.50	0.67	0.49	0.75
MNT1/4	MNT2/3	126	112	79	90.2	0.50	0.66	0.57	0.80
MNT1/4	MNT2/4	126	104	78	95.9	0.51	0.68	0.58	0.84
	Mean	115.8	100.4	71.1	84.3	0.49	0.66	0.54	0.74
	± SD	8.2	12.0	9.0	14.2	0.05	0.04	0.05	0.05
MNT1/1-4	MNT2/1-4	162	144	119	123.2	0.64	0.78	0.62	0.82
B) $MTW_{pop}$									
MNT1	MNT2	162	144	119	119.4	0.64	0.78	0.65	0.73

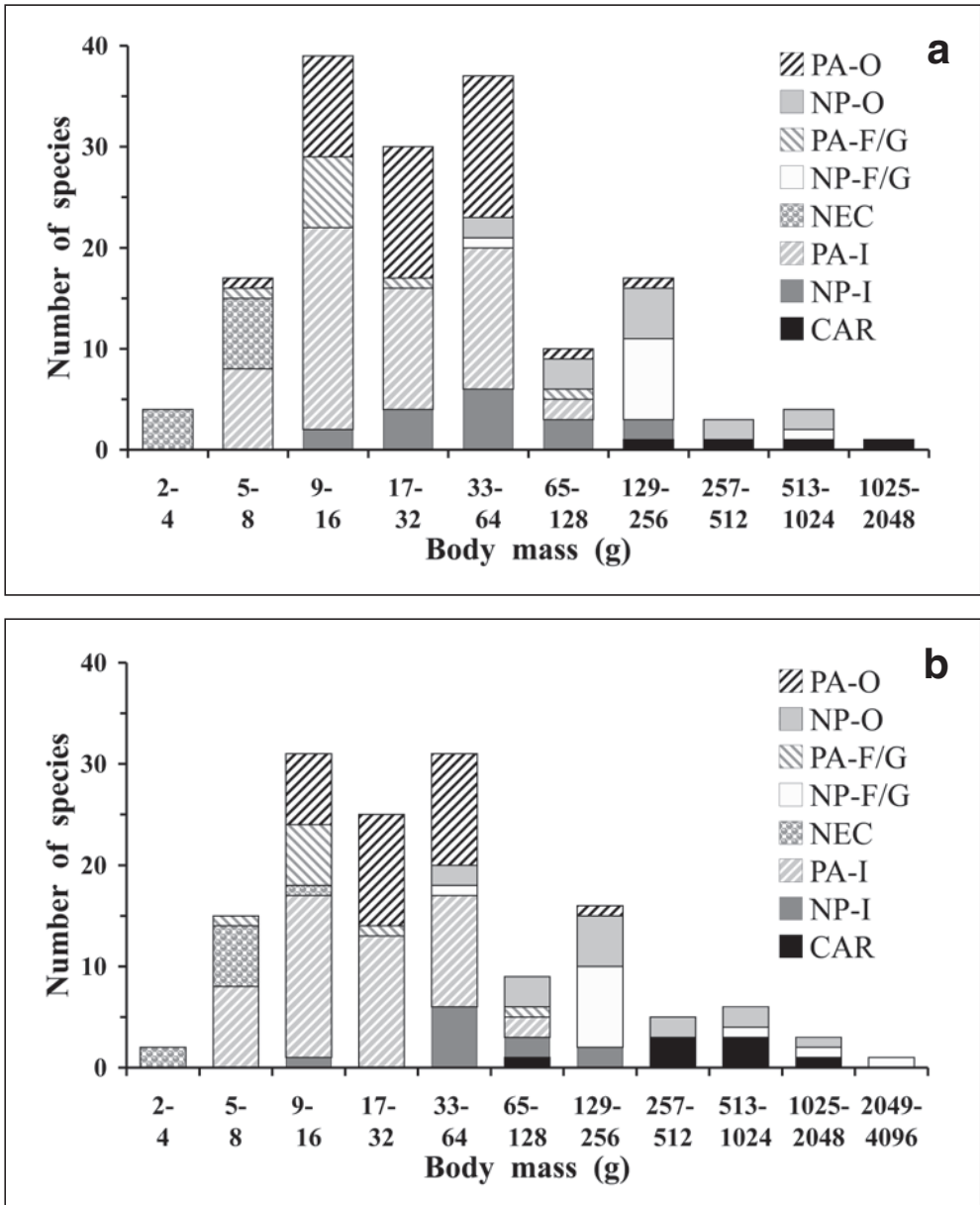


FIG. 35. Proportion of species per body mass class (log<sub>2</sub> scale) and broad foraging guilds in the bird communities of (a) MNT1 (n = 162) and (b) MNT2 (n = 144), according to transect-mapping (MTW) data. Abbreviations used: PA-O = passerine omnivore; NP-O = non-passerine omnivore; PA-F/G = passerine frugivore and/or granivore; NP-F/G = non-passerine frugivore and/or granivore; NEC = nectarivore; PA-I = passerine insectivore; NP-I = non-passerine insectivore; CAR = carnivore; includes here, apart from scavengers, diurnal raptors, and nocturnal raptors, as well as piscivores. Note: For the Chi-squared test, comparing proportions between transects, I used the following combined body mass categories to avoid the expected count of some cells in the contingency table being less than five: 2-8 g, 129-512 g, and  $\geq 513$  g.

TABLE 38. Guilds and guild biomass in the bird communities of two human-influenced habitat mosaics of 100 ha each in the transect areas of MNT1 and MNT2. Extrapolated on the basis of the transect-mapping data (Appendices 18a and 19a). Abbreviations used: N<sub>sp</sub> = number of species.

Foraging guild	MNT1				MNT2			
	Number of		Biomass density		Number of		Biomass density	
	N <sub>sp</sub>	individuals/km <sup>2</sup>	Mean body mass (g)	(g/km <sup>2</sup> )	N <sub>sp</sub>	individuals/km <sup>2</sup>	Mean body mass (g)	(g/km <sup>2</sup> )
A) Aquatic (piscivores and others)								
B) Carnivore								
Carnion feeder	1	11.0	1467.0	16137.0	1	1.5	1467.0	2222.7
Terrestrial & arboreal raptor	3	9.4	395.7	2794.4	5	20.0	566.0	5948.7
Arboreal raptor					1	2.2	484.0	1050.4
Total carnivore	4	20.4	663.5	18931.4	7	23.7	683.0	9221.8
C) Insectivore								
Terrestrial gleaning insectivore	4	53.4	32.9	1713.7	5	116.3	31.3	4185.9
Terrestrial sallying insectivore	2	20.0	52.5	1049.0	2	20.7	52.5	1086.1
Bark-climbing surface-feeding insectivore	8	177.2	38.3	4412.1	6	159.3	44.2	4946.5
Bark-climbing in-trunk-interior-feeding insectivore	4	34.1	81.3	2174.9	5	33.8	118.6	2843.8
Arboreal gleaning insectivore	29	963.3	24.9	20667.5	25	944.8	21.2	19394.9
Arboreal dead-leaf-searching insectivore	4	94.8	38.1	2496.6	3	105.8	29.5	2034.9
Arboreal sallying insectivore	16	577.8	27.5	9259.0	11	402.2	13.8	6011.3
Aerial insectivore	6	312.7	30.3	6509.3	4	59.1	34.3	1525.0
Total Insectivore	73	2233.2	32.4	48282.0	61	1841.9	33.2	42028.4
D) Nectarivore	11	366.8	5.0	1907.1	9	414.8	6.1	2440.0
E) Frugivore								
Terrestrial frugivore	1	61.3	152.0	9318.0	1	86.8	152.0	13195.4
Arboreal frugivore	11	648.7	72.1	24925.6	11	768.3	258.0	25056.9
Total Frugivore	12	710.0	78.8	34243.6	12	855.1	249.2	38252.3
F) Granivore								
Terrestrial granivore	1	86.8	157.0	13634.7	1	69.4	157.0	10903.5
Stem-feeding granivore	3	88.2	10.2	900.2	3	73.2	10.2	739.3
Arboreal granivore	4	33.3	304.3	7586.2	5	61.5	513.0	15125.0
Total Granivore	8	208.4	175.6	22121.1	9	204.2	305.8	26767.9
G) Omnivore								
Terrestrial omnivore	7	143.0	201.1	20614.7	7	119.8	344.3	30348.9
Arboreal gleaning omnivore	30	1257.2	74.0	37372.8	24	895.2	87.7	34125.2
Arboreal sallying omnivore	17	370.0	45.2	9915.0	14	457.2	45.6	13520.6
Total Omnivore	54	1770.2	81.4	67902.5	45	1472.3	114.5	77994.7
Grand Total	162	5309.0	73.0	193387.7	144	4814.8	125.5	197622.4



pulation densities. Raw observational data are extremely biased due to heterogeneities in species detectability, resulting in unrealistic percentage values and ranks. At transect MNT2, for instance, *Glyphorynchus spirurus* ranked 85<sup>th</sup> by its number of records but 11<sup>th</sup> on the basis of extrapolated population data. At MNT1, on the other extreme, *Crypturellus soui* ranked 9<sup>th</sup> by its raw data but 61<sup>st</sup> in the modeled population. Thus, the differences in relative abundances and species ranks reported by Blake (2007: Table 3) for the commonest species between study plots at Tiputini (Ecuador), Cocha Cashu (Peru), Nouragues (French Guiana), and Limbo plot (Panama) do not describe the real situation because his Ecuador data were calculated with numbers of detections but those for the other sites with absolute population densities (Terborgh *et al.* 1990, Thiollay 1994b, Robinson *et al.* 2000).

#### Comparison with other Neotropical sites

Before comparing the bird community data of Playa de Oro with those of other well-studied Neotropical lowland localities, like La Selva (Costa Rica), Panama Canal Zone, Manaus (Brazil), and Río Manu (Peru), it has to be taken into account that bird inventories and ecological studies at the Ecuadorian site were less comprehensive than at the other sites. But differences in the completeness of data sets also exist between the four best-known localities (Karr *et al.* 1990) due to the distinct history and focus of the ornithological research at each site as well as the differences in the habitats represented (Table 3). Initial comprehensive inventories of the Central American avifaunas were published as early as the 1950s for Barro Colorado Island (Eisenmann 1952, Willis & Eisenmann 1979) and a few years later also for La Selva (Slud 1960, Levey & Stiles 1994). At the Amazonian localities, intensive avifaunistic research started almost two decades later, at Cocha Cashu in 1973 (Robinson & Terborgh 1990) and in the study area of the Biological Dynamics of Forest Fragments Project (BDFFP; formerly Minimum Critical Size of Ecosystems Project, MCSE) north of Manaus in 1979 (Lewin 1984, Laurance *et al.* 2002). However, for Reserva Forestal Adolfo Ducke, a site close to Manaus, a first bird inventory had been published some years earlier (Willis 1977). Ornithological studies at Nouragues, French Guiana, began 1986, the founding year of the field station there (Thiollay 1994b). By contrast, the first bird surveys at Playa de Oro were not carried out

until 1993 (Benítez & Matheus 1997). Furthermore, the preliminary inventory of Benítez & Matheus (1997), as well as the much more comprehensive studies carried out by P. Mena V. (pers. comm.) and myself, concentrated mostly on the lowlands below 200 m. Thus the bird list of Playa de Oro is still relatively incomplete, with 344 species recorded until 2009 (Table 39). I estimate that the final count will be about 400 species (Jahn *et al.* 1999b), especially when latitudinal and altitudinal migrants have been inventoried and the foothill zone above c. 300 m thoroughly investigated. Therefore, total species richness at Playa de Oro is probably similar to that of La Selva ( $n = 411$ ), but lower than in central Panama or western Peru. The relatively low number of species ( $n = 351$ ) recorded in the BDFFP area 80 km north of Manaus is not directly comparable to that at the other lowland sites because no large rivers occur there and, in addition, open habitats have not yet been fully inventoried (Karr *et al.* 1990). Species richness at Playa de Oro is, however, very similar to that of eastern Amazonia, where 323 taxa were recorded at Nouragues and total richness of residents was estimated to be 378 species (Thiollay 2002a).

Río Nambí, on the western Andean slope of SW Colombia (Table 3), where 248 species have been recorded (Appendix I in Salaman 2001), is less species rich or at least not so completely assessed as Playa de Oro.

The proportion of core taxa varied between 86% (Canal Zone) and 91.7% (Cocha Cashu) of the total species richness, and thus was very similar to that at Playa de Oro (86.6%). Although the completeness of the Playa de Oro bird list is only c. 80% of the expected total, the number of forest species known from there is already as high as at La Selva, the Panama Canal Zone, and Nouragues, with about 250 taxa (Table 39; Thiollay 1994b, 2002a). However, it is clear that some differences existed in the definition of forest species between the data published by Karr *et al.* (1990) and the present work. Some taxa regarded here as non-forest, e.g., *Crypturellus soui* and *Lepidocolaptes souleyetii* (Appendix 8), were counted as forest species by Karr *et al.* (1990), and vice versa. With a more standardized approach, the number of 'forest families' was very similar for all five lowland localities. On the other hand, the number of 'forest genera' in Playa de Oro is similar to that in central Panama, but lower than at La Selva, Manaus, or Cocha Cashu. Another major avifaunal

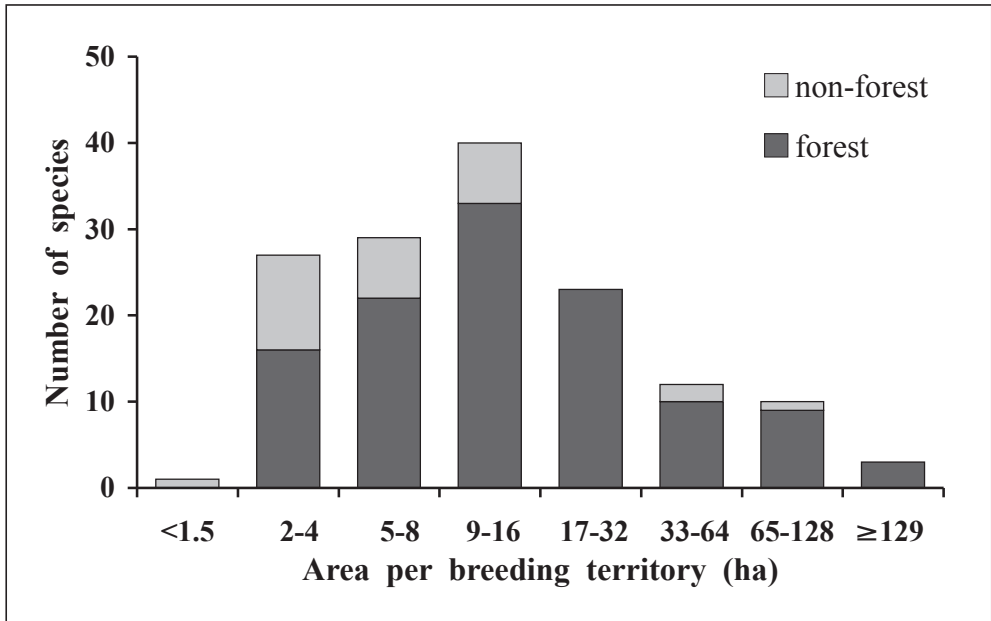


FIG. 36. Proportion of forest ( $n = 116$ ) and non-forest ( $n = 29$ ) species in categories (log<sub>2</sub> scale) of the available area per breeding territory within appropriate habitat at transects MNT1 and MNT2. Calculated on the basis of the MTW data, using the estimated number of territories per square kilometer within habitat (Appendices 18b and 19b). For territorial species present at both transects ( $n = 93$ ), I used the arithmetic mean of the area per territory determined for each transect; for the others ( $n = 52$ ), I directly employed the single estimates. Note: For the Chi-squared test, comparing proportions between forest and non-forest taxa, I used the following combined area categories to avoid the expected count of some cells in the contingency table being less than five: 0–4 ha, 9–32 ha, and  $\geq 33$  ha.

difference among the areas is the richer assemblage of Nearctic-Neotropical migrants in Central America (La Selva = 86 species; central Panama = 66) than in South America (Río Nambí = 11; Playa de Oro = 25; Manaus = 20; Cocha Cashu = 40) (Karr *et al.* 1990, Levey & Stiles 1994, Salaman 2001; Table 13).

Species accumulation curves for 1000-capture samples gathered in *terra firme* forest were very similar for Playa de Oro, La Selva, Manaus, and the Pipeline Road (Fig. 38; Table 40). Mist-netting samples from the Río Manu area were much more species-rich in comparison (Karr *et al.* 1990). Interestingly, with 68 taxa, Playa de Oro produced the least species-rich sample of any of the lowland forest sites considered here. Only the Río Nambí data set contained even less species, which is no surprise considering that the site is located on the Andean slope. Furthermore, the curve for Playa de Oro was

the only one that fully flattened out after c. 900 captures, whereas all others tended to increase further.

Several factors may have negatively influenced species accumulation at the Ecuadorian Chocó locality. Firstly, the data set was obtained through re-sampling of only three transect sections rather than through trapping with several widely dispersed net lines. The number of species would likely be higher if the data set had contained 100-bird samples from 10 different forest transects, just to give an example. Secondly, the transect sections covered relatively homogeneous medium-aged forest, and several undergrowth taxa were never captured, although their territories existed within 1000 m or less from the net lines; e.g., *Automolus ochrolaemus*, *Sclerurus mexicanus*, *Campylorhamphus pusillus*, *Phaenostictus mcleani*, or *Pittasoma rufopileatum*. Furthermore, with 18 mm instead of 36 mm, I used a much smaller

mesh size in comparison with the other researchers, so that taxa > 64 g were captured with lower efficiency than in the other studies (Fig. 24; p. 83, Influence of body size).

Other characteristics of the 1000-capture sample from Playa de Oro were similar to those of the two Central American and the Río Nambí data sets. In all of the former samples at least one species was represented by more than 100 captures, and the 10 most frequently trapped taxa together comprised more than 50% of all captures. La Selva was the only site with two species above the 100-capture threshold and, in addition, also held the highest proportion of top 10 taxa per sample (63.7%). By contrast, at the Amazonian localities none of the species were represented by more than 100 captures and the proportion of top 10 species was only about 40%, demonstrating the high evenness of the undergrowth bird community there. The proportion of species represented only by 10 or less captures was lowest for Playa de Oro (57.4%) and the area north of Manaus (57.9%) and highest for central Panama (71.4%) and Cocha Cashu (71.2%). The Río Nambí area (63.6%) and La Selva (65.7%) were interme-

diate. However, only a few of these species might be genuinely rare. Most of them were probably under-detected due to the extreme selectivity of the mist-netting method for small body size and low vegetation strata (Chapter 4).

Some cautious notes on the general comparability of 1000-capture samples between sites should be made. Do the results really reflect the patterns of the corresponding undergrowth bird communities? In my opinion it is rather doubtful whether the results are comparable. Although the samples of all localities shown in Table 40 were gathered in *terra firme* forest, considerable differences in topography, presence/absence of forest streams, distance to forest borders, canopy height, and forest structure, among many other factors, certainly existed among sites, biasing direct comparisons. For example, in the Río Nambí area, Salaman (2001) found considerable differences between 1000-capture samples from young secondary growth, old secondary growth, and primary forest. Species richness decreased from 93 to 60 species from young forest to virgin forest. In each of the data sets for old secondary growth and primary forest, one species was represented by more than 100

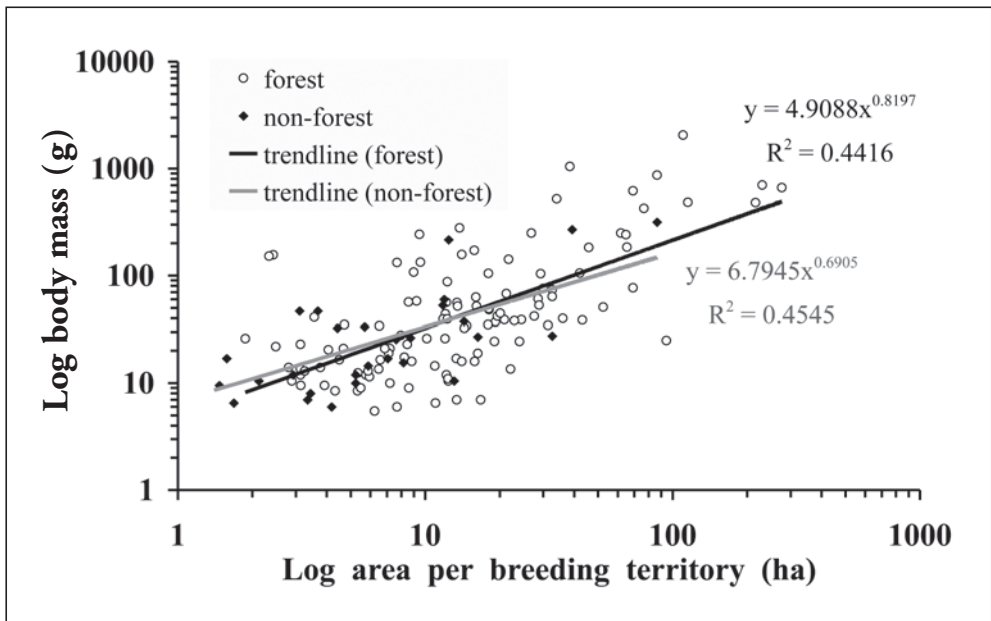


FIG. 37. Relationship between body size and available area per breeding territory within appropriate habitat for forest ( $n = 116$ ) and non-forest ( $n = 29$ ) species. Log of body mass vs. log of available area per breeding territory (cf. Fig. 36; Appendices 18b and 19b).

TABLE 39. Number of birds recorded in Playa de Oro in comparison with four well-studied Neotropical lowland areas. Enhanced from Karr *et al.* (1990). See Table 3 for details on the environmental conditions of each locality. Notes: (a) 'non-vagrant' in Karr *et al.* (1990); (b) some aquatic species were also counted as vagrants; (c) numbers changed from basis of Levey & Stiles (1994); (d) since Nov. 2004, I confirmed the presence of eight additional species (p. 117f, Species richness and confirmation status) and the final count is expected to increase to > 400 species when the foothill zone up to 590 m has been intensively studied; (e) some of the taxa counted here as 'non-core' will, in fact, likely turn out to be in fact core species; (f) two taxa, *Chloroceryle inda* and *C. aenea*, were also counted as forest species; all rail taxa recorded in Playa de Oro were regarded as landbirds; (g) number clearly includes some taxa (at least five) that were not counted as forest species by Karr *et al.* (1990); (h) number in parenthesis includes the Cathartidae, Apodidae, and Hirundinidae, which were regarded as 'forest families' in this study, as well as recent taxonomic changes regarding the family-level assignment of *Sapayoa aenigma* as well as of the genera *Chlorophonia* and *Euphonia* (Appendix 5); (i) number in parenthesis includes five forest edge species of the families mentioned before (cf. Appendix 8).

	La Selva (Costa Rica)	Canal zone (Panama)	Playa de Oro (Ecuador)	Manaus (Brazil)	Río Manu (Peru)
Total species	411 <sup>c</sup>	443	336 <sup>d</sup>	351	554
Core species <sup>a</sup>	369 <sup>c</sup>	381	291 <sup>e</sup>	?	508
Aquatic species <sup>b</sup>	28	57	17 <sup>f</sup>	16	51
Forest species	244	251	250 <sup>g</sup>	300	332
Forest families	36	39	39 (44) <sup>h</sup>	38	37
Forest genera	205	179	181 (186) <sup>i</sup>	208	230

captures, whereas no species passed this threshold in young secondary forest. The proportion of top 10 species increased from 49.4% to 65.1% from young to unlogged forest. However, all top 10 species in any of these samples were also present in the other two, and the number of top 10 taxa shared between samples was six for the three possible habitat pairs. Examples for the fact that stochastic and seasonal factors may also cause considerable variation in similarity coefficients between data sets obtained through constant time-effort resampling at one and the same transect were provided for Playa de Oro (Tables 35 and 36). The presence of an altitudinal migrant (*Corapipo altera*) as well as a Nearctic-Neotropical migrant (*Hylocichla mustelina*) among the 10 most frequently netted species at La Selva also unequivocally demonstrates that species-abundance relationships are heavily influenced by season (Table 41). These species would likely not even be present, or at least considerably less abundant, if the sample had been gathered during their breeding seasons. In conclusion, with such variability between data sets obtained in a given area but during distinct seasons or in forest sections at different stages of regeneration, comparisons between geographic regions should be regarded as preliminary at best.

Comparing the most frequently captured taxa between localities, it is evident that few similarities existed at the species level (Table 41). Playa de Oro shared only two top 10 species with each of the other sites, with the exception of central Amazonia where it was only one. By contrast, the two Central American sites shared four of the most abundant taxa, and the Amazonian localities three. Just three of the species belonging in the group of top 10 species at any of the sites were also present at all others. *Glyphorhynchus spirurus* was the most ubiquitously common species and ranked top 10 at five of six localities, including Playa de Oro. In central Panama, the only area where this small bark-climbing insectivore was less abundant, another widespread woodcreeper, *Dendrocincla fuliginosa*, was among to the most common species. The only other species present at all localities was *Automolus ochrolaemus*, a dead-leaf-searching insectivorous ovenbird. *Myrmotherula axillaris*, *Platyrinchus coronatus*, and *Geotrygon montana* were captured at all lowland sites but were absent in the Río Nambí sample, whereas *M. fulviventris*, *Threnetes ruckeri*, and *Tachyphonus delatrii* were present at the localities in Central America as well as west of the Andes, but not at the cis-Andean sites. On the other hand, *Mionectes olivaceus* and *M. oleagi-*

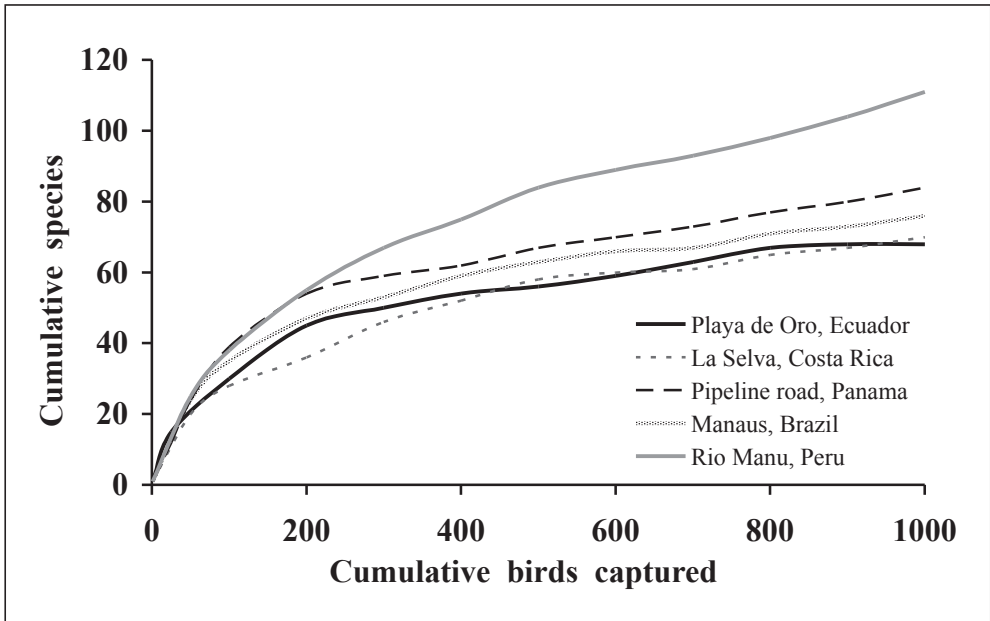


FIG. 38. Species accumulation curves for 1000-capture undergrowth mist-netting samples from *terra firme* forest of five Neotropical lowland areas. Enhanced from Karr *et al.* (1990).

*neus* were missing only in Central Amazonia. *Pipra mentalis* belonged in the top 10 species only at the two Central American sites as well as at Playa de Oro. Even at the level of foraging guilds, similarities between geographic regions were rather scarce. However, some interesting patterns appeared. Apart from the previously mentioned bark-climbing insectivores, frugivores were the only other guild represented by

at least one top 10 species at all sites. Three other guilds contained at least one species among the 10 commonest ones at five of the six localities: arboreal gleaning insectivores, nectarivores, and omnivores. The Río Nambí sample was very distinctive in comparison with the lowland sites. Three insectivorous guilds (terrestrial gleaning, ant-following, and arboreal sallying) were represented there neither by any

TABLE 40. Summary of selected attributes of 1000-capture undergrowth mist-netting samples from *terra firme* forest of six Neotropical areas. Enhanced from Karr *et al.* (1990) and Salaman (2001). Notes: (a) the data set shown represents old second growth forest (Salaman 2001).

	La Selva (Costa Rica)	Pipeline road (Panama)	Río Nambí (Colombia) <sup>a</sup>	Playa de Oro (Ecuador)	Manaus (Brazil)	Río Manu (Peru)
Total species captured	70	84	66	68	76	111
Number of species represented by:						
101 or more captures	2	1	1	1	0	0
21-100 captures	8	13	16	15	17	13
11-20 captures	14	10	7	13	15	19
2-10 captures	33	43	28	24	34	44
1 capture	13	17	14	15	10	35
Number of captures in top 10 species	637	548	595	523	412	398

TABLE 41. Number of captures and rank of the 10 most frequently trapped species in 1000-capture undergrowth mist-netting samples from *terra firme* forest of six Neotropical areas. Enhanced from Karr *et al.* (1990) and Salaman (2001b). Taxonomy and species sequence updated according to Ridgley & Greenfield (2001b) and Remsen *et al.* (2004). For species with equal abundance I assigned tied ranks according to the rules of nonparametric statistics. Abbreviations used: cap. = captured, but not within sample considered; n. cap. = not captured, but present in area (cf. Appendix 6); + = present in area but not in top 10 species. Notes: (a) more than one species might be involved at the sites considered here; references summarized by Remsen *et al.* (2004); (b) taxonomy or spelling was changed since the publication of Karr *et al.* (1990); (c) altitudinal migrant; (d) latitudinal migrant; (e) the data set shown represents old second growth forest (Salaman 2001).

	La Selva (Costa Rica)		Pipeline rd (Panama)		Río Nambí (Colombia) <sup>c</sup>		Playa de Oro (Ecuador)		Manaus (Brazil)		Río Manu (Peru)	
	N	Rank	N	Rank	N	Rank	N	Rank	N	Rank	N	Rank
Terrestrial gleaning insectivore												
<i>Formicarius analis</i> <sup>a</sup>	21	9.5	+						+		+	
<i>Sclerurus guatemalensis</i>	+		30	10								
<i>Microcerculus marginatus</i> <sup>a, b</sup>			+				+	(26)			24	6.5
<i>Cyphorhinus phaeocephalus</i>	+		32	8			+	(61)				
Ant-following insectivore												
<i>Pithys albifrons</i>									46	4.5		
<i>Gymnopithys leucaspis</i>	29	7	78	2			+	(18)				
<i>G. rufigula</i>									54	3		
<i>Hylophylax naevioides</i>	+		44	5			+	(14)				
<i>H. poecilinotus</i> <sup>b</sup>									58	2	24	6.5
Bark-climbing insectivore												
<i>Dendrocicla fuliginosa</i>	+		39	7	+		+	(34)	+		+	
<i>Glyphorhynchus spirurus</i> <sup>a</sup>	152	1	+		55	5	42	6	46	4.5	84	2
Arboreal gleaning insectivore												
<i>Premnoplex brunnescens</i>					51	6						
<i>Automolus ochrolaemus</i>	+		+		+		+	n.cap.	+		23	8.5
<i>Myrmotherula fulviventris</i>	+		+		+		36	8				
<i>M. axillaris</i> <sup>a</sup>	+		+				35	9	+		22	10
<i>M. schisticolor</i>					34	10	+	(61)				
<i>M. longipennis</i> <sup>a</sup>									29	8	+	
<i>Myrmoborus myotherinus</i>											34	4
<i>Henicorhina leucosticta</i>	25	8	+				+	(32)				
Arboreal sallying insectivore												
<i>Thamnomanes ardesiacus</i>									30	6.5	+	
<i>T. caesioides</i>									30	6.5		
<i>Platyrinchus coronatus</i>	+		42	6			+	(34)	+		+	
<i>Myiobius sulphureipygius</i>	+		+				38	7				
Frugivore												
<i>Geotrygon montana</i>	+		+				+	(42)	29	8	23	8.5
<i>Masius chrysopterus</i>					89	2	+	n.cap.				
<i>Corapipo altera</i> <sup>b, c</sup>	38	6										
<i>Machaeropterus deliciosus</i>					65	3	+	(61)				
<i>Lepidothrix coronata</i> <sup>b</sup>			31	9			48	5			31	5
<i>Chloropipo holochlora</i>							30	10.5				
<i>Dixiphia pipra</i> <sup>a, b</sup>	+								62	1		
<i>Pipra fasciicauda</i>											94	1
<i>Pipra mentalis</i>	134	2	121	1			50	4				
<i>Euphonia xanthogaster</i>					62	4	+	(16)			+	



TABLE 41. Continued.

	La Selva (Costa Rica)		Pipeline rd (Panama)		Río Nambí (Colombia) <sup>c</sup>		Playa de Oro (Ecuador)		Manaus (Brazil)		Río Manu (Peru)	
	N	Rank	N	Rank	N	Rank	N	Rank	N	Rank	N	Rank
Omnivore (insectivore-frugivore)												
<i>Mionectes olivaceus</i>	+		+		37	9	78	2			+	
<i>M. oleagineus</i>	94	3	72	2	+		+	cap.			+	
<i>Hylocichla mustelina</i> <sup>d</sup>	63	4	+									
<i>Turdus albicollis</i> <sup>a</sup>									28	10	+	
<i>Tachyphonus delatrii</i>	+		+		+		108	1				

top 10 species nor by the presence of any taxon that belonged to the most frequently trapped birds in the lowland forests.

Regarding nectarivores, members of the genus *Phaethornis* were missing among the most frequently trapped hummingbirds only in the BDFFP area north of Manaus. In comparison with all other sites (Table 3), the latter area is characterized by poor soils, low abundance of water and streams, and an intense dry season. These factors decrease the diversity and abundance of bird-pollinated *Heliconia* (Musaceae) and other terrestrial herbs, like *Costus* (Zingiberaceae), which are important food resources for these undergrowth-dwelling hermit hummingbirds. In fact, the Musaceae is one of 29 widespread plant families not recorded at the Reserva Forestal Adolfo Ducke (Prance 1990), which could, however, be a case of inadequate collecting (Gentry 1990a). In general, the abundance of trochilids rose with increasing annual precipitation and decreasing distance to foothills and middle elevations of the cordilleras. Consequently, in Central Amazonia no hummingbird was among the commonest species, but in the Río Nambí area there were three among the top 10 taxa, and *Agelaiocercus coelestis* was even the most abundant species on the western Andean slope. At Playa de Oro two trochilids (*Threnetes ruckeri*, *Phaethornis yaruqui*) were among the most frequently captured taxa, as at La Selva (*P. longirostris*, *Chalybura urochrysis*). This pattern is due to the fact that the number of ornithophilous plants is lowest in dry forest and highest in wet forest at low to middle altitudes (Stiles 1981, 1985).

Ant-following birds provided most top 10 species at sites with low to medium soil fertility, moderate annual precipitation, and pronounced dry season, with three taxa north of Manaus and two in central Panama, three if *Dendrocincla fuliginosa* is also counted as an obligate ant-follower, as it is by some

authors (e.g., Karr *et al.* 1990; but see Appendix 9). In addition, the latter area was also the only one that held two top 10 species of terrestrial gleaning insectivores. At Playa de Oro none of the two previous foraging guilds were represented by a top 10 species, although two species per guild that belonged to the most abundant birds at other sites were present.

Frugivores were represented by at least one top 10 species among the Pipridae in all Neotropical forests. Playa de Oro held the highest number of frequently netted manakins, with three species, *Lepidothrix coronata*, *Chloropipo holochlora*, and *Pipra mentalis*. However, *C. holochlora* was the taxon with the highest recapture rate (64%) of all species, and thus would certainly not belong in this group if only first captures had been included in the sample. In the Manaus area only one manakin belonged to the top 10 species, at all other sites it was two species of Pipridae.

The bird community of human-influenced habitat mosaics

Performance of species richness estimators

Some important lessons are to be learned from the mist-netting and transect-mapping data gathered at transects MNT1 and MNT2. Firstly, it is not possible to obtain reliable estimates of total species richness on the basis of undergrowth mist-netting samples. If capture data do have to be used, e.g., because they are the only ones available, then it is preferable to combine as many samples as possible for each transect or study plot and to compute the richness estimators from these accumulated data sets. The overall performance of incidence-based models was better than abundance-based statistics ACE and Chao 1. The latter two tended to underestimate species richness more extremely. Another advantage of presence/absence-based estimators is that recaptures do not affect the results. However, at least two

data sets are needed for their calculation. Jackknife 2 or Chao 2 performed best when estimations were based on multiple data sets, e.g., one for each complete mist-netting survey. ICE, MMRuns, and MM-Mean returned the highest estimates for the two accumulated data sets of the complete mist-netting studies at MNT1 and MNT2, with an accuracy of 75.3 to 84.4% of the number of core species known to occur at both transects together (Tables 27 and 29).

Transect-mapping data are much better suited for the estimation of total species richness than mist-netting samples. Again, it is advisable to compute incidence-based estimators for at least two transects (or study plots) with combined data sets from various surveys. In general, the more complete the samples the more accurate are the estimates. ICE, MMRuns, and MM-Mean performed best for the MTW data. When I used one accumulated data set per transect, they predicted the combined richness of core species at MNT1 and MNT2 with a surprising accuracy of 98.6 to 107.0% after only 45.5 h of sampling. ICE is extremely sensitive to the number of (combined) samples, but always returned the highest estimates when calculations were based on only two accumulated data sets (Table 28). Thus I recommend ICE for rapid assessment studies in which the completeness of sampling is thought to be low compared with comprehensive monitoring projects, and high accuracy of estimates should not be expected anyway. The performance of MMRuns and MM-Mean was much more robust, and these estimators should always be employed when transect-mapping surveys reach higher degrees of completeness or when calculations are based on more than two data sets. These results are in agreement with Herzog *et al.* (2002), who also found the Michaelis-Menten statistics to be the most accurate of nine estimators tested for simulated exponential decline and empirical data sets in Bolivian bird communities. With simulated data, MMRuns tended to be more sensitive to species richness and sample size than MM-Mean, and therefore the authors recommended the latter as the least biased estimator. However, in the present study MMRuns performed slightly better than MM-Mean, although both computed very similar results (Tables 27 and 29).

Chao 2 showed a poor performance with transect-mapping data, and consequently should not be used for analysing them. This finding stands in stark contrast to several other studies, which recommended it as one of the least biased estimators (e.g., Colwell

& Coddington 1994, Chazdon *et al.* 1998, Walther & Morand 1998, Walther & Martin 2001). However, Herzog *et al.* (2002) arrived at a similar result as the present study, concluding that their species-list method violated the estimator's assumption of random incidence samples (Chao 1987). Of course, the same argument also applies to transect-mapping data. Furthermore, the studies mentioned above used species-poor data sets of only 3 to 40 species in contrast to the species-rich bird communities studied here and in the work of Herzog *et al.* (2002).

In recent years, capture/recapture models have been increasingly used to estimate total species richness for data sets of large-scale bird monitoring studies, such as the North American Breeding Bird Survey (BBS) (e.g., Boulinier *et al.* 1998, Nichols *et al.* 1998) and the Swiss Breeding Bird Survey (MHB) (e.g., Kéry & Schmid 2006), one argument in favor being that these models much better account for heterogeneous species detectability than species accumulation curves and related methods (Kéry & Schmid 2004). Particularly jackknife estimators have become a standard for estimation of species richness (and species detectability) as they performed well in several comparative studies (e.g., Palmer 1990, 1991; Brose *et al.* 2003, Baker 2004). Although in the present work Michaelis-Menten statistics and ICE returned better richness estimates on the basis of the modeled bird communities of MNT1 and MNT2, with an accuracy of 91% both jackknife estimators performed reasonably well in comparison with other statistics (ACE, Chao 1, Chao 2, and bootstrap). Thus, the performance of capture-recapture statistics certainly deserves a more detailed analysis in future transect-mapping studies.

It is probable that no single richness estimator can work well for all taxonomic groups (Herzog *et al.* 2002), but apart from inherent differences in community structure, the methods used for data collection also clearly affect estimator performance. For example, my mist-netting data fitted the logarithmic series model better than the truncated lognormal distribution, whereas the extrapolated bird populations of the same transects were best described either by the truncated lognormal or the broken-stick models (Table 30; Figs. 32a to 34b). It is known that Michaelis-Menten statistics are not robust regarding differences in community structure (Keating & Quinn 1998, Herzog *et al.* 2002). Both estimators perform well for at least moderately large communities ( $\geq 100$  species), matching the broken-stick distri-

bution, with the prerequisites fulfilled by the modeled bird communities of MNT1 and MNT2 but not so well for the mist-netting data. For species-poor and less even communities, Michaelis-Menten models are unreliable in the estimation of species richness (Keating & Quinn 1998).

#### Performance of diversity indices and similarity coefficients

The truncated lognormal model describes the species abundance distribution of the complete mist-netting studies and the extrapolated transect-mapping data, whereas Fisher's logarithmic series model fits only the former samples (Table 30). Thus, it might be assumed that of the parametric diversity measurements only lognormal index  $\lambda$  provides meaningful information for mist netting as well as modeled population data. Nonparametric indices, such as the information-theory-based Shannon's diversity  $H'$  and Shannon's evenness  $EH'$  as well as Simpson's dominance measure  $D$  make no assumptions about the shape of the underlying species abundance distribution (Magurran 1988) and thus might also be appropriate for assessing the diversity of mist-netting and transect-mapping data alike.

In general, there is little consensus on the best diversity index to use (Magurran 1988). Most diversity estimators are either sensitive to sample size (i.e., species richness), the underlying species abundance distribution (e.g., lognormal  $\lambda$ ), or have a poor discriminant ability (e.g., Shannon's  $EH'$ , Simpson's  $D$ ) (Magurran 1988, Kempton 2002). Other diversity measurements with intermediate discriminant abilities as well as moderate sensitivities to sample size, like Shannon's  $H'$ , have been discredited on many occasions (e.g., Peet 1974, Goodman 1975, May 1975, Routledge 1979, Flade 1994).

Only Fisher's  $\alpha$  has been attested a satisfactory performance in a wide range of circumstances, even when the underlying species abundance distribution does not fit the log-series model (Taylor 1978). Furthermore,  $\alpha$  is less affected by the abundance of the commonest species than widely used nonparametric indices. Due to its good discriminant ability and low sensitivity to sample size it is a potential candidate for a universal diversity statistics application (Southwood 1978). In agreement with this,  $\alpha$  turned out to be the least biased of the diversity indices considered in the present study. This parametric index computed very similar values for first captures ( $MN_{fc}$ ) and modeled bird populations ( $MTW_{pop}$ ) for

transect MNT2 and the combined data set of both transects together (Table 33). Only for MNT1 did  $\alpha$  return higher values for first captures than for the extrapolated community. All other diversity measurements tended to be considerably higher for the much larger samples of the extrapolated populations. In conclusion, Fisher's  $\alpha$  might be the most appropriate diversity statistics for comparison between mist-netting or transect-mapping samples because for both survey methods time effort is easily standardized but species richness can vary considerably.

Another important aspect has to be considered. Diversity measurements for mist-netting data containing recaptures were almost always lower than the corresponding values for data sets of first captures only (Tables 33 and 34). Thus, if indices are computed based on mist-netting samples with an unknown number of recaptures, e.g., because not all birds could be permanently marked, then calculations almost certainly underestimate true diversity. A similar pattern was also found for transect-mapping data. Extrapolated populations were attributed higher diversity estimates than the corresponding crude samples containing unknown numbers of repeatedly observed birds. However, one important exception existed:  $\alpha$  was 9.6 to 13.2% lower for the modeled bird communities than for the combined raw data on which the extrapolations were based. The reason is, of course, that during the modeling procedure species richness is kept constant, whereas abundance is increased for the majority of taxa – an excellent demonstration of the fact that  $\alpha$  is not biased by sample size like other diversity statistics. As a consequence, for transect-mapping data  $\alpha$  should be exclusively interpreted on the basis of the modeled bird communities.

Parametric diversity statistics, like  $\alpha$  and  $\lambda$ , are credited with a good discriminant ability (Magurran 1988, Kempton 2002). Thus, it must be concluded that transect MNT1 was more diverse than MNT2 (Tables 33 and 34). This result was anticipated for the mist-netting samples based on the  $k$ -dominance plots (Fig. 30b), but not so clearly for the modeled bird communities (Fig. 31). Platt *et al.* (1984) claimed that it is not possible to decide which of two sites holds the more diverse community when their curves intersect in  $k$ -dominance plots, due to the fact that different diversity indices rank them in different ways. However, others have criticized that these rank abundance plots are overly dependent on the abundance of the most common taxa (Gray 1987), and

Magurran (1988) emphasized that plots with intersecting curves might be the most informative because they illustrate the shift of dominance relative to species richness. Considering these arguments, it is no surprise that the only statistics that computed higher values for the modeled bird community of transect MNT2 ( $D = 62.56$ ) than of MNT1 ( $D = 62.32$ ) was Simpson's dominance measurement  $D$ , because it is weighted towards the abundance of the commonest species (Magurran 1988).

Regarding the use of similarity coefficients, several researchers have demonstrated that presence/absence-based (qualitative) measures are unsatisfactory due to their strong sensitivity to species richness and sample size (e.g., Wolda 1981, Smith 1986, cited in Magurran 1988). These indices perform particularly poor as measures of similarity between diverse assemblages that contain numerous rare species (e.g., Colwell & Coddington 1994, Plotkin & Muller-Landau 2002), which is a consequence of unrecorded shared species in incomplete samples (Chao *et al.* 2005). In accordance with these findings, Jaccard and Sørensen I (qualitative) models computed very similar mean values in within-transect comparisons of complete mist-netting and MTW surveys and in between-transect analysis. Thus, the variation in similarity coefficients between various surveys collected at each transect was almost as high as the differences found between transects (Tables 35, 36, and 37). For the transect-mapping data, similarly poor discriminant abilities were also observed for the quantitative Sørensen II coefficient (Table 37). Only the Morisita-Horn model calculated more consistent values, in agreement with the results of the studies cited above. In transect-mapping studies, the Morisita-Horn index should be exclusively calculated on the basis of modeled bird communities due to the fact that raw MTW data represent only 'pseudo-abundance' information, which is largely influenced by species detectability and thus disguise the true abundance relationship within the bird community (Tables 31 and 32).

How real are the modeled community data based on transect mapping?

The first comprehensive and accurate survey of any Neotropical bird community was presented by Terborgh *et al.* (1990) for a 97-ha plot of floodplain forest in Amazonian Peru. The study was carried out over a three-months period in 1982, with a total effort of c. 12 person-months by a group of 5 ornithologists who had many years of field experience with the local avifauna. In addition to spot mapping, their principal survey technique, they applied several other methods, including mist netting, to estimate the number of individuals for non-territorial and flock-forming species. Robinson *et al.* (2000) used the same suite of methods as Terborgh *et al.* (1990) plus point counts to characterize the bird community of the 104-ha Limbo plot, Soberanía National Park, Panama (field effort: at least 15 person-months). Thiollay (1994b) presented the only other comparable study providing population density estimates for Neotropical birds for a 100-ha plot at Nouragues field station, French Guiana (field effort: at least 8 person-months). Of course, the population estimates presented here cannot possibly reach the same level of accuracy as those presented by aforementioned studies and should be regarded as preliminary at best. My calculations were based on only two short transects and a single survey method (MTW). The total effort was merely 44.5 h, distributed over 22 days from Feb. to Nov. 1997 (Appendix 3). I consciously did not consider the mist-netting data in the modeling procedure because my aim was to assess the feasibility of estimating absolute population densities exclusively based on transect-mapping data. Thus, before comparing the modeled bird communities of MNT1 and MNT2 with population data in other studies, it seems advisable to take a closer look at the many potential sources of bias that may have affected the accuracy of my results.

Obviously, species that were common but went undetected in the transect-mapping surveys were lost for the estimation of population data. This group includes especially non-breeding visitors and floaters that did not establish feeding territories in the transect areas (Chapter 4). In addition, up to 20% of the presumed breeding species were not observed in the MTW surveys (Appendices 15a and 15b). At least some of them probably occurred at densities too low to measure. Terborgh *et al.* (1990) used a similar argumentation for presenting population data only for 76.8% (245) of the 319 species recorded, and Robinson *et al.* (2000) reported density estimates for only 165 (65.5%) of 252 species. Thus, besides some shortcomings of my pilot study, the fact that I provided population densities for 70.1% (162) and 62.3% (144) of all bird taxa known to occur at transects MNT1 and MNT2, respectively, is rather promising. Still, it is likely that the alleged 'low-density' species together still contribute several kilo-

grams to the total biomass density of the bird communities. For example, a single pair of *Harpia harpyja* with a fledged juvenile, which routinely stays over one year on its parents' territory (Bierregaard 1994), would add c. 0.3 kg/km<sup>2</sup>, assuming a territory size of 50 km<sup>2</sup> and body weights of between 4 and 9 kg per individual. Although other 'low-density' taxa may be lighter than a Harpy Eagle, their mean territory size is also much smaller, so that they still add a few hundred grams per species and square kilometer.

Mist-netting surveys revealed that at least some of the overlooked or underrecorded taxa were in fact common in the transect areas (Table 10, Appendices 12a and 12b). The affected species were not identical for MNT1 and MNT2, in part due to differences in their status and general vocal activity (e.g., presence/absence of leks and display territories) as well as to stochastic factors (p. 83-85, Influence of breeding/non-breeding status and territory/home-range size). Based on the extrapolated abundance data of other common small suboscine passerines (Appendices 18a and 19a), I estimate that the number of individuals lost to the analysis was about 200-300 per km<sup>2</sup> (c. 2-3 kg/km<sup>2</sup>) for MNT1 and 100-200 per km<sup>2</sup> (c. 1-2 kg/km<sup>2</sup>) for MNT2.

It is possible that the population density of some other common species was underestimated because of the low resolution of the original two-belt transect-mapping approach. Potential candidates for this bias were species with relatively small territories but far-carrying vocalizations, like *Crypturellus soui*, *Myrmeciza exsul*, or *Saltator maximus*. However, it is unclear to which extent population densities were really underestimated for these species. For example, for *M. exsul* I calculated a 'within-habitat' population density of c. 32 territories per km<sup>2</sup> at both transects, corresponding to an available area per territory of 3.1 ha (Appendices 18b and 19b). These figures are very similar to those estimated for Barro Colorado Island, Panama, where the extent of its territories was at least 2.5 ha and the population density 30 pairs per km<sup>2</sup> (Willis & Oniki 1972). Another territory mapped in Corcovado National Park, Costa Rica, covered about 2.6 ha (Marcotullio & Gill 1985). However, following Terborgh *et al.* (1990: 222), I assumed that on average one juvenile or immature bird was present per two pairs, resulting in a year-round mean of about 80 individuals per km<sup>2</sup> and a biomass density of c. 18 g/ha. By contrast, Willis & Oniki (1972) estimated absolute population density

at only 65 birds per km<sup>2</sup>. Their biomass density estimate was nevertheless identical to mine because mean weight of Central American birds is 3 to 5 g higher than that of northwestern Ecuadorian birds (Stiles & Skutch 1989, Dunning 1993; Appendix 11).

The extrapolated abundance of some species was surprisingly high. According to the modeled bird population data, *Manacus manacus* was the most abundant species in the habitat mosaic at MNT1, with 328 birds/km<sup>2</sup>, corresponding to 51 individuals within the transect area ( $\leq 100$  m around MNT1). The estimate was based on a maximum of 15 displaying males recorded at the leks along the transect line (Appendix 18a). By comparison, only 12 adult males were captured in a total sample of 57 individuals in the non-standardized mist-netting study. Considering that displaying males are quasi-territorial at the lek sites, and that their estimated effective DTD in audiovisual surveys was about 90 m, it seems likely that not all adult males present in the detection area were mist-netted. Thus, the population estimate for this species at MNT1 might be fairly accurate, assuming that equal sex ratio and presence of one juvenile/immature per two 'pairs' of males and females approximates to the real demographic proportions.

On the other hand, there were several bird species for which I suspect that population densities were considerably overestimated. Many of them are members of groups that could not be analyzed in units of territories or displaying males. For these species the calculation of population densities was based on the average maximum number of unsexed and unaged individuals recorded per complete survey. Especially in the case of fast-moving and erratic species (e.g., Apodidae, Psittacidae, and Hirundinidae), it is likely that, during some samples, many more than the mean number of individuals were present in the transect areas, depending on daily or seasonal fluctuations. At MNT2, for example, *Ara ambiguus* had an estimated population density of 1.1 individuals per km<sup>2</sup>, corresponding to a biomass density of 1.5 kg/km<sup>2</sup>. Considering that the total macaw population of Playa de Oro consisted of only about 6 to 8 individuals, occupying c. 50% or less of the community area, a more realistic estimate would have been a biomass density of c. 0.2 kg/km<sup>2</sup>.

Most swift species tend to gather over forest edges, rivers, and clearings during late morning to afternoon hours in fast-moving and wide-ranging



aerial flocks of varying size. These flocks might be attended by birds that have traveled many dozens of kilometers from their breeding grounds in just a few hours, leading to an overestimation of the local population. This might explain the unrealistically high population estimate of 164 individuals per km<sup>2</sup> for *Chaetura spinicaudus* at MNT1. By comparison, only 18 birds per km<sup>2</sup> were estimated at MNT2, which might reflect the true breeding population much better. As a consequence, at MNT1 I may have overestimated the population density of a single species by 100+ individuals per km<sup>2</sup> (1.5+ kg/km<sup>2</sup>), erroneously making it one of the 10 commonest taxa (Table 31). Of course, it is very difficult to sample aerial feeders accurately, and thus they are routinely excluded from analysis by most researchers (e.g., Lynch 1989, Terborgh *et al.* 1990, Thiollay 1994b, Robinson *et al.* 2000). However, I do not agree that this is the correct course, at least not for those taxa representing core species. Instead, it would be more appropriate to include them, but to emphasize that the data are biased. In future transect-mapping studies, population estimates should be based on a set of at least four transects in homogeneous habitat and of constant length (e.g., 1200 m), so that standard deviations could provide information about the variation of the average value for each species.

Other causes of bias include the presence of dispersing birds in mixed-species canopy flocks, as well as the shifting position of some territories. Due to the delayed accumulation of canopy species in the MTW pilot study (Chapter 4), the existence of some territories was based on only a very few observations. Thus, some of the presumed territories were perhaps attributable to dispersing individuals only temporarily attending the flocks. Shifting territories arose as a problem because calculations of population data had to be based on various MTW surveys, which were carried out over a period of several months. So the determination of the number of territories was distorted when changes in habitat structure occurred between surveys, e.g., through weeding of mixed-culture plantations. The position of some territories may also have changed due to the advancing regeneration of disturbed habitats as well as the generation of new tree-fall gaps.

The single most important source of bias was the fact that only two short transects were considered. Robinson *et al.* (2000) demonstrated how studies of small areas can result in very different population density estimates from those of larger plots. In my study, population estimates often had to be based on

very low numbers of recorded territories or individuals (Appendices 18a and 19a). Furthermore, the average detection threshold distances (DTD) used in the modeling procedure might be imprecise for some species, especially for those mainly recorded by sight. Curiously, the estimated biomass density was almost identical for MNT1 (193.4 kg/km<sup>2</sup>) and MNT2 (197.6 kg/km<sup>2</sup>), although the species composition was quite distinct at each transect. Even more surprising, the biomass densities of two very different Neotropical bird communities in a floodplain forest at Cocha Cashu, Peru (Terborgh *et al.* 1990), and in a mature secondary forest at Limbo plot, Panama (Robinson *et al.* 2000), were apparently also similar to those found for the habitat mosaics in Playa de Oro (see next subchapter). Optimistically, that could mean that errors in the DTD estimates as well as stochastic biases in the number of recorded territories/birds were roughly neutralized on average for the entire bird community. As a result, population density values for single species should be treated with caution, particularly those based on very low numbers of actual records and for species that could not be analyzed in units of territories or displaying males. Nevertheless, the overall results may reflect the real situation of the bird community rather well. One argument in favor of this might be provided by the species abundance distributions of the extrapolated avian communities, which are described well by the truncated lognormal and broken-stick models (Figs. 33b and 34b). In fact, commonly used species abundance statistics seem to fit the modeled bird communities of MNT1 and MNT2 so well that abundance-based species richness estimators (ACE and Chao 1) regard these assemblages as completely surveyed (Table 26), which of course they are not, as demonstrated earlier. However, some authors have emphasized that ubiquity of lognormal distributions in large data sets could be simply an artifact of mathematics (e.g., May 1975 cited in Magurran 1988). According to the Central Limit Theorem, random variation in factors will cause a variable to be normally distributed when a large number of factors interact to determine the magnitude of that variable. As the number of determining factors increases, this effect becomes more prevalent.

Comparison of the community structure at MNT1 and MNT2 with other sites

Although avian biomass densities calculated for the habitat mosaics in Playa de Oro (193–198 kg/km<sup>2</sup>) were, at first sight, similar to those estimated for



western Amazonian Peru (Terborgh *et al.* 1990) and central Panama (Robinson *et al.* 2000), it has to be considered that at the latter sites juveniles, immatures, and most non-breeding visitors were not included in the calculation. Consequently, the total avian biomass densities at Cocha Cashu and Limbo plot were 230–240 kg/km<sup>2</sup> rather than the 187 kg/km<sup>2</sup> stated for both areas, and thus at least 20–25% higher than in Playa de Oro. Of course, bird community structures and compositions in Peru and Panama differed in many aspects from those in northwestern Ecuador. The 97 ha study plot at the Río Manu was located amidst one of the richest and least disturbed forest areas in the world (Robinson & Terborgh 1990), whereas the habitat mosaics at the Río Santiago were continuously affected by human activities. Although much more disturbed than the Cocha Cashu area, the Limbo plot was still in continuous secondary forest, which was not logged for at least 60–120 years, with the exception of the immediate vicinity of the Pipeline road. In Peru, about 1910 individual birds of 245 species nested in 100 ha of floodplain forest (Terborgh *et al.* 1990), a figure that increases to c. 2400 birds/km<sup>2</sup> when juveniles and immatures are included. The overall avian density in western Amazonia was very similar to that of a hardwood forest at Hubbard Brook, USA, where about 1000 breeding pairs of 24 species on average were counted per 100 ha, comprising a biomass of only c. 40 kg/km<sup>2</sup> (Holmes & Sturges 1975). Lower population densities were reported from *terra firme* forest at Nouragues (829 pairs/km<sup>2</sup> for 221 species; biomass not provided; Thiollay 1994b) and from extensive habitat mosaics of palm swamps, riparian forest, *terra firme* forest, ridge-top forest, and others in Belvédère (760 pairs/km<sup>2</sup> for 263 species; biomass 148 kg/km<sup>2</sup>; Thiollay 1986), both sites in French Guiana. In stark contrast, the modeled Chocoan populations amounted to about 5300 individuals/km<sup>2</sup> at MNT1 and 4800 at MNT2. If non-breeding visitors (some Cathartidae, Psittacidae, Apodidae, Trochilidae, and Tyrannidae), as well as juveniles and immatures are omitted from the total population estimate, the number of breeding ‘pairs’ was roughly 2000/km<sup>2</sup> at MNT1 and 1800/km<sup>2</sup> at MNT2 – still about twice as many as in Peru or at Hubbard Brook. However, Karr (1977) reported equally high population densities of 1820 pairs/km<sup>2</sup>, corresponding to a biomass density of 131 kg/km<sup>2</sup>, for a 2 ha forest plot in central Panama. In the same area Robinson *et al.* (2000) counted 1617 pairs/km<sup>2</sup> in the 100-ha

Limbo plot, confirming that the lower Amazonian bird population densities should not be taken as a rule for tropical bird communities. As some larger frugivores and granivores were locally extinct at the former site, the average biomass per bird was only 56 g (*sensu* Robinson *et al.* 2000), compared with 100 g in Peru, where hunting pressure was basically nonexistent (Karr *et al.* 1990, Terborgh 1990). The average biomass per individual was even lower in the human-influenced landscapes in Playa de Oro, at only 36 g at MNT1 and 41 g at MNT2. Interestingly, despite these differences in mean biomass per bird, the proportion of the combined biomass of frugivores, granivores, and omnivores was very similar for Cocha Cashu (73%) and transect MNT2 (72%). The values were considerably lower for Limbo (66%) and MNT1 (64%), at the Ecuadorian site likely due to the more severe habitat disturbance, which was reflected, among other things, by an 8.3% contribution of the carrion feeder *Cathartes aura* to total biomass.

Terborgh *et al.* (1990) criticized that the 2-ha plot studied by Karr (1977) was much smaller than the average territory size of tropical forest birds, and suspected that true population densities were overestimated; e.g., Karr listed 12 species as having densities  $\geq 1$  pair/2 ha, whereas no taxon at Cocha Cashu had a territory as small as 2 ha. However, Robinson *et al.* (2000: Fig. 6) obtained no less than 15 species with territories  $\leq 2$  ha, confirming the striking differences in the territory-size distribution between Amazonian and Central American forest bird communities. Anyway, Terborgh *et al.*’s argument might not apply for the habitat mosaics in Playa de Oro, considering that the average detection area was 22.4 ha at MNT1 and 23.6 ha at MNT2 (calculated on the basis of the average detection threshold distances of all species recorded by transect mapping at each site; cf. Appendices 18a and 19a). Furthermore, in the present study only one species had an available area per breeding territory < 2 ha; it was *Synallaxis brachyura*, a non-forest bird (Fig. 36; Appendices 18b and 19b). Bird densities in semi-open and successional habitats are often much higher than in mature forest, especially in nutrient-rich floodplain areas. Important reasons for this are the higher fruit and insect abundances in young second-growth habitats compared with mature forest (e.g., Janzen 1975, Blake & Loiselle 1991, 2001). As a consequence, mean territory size of non-forest species is smaller, sometimes less than 0.25 ha, than that of

forest birds of comparable body size (Robinson & Terborgh 1990; see also Fig. 37). Of the territorial forest species, 16 had an available area of 2–4 ha within appropriate habitat, in comparison with 11 taxa that occupied territories of 3–4 ha in Peru. The slightly higher numbers for Playa de Oro seem reasonable, considering that in Central American bird communities, to which the Chocóan ones are closely related, territory sizes of common forest birds tend to be smaller than in Amazonia (e.g., Greenberg & Gradwohl 1986, Karr *et al.* 1990, Robinson *et al.* 2000). In Peru, most species ( $n = 41$ ) defended territories of 5–8 ha, whereas in northwestern Ecuador most taxa ( $n = 33$ ) had an available area of 9–16 ha per territory. Although in Playa de Oro actual territory sizes might be considerably smaller than the 'available area' (p. 144f, Estimation of population densities on the basis of transect-mapping data), it is evident that no systematic overestimation of population densities occurred. Some species, for which an overestimation of true densities was indeed suspected, are identified in Appendices 18a and 19a.

Smaller extent of disturbed habitats at MNT2 was the likely reason for the bird population density being c. 10% lower there than at MNT1. The phenomenon of decreasing bird densities in maturing forests has also been documented in the temperate zone, such as at Hubbard Brook, where population densities decreased from about 1000 pairs/km<sup>2</sup> to only 600 pairs/km<sup>2</sup> between 1968 and 1988 (Holmes *et al.* 1986, Holmes 1990). In some plots of temperate primary forest of Białowieża National Park, Poland, bird population densities are as low as 400 pairs/km<sup>2</sup> (Tomiałojć & Wesołowski 2004). Consequently, the high avian densities found in habitat mosaics at Playa de Oro are not representative for the Ecuadorian Chocó, but rather reflect the specific situation of anthropogenic landscapes in the Río Santiago floodplain. Species richness as well as bird densities are considerably lower within continuous *terra firme* forest in Playa de Oro (data not shown). However, as larger species like tinamous, raptors, cracids, and parrots are more abundant in undisturbed forest, the biomass density might in fact be similar or even higher there than at transects MNT1 and MNT2.

At Cocha Cashu the most abundant taxon, *Cacicus cela*, had only 50 individuals/km<sup>2</sup> (Terborgh *et al.* 1990). By contrast, in Playa de Oro the commonest species at MNT1 (*Manacus manacus*) was represented by 328 birds/km<sup>2</sup> and the commonest

species at MNT2 (*Lepidothrix coronata*) by 221 individuals/km<sup>2</sup> (Appendices 18a and 19a). This is five to seven times the population of the commonest Pipridae (*Pipra fasciicauda*,  $n = 45$  birds/km<sup>2</sup>) in Peru, where it was the most frequently trapped species in 1000-capture mist-netting samples (Table 41). However, Robinson *et al.* (2000) also reported very high numbers of individuals per unit area for Limbo, with *Thamnophilus atrinucha* (212 birds/km<sup>2</sup>) being the most common species and *P. mentalis* (96 birds/km<sup>2</sup>) the most abundant Pipridae. Even higher abundances than in northwestern Ecuador were reported for a 2-km<sup>2</sup> plot on the Ivindo River, Gabon, Africa, where the commonest species showed a density of 500 individuals/km<sup>2</sup> (*Andropadus latirostris*, Pycnonotidae; Brosset 1990). Striking differences between the Río Manu and Río Santiago floodplains also existed in the abundance of nectarivorous birds. *Threnetes ruckeri*, the most abundant hummingbird in the mosaic landscapes of the Río Santiago floodplain, was 14 to 15 times more abundant than *T. leucurus*, the most common trochilid at Cocha Cashu. On the other hand, the total number of hummingbirds was only about three times higher at MNT1 (366 individuals/km<sup>2</sup>) and MNT2 (415) in comparison with central Panama (131), the likely reason being that the former sites were located closer to a major river and also in a wetter climate than the Limbo plot.

A puzzling detail is the difference in body size relationships between the bird assemblages of Playa de Oro and Cocha Cashu. As confirmed by mist netting (Fig. 24), transect mapping (Figs. 35a,b), and standardized and non-standardized sampling of the entire bird community (Figs. 28a,b, and 29), in Playa de Oro the body mass class of 17–32 g included considerably fewer species than the nearest categories below or above these weights, whereas in Peru it was the most species-rich of all body size classes (Fig. 7 in Terborgh *et al.* 1990). Similarly, in relation to other body mass categories, birds weighing 65–128 g were also underrepresented in avian communities of Playa de Oro. Analyzing this phenomenon, it seems that lower species richness in just a few avian families is responsible for the unexpected body size distribution pattern in the study area. In the body mass category 17–32 g, the Furnariidae were represented by only two species, *S. brachyura* and *Sclerurus mexicanus*, in the habitat mosaics on the Río Santiago, while five species occurred in the Río Manu floodplain forest. The genus *Philydor*, which alone embraced

four taxa in western Peru, is represented by not even a single species in the wet tropical lowlands of the Chocó region. In Cocha Cashu, the *Thamnophilidae* were represented by at least 16 species in the size class in question, while only 7 were present at transects MNT1 and MNT2. The much higher diversity of antbirds in western Amazonian Peru is emphasized by the fact that seven genera, comprising species of 17–32 g, viz. *Pygiptila*, *Neotantes*, *Thamnomanes*, *Myrmoborus*, *Percnostola*, *Sclateria*, and *Rhegmatorhina*, do not occur in the Ecuadorian Chocó, conversely, only two genera, *Thamnistes* and *Dysithamnus*, occur vice versa. In the body mass category of 65–128 g, the *Psittacidae* (five in western Peru versus two in northwestern Ecuador) and *Dendrocolaptidae* (five vs. one) accounted for most of the discrepancies in the number of species. For other families, differences in species richness in the corresponding size categories were much less pronounced or nonexistent. At this point it is unclear why the proportions of body mass categories are so distinct for the avian community in Peru in comparison with that of northwestern Ecuador. Evidently the higher bird species richness in western Amazonia alone does not provide a satisfying explanation as to why the body mass relationship of the Chocoan assemblage looks so uneven in comparison with the neatly positively skewed pattern found in Peru. Future studies have to clarify what ecological and historical factors cause these differences.

#### Guidelines for the use of transect mapping (MTW) in monitoring studies

As discussed in the previous chapter, the original protocol (p. 67–70, The transect-mapping (MTW) protocol of the pilot study) had several shortcomings for monitoring purposes, the most important being the two-belt approach, which may have caused an underestimation of the true number of territories present in the effective detection area, especially in the case of common species. This source of bias can be avoided by employing a multi-belt transect-mapping form in combination with a rigorous assessment of simultaneously singing territory holders and the repeated mapping of particular bird individuals or groups when their movements can be tracked over distances > 50 m (p. 103–106, Guidelines for an optimized transect-mapping protocol for rapid assessments). In the case of short transects, the problem arose that diurnal raptors and, to a lesser degree, also subcanopy and canopy species showed a delayed

accumulation in MTW rapid assessment surveys, indicating that late-morning hours were not sufficiently sampled. Thus, the survey effort in late morning hours should be increased. For long transects, potential biases arose because periods of major activity of some bird taxa were not covered appropriately in the central parts of the trails because, according to the rapid assessment schedules, only the start and end sections were surveyed during twilight hours. As a consequence, some territories of these species might have been overlooked. To solve this problem in monitoring studies, additional samples should be carried out in a staggered time schedule, ensuring that all transect sections are sampled during all critical time-windows of the day. Finally, potential bias arose from the fact that population estimates had to be based on various complete rapid assessment surveys that were carried out in the course of many months rather than during a few days or weeks. Thus, it is rather likely that some territories shifted between surveys. Consequently, it would be advantageous to carry out a sufficient number of samples in a short period of time.

According to the enhanced MTW time schedule for monitoring studies, one complete survey consists of a set of 24 samples, which can be carried out within six days under optimal climatic conditions (Tables 42 and 43). Up to four samples are gathered during a single morning and up to two samples per afternoon. The minimum average time effort per 100-m transect section sums to 205 min and thus corresponds to roughly four complete surveys according to the original method (Table 9). However, two samples, M4A and M6A, are carried out during absolute darkness so that the probability of recording any birds is low. They are necessary to start the corresponding return-route samples, M4B and M6B, at the correct time of the day, ensuring that central transect sections are surveyed also during twilight hours. In contrast to the rapid assessment protocols, observer speeds have to be switched within some of the samples (M3A, M4B, M5A, M6B, A1A, and A2B) that cover twilight hours in middle sections of the transect. For early morning samples the precise moment for switching from c. 4 min to 12 min per 100 m is when the dawn chorus erupts. At dusk, observer speed should be changed from c. 9 min to 4 min as soon as crepuscular species start to vocalize. This ensures that more transect sections can be covered during the short twilight periods. I should emphasize that the observer speeds shown in Table 42 represent only approximate values, that is minimum

TABLE 42. Idealized time schedules and minimum average observer speeds for monitoring surveys according to the optimized transect-mapping (MTW) method. A total of 24 samples is carried out within 6 days (under optimal conditions) instead of the 8 samples in 2 days in rapid assessment surveys (Table 12). The protocol is further optimized for species with short activity periods, increasing the probability of detecting even the most unobtrusive taxa. To ensure that all transect sections are surveyed during the brief twilight periods of tropical latitudes, each sample starts at slightly different times in relation to dawn and dusk. The staggered observation periods ensure that territories can be mapped more accurately and completely than in rapid assessment surveys. In some cases it is necessary to switch observer speeds within ongoing samples as soon as the dawn chorus begins or activity of diurnal species around dusk ceases. It must be emphasized that observers should aim to reach the corresponding transect markers roughly at the time indicated in the schedules to witness the bird chorus at dawn and dusk. For later morning samples start times and travel speeds are much more flexible (for the various reasons that might result in lower observer speeds, and thus a higher time effort in MTW surveys; see p. 103-106). Guidelines for an optimized transect-mapping protocol for rapid assessments. In the scheme below, sample periods in darkness or poor light have a gray background.

Transect length 1200 m:			Distance on transect (m)																	
Survey	Effort (min/100 m)	(min)	Start	End	Start relative to sunrise/sunset (min)	Sunrise	Sunset	0-	100-	200-	300-	400-	500-	600-	700-	800-	900-	1000-	1100-	1200-
M1A →	4.0	48	05:02	05:50	-68	06:10	18:15	4	4	4	4	4	4	4	4	4	4	4	4	4
M1B ←	12.0	144	05:50	08:14	-20	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M1C →	9.0	108	8:14	10:02	+124	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
M1D ←	9.0	108	10:02	11:50	+232	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
M2A →	12.0	144	05:50	08:14	-20	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M2B ←	12.0	144	08:14	10:38	+124	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M3A →	9.3	112	05:34	07:26	-36	06:10	18:15	4	4	4	4	12	12	12	12	12	12	12	12	12
M3B ←	12.0	144	07:26	09:50	+76	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M4A →	4.0	48	04:30	05:18	-100	06:10	18:15	4	4	4	4	4	4	4	4	4	4	4	4	4
M4B ←	6.7	80	05:18	06:38	-52	06:10	18:15	12	12	12	12	4	4	4	4	4	4	4	4	4
M4C →	12.0	144	06:38	09:02	+28	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M4D ←	9.0	108	09:02	10:50	+172	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
M5A →	6.7	80	05:18	06:38	-52	06:10	18:15	4	4	4	4	4	4	4	4	4	4	4	4	4
M5B ←	12.0	144	06:38	09:02	+28	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M5C →	9.0	108	09:02	10:50	+172	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
M5D ←	6.0	72	10:50	12:02	+280	06:10	18:15	6	6	6	6	6	6	6	6	6	6	6	6	6
M6A →	4.0	48	04:46	05:34	-84	06:10	18:15	4	4	4	4	4	4	4	4	4	4	4	4	4
M6B ←	9.3	112	05:34	07:26	-36	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M6C →	12.0	144	07:26	09:50	+76	06:10	18:15	12	12	12	12	12	12	12	12	12	12	12	12	12
M6D ←	9.0	108	09:50	11:38	+220	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
A1A →	6.5	78	17:01	18:19	-74	06:10	18:15	9	9	9	9	9	9	9	4	4	4	4	4	4
A1B ←	4.0	48	18:19	19:07	+4	06:10	18:15	4	4	4	4	4	4	4	4	4	4	4	4	4
A2A →	9.0	108	15:13	17:01	-182	06:10	18:15	9	9	9	9	9	9	9	9	9	9	9	9	9
A2B ←	6.5	78	17:01	18:19	-74	06:10	18:15	4	4	4	4	4	4	4	9	9	9	9	9	9
Sum	205.0	2460						205	205	205	205	205	205	205	205	205	205	205	205	205

TABLE 43. Idealized time schedules and minutes surveyed per time window of 30 min in monitoring surveys according to the optimized transect-mapping (MTW) method. Hours of peak bird activity around dawn and dusk are more intensively sampled than hours of low activity. Nevertheless, considerable observation time is spent in late morning hours on the detection of canopy flocks and flight-displaying raptors. Due to the fact that surveys from late morning through early afternoon hours are often unproductive the 'optimal' transect length is 1200 m. The times of sunrise and sunset were arbitrarily chosen (cf. Table 9). Note that the time schedules are optimized for forest habitats and for latitudes close to the equator. In semi-open country and at higher or lower latitudes the dawn chorus might begin earlier, and at dusk diurnal bird activity might cease later. Furthermore, the ratio between sampled mornings and afternoons (= 6 : 2) was adapted to the climatic conditions of the Chocó region in order to avoid surveys being prolonged by the frequent rainfall in the second half of the day. In theory, the number of sampled afternoons could be increased in drier climates. For instance, the last way-back 'morning' samples (i.e., M1D, M4D, M5D, and M6D) could be carried out in the late afternoon (starting at about three hours before sunset) after a prolonged pause at the final transect marker. That is to say, it might be necessary to adapt the schedules, at least to some degree, to the particular conditions of the habitat and latitude. However, the minimum average survey effort of these alternative transect-mapping schedules should be roughly the same as in the protocol presented here. Alternatively, additional afternoon or night samples could be added to the 'standard' monitoring protocol. These would have to be excluded from analysis when comparing the data collected with 'enhanced' and 'standard' survey schedules of different monitoring projects.

Transect length 1200 m										Minutes surveyed in time windows of 30 min relative to sunrise and sunset																							
Effort				Start relative to sunrise/sunset (min)		before sunrise						after sunrise												before sunset						after sunset			
Survey	(min/100 m)	(min)	Start	End	Sunrise	Sunset	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	-7	-6	-5	-4	-3	-2	-1	1	2		
M1A →	4.0	48	05:02	05:50	-68	06:10 18:15		8	30	10																							
M1B ←	12.0	144	05:50	08:14	-20	06:10 18:15				20	30	30	30	30	4																		
M1C →	9.0	108	08:14	10:02	+124	06:10 18:15									26	30	30	22															
M1D ←	9.0	108	10:02	11:50	+232	06:10 18:15												8	30	30	30	10											
M2A →	12.0	144	05:50	08:14	-20	06:10 18:15				20	30	30	30	30	4																		
M2B ←	12.0	144	08:14	10:38	+124	06:10 18:15									26	30	30	30	28														
M3A →	9.3	112	05:34	07:26	-36	06:10 18:15			6	30	30	30	16																				
M3B ←	12.0	144	07:26	09:50	+76	06:10 18:15							14	30	30	30	30	10															
M4A →	4.0	48	04:30	05:18	-100	06:10 18:15	10	30	8																								
M4B ←	6.7	80	05:18	06:38	-52	06:10 18:15			22	30	28																						
M4C →	12.0	144	06:38	09:02	+28	06:10 18:15					2	30	30	30	22																		
M4D ←	9.0	108	09:02	10:50	+172	06:10 18:15									8	30	30	30	10														
M5A →	6.7	80	05:18	06:38	-52	06:10 18:15			22	30	28																						
M5B ←	12.0	144	06:38	09:02	+28	06:10 18:15					2	30	30	30	22																		
M5C →	9.0	108	09:02	10:50	+172	06:10 18:15									8	30	30	30	10														
M5D ←	6.0	72	10:50	12:02	+280	06:10 18:15												20	30	22													
M6A →	4.0	48	04:46	05:34	-84	06:10 18:15	24	24																									
M6B ←	9.3	112	05:34	07:26	-36	06:10 18:15			6	30	30	30	16																				
M6C →	12.0	144	07:26	09:50	+76	06:10 18:15							14	30	30	30	30	10															
M6D ←	9.0	108	09:50	11:38	+220	06:10 18:15												20	30	30	28												
A1A →	6.5	78	17:01	18:19	-74	06:10 18:15																								14	30	30	4
A1B ←	4.0	48	18:19	19:07	+4	06:10 18:15																								26	22		
A2A →	9.0	108	15:13	17:01	-182	06:10 18:15																	2	30	30	30	16						
A2B ←	6.5	78	17:01	18:19	-74	06:10 18:15																								14	30	30	4
Sum	205.0	2460					10	62	118	170	180	180	180	180	180	180	180	160	148	100	88	32	2	30	30	30	44	60	60	34	22		

average speeds in most circumstances. For samples including twilight periods, the observers should always aim to be at the markers indicated roughly at the time when the dawn chorus begins (M1B, M2A, M3A, M4B, M5A, and M6B) or diurnal bird activity at dusk ceases (A1A and A2B). During daylight periods travel time is much more flexible than before dawn or dusk and should be adapted to bird activity levels and other factors, usually resulting in lower observer speeds than those indicated in the MTW schedules (p. 106, Guidelines for an optimized transect-mapping protocol for rapid assessments). Because up to four MTW samples are gathered in a single morning, the ideal transect length is 1200 m. The extremely staggered schedule makes it possible for the total survey effort per time window of 30 min to quickly increase to 180 min with approaching sunrise, then keep constant for at least 3 1/2 hours of the early morning, and finally decrease gradually towards (or around) noon (Table 43). For afternoon samples there is a similar increase in effort around sunset, with the difference that a maximum of 60 min are surveyed per time window of 30 min due to the much lower number of samples in the second half of the day.

The general procedures for estimating population densities are very similar to those outlined above (p. 110-115, Estimation of population densities on the basis of transect-mapping data). Of course, the improvements made in the collection of the field data should be taken into account (p. 103-106, Guidelines for an optimized transect-mapping protocol for rapid assessments). If multi-belt transect-mapping forms with a sufficient number of perpendicular distance intervals (four to eight) have been used for data collection, then average DTDs might be determined with DISTANCE (Thomas *et al.* 2002b), as long as the method's assumptions are met (Buckland *et al.* 1993; however, cf. Bart *et al.* 2004 and p. 110-115, Estimation of population densities on the basis of transect-mapping data, for the many cases in which the corresponding assumptions might be violated in MTW surveys).

In contrast to the original method, for those species that cannot be analyzed in units of territories or displaying males (e.g., Cathartidae, Apodidae, Trochilidae, Psittacidae, and Hirundinidae), the mean maximum number of birds present in the transect area cannot be calculated by averaging over various independent surveys. As mentioned in the previous subchapters, an overestimation of population density based on the mean maximum number was suspected

for several species, suggesting that methodological improvements should be considered in any case. A possible solution might be to average the number of individuals present over the number of samples that covered time periods of activity by the relevant species ('valid' samples), e.g., for diurnal species night time samples would be excluded. Of course, all records obtained during 'invalid' samples have to be ignored in the subsequent calculations. I presume that population densities calculated this way will be slightly to considerably lower than the estimates obtained based on the average maximum number of individuals present per survey.

Small and inconspicuous suboscine passerines that do not form permanent pairs, like *Terenotriccus erythrurus*, *Myiobius* spp., *Chloropipo holochlora*, and others, were identified as another 'problematic' group for the estimation of population densities. All of these taxa should be searched for visually during MTW samples. Once the detectability of these species has been improved, the calculation of population densities should be based on the effective 'detection threshold distances' (DTDs) instead of on the average DTDs, just as in any territorial species. An exception would be the lek-forming species at transects where no leks occur (e.g., *Pipra mentalis* at MNT1). Here, calculations of population data should be based on average DTDs and the maximum number of unsexed individuals independently recorded during any of the samples.

The estimation of effective DTDs according to the improved transect-mapping protocol is a challenge on its own. A new approach could be based on the ratio between detection rates for core and peripheral territories. This seems feasible, considering the higher resolution of the mapping results according to the enhanced MTW method. Core territories can be defined as those territories that are entirely or mostly located within the average DTD of the relevant species. Thus, for central territories, clumped registrations should either be concentrated within one of the near belts or the number of observations to the left and right of the transect line should be similar. Of course, if a species's territory in the far belts was detected with roughly the same frequency as its territories in the near belts, then it should also be counted as core. This might happen for taxa with relatively small territories but with loud, far-carrying, and frequently emitted vocalizations. For peripheral territories, most registrations might be expected in the far belts on only one side of the transect. In ad-



dition, they should have been detected in less samples than core territories of the same species.

Once the number of core and peripheral territories is known, it has to be determined how many of them were recorded during 'valid' samples (see above). Subsequently, the factor  $\bar{v}$  by which the average DTD  $\mu_i$  has to be increased in order to obtain an estimate for the effective DTD  $\hat{\mu}_i$ , might be calculated as follows:

$$\bar{v} = \frac{\left( \sum_{i=1}^T t_i + 1 \right)}{\left( \sum_{i=1}^T c_i + 1 \right)}$$

with  $T$  representing all territorial species considered in the analysis,  $t_i$  the total number of central and marginal territories found for species  $i$ , and  $c_i$  the number of core territories of species  $i$  detected during 'valid' samples. The factor  $\bar{v}$  represents an average value for all territorial species sharing an equal number of valid samples and should be smaller for nocturnal and crepuscular species than for diurnal taxa. Potential problems with the applicability of this formula may arise from the enormous intraspecific and interspecific differences in the detectability of territorial breeding birds, making an unbiased differentiation between core and peripheral territories difficult.

Once the factor  $\bar{v}$  has been determined, estimates for the effective DTD  $\hat{\mu}_i$  can be derived:

$$\hat{\mu}_i = \bar{v} \mu_i$$

where  $\mu_i$  is the average DTD of species  $i$ . Subsequently, the effective 'detection areas' (DAs) should be calculated using the following equation:

$$\hat{A}_i = (2L\hat{\mu}_i) + (\pi\hat{\mu}_i^2)$$

where  $\hat{A}_i$  is the estimated effective detection area of species  $i$ , and  $L$  the transect length. Deviating from the method used for the calculation of the population data for transects MNT1 and MNT2, I also add here the area surveyed beyond the two transect ends, which corresponds to a circle with the radius  $\hat{\mu}_i$ . This should be done only when the positions of the birds were accurately mapped also at the transect ends, i.e., when the improved transect-mapping form was employed (p. 104, Guidelines for an optimized transect-mapping protocol for rapid assessments). Of course, if effective DAs are calculated this way, then all territories have to be counted completely. One prerequisite is that appropriate habitat continues for

a distance that corresponds roughly to the average DTD of the species recorded. For those species for which this condition is not fulfilled, it has to be considered whether more accurate estimates might be obtained by omitting the semicircles at the transect ends and counting only fractions of one territory. Likewise, if one continuous trail is subdivided into various unified subtransects, then territories shared by different sampling units obviously have to be counted as fractions and the semicircles have to be omitted in the calculation of effective DAs. Fractions of territories should also be used when abundance indices are analyzed in the form of recorded territories/birds per kilometer transect, e.g., for monitoring purposes.

A growing body of literature has been emphasizing that incomplete survey data must be corrected for imperfect species detectability, in order to allow meaningful multi-temporal interpretations of trends in population size (e.g., Nichols *et al.* 2000, Rosenstock *et al.* 2002, Thompson 2002) and species richness (e.g., Kéry & Schmid 2004, 2006). Although the procedure for population density estimation described above at least partially corrects for heterogeneities in species detectability by determining the presence of a territory on the basis of varying numbers of clumped records (and in extreme cases even through a single record of a presumed territorial individual), it is unsatisfying that there is no numerical assessment of the potential bias and variance of results. However, the improved multi-belt mapping form (p. 104, Guidelines for an optimized transect-mapping protocol for rapid assessments) might provide a possible solution, at least for more common territorial species, by facilitating the use of statistics originally developed for plot-mapping data (Emlen 1977, Christman 1984). Using this approach, we would define appropriate species-specific fixed belts on both sides of the transect (25, 50, 100 or more meters in width) and then determine the density of territories within these areas as  $\hat{D} = \bar{d} / P(d)$ , where  $\bar{d}$  is the mean number of detections per 'valid' sample (see above) and  $P(d)$  the probability of detection (= mean frequency of detections per valid sample). The mean number of detections per replicate must only include records from within the fixed belts of known area. On the other hand, calculation of the probability of detection also considers records beyond the fixed boundaries as long as they were obtained in valid samples and can be attributed to a presumed territory that does not extend beyond

the observer's range of detection. Of course, known and suspected double counts of moving individuals must always be excluded. Even the variance of density estimates can be determined whenever data from various transects with comparable characteristics are available (cf. Christman 1984). Although it seems, at first sight, that the procedure might only be useful for small to medium-sized territorial species, it would certainly be worth the effort to test the method's applicability for other bird groups as well.

Other potential options to account for imperfect species detection probabilities and observer bias in transect-mapping data could be based on distance sampling (e.g., Buckland *et al.* 1993, Rosenstock *et al.* 2002), repeated sampling (e.g., Dorazio & Royle 2005, Kéry *et al.* 2005), double-observer approaches (e.g., Nichols *et al.* 2000, Moore *et al.* 2004, Fletcher & Hutto 2006), or double-survey strategies (e.g., Bart 2004). For the numerous ways in which data collection might violate the assumptions of distance-sampling protocols (cf. Bart *et al.* 2004 and p. 110f, Estimation of population densities on the basis of transect-mapping data), it is rather doubtful whether the program DISTANCE (Thomas *et al.* 2002b) can compute accurate population estimates on the basis of MTW samples. Nevertheless, this question should be exhaustively addressed in future studies, once the multi-belt transect-mapping form has been used in field practice. Repeated sampling by the same observer is one of the principal strategies of transect mapping, and thus can be directly used for the determination of observer-dependent species-specific detection probabilities by comparing, for complete monitoring surveys of a transect, six groups of four samples each; i.e., M1A-M1D; M2A, M2B plus A1A, A1B; M3A, M3B plus A2A, A2B, etc. (cf. Table 42). Likewise, for resident species, seasonal fluctuations in detectability could be determined for transects where the same observer carried out dry- and wet-season surveys (see below). Observer bias could be assessed through the double-observer approach. Here, two observers would simultaneously but independently take data of all birds seen and heard. Subsequently, the data would be georeferenced and analyzed in the form of two-sample mark-recapture histories (cf. Fletcher & Hutto 2006). Bart *et al.* (2004) criticized that neither distance-sampling nor double-observer nor removal methods reduce bias due to coverage, closure, or surplus birds. As an alternative, they promoted the double-survey approach (dubbed "double sampling" in their work), where a large

sample is surveyed with a rapid technique (e.g., point counts), and a randomly chosen subsample is, subsequently, intensively studied with a second method to obtain correction factors for the rapid survey. The authors recommended intensive nest searching in combination with a double-observer protocol as the method of choice, but admitted that it may be impossible to obtain unbiased estimates in structurally diverse or dense habitats. It would evidently be very unrealistic to expect that nest searching could provide unbiased bird population data in high-canopy tropical rainforest or dense high-Andean montane forest. Asynchronous breeding periods of many tropical bird taxa (see below) would further increase the bias. Thus, considering that MTW monitoring surveys produce rather complete results in comparison with almost all other bird sampling methods, I recommend carrying out intensive playback trials to confirm the presence of additional territories of elusive species not noted during standardized transect mapping (e.g., Johnson *et al.* 1981); see p. 177, Conclusion, for more expensive alternatives for carrying out double surveys.

Good candidates for the inclusion in playback surveys might be from the following non-passerine groups: Accipitridae, Falconidae, Rallidae, *Geotrygon* spp., Cuculidae, Strigidae, Nyctibiidae, Caprimulgidae, *Chloroceryle* spp., Bucconidae, and Picidae. However, to ensure comparability between surveys, prerecorded vocalizations should not be broadcasted during the MTW samples themselves but only after the standardized survey has been completed. Thus, apart from the six or more days spent per complete monitoring survey, additional days and nights could be used for playback sampling. It has to be considered that response rates are influenced by a number of factors, including weather (Dow 1970), temperature and background noise (Wiley & Richards 1978, 1982), topography and vegetation structure (Aylor 1972, Marten & Marler 1977, Marten *et al.* 1977, Mosher *et al.* 1990), time of day and season (Marion *et al.* 1981, Johnson & Dinsmore 1986, Yahner & Ross 1995), lunar cycles (Johnson *et al.* 1979), type of vocalizations broadcast and species-specific response traits (Levy *et al.* 1966, Johnson *et al.* 1981), as well as disturbance by man or predators (Oelklaus 1976). Furthermore, the use of playback recordings may attract some individuals away from their territories, resulting in inflated population density estimates (Johnson *et al.* 1981, Marion *et al.* 1981). Finally, habituation might occur in some species so

that the frequency and duration of broadcastings should be carefully planned (Smith 1981, Mosher *et al.* 1990). Ideally, a preestablished scheme should be employed regarding species and type of vocalization, period of the day, duration of broadcasting, and distance between playback stations on the transect. This information should be noted on mapping forms, similar to those used for the MTW samples, in order to optimize the playback results with increasing experience of the researcher. If a positive response is obtained, the initial position of the bird should be mapped to avoid overestimation of population density (Marion *et al.* 1981). The data gathered during standardized MTW surveys and subsequent playback samples have to be analyzed separately and, if presented together, they should be unequivocally marked in the corresponding tables. If the calculation of population densities for one or another taxon is based on playback data, it has to be taken into account that species-specific detection areas are probably greater than in MTW surveys due to the fact that birds might be more sensitive in perceiving sounds of their conspecifics than the human ear (Dooling 1982, Okanoya & Dooling 1988). Thus, it is rather likely that some of the birds attracted had already approached the playback station before they were detected for the first time by the observer.

Even without playback trials, the probability of detecting secretive and rare species should be higher than in repetitive MTW surveys according to the rapid assessment protocol due to the elevated number of samples and, especially, the more staggered time schedule. Thus, using the improved MTW monitoring protocol, a well-trained observer might record c. 70% of the total species richness and 80-90% of all breeding residents present in the transect area with a single complete survey. Such high time efficiency is probably unmatched by any other monitoring technique published to date, including all combined methods (e.g., Salaman & Donegan in prep., cited in Salaman 2001).

The enhanced MTW protocol presented here has been used in the Chocoan lowlands and foothills (data not shown), on the western Andean slopes (Jahn *et al.* 2007), as well as in high-Andean montane forest and páramo (Jahn 2008), between about 60 and 3600 m a.s.l. It can be employed for short-term and long-term monitoring purposes as well as for impact assessment studies.

Some general aspects of natural history traits of Neotropical birds should be taken into account when designing monitoring studies. For instance, at least one survey should fall in the period when the majority of species start to breed, e.g., at the beginning of rainy seasons (Salaman 2001, Stutchbury & Morton 2001; pers. obs.). Fortunately, the length of the reproductive season in most tropical birds is considerably longer than in temperate species (Baker 1938). In the case of passerines, the mean breeding season ranges from 6.6 to 9.8 months in tropical latitudes, compared with only 3.1 to 4.2 months in temperate zones (Ricklefs 1966). Consequently, vocal activity remains similar for many months in most tropical species but of course might fluctuate considerably with daily differences in weather conditions. However, the asynchronous breeding of tropical taxa might also mean that different territories of the same species have unequal chances of being detected at any given moment. Furthermore, some tropical species tend to reproduce during periods when most other species do not breed. For example, many Central American hummingbirds breed in the dry season when flowers are most abundant (Skutch 1950). In Panama, *Turdus grayi* also breeds during the dry season, although food availability for nestlings is lowest then (Morton 1971); the likely reason for this unexpected behavior might be the much lower predation risk compared with the wet season. In conclusion, when time and budget allows, several complete MTW monitoring surveys per year and transect should be carried out. The most time-efficient compromise between accuracy and effort might be to carry out one monitoring survey during the dry season and another at the beginning of the rainy season, ideally always in the same months of the year. To minimize costs in long-term programs, each transect might be surveyed twice per year but only every other year. For a given annual budget this allows to roughly double the number of transects with the aim of improving the robustness of statistical analysis (Fig. 39; see also p. 229-238, Transect mapping as a tool for adaptive management, for additional details on the design of monitoring studies).

## Conclusion

Between Jun. 1993 and Nov. 2000, a total of 336 species, belonging to 48 families and 243 genera, were recorded in Playa de Oro at elevations between c. 50 and 450 m a.s.l. Eight additional species were confirmed until Jul. 2009. The final count is ex-

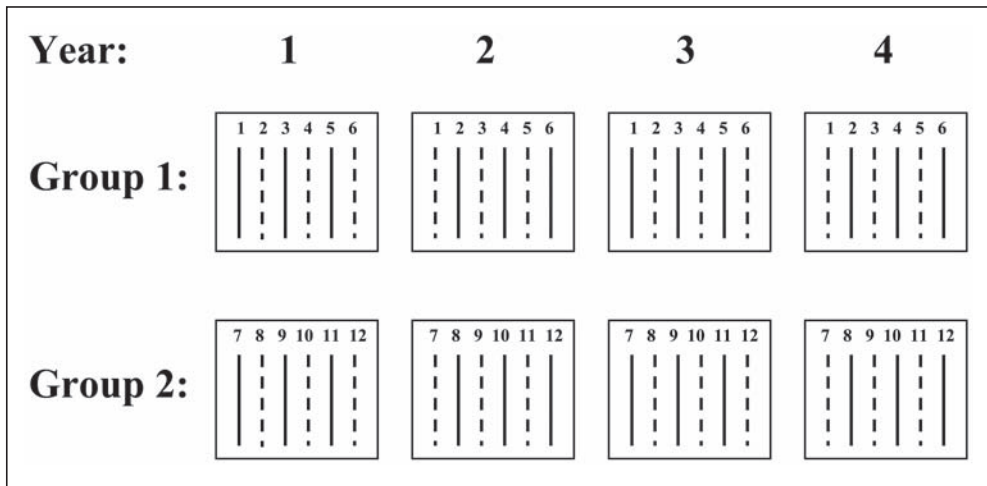


FIG. 39. Recommended design for monitoring studies. Transects surveyed in a particular year are shown as continuous lines, whereas transects not surveyed that year are symbolized by broken lines. In the example shown, there are two groups of six independent and randomly selected transects each, representing distinct habitat types (e.g., lowland vs. foothill forest) or treatments (e.g., hunting grounds of human communities vs. remote uninhabited areas). To reduce costs, each transect is surveyed twice per year but only every second year. This study design allows for testing differences between groups (e.g., in bird community composition or population densities of particular species) with Mann Whitney U-tests, e.g., year 1+2 (group 1) vs. year 1+2 (group 2). Changes in population densities or abundance indices within each group can be tested with Wilcoxon's test for matched pairs (e.g., group 1: year 1+2 vs. year 3+4) and, after 14 years of continuous monitoring, also with Spearman's rank correlation coefficient. If the aim of a study is rather the monitoring of changes in avian population size (e.g., within a particular area or region covering only a single habitat type) and not the comparison of the ecological conditions or conservation status between various study sites, then it is sufficient to work with only one group, because no controls are needed. In any case, the minimum number of sampling units (transects) per group is four, allowing for U-tests but not for Wilcoxon's tests.

pected to increase to > 400 species when the foothill zone up to 590 m has been intensively studied. Non-passerines ( $n = 137$ ) were more species-rich than suboscine (102) and oscine passerines (97). About 82% ( $n = 276$ ) of the species known to occur in Playa de Oro certainly or possibly breed in the area and 86.6% (291) can be regarded as core species. Forest or forest-edge-inhabiting birds make up c. 74.4% ( $n = 250$ ) of all species. In comparison with five well documented Neotropical sites, La Selva – Costa Rica, Canal Zone – Panama, Nouragues – French Guiana, Manaus – Brazil, and Río Manu – Peru, the bird community of Playa de Oro is most similar to that of Central American forests, the most striking difference being the much lower number of Nearctic-Neotropical migrants in the Ecuadorian Chocó.

Based on the transect-mapping data, I extrapolated the bird populations for habitat mosaics of 100 ha in the transect areas of MNT1 and MNT2. Although some clear differences existed between the sites with regard to species richness as well as species composition, the biomass density was almost identical, with an estimated 193 kg/km<sup>2</sup> for MNT1 and 198 kg/km<sup>2</sup> for MNT2. Compared with data published by other authors, biomass density was presumably 20-25% higher in a mature floodplain forest in western Amazonian Peru (Terborgh *et al.* 1990) and a *terra firme* forest in central Panama (Robinson *et al.* 2000) than in Playa de Oro, if juveniles, immatures, and non-breeding visitors were included in the calculation. However, the number of breeding 'pairs' was roughly 2000/km<sup>2</sup> at MNT1 and 1800/km<sup>2</sup> at MNT2, and thus about twice as high as in Peru

(c. 950 'pairs'/km<sup>2</sup>). High population densities of 1617 pairs/km<sup>2</sup> were also reported from Panama (Robinson *et al.* 2000). The average biomass per individual was only 36 g at MNT1 and 41 g at MNT2, in comparison with 55.6 g in Panama and 100 g in Peru, reflecting the disturbed character of the habitat in the Río Santiago floodplain.

The preliminary bird population data obtained in the pilot study look rather promising, except for some species. Many of the presumed biases in sampling and modeling can be avoided when an improved transect-mapping protocol for monitoring projects is applied. Implementing this procedure, a well-trained observer might record c. 70% of the total species richness and 80-90% of all breeding residents present in the transect area within as few as six days.

Various alternatives are available for estimating absolute bird densities on the basis of MTW data, all of which should be rigorously tested in future studies. Likewise, it is imperative to account for heterogeneities in species detectability and to address the precision and bias of resulting population estimates. Repeated sampling by the same observer should be used to determine observer-dependent species-specific detection probabilities, including their seasonal fluctuations (e.g., Kéry *et al.* 2005), whereas double-observer approaches could also help to assess observer bias (e.g., Fletcher & Hutto 2006). Double surveys of a randomly selected subsample should be carried out with another method in order to obtain correction factors for the less intense surveys (e.g., Bart *et al.* 2004), which in the case of transect mapping could be intensive playback trials to pinpoint additional territories of some difficult-to-detect species. If limited funds are not a matter of concern, spot mapping (e.g., Thiollay 1994b) and nest searching (e.g., Bart *et al.* 2004) might be carried out, using 28 1-ha plots per 1200-m transect (i.e., 12 plots of 100 x 100 m each would be established to the left and right of the transect route and a total of 4 beyond the transect ends). Additionally, it should be considered to subdivide the corresponding transects into sections of about 100 m and to mist-net these, one after another, for a period of two days, using a mark-recapture approach. This would facilitate more accurate estimations of the population size of undergrowth-dwelling non-breeding visitors and some elusive breeding residents that were underdetected in transect- and spot-mapping surveys and playback trials.

The present work is challenging the paradigm that entire tropical bird communities can be accurately characterized only with a combination of various survey techniques (e.g., Terborgh *et al.* 1990, Thiollay 1994b, Robinson *et al.* 2000). It is also questioning the presumption that appropriate study plots must be at least 100 ha in size, and ideally much bigger, to generate robust population density estimates. Although effects of spatial scale definitely must be considered (e.g., Wiens 1989, Levin 1992), it is simply not feasible to intensively survey areas as large as 500-1000 ha with the methods used, for example, by Robinson *et al.* (2000). It might also not be desirable to sample such huge plots because, in all likelihood, these areas would not accurately represent the wider landscape in which they are embedded either. The alternative proposed here is distributing independent transects evenly or randomly in the landscape and its habitat types (cf. Gregory *et al.* 2004), study them according to the improved transect-mapping protocol for monitoring studies and rigorously account for heterogeneities in species detectability and observer bias. Thus, determining the accuracy of the population data and establishing correction factors would be possible. If each transect is visited once in the rainy season and again in the dry season, the total field effort per transect is only about two weeks per year, meaning that several-to-many transects can be studied each year. Consequently, inferential statistics can be computed, allowing us to assess the precision of the population estimates and, most importantly, to study changes in bird community composition and density over time.

Although the calculation of absolute population densities is quite labor intensive, valuable information on the bird communities is already analyzable on the basis of crude field data (e.g., species richness and composition). Incidence-based statistics, especially MMRuns, MMMean, ICE, and Jackknife, allow accurate estimations of landscape-level core species richness, when computed using the raw data of complete MTW monitoring surveys of as few as two transects. At the next level of analysis, abundance indices can be obtained in the form of the number of territories or birds per kilometer of transect. These data allow full statistical testing of assumed changes in bird populations between sites or time periods without the need to calculate absolute population data. However, species-abundance relationships, diversity indices, and abundance-based similarity coefficients should be compared only on the basis of fully

modeled bird communities. In agreement with other studies (Southwood 1978, Taylor 1978, Magurran 1988), I recommend Fisher's  $\alpha$  as a diversity measure that is less sensitive regarding sample size than all other commonly used indices and, in addition, also has good discriminant abilities. Likewise, Morisita-Horn is the most satisfactory similarity coefficient of the classic  $\beta$ -diversity measures. Furthermore, Chao *et al.* (2005) recently presented several new Jaccard-

type and Sørensen-type indices that account for the effect of unseen shared species, based on either replicated incidence or abundance sample data. In sampling simulations, these new estimators proved to be considerably less biased than their classic variants. In the meantime, they have been incorporated in revised versions of the program EstimateS (Colwell 2009), and thus their performance should be exhaustively tested in future transect-mapping studies.



## 6. CONSERVATION STATUS, HABITAT SELECTION, AND INDICATOR SPECIES

### Introduction

In the previous two chapters I have demonstrated how species-rich tropical bird communities can be assessed and monitored effectively. However, the resulting wealth of data is very complex, and it is obviously not a simple task to apply this information in practical conservation. Here I will discuss some options on how the avifaunistic data gathered at Playa de Oro can be analyzed in order to obtain practical information permitting conservation-oriented interpretations.

To facilitate the maintenance of biodiversity in human-influenced landscapes through the establishment of nature reserves, adaptive management of natural resources, and mitigating measures for environmentally adverse operations, basic information on the status and distribution of biological taxa and their habitats is required. However, especially in tropical countries, comprehensive inventories of various plant and animal groups are usually not feasible due to lack of funds and time (Pearson 1994, Kerr *et al.* 2000). It has been estimated that an all-taxa inventory of just one hectare of tropical humid forest might take 50-500 researcher years to accomplish (Lawton *et al.* 1998). Not surprisingly, contemporary conservation biologists and managers have therefore increasingly used indicator species (or species groups) as a shortcut to monitoring and solving conservation problems (Raven & Wilson 1992, Flather *et al.* 1997, Caro & O'Doherty 1999). Surrogate species are principally employed in two conservation contexts: first, to pinpoint areas of high conservation value (biodiversity indicators), and second, to identify environmental change (Pearson 1994). In the former case, the indicator concept is based on the assumption that the presence of certain proxy taxa also captures a broad range of other organisms or conservation targets (Pearson & Cassola 1992, Carroll & Pearson 1998, Crisp *et al.* 1998, Duelli & Obrist 1998, Rodrigues *et al.* 1998, Tardif & DesGranges 1998, Lawler *et al.* 2003); thus, they can help in siting and designing reserves (Terborgh & Winter 1983). The second group can be subdivided further into indicators of environmental contaminants, habitat quality, and population trends (Landres *et al.* 1988, Landres 1992). Obviously, effective indicators of environ-

mental change need to be sufficiently sensitive to human-caused disturbance in order to provide an early warning of decaying environmental conditions (Cairns 1986, Munn 1988, Frost *et al.* 1992), and their population trends should mirror those of other species sensitive to the same anthropogenic impacts (Caro & O'Doherty 1999).

A growing body of literature has questioned the effectiveness of indicator groups for conservation purposes, especially those of vertebrates (e.g., Landres *et al.* 1988, Prendergast *et al.* 1993, Dobson *et al.* 1997, Andelman & Fagan 2000). Thus, it seems worthwhile to analyze the performance of tropical birds as indicators in different conservation contexts and on different geographical scales, which here include the global level, the regional context of the Ecuadorian Chocó, and the local perspective of Playa de Oro. Hence, I will focus on birds as indicators of habitat quality as well as of biodiversity patterns.

### Methods

#### Collection of habitat and bird data

The methods used for the mapping of habitats, vegetation structure, and human impacts are described on p. 35, Methods. The bird survey methods included mist netting, transect mapping, and non-standardized observation hours (p. 65-71, Methods).

#### Endemic and threatened species

For the determination of endemic species I used Stattersfield *et al.* (1998: 199-203, 210-215) and, in addition, Ridgely & Greenfield (2001b: 63-68). Differences in the assignment of endemic species between the two publications are due to the following factors: (1) divergent treatment of taxonomy at the species/subspecies level; (2) deviation in the criteria defining an endemic taxon: '50 000 km<sup>2</sup> historic breeding range' criterion (Stattersfield *et al.* 1998: 19-26) versus 'mostly restricted to only one biogeographic area' (Ridgely & Greenfield 2001b: 62-63); and (3) differences in the definitions of the 'centers of endemism'.

For the threat status, I exclusively employed lists based on the official IUCN threat categories sensu

IUCN (2001) and Gärdenfors *et al.* (2001), in particular BirdLife International (2000, 2004b) for the global level and Granizo *et al.* (2002) for the national level.

### Flagship and umbrella species

Flagship species are charismatic animals that attract public attention and support. Successful candidates are often chosen on the basis of their decreasing population size or threat status (Dietz *et al.* 1994). In addition, they are usually rather large in size to better promote the conservation of extensive areas of natural habitat (Caro & O'Doherty 1999).

In contrast to flagships, which need only be attractive and popular but not ecologically significant, umbrella species have to be ecologically important but not necessarily attractive to the public (Caro & O'Doherty 1999). Naturally, they should be large (Wicox 1984) because of the positive correlation between body size and area requirement (Brown 1995). Furthermore, to provide an effective protective shield for local biodiversity, they must have large ranges in comparison with sympatric species. In this way, the ranges of viable populations of the target species can encompass the area necessary to ensure the survival of other species with similar habitat requirements (Berger 1997).

Using Playa de Oro and the Ecuadorian Chocó as examples, I discuss how useful these surrogate species are in achieving certain conservation goals.

### Life zone assemblages

In northwestern Ecuador, many forest-dependent bird species clearly have a narrow niche width as regards climatic conditions, altitudinal range, vegetation types, and other ecological factors (e.g., inter-specific competition and pathogens). Here, I define as 'life zone specialists' those forest- and forest-edge-inhabiting avian taxa that in Esmeraldas Province, Ecuador, occupy only one to three different life zones *sensu* Holdridge (1967). Most of these species have a strong indicator function regarding certain forest types, and many of them would quickly be in trouble if their main habitat were cleared or if their life zones shifted due to climate change. Thus, they are of potential importance for biologists and managers in directing conservation efforts, as the composition and completeness of these habitat assemblages might function as a surrogate for the integrity and quality of the associated forest types.

Ideally 'life zone assemblages' would be determined through intensive sampling of all forest habitats in a defined geographic area, e.g., the coastal lowlands of Ecuador between sea level and the 900 m contour line. Associations of bird species with certain life zones could then be tested statistically. However, such comprehensive bird data are not available for western Ecuador, and therefore I had to base the assignments on my own and other workers' field experience as well as on published records on avian habitat requirements and distributions (e.g., Ridgely & Greenfield 2001b). Consequently, the life zone assemblages presented here should be regarded as preliminary at best. Furthermore, I determined these indicator groups only for five life zones, as I did not have sufficient field experience in other regions of the western Ecuadorian lowlands. Very important for the determination of life zone assemblages was the exchange of information with P. Mena V., who has also carried out intensive field work in northwestern Ecuador. Together we studied a total of 18 localities at an elevational range of c. 5 to 550 m in Esmeraldas Province between Apr. 1995 and May 2001 (Fig. 40). The survey effort was different at each locality. Playa de Oro was by far the most intensively studied site, with > 27 km of sampled transects – almost half the total transect length. Some of the localities at the periphery of the study area were sampled in only a single transect or a few transects of c. 1000 to 1500 m. Apart from transect mapping, the principal survey method, mist netting was used at Playa de Oro and San Miguel.

The life zones considered were tropical dry forest, tropical humid forest, tropical wet forest, the 'lowermost base of the Andean foothills' (cf. p. 26, Life zones), and premontane pluvial forest. In northwestern Ecuador, tropical dry forest includes deciduous and semi-deciduous forest types close to the coast, which were not present in the studied sites. Likewise, in the case of premontane pluvial forest, only the lowermost 100–200 m of an altitudinal range between c. 350 and 1800 m were sampled until May 2001. Therefore, the assignment of birds to these life zones was based mainly on published accounts. However, since Nov. 2004, the author and P. Mena V. studied at least nine additional sites in Esmeraldas and several more in Imbabura, Pichincha, Cotopaxi, and Guayas, between about 40 and 3600 m above sea level, thus widening the base of knowledge on the species composition in additional

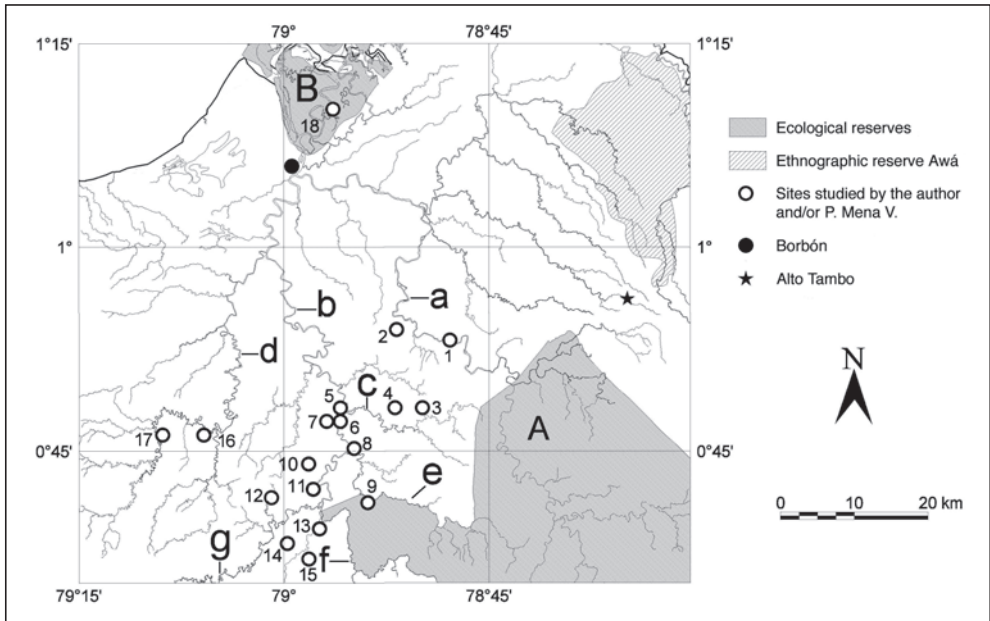


FIG. 40. Localities studied by the author (OJ) and/or P. Mena V. (PMV; pers. comm.) in Esmeraldas Province, Ecuador, between Apr. 1995 and May 2001. Abbreviations used: (I) reserves: A = Cotacachi-Cayapas Ecological Reserve; B = Cayapas-Mataje Ecological Reserve; (II) rivers: a = Río Santiago; b = Río Cayapas; c = Río Zapallo; d = Río Ónzole; e = Río San Miguel; f = Río Bravo; g = Río Chimbagal; (III) localities studied: 1 = Playa de Oro, Río Santiago (00°53'N, 78°48'W; 50-450 m; OJ & PMV; cf. Fig. 1b); 2 = Palma Real, Río Santiago (00°55'N, 78°51'W; 30-120 m; OJ & PMV); 3 = Tsejpi, Río Zapallo (00°48'N, 78°50'W; 50-250 m; OJ & PMV); 4 = Jeyambi, Río Zapallo (00°48'N, 78°52'W; 60-210 m; OJ); 5 = Chispero, Río Cayapas (00°48'N, 78°56'W; 130-200 m; PMV); 6 = Majua, Río Cayapas (00°47'N, 78°56'W; 50-150 m; PMV & OJ); 7 = Guadual, Río Cayapas (00°47'N, 78°57'W; 50-150 m; OJ & PMV); 8 = San Miguel, Río Cayapas (00°45'N, 78°55'W; 50-150 m; PMV & OJ); 9 = Charco Vicente, Río San Miguel (00°41'N, 78°54'W; 80-550 m; PMV & OJ); 10 = Agua Blanca, Río Chimbagal (00°44'N, 78°57'W; 50-130 m; OJ); 11 = Calle Manza, Río Chimbagal (00°42'N, 78°58'W; 90-190 m; PMV); 12 = Corriente Grande, Estero Sabalito, Río Chimbagal (00°41'N, 79°01'W; 60-150 m; OJ); 13 = Corriente Grande, Salto del Bravo, Río Bravo (00°40'N, 78°58'W; 80-400 m; OJ & PMV); 14 = Cooperativa Nueva Aurora, Río Guadual (00°36'N, 79°00'W; 200-400 m; PMV); 15 = Corriente Grande, Río Guadual (00°38'N, 78°59'W; 80-400 m; OJ); 16 = Colón, Estero Tangaral, Río Ónzole (00°47'N, 79°04'W; 30-150 m; PMV & OJ); 17 = Gualpi de Ónzole, Río Ónzole (00°46'N, 79°09'W; 30-180 m; PMV & OJ); 18 = La Pampa, Río Cayapas (01°08'N, 78°58'W; 5-10 m; OJ). Additional sites were studied since Nov. 2004 (see text for details).

habitats and 'life zones' and confirming the general composition of life zone assemblages presented here.

#### Assessment of the conservation value of MNT1 and MNT2

To demonstrate how the conservation value of study sites can be assessed by analyzing the composition of their avian communities, I used the transect-mapping

data of MNT1 and MNT2 as an example (Appendices 12a and 12b; Table 52). In particular, I looked at the species' habitat preferences as well as at the presence/absence of threatened and endemic bird taxa. Furthermore, I applied the 'bird community index' approach described by Bradford *et al.* (1998) and Canterbury *et al.* (2000), which analyzes the entire avian community as an indicator of forest condition at the local level. The principal assumption

of the method is that individual habitat assemblages of birds can indicate only the particular resource condition defining them, whereas ecological status and biotic integrity should be evaluated on the basis of multiple habitat assemblages. For example, large-scale timber harvest often results in the loss of bird taxa requiring mature stands or continuous forest as well as in the invasion by species characteristic of earlier successional stages and forest edges. Thus, the forest bird community index  $BCI_{forest}$  should contrast disturbance-sensitive forest taxa against disturbance-tolerant species. I used the formula

$$BCI_{forest} = \ln(\sum S_F + 1) - \ln(\sum S_{OC} + \sum S_{FE} + 1)$$

with  $S_F$  representing forest-dependent species in the sample [not only mature forest taxa as in Canterbury *et al.* (2000)],  $S_{OC}$  open-country birds, and  $S_{FE}$  forest-edge species.

I calculated the  $BCI_{forest}$  for MNT1 and MNT2, using the presence/absence data gathered in the transect-mapping study. I employed the general habitat category of each species (Appendix 8). Non-core taxa (*sensu* Remsen 1994), habitat generalists, and species depending on open water, large rivers, and fast-flowing streams were omitted.

#### Data analysis

##### Multivariate analysis

Ecological problems, like habitat selection by birds, naturally involve numerous environmental variables, gradients, and numerous species and individuals (Gauch 1982). Thus, community data are clearly multivariate and should be analyzed with corresponding methods, whereas univariate or bivariate statistics would be appropriate if only one or two environmental gradients existed (McCune & Grace 2002). Multivariate analyses provide a relatively objective and straightforward summary of complex information and thus contribute to hypothesis generation by leading ecologists to the discovery of structure in the data (Gauch 1982).

Here, I considered the standardized mist-netting and transect-mapping data gathered in the habitat mosaics at MNT1 and MNT2 (Appendices 12a and 12b). The data of both transects were pooled. In the case of mist netting, I omitted individuals that were recaptured within six hours to ensure that their habitat selection was not influenced by the locality at which they were previously released. Furthermore, to avoid uninterpretable noise in the data set, species

with less than three independent capture events had to be excluded. A total of 2545 captures of 87 species was considered. In the case of the transect-mapping data only near-belt records were taken into account because habitat characterization in the far belts was not detailed enough to permit meaningful testing for bird-habitat associations (p. 35f, Mapping of habitats, vegetation structure, and human impact). Again, species with less than three MTW records were omitted. In total, 2626 records of 114 species were valid. In both data sets bird abundances were log-transformed to reduce the influence of the most common species. Likewise, rare species, defined as those with relative abundances < 20% of the most frequently recorded birds, were down-weighted in relation to more abundant species in order to minimize an unduly high influence of eventual outliers, adding noise to the data sets.

The nets ( $n = 136$ ), which had a fixed position along the habitat gradients, were the sample units of the mist-netting study. They were, of course, not statistically independent of each other. However, independence of sample units is not a prerequisite for the use of ordination techniques, such as correspondence analysis or canonical correspondence analysis (ter Braak & Smilauer 2002), as long as interpretations are of a descriptive nature. Gradients were measured from the center of each net. Thus the true position of captures had an error of up to  $\pm 3.3$  m relative to the environmental factor. In reality the error was greater, up to an estimated  $\pm 9$  m, because the distances between net-centers and environmental factors were measured on the maps and not in the field.

In the transect-mapping study, sample units were the 25 x 25-m main belt plots ( $n = 94$ ). These plots were obviously not statistically independent either. Gradients were measured from the centers of the plots. As a consequence, the true position of the birds had an error of up to  $\pm 17.7$  m (= half-diagonal of the plot) relative to the environmental factor. Due to the reasons mentioned above, the real error was probably greater, up to an estimated  $\pm 24$  m.

For direct multivariate analyses I considered the following environmental variables:

- Main habitat types (cf. p. 45–54, Structural features of the main habitats of MNT1 and MNT2), i.e., open country (OC), young successional forest (ysF), and medium-age forest (magF), were used as binary 'dummy' variables, which are shown in some figures, but did not influence the ordination results.

- Distance to the nearest forest edge (D-F/OC) was measured as a linear gradient, with distances within open country having negative signs and distances within forest positive signs. Forest birds that avoid open country as well as grassland and scrubland species that avoid forest or their edges should respond strongly to this variable.
- Proximity to the nearest forest edge (P-F/OC) was expressed in positive metric scores, with sample units closer to the forest edge having higher positive values than those at greater distances, independently of the main habitat in which they were located. Forest-edge species that use the entire ecotone, in other words the outside as well as the inside portion of the forest border, are expected to respond positively to this variable.
- Proximity to the river (P-R) was expressed in positive metric scores, with sample units closer to the river having higher values than those at greater distances. This environmental variable is important because human disturbance (including hunting pressure) decreases with increasing distance from navigable rivers. Furthermore, some bird taxa are more frequently encountered in river-edge vegetation than in any other habitat.
- Proximity to the nearest water body (stream, artificial channel, etc.) within open country (P-waOC) was expressed in positive metric scores. In single variable analyses (see below), I have used the distances to the water bodies instead (D-waOC). In extensively forested areas, like the Chocó region, streams in open country are a surrogate habitat for river-edge species. Consequently, this variable might help to uncover corresponding habitat associations.
- Proximity to nearest forest stream (P-strF) in positive metric scores. Some forest birds construct their nests above streams or in stream banks, and others forage preferably in their vicinity. These taxa may also show a close association with forest streams in survey data.
- Proximity to nearest tree-fall gap within forest (P-tgF) in positive metric scores. Tree-fall gaps influence the distribution pattern of certain forest-dwelling birds (e.g., Schemske & Brokaw 1981) and were thus considered here.
- The combined foliage density of the midstory and canopy (COV-M+C) was expressed in cover scores according to Table 4. Thus, values between zero and eight were theoretically possible. In some graphics I used the uncovered portion of the mid-

story and canopy (UNC-M+C), which was obtained by subtracting the combined cover from the maximum value of eight. I selected this variable because it was identified as the structural feature with the highest potential to differentiate between the three main habitat types (Chapter 3).

All potential environmental variables were tested for collinearity by inspecting weighted correlation matrices generated in CANOCO (ter Braak & Smilauer 2002). If two or several variables showed high correlation coefficients ( $> 0.75$ ) and/or elevated 'inflation factors' (IF  $> 20$ ), only one of them was used in the subsequent analyses. Finally, four variables were used for the mist-netting data and five for the MTW data. The importance of each of these variables was tested using CANOCO's 'forward selection tool' and a Monte Carlo permutation test (Table 44). However, some omitted colinear variables, subjectively judged to be important, were shown as supplementary (passive) variables in the ordination graphs. The following multivariate analyses were carried out:

*Detrended Correspondence Analysis (DCA).* – A widely used indirect eigenanalysis-based ordination technique derived from Correspondence Analysis (CA; synonymous with Reciprocal Averaging, RA), that can be used if a strong gradient is expected (Hill & Gauch 1980). DCA performs detrending by dividing the first axis into segments and subsequently centering the second axis on zero in order to remove the 'arch effect', an artifact obtained in the CA and other ordination techniques (Gauch 1982, Pielou 1984, Digby & Kempton 1987). The first axis explains most of the variance of species data, and thus is the most worthwhile in interpretation. Analyses were carried out with the software package CANOCO (ter Braak & Smilauer 2002). Since bird species were the focus of interest, I used the scaling options 'biplot scaling' and 'focus on species distance'. Output graphics were subsequently edited in CANODRAW (ter Braak & Smilauer 2002).

*Canonical Correspondence Analysis (CCA).* – An ordination method for direct eigenanalysis-based gradient analysis that permits the interpretation of environmental correlations (ter Braak 1986, 1987; Jongman *et al.* 1987). The significance level of each environmental factor might be determined by Monte Carlo permutation tests (Table 44). The ordination technique, like other correspondence analysis methods, assumes that species have unimodal distributions along environmental gradients (ter Braak & Prentice



TABLE 44. Results of the forward selection and Monte Carlo permutation test of the environmental variables used in the direct multivariate analyses. These tests are an option of the Canonical Correspondence Analysis (CCA) function of CANOCO (ter Braak & Šmilauer 2002); 999 permutations were carried out in the Monte Carlo permutation test, permitting the assessment of a significance level of  $P = 0.001$ . Abbreviations used: (a) variable: D-F/OC = distance to forest-open country edge; P-F/OC = proximity to forest-open country edge; P-R = proximity to river; P-strF = proximity to forest stream; UNC-M+C = combined cover of midstory and canopy; (b) marginal effects:  $\lambda_1$  = shows the sequence of the most important environmental variables obtained by the forward selection; each value represents the explained fraction of variance the variable would have if included singly in the CCA (c) conditional effects:  $\lambda_A$  = effect of each single variable, which is identical to  $\lambda_1$  for the first (best fit) variable. In subsequent variables, the joint effect of the preceding variables is removed; F = value of the F-statistics; P = probability.

A) Mist-netting (MN) data				
Variable <sup>a</sup>	Marginal effects <sup>b</sup>	Conditional effects <sup>c</sup>		
	$\lambda_1$	$\lambda_A$	F	P
D-F/OC	0.38	0.38	12.53	0.004
UNC-M+C	0.33	0.07	2.42	0.004
P-R	0.24	0.08	2.59	0.056
P-F/OC	0.11	0.13	4.55	0.010
B) Transect-mapping (MTW) data				
Variable <sup>a</sup>	Marginal effects <sup>b</sup>	Conditional effects <sup>c</sup>		
	$\lambda_1$	$\lambda_A$	F	P
D-F/OC	0.57	0.57	14.55	0.006
UNC-M+C	0.46	0.06	1.66	0.016
P-R	0.42	0.11	3.15	0.014
P-strF	0.31	0.09	2.44	0.004
P-F/OC	0.18	0.15	4.07	0.012

1988). Meaningful interpretation might be mostly obtained for the first two axes. Here, I used CCAs with single variables to demonstrate the effect of the most important environmental gradients. The software and scaling options employed were the same as for the DCAs (see above).

*Detrended Canonical Correspondence Analysis (DCCA).* – The detrended form of the CCA was chosen to minimize the so-called ‘arch effect’, a mathematically intrinsic problem of the CCA algorithm. Since this arch effect was quite obvious, I decided to apply detrending by 2nd order polynomials, an option in CANOCO. The scaling options were the same as for the DCAs (see above).

*Nonmetric Multidimensional Scaling (NMDS).* – The most widely used distance-based ordination method, which maximizes rank-order correlation between distance measures and distance in ordination space (Palmer 2004). Points are moved to minimize the mismatch (‘stress’) between the ordination and

measured ecological distances. The method assumes that dissimilarity is monotonically related to ecological distance. Calculations were carried out with the program PC-ORD (McCune & Mefford 1999). I used the recommended qualitative form of the Sørensen similarity coefficient as distance measurement. The algorithm followed the methods developed by Kruskal (1964) and Mather (1976). The number of axes producing the lowest stress was determined through multiple runs with randomized data. That is, runs were started with random configuration and a total of 15 runs were carried out for each data set. This ‘dimensionality assessment’ resulted in a final configuration of more than 3 axes for the mist-netting sample and 2 axes in the transect-mapping data.

Determination of indicator species

Potential indicator species for the three main habitat types represented in the mosaic landscape of the Río



Santiago drainage were determined on the basis of the mist-netting and transect-mapping data sets described in the previous chapters. The following methods were used:

*Two-way Indicator Species Analysis (TWINSPAN).*

– The most widely used program for classifying species and samples by phytosociologists and vegetation ecologists. The method is derived from Correspondence Analysis (CA) and is thus based on reciprocal averaging ordination (Hill 1979). The process of classification is hierarchical (Hill *et al.* 1975). First, samples are successively divided into categories. In a second step, species are divided into categories on the basis of the sample classification. The final result is an arranged data matrix, or ordered two-way table, of the occurrence of species and samples (Gauch 1982). Potential indicator species are those arranged near either end of the ordination axis by reciprocal averaging. They are assigned higher weights (positive or negative) than the other species, and recomputing further polarizes the ordination. Subsequently, the samples are divided into two clusters by breaking the ordination axis, usually near the middle. Species are then assessed in terms of their fidelity to each of the two clusters and classified in the group to which they show a high fidelity. This procedure is then repeated for each of the clusters; see Gauch (1982) and Legendre & Legendre (1998) for details. The analyses were carried out using presence/absence as well as log-abundance data. Input parameters were set to default, with the exception of the maximum level of divisions, which was set to three because interpretation of further divided clusters was judged to be meaningless.

*Indicator Value (IndVal).* – A rather new approach, developed by Dufrêne & Legendre (1997), which assesses a species's abundance in relation to its relative frequency of occurrence in various groups of samples. Indicator species are the most characteristic taxa of each group (McGeoch & Chown 1998). 'Asymmetrical indicators' are rare species that are found only at one or a few sites in one habitat group and are present exclusively in that group. Their presence cannot be predicted for all sites representing appropriate habitat, but they nevertheless contribute to the habitat specificity. By contrast, 'symmetrical indicators' occupy all sites of their habitat group and are found only in that group. Their presence at all sites of the group can be predicted. The indicator value of each species is calculated as the product of its habitat specificity and fidelity; see Dufrêne & Legendre

(1997) and Legendre & Legendre (1998) for details. The statistical significance of the indicator index is evaluated through a randomization procedure. In contrast to TWINSPAN, the indicator value for a given species is independent of the relative abundances of the other taxa. The analyses were carried out for the main habitat types using the default settings. In the case of mist netting, 2616 captures of 135 species were taken into account. The corresponding transect-mapping data embraced 2694 main-belt records of 155 species. I computed 499 randomizations for significance levels  $< 0.05$  and  $< 0.01$ , and 999 randomizations for a probability of  $\leq 0.001$ .

#### Other statistical methods

For the comparison of the life zone assemblages, I determined the number of shared species using EstimateS 6.0b (Colwell 2001). Furthermore, I computed two qualitative (incidence-based) similarity indices, Jaccard and Sørensen I, according to the equations in Magurran (1988: 95), using the same software. Assumed correlations between the body size of the birds and their IUCN threat categories on global and national levels were assessed with the nonparametric Spearman's rank test (Conover 1980, Fowler & Cohen 1986), using SPSS software (SPSS 2003). The test for species threatened at the national level was one-tailed, as a strong positive correlation between variables was anticipated. However, for globally threatened taxa a two-tailed test had to be carried out. I employed Microsoft Excel (Microsoft 2001) for the generation of graphics other than those based on ordination techniques. In all tests, differences were regarded as significant at a probability level of  $P < 0.05$ .

## Results

### Endemic species

Of the 336 bird species recorded in Playa de Oro until Nov. 2004, 13.1% ( $n = 44$ ) are listed as endemic taxa by Stattersfield *et al.* (1998) and/or Ridgely & Greenfield (2001b) (Table 45).

According to Stattersfield *et al.* (1998), 24 species of Playa de Oro's avifauna are endemic to the 'Chocó Endemic Bird Area (EBA)', and Ridgely & Greenfield (2001b) listed eight additional taxa as endemic to the 'Chocó lowlands'. Stattersfield *et al.* (1998) regarded two species as endemic to the 'Tumbesian EBA', while Ridgely & Greenfield (2001b) cata-

TABLE 45. Endemic and threatened bird species of Playa de Oro. Abbreviations used: (a) Endemic bird area: Cho1 = Chocó EBA 041 sensu Stattersfield *et al.* (1998); Cho2 = Chocó lowlands; additional endemic species listed by Ridgely & Greenfield (2001b); Tum1 = Tumbesian region EBA 045 sensu Stattersfield *et al.* (1998); Tum2 = Tumbesian lowlands; additional endemic species listed by Ridgely & Greenfield (2001b); wAnd2 = western Andean slope; additional endemic species listed by Ridgely & Greenfield (2001b); (b) Threat status: international threat status categories sensu IUCN (2001): NT = Near Threatened; DD = Data Deficient; VU = Vulnerable; EN = Endangered; CR = Critically Endangered; (c) population estimate: estimates for Ecuador refer to the number of mature individuals only; n.a. = estimate not available. Note: the taxa listed here, according to Ridgely & Greenfield (2001b), as restricted-range species for the Chocó lowlands, the western Andean slope, and the Tumbesian lowlands, were not regarded as endemic species by Stattersfield *et al.* (1998). See text for additional endemic and threatened species recorded after Nov. 2004.

Scientific name	Endemic bird area <sup>a</sup>	Threat status <sup>b</sup>		Population estimate <sup>c</sup> for Ecuador (World)	References on threat status and population
		Ecuador	World		
<i>Crypturellus berlepschi</i>	Cho1	EN		6000-18 000	Mena & Jahn (2002l)
<i>Leucopternis plumbeus</i>		VU	NT	6000-18 000	Mena & Jahn (2002f); BirdLife International (2000: 637)
<i>Leucopternis semiplumbeus</i>		EN		2500-7500	Mena & Jahn (2002g)
<i>Leucopternis princeps</i>		VU		10 000-30 000	Mena & Jahn (2002e)
<i>Harpia harpyja</i>		VU	NT	n.a.	Guerrero (2002a); BirdLife International (2000: 637-638)
<i>Micrastur plumbeus</i>	Cho1	EN	VU	(2500-10 000)	Pacheco (2002a); BirdLife International (2000: 121)
<i>Falco peregrinus</i>		VU		<1000	Hilgert & Benavides (2002)
<i>Ortalis erythroptera</i>	Tum1	VU	VU	(2500-10 000)	Pacheco (2002b); BirdLife International (2000: 128)
<i>Penelope orton</i>	Cho1	EN	EN	2500-7500	Jahn & Mena (2002Ä); BirdLife International (2004b)
<i>Penelope purpurascens</i>		EN		5000-15 000	Mena & Jahn (2002i)
<i>Crax rubra</i>		CR	VU	30-60	Mena & Jahn (2002j); BirdLife International (2009c)
<i>Odontophorus erythrops</i>		VU		40 000-120 000	Jahn & Mena (2002m)
<i>Rhynchortyx cinctus</i>		EN		30 000-90 000	Mena & Jahn (2002c)
<i>Neocrex colombiana</i>			DD	n.a.	BirdLife International (2000: 695)
<i>Patagioenas goodsoni</i>	Cho1	VU		45 000-135 000	Jahn & Mena (2002†)
<i>Leptotila pallida</i>	Cho2			n.a.	
<i>Geotrygon purpurata</i>	Cho2	VU		2500-10 000	Jahn & Mena (2002V)
<i>Geotrygon veraguensis</i>		EN		6000-18 000	Jahn & Mena (2002π)
<i>Ara ambiguus</i>		CR	EN	60-90	Benitez <i>et al.</i> (2002); BirdLife International (2000: 260; 2008)
<i>Touit dilectissimus</i>		NT		n.a.	Ribadeneira (2002)
<i>Pionopsitta pulchra</i>	Cho1	VU		25 000-75 000	Jahn & Mena (2002x)
<i>Pionus chalcopterus</i>		VU		25 000-75 000	Jahn & Mena (2002w)
<i>Amazona autumnalis</i>		EN		<2500	Mena <i>et al.</i> (2002)
<i>Neomorphus radiolus</i>	Cho1	EN	EN	(2500-10 000)	Greenfield (2002); BirdLife International (2009d)
<i>Megascops centralis</i>		NT		12 000-36 000	Jahn & Mena (2002b)
<i>Glaucidium griseiceps</i>		VU		<5000	Jahn & Mena (2002y)
<i>Nyctiphrynus rosenbergi</i>	Cho1	VU	NT	12 000-36 000	Mena & Jahn (2002b); BirdLife International (2000: 653)
<i>Phaethornis yaruqui</i>	Cho2			n.a.	
<i>Androdon aequatorialis</i>		NT		25 000-75 000	Jahn & Mena (2002k)
<i>Amazilia rosenbergi</i>	Cho1			n.a.	
<i>Chalybura urochrysa</i>		VU		10 000-30 000	Jahn & Mena (2002g)
<i>Trogon comptus</i>	Cho1	NT		25 000-75 000	Jahn & Mena (2002i)
<i>Capito squamatus</i>	Cho1	NT	NT	12 000-36 000	Jahn & Mena (2002d); BirdLife International (2000: 658)
<i>Capito quinticolor</i>	Cho1	EN	VU	5000-15 000	Jahn & Mena (2002c); BirdLife International (2009b)
<i>Selenidera spectabilis</i>		DD		n.a.	Jahn & Mena (2002ò)

TABLE 45. Continued.

Scientific name	Endemic bird area <sup>a</sup>	Threat status <sup>b</sup>		Population estimate <sup>c</sup> for Ecuador (World)	References on threat status and population
		Ecuador	World		
<i>Pteroglossus sanguineus</i>	Cho2	VU		10 000-30 000	Jahn & Mena (2002a)
<i>Ramphastos brevis</i>	Cho1	VU		15 000-45 000	Jahn & Mena (2002g)
<i>Ramphastos swainsonii</i>		VU		20 000-60 000	Jahn & Mena (2002ñ)
<i>Picus litae</i>	Cho1	VU		8000-24 000	Mena & Jahn (2002a)
<i>Celeus loricatus</i>		NT		20 000-60 000	Jahn & Mena (2002h)
<i>Veniliornis chocoensis</i>	Cho1	VU	NT	2500-10 000	Jahn & Mena (2002i); BirdLife International (2000: 659)
<i>Veniliornis callonotus</i>	Tum2			n.a.	
<i>Campephilus gayaquilensis</i>	Tum2	VU	NT	12 000-36 000	Jahn & Mena (2002j); BirdLife International (2000: 659)
<i>Xenerpestes minlosi</i>	Cho2	VU		n.a.	Guerrero (2002b)
<i>Hylocistis virgatus</i>		NT		30 000-90 000	Jahn & Mena (2002Ü)
<i>Dendrocolaptes sanctithomae</i>		VU		10 000-30 000	Jahn & Mena (2002i)
<i>Xiphorhynchus lachrymosus</i>		VU		40 000-120 000	Jahn & Mena (2002i)
<i>Xiphorhynchus erythropygius</i>		NT		45 000-135 000	Jahn & Mena (2002i)
<i>Dysithamnus puncticeps</i>		NT		50 000-150 000	Jahn & Mena (2002e)
<i>Myrmotherula ignota</i>		NT		30 000-90 000	Jahn & Mena (2002r)
<i>Hylophylax naevioides</i>		NT		60 000-180 000	Jahn & Mena (2002u)
<i>Myrmeciza immaculata</i>		NT		25 000-75 000	Jahn & Mena (2002t)
<i>Myrmeciza nigricauda</i>	wAnd2			n.a.	
<i>Myrmeciza berlepschi</i>	Cho1	NT		15 000-45 000	Jahn & Mena (2002s)
<i>Phaenostictus mcleannani</i>		VU		8000-24 000	Jahn & Mena (2002v)
<i>Pittasoma rufopileatum</i>	Cho1	VU	NT	2500-10 000	Jahn & Mena (2002Ñ); BirdLife International (2000: 663)
<i>Hylopezus perspicillatus</i>		VU		12 000-36 000	Jahn & Mena (2002e)
<i>Scytalopus chocoensis</i>	wAnd2	EN		n.a.	Freile (2002)
<i>Rhynchocyclus pacificus</i>	Cho2	NT		12 000-36 000	Jahn & Mena (2002C)
<i>Rhytipterna holerythra</i>		NT		15 000-45 000	Jahn & Mena (2002I)
<i>Sirystes albogriseus</i>		VU		8000-24 000	Jahn & Mena (2002á)
<i>Conopias albobittatus</i>		NT		15 000-45 000	Jahn & Mena (2002z)
<i>Tyrannus niveigularis</i>	Tum2			n.a.	
<i>Laniocera rufescens</i>		VU		2500-10 000	Jahn & Mena (2002Ö)
<i>Lipaugus unirufus</i>		VU		20 000-60 000	Jahn & Mena (2002É)
<i>Cotinga nattererii</i>		VU		2500-10 000	Jahn & Mena (2002n)
<i>Carpodectes hopkei</i>		VU		2500-10 000	Jahn & Mena (2002o)
<i>Cephalopterus penduliger</i>	Cho1	EN	VU	2000-8000	Jahn & Mena (2002*); BirdLife International (2000: 386)
<i>Machaeropterus deliciosus</i>	Cho1			n.a.	
<i>Sapayoa aenigma</i>		VU		15 000-45 000	Mena & Jahn (2002k)
<i>Turdus daguae</i>		NT		50 000-150 000	Mena & Jahn (2002h)
<i>Thryothorus leucopogon</i>		NT		40 000-120 000	Jahn & Mena (2002á)
<i>Cyphorhinus phaeocephalus</i>		NT		15 000-45 000	Jahn & Mena (2002à)
<i>Polioptila schistaceigula</i>		VU		15 000-45 000	Jahn & Mena (2002Ä)
<i>Geothlypis auricularis</i>	Tum2			n.a.	
<i>Basileuterus chlorophrys</i>	wAnd2			n.a.	
<i>Dacnis venusta</i>		NT		10 000-30 000	Jahn & Mena (2002p)
<i>Dacnis berlepschi</i>	Cho1	VU	VU	15 000-45 000	Mena & Jahn (2002d); BirdLife International (2000: 567)
<i>Erythrolipis salmoni</i>	Cho1	NT		18 000-56 000	Jahn & Mena (2002é)
<i>Chlorophonia flaviviridis</i>	Cho1			n.a.	
<i>Euphonia fulvicrissa</i>		NT		20 000-60 000	Jahn & Mena (2002q)
<i>Tangara rufigula</i>	wAnd2			n.a.	
<i>Tangara palmeri</i>	wAnd2	NT		20 000-56 000	Jahn & Mena (2002ç)

TABLE 45. Continued.

Scientific name	Endemic bird area <sup>a</sup>	Threat status <sup>b</sup>		Population estimate <sup>c</sup> for Ecuador (World)	References on threat status and population
		Ecuador	World		
<i>Tangara johannae</i>	Cho1	VU	NT	8000-24 000	Jahn & Mena (2002a); BirdLife International (2000: 684)
<i>Tangara lavinia</i>		NT		15 000-45 000	Jahn & Mena (2002a)
<i>Bangsia rothschildi</i>	Cho1	VU		2500-10 000	Jahn & Mena (2002e)
<i>Bangsia edwardsi</i>	Cho1			n.a.	
<i>Chlorothraupis olivacea</i>	Cho2	VU		20 000-60 000	Jahn & Mena (2002e)
<i>Chlorothraupis stolzmanni</i>	wAnd2			n.a.	
<i>Heterospingus xanthopygius</i>	Cho2	NT		25 000-75 000	Jahn & Mena (2002a)
<i>Rhodospingus cruentus</i>	Tum1			n.a.	
<i>Cacicus microrhynchus</i>		NT		20 000-60 000	Jahn & Mena (2002f)
<i>Zarhynchus wagleri</i>		VU		2500-10 000	Jahn & Mena (2002#)

logged four additional taxa as endemic to the ‘Tumbesian lowlands’. Furthermore, Ridgely & Greenfield (2001b) considered six species to be endemic to the ‘western Andean slope’, an area that was mostly lumped into the Chocó region by Stattersfield *et al.* (1998).

In Nov. 2005, two additional range-restricted species were recorded: the Tumbesian endemic *Pachyrhamphus spodiurus* and the Chocó lowlands endemic (sensu Ridgely & Greenfield 2001b) *Hylocharis humboldtii*.

#### Threatened species

According to the red list criteria of the IUCN (2001) and Gärdenfors *et al.* (2001), 18 (5.4%) of the bird species recorded in Playa de Oro until Nov. 2004 are considered to be either threatened or near-threatened at the global level (BirdLife International 2000, 2004b, 2009a), whereas 78 (23.2%) are listed for Ecuador (Granizo *et al.* 2002; Table 45). As far as can be judged from the short study period and our limited knowledge, none of the bird species that were originally present in Playa de Oro has been extirpated from the community area (but see below). Since Nov. 2004, four additional threatened and near-threatened taxa were recorded in the area: *Oroaetus isidori* (World = NT, Ec = VU), *Cypseloides cherriei* (World = DD), *Hylocharis humboldtii* (Ec = VU), and *Pachyrhamphus spodiurus* (World = EN, Ec = EN). All four are probably non-breeding visitors in Playa de Oro.

At the global level, *Penelope ortonii*, *Ara ambiguus*, and *Neomorphus radiolus* are the most threatened of Playa de Oro’s bird species, after their official threat status was recently upgraded from Vulnerable to Endangered (BirdLife International 2004b, 2008,

2009a). From a purely Ecuadorian perspective, the threat status of many bird species is much more serious because of the rapidly advancing deforestation in the coastal lowlands (p. 21-23, Conservation status of the Ecuadorian Chocó). As a consequence, *Crax rubra* (Mena & Jahn 2002j) and *Ara ambiguus* (Benítez *et al.* 2002) are Critically Endangered in Ecuador. At the regional level, *Harpia harpyja* certainly belongs in the same category, although it is still relatively widespread in the Amazonian lowlands, for which reason it was listed as Vulnerable at the national level (Guerrero 2002a). The species had probably not been breeding in Playa de Oro for several decades (from about 1970 to 2003; see Appendix 6 for details). Its reappearance is likely due to the encroaching deforestation to the west and north of the community area. The same ‘refugee effect’ might explain why reports of sighted and killed individuals of *C. rubra* have seemingly increased in recent years (from c. 1999 onwards).

#### Surrogate species

##### Flagship species

Charismatic species of Playa de Oro’s avifauna that fulfill the prerequisites of flagships are *Harpia harpyja*, *Crax rubra*, and *Ara ambiguus*. However, flagship taxa might be most effective if they are endemic to a country or region (Kleinman & Mallinson 1998), a condition that the three bird species mentioned above do not comply with (Table 45). Unfortunately, among the Chocó endemics there are very few charismatic species that are large in body size and conspicuous in appearance. Potential candidates are *Penelope ortonii* and *Cephalopterus penduliger*.

TABLE 46. Life zone selection of forest-dependent birds between sea level and an elevation of c. 900 m in Esmeraldas Province, Ecuador. Shown are species (n = 154) that inhabit three or less life zones in the region, and so may have a relatively narrow niche width regarding climatic conditions and other environmental factors. See Appendix 8 for the abundance rank per life zone for those species already recorded in Playa de Oro. Abbreviations used: (a) Life zones: sensu Holdridge (1967), cf. Table 1; TrDF = tropical dry forest; deciduous and semi-deciduous lowland forest close to the Pacific coast; annual precipitation < 2000 mm; in Esmeraldas Province this forest type has almost entirely disappeared; TrHF = tropical humid forest; TrWF = tropical wet forest; low foothills = lowermost foothills (c. 100-400 m), which may be covered by either tropical wet forest or premontane wet forest; PmPF = premontane pluvial forest; here I included species that regularly or seasonally occur down to about 900 m or lower; \* = species recorded in Playa de Oro until Nov. 2004 (Appendix 6); ? = records from Playa de Oro that need further confirmation or are regarded as uncertain (Appendix 6); + = species is regularly present; (+) = species might occur locally or seasonally but presumably at very low population densities. Note: Species that are basically restricted to only one life zone within the area considered have a very dark gray background, taxa that occur mostly in two life zones have a medium dark background, and those occupying three life zones have a light gray background in the corresponding field. The number of singletons for tropical dry forest and premontane pluvial forest would be considerably lower if other life zones, e.g., in the southwestern lowlands as well as in the subtropics, had been taken into account.

Species	Life zones <sup>a</sup>				
	TrDF	TrHF	TrWF	Low foothills	PmPF
<i>Crypturellus berlepschi</i> *		+	+	+	(+)
<i>Sarcoramphus papa</i> *	+	+	+	(+)	
<i>Leucopternis semiplumbeus</i> *		+	+	+	(+)
<i>Leucopternis occidentalis</i>	+	+	(+)		
<i>Harpia harpyja</i> *		+	+	+	
<i>Ibycter americanus</i>				(+)	+
<i>Micrastur mirandollei</i> ?		+	(+)		
<i>Ortalis erythroptera</i> *	+	+	(+)		
<i>Penelope ortonii</i> *			+	+	+
<i>Rhynchortyx cinctus</i> *		+	+	+	(+)
<i>Aramides wolfi</i>	(+)	+	(+)		
<i>Patagioenas plumbea</i>					+
<i>Geotrygon purpurata</i> *				+	+
<i>Geotrygon veraguensis</i> *		+	+		
<i>Ara severus</i>		+	(+)		
<i>Pyrrhura melanura</i> ?				(+)	+
<i>Touit dilectissimus</i> *		+	(+)	(+)	+
<i>Amazona autumnalis</i> ?	+	+	(+)	(+)	(+)
<i>Neomorphus radiolus</i> *				(+)	+
<i>Glaucidium griseiceps</i> *			(+)	+	(+)
<i>Nyctiphrynus rosenbergi</i> *		+	+	+	(+)
<i>Androdon aequatorialis</i> *		(+)	+	+	+
<i>Popelairia conversii</i> *		(+)	+	+	+
<i>Amazilia amabilis</i> *		+	(+)		
<i>Amazilia rosenbergi</i> *		+	+	+	(+)
<i>Chalybura urochrysa</i> *		(+)	+	+	+
<i>Urosticte benjamini</i>					+
<i>Heliodoxa jacula</i>				(+)	+
<i>Coeligena wilsoni</i>					+
<i>Boissonneaua jardini</i>					+
<i>Ocreatus underwoodii</i>					+
<i>Agelaiocercus coelestis</i>					+
<i>Calliphlox mitchellii</i>			(+)	(+)	+
<i>Chaetocercus berlepschi</i>	+				

TABLE 46. Continued.

Species	Life zones <sup>a</sup>				
	TrDF	TrHF	TrWF	Low foothills <sup>b</sup>	PmPF
<i>Trogon mesurus</i>	+	(+)			
<i>Trogon comptus</i> *		(+)	+	+	+
<i>Trogon massena</i>		+			
<i>Trogon chionurus</i> *		+	+	+	(+)
<i>Trogon collaris</i> *				(+)	+
<i>Trogon caligatus</i>	+	+	(+)		
<i>Chloroceryle inda</i> *		+	+	+	(+)
<i>Chloroceryle aenea</i> *		+	+	+	(+)
<i>Momotus momota</i>	+	(+)			
<i>Jacamerops aureus</i> *		(+)	+	+	
<i>Notharchus pectoralis</i> *		+	(+)		
<i>Notharchus tectus</i>		+			
<i>Capito quinticolor</i> *		(+)	+	+	(+)
<i>Eubucco bourcierii</i>			(+)	(+)	+
<i>Aulacorhynchus haematopygus</i> ?			(+)	(+)	+
<i>Veniliornis chocoensis</i> *		(+)	(+)	+	+
<i>Cranioleuca erythrops</i> *				(+)	+
<i>Xenerpestes minlosi</i> ?			(+)	(+)	+
<i>Premnoplex brunnescens</i>					+
<i>Anabacerthia variegaticeps</i>					+
<i>Philydor rufum</i>					+
<i>Automolus ochrolaemus</i> *		+	+	(+)	
<i>Thripadectes ignobilis</i>					+
<i>Xenops rutilans</i>	+	(+)			+
<i>Sclerurus guatemalensis</i>		+	(+)		
<i>Sittasomus griseicapillus</i>	+	+			
<i>Xiphorhynchus lachrymosus</i> *		+	+	+	
<i>Campylorhamphus trochilrostris</i> *	+	+	+		
<i>Campylorhamphus pusillus</i> *			(+)	+	+
<i>Thamnistes anabatinus</i> *			+	+	+
<i>Dysithamnus mentalis</i>	+	(+)			
<i>Myrmotherula ignota</i> *		+	+	+	(+)
<i>Myrmotherula schisticolor</i> *				(+)	+
<i>Herpsilochmus rufimarginatus</i>	(+)	+			
<i>Terenura callinota</i>					+
<i>Cercomacra nigricans</i>	+				
<i>Hylophylax naevioides</i> *		+	+	+	(+)
<i>Pyriglena leuconota</i>	+	(+)			
<i>Myrmeciza nigricauda</i> *				(+)	+
<i>Myrmeciza berlepschi</i> *		(+)	+	+	(+)
<i>Phaenostictus mcleannani</i> *		+	+	+	(+)
<i>Pittasoma rufopileatum</i> *		(+)	+	+	+
<i>Grallaria haplonota</i>					+
<i>Hylopezus perspicillatus</i> *		+	+	+	(+)
<i>Grallaricula flavirostris</i>					+
<i>Scytalopus chocoensis</i> *				(+)	+
<i>Ornithion brunneicapillus</i> *		+	+	+	(+)
<i>Myiopagis caniceps</i> *		+	+	+	(+)
<i>Myiopagis subplacens</i>	+				
<i>Myiopagis viridicata</i> *	+	+	(+)	(+)	



TABLE 46. Continued.

Species	Life zones <sup>a</sup>				
	TrDF	TrHF	TrWF	Low foothills <sup>b</sup>	PmPF
<i>Mecocerculus calopterus</i>					+
<i>Pseudotriccus pelzelni</i>					+
<i>Cnipodectes subbrunneus</i>	+	(+)			
<i>Rhynchocyclus fulvipectus</i>					+
<i>Tolmomyias sulphurescens</i>	+	(+)			
<i>Tolmomyias flavotectus</i> *		+	+	+	(+)
<i>Platyrinchus mystaceus</i>					+
<i>Onychorhynchus occidentalis</i>	+				
<i>Myiotriccus ornatus</i> *				(+)	+
<i>Myiobius villosus</i> ?					+
<i>Myiophobus phoenicomitra</i>					+
<i>Mitrephanes phaeocercus</i> *			+	+	(+)
<i>Lathrotriccus griseipectus</i>	+	(+)			
<i>Attila torridus</i>	+	+	(+)		
<i>Sirystes albogriseus</i> *		+	+	+	(+)
<i>Conopias albobittatus</i> *		+	+	+	(+)
<i>Myiodynastes maculatus</i> *	+	(+)	(+)	(+)	
<i>Pachyramphus spodiurus</i>	+	(+)	(+)		
<i>Pachyramphus polychopterus</i>		(+)	(+)	(+)	+
<i>Pachyramphus albogriseus</i> *	+	(+)	(+)	(+)	+
<i>Pipreola jucunda</i>					+
<i>Ampelioides tschudii</i>					+
<i>Laniocera rufescens</i> *		+	+	+	(+)
<i>Cotinga nattererii</i> *		+	+	(+)	
<i>Carpodectes hopkei</i> *		+	+	+	(+)
<i>Querula purpurata</i> *		+	+	+	
<i>Pyroderus scutatus</i>					+
<i>Rupicola peruvianus</i>					+
<i>Pipra mentalis</i> *		+	+	+	(+)
<i>Masius chrysopterus</i> *				(+)	+
<i>Machaeropterus deliciosus</i> *			(+)	(+)	+
<i>Sapayoa aenigma</i> *		(+)	+	+	(+)
<i>Cyclarhis nigristrois</i>					+
<i>Vireo olivaceus</i> *	+	(+)	(+)	(+)	
<i>Myadestes ralioides</i> *					+
<i>Cichlopsis leucogenys</i> *				(+)	+
<i>Turdus obsoletus</i> *				(+)	+
<i>Turdus maculirostris</i>	+	(+)			
<i>Turdus daguae</i> *		+	+	+	(+)
<i>Odontorchilus branickii</i> *			+	+	(+)
<i>Ramphocaenus melanurus</i>	+	+	(+)		
<i>Myioborus miniatus</i>					+
<i>Basileuterus chlorophrys</i> *					+
<i>Basileuterus fraseri</i>	+	(+)			
<i>Iridophanes pulcherrimus</i>					+
<i>Dacnis berlepschi</i> *		+	+	+	(+)
<i>Hemithraupis guira</i>	+	(+)	(+)		
<i>Erythrolithypis salmoni</i> *		(+)	+	+	+
<i>Chlorophonia flavirostris</i> *					+
<i>Euphonia fulvicrissa</i> *		+	+	+	(+)

TABLE 46. Continued.

Species	Life zones <sup>a</sup>				
	TrDF	TrHF	TrWF	Low foothills <sup>b</sup>	PmPF
<i>Chlorochrysa phoenicotis</i>					+
<i>Tangara rufigula</i> *					+
<i>Tangara palmeri</i> *		(+)	+	+	+
<i>Tangara florida</i> *			(+)	+	+
<i>Tangara icterocephala</i>					+
<i>Tangara johannae</i> *		+	+	+	(+)
<i>Tangara lavinia</i> *		(+)	+	+	+
<i>Bangsia rothschildi</i> *			(+)	+	(+)
<i>Bangsia edwardsi</i> *					+
<i>Piranga lutea</i>	+				
<i>Piranga leucoptera</i>					+
<i>Chlorothraupis olivacea</i> *		(+)	+	+	
<i>Chlorothraupis stolzmanni</i> *					+
<i>Chlorospingus flavovirens</i>					+
<i>Chlorospingus flavigularis</i>					+
<i>Cyanocopsa cyanoides</i> *		+	(+)		
<i>Atlapietes tricolor</i>					+
<i>Buarremon brunneinucha</i>					+
<i>Lysurus castaneiceps</i>					+
<i>Cacicus cela</i>	+				
Singles	19	10	0	2	59
Doubles	10	12	10	11	7
Triples	2	29	39	37	10
Sum	31	51	49	50	76

## Umbrella species

Regarding the avifauna, only the largest taxon, *Harpyia harpyja*, might serve as an effective umbrella species. One pair may need an area of up to 5000 ha (Thiollay 1989b), and thus a viable population of at least 50 pairs requires a preserve of not less than

250 000 ha of tropical lowland rainforest. This area covers almost all of what remains of intact and continuous tropical rainforest in northwestern Ecuador (Sierra 1999). Of course, the extant population of *H. harpyja* in Esmeraldas Province is already much smaller than 50 pairs.

TABLE 47. 'Indicator species' (n = 154) shared and incidence-based Jaccard and Sørensen similarity indices between five life zones in Esmeraldas Province, Ecuador. Elevational range between sea level and c. 900 m; see Table 45 for details.

Sample 1	Sample 2	S <sub>ob</sub> 1	S <sub>ob</sub> 2	Shared <sub>ob</sub>	Jaccard	Sørensen 1
Tropical dry forest	Tropical humid forest	31	51	10	0.14	0.24
Tropical dry forest	Tropical wet forest	31	49	2	0.03	0.05
Tropical dry forest	Lowermost foothills	31	50	0	0.00	0.00
Tropical dry forest	Premontane pluvial forest	31	76	2	0.02	0.04
Tropical humid forest	Tropical wet forest	51	49	32	0.47	0.64
Tropical humid forest	Lowermost foothills	51	50	27	0.36	0.53
Tropical humid forest	Premontane pluvial forest	51	76	1	0.01	0.02
Tropical wet forest	Lowermost foothills	49	50	44	0.80	0.89
Tropical wet forest	Premontane pluvial forest	49	76	10	0.09	0.16
Lowermost foothills	Premontane pluvial forest	50	76	14	0.13	0.22

### Life zone assemblages

In a first analysis, considering five life zones between sea level and the 900 m contour line, I identified 154 avian taxa that are restricted to only three or less life zones within Esmeraldas Province (Table 46). Each life zone assemblage consists of 31 to 76 species, with the three 'central' life zones (see below) having similar numbers of indicator species, with 49 to 51 per category. Within the area considered, no less than 58% ( $n = 90$ ) of these species are restricted to only a single life zone. However, the high number of singletons for the 'peripheral' life zones, premontane pluvial forest and tropical dry forest, is partly an artifact of scope, because some of these species inhabit other life zones outside the study area, e.g., montane forest on the upper Andean slopes or very dry forest in southwestern Ecuador. Thus, interpretations should mainly focus on the three 'central' life zones, viz. tropical humid forest, tropical wet forest, and the lowermost foothills (Table 1). Furthermore, many species also occur locally, though usually at low densities, in neighboring life zones, even if they are regarded as restricted to only one category. This is not surprising, considering that the area between the coast and the lowermost foothills is characterized by a steep precipitation gradient. Thus, minor differences in the ecological requirements of birds, as well as in local climatic conditions and year-to-year variations in precipitation, make the area a transition zone for many species at many localities.

The life zone assemblages for tropical humid forest contain 10 singletons and those for the lowermost foothills contain two, whereas the tropical wet forest has no bird species that are entirely restricted to this life zone. The reason why I still differentiate between the lowermost foothills and tropical wet forest is the existence of a very few species that occur only in either but not both zones. *Geotrygon veraguensis*, *Automolus ochrolaemus*, and *Cotinga nattererii* are taxa mostly restricted to tropical humid and tropical wet forest. Species that, in addition, occur in tropical dry forest but are virtually absent from the wet foothills are *Sarcoramphus papa* and *Campylorhamphus trochilirostris*. By contrast, *Geotrygon purpurata*, *Glaucidium griseiceps*, and *Bangsia rothschildi* occur only in the lowermost foothills but usually not in the rolling lowlands of tropical wet forest. Three additional species, viz. *Veniliornis chocoensis*, *Campylorhamphus pusillus*, and *Tangara florida*, are extremely rare

in the wet lowlands but regularly occur in the lowermost foothills up to the premontane pluvial forest life zone. The quail-doves *G. veraguensis* and *G. purpurata* seem to be ecologically exclusive and usually do not occur together. Furthermore, the abundance of many wet forest specialists peaks in the narrow belt of rolling lowland hills close to the foothills, but rapidly declines in the foothills themselves as well as in the tropical humid forest closer to the coast. Examples of species with such pronounced unimodal abundance distribution within their altitudinal range and along the corresponding precipitation gradient are *G. veraguensis*, *Myrmeciza berlepschi*, *Sapayoa aenigma*, and *Chlorothraupis olivacea* (pers. obs.). Nevertheless, the life zone assemblages of tropical wet forest and the lowermost foothills are very similar, with an incidence-based Sørensen index of 0.89 (Table 47). The corresponding similarity coefficient of the indicator groups for tropical humid and tropical wet forests is only 0.64. The only assemblages not sharing any indicator species are those of tropical dry forest and the lowermost foothills.

In Playa de Oro a very pronounced change in bird community composition was found in the transition zone between the lowermost foothills and the premontane pluvial forest. Many avian species of the latter life zone first appear at an altitude of c. 400 m, e.g., *Trogon collaris*, *Myrmotherula schisticolor*, *Myrmeciza nigricauda*, *Scytalopus chocoensis*, *Turdus obsoletus*, *Basileuterus chocoensis*, *Chlorophonia flavirostris*, *Tangara rufigula*, *Bangsia edwardsi*, and *Chlorothraupis stolzmanni*, whereas several lowland taxa reach their uppermost altitudinal limit there. Examples for the latter group are *Xiphorhynchus lachrymosus*, *Hylaphylax naevioides*, *Myrmeciza berlepschi*, *Pipra mentalis*, *Euphonia fulvicrissa*, and *Chlorothraupis olivacea*.

Avian habitat selection and indicators in human-influenced mosaic landscapes

### Multivariate analysis

Open-country, forest-edge, and forest-inhabiting bird species were well separated along the first axis in indirect ordinations based on Detrended Correspondence Analysis (DCA). For many taxa the position of the center of abundance along the first axis is rather similar in mist-netting (Fig. 41) and transect-mapping data (Fig. 42). Two examples of species for which the centers of abundance appear in very distinct positions along the first axis for mist netting

194

mapping data (Figs. 43 to 50). This phenomenon is much more pronounced for forest-dwelling birds than for non-forest taxa, e.g., the DCCA of captures (Fig. 43) contains only one best-fit forest species, viz. *Tachyphonus delarrii*, whereas the MTW data (Fig. 44) resulted in no less than 12 best-fit forest taxa.

In the DCCAs only a few of the best-fit forest species, such as *Microbates cinereiventris*, *Hyloctistes virgatus*, and *Lepidothrix coronata*, seem to have a close association with tree-fall gaps (Fig. 44). The single-variable analyses revealed that *Myrmeciza exsul* and *Tachyphonus delatrii* might also belong in this group (CCAs not shown).

Most best-fit forest species had their center of abundance in the forest interior rather than close to the forest edge (Figs. 44 and 46). Not surprisingly, all of these taxa inhabit the forest undergrowth or understory. Furthermore, many are core species, or at least regular attendants of mixed-species flocks, like *H. virgatus*, *Xiphorhynchus erythropygius*, *Myrmotherula axillaris*, *Sapayoa aenigma*, *Thryothorus leucopogon*, *M. cinereiventris*, *Chlorothraupis olivacea*, and *T. delatrii*. Examples of forest species more frequently encountered close to edges were *Amazilia rosebergi* and *Eutoxeres aquila* according to the mist-netting data (Fig. 45), and *Microrhopias quixensis*

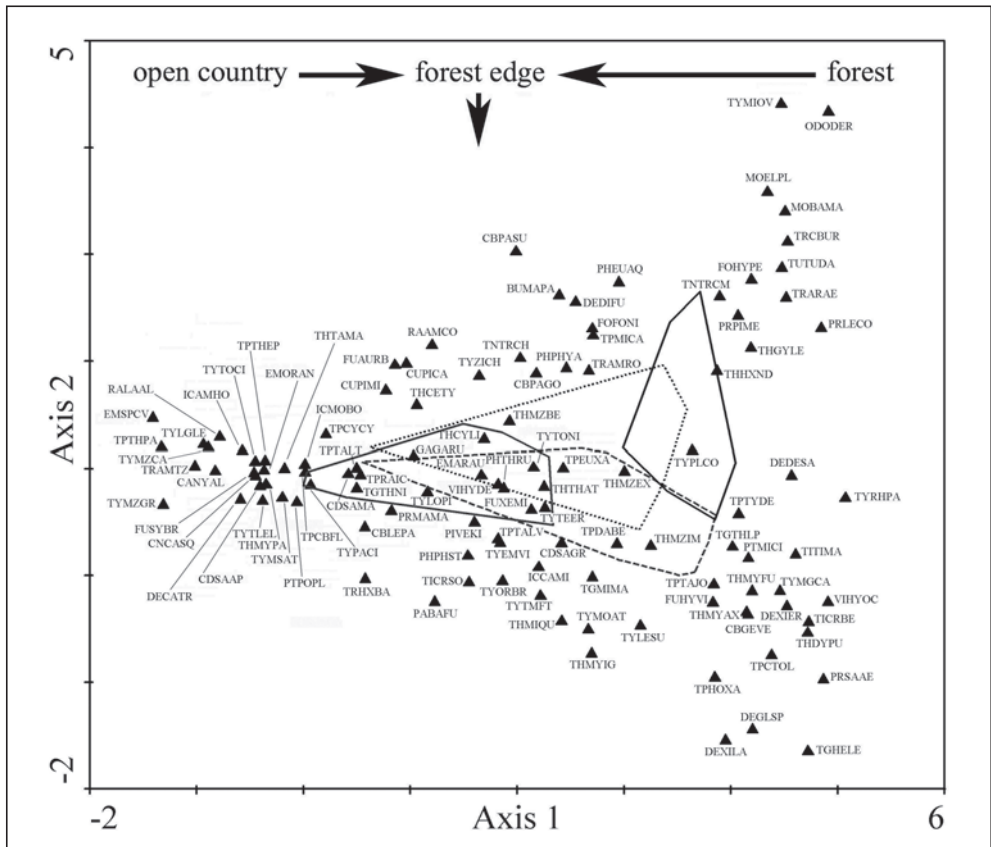


FIG. 42. Detrended Correspondence Analysis (DCA) for the transect-mapping data of MNT1 and MNT2 combined. Detrended by segments; with TWINSpan envelopes. The ordination result for 2 axes explains 20.4% of the entire variance in the data set. Axis 1 explains 16% and axis 2 4.4%. All species (n = 114) with  $\geq 3$  records are shown. The habitat types were added manually to assist in the interpretation. See Appendices 4 or 5 for the bird species codes.

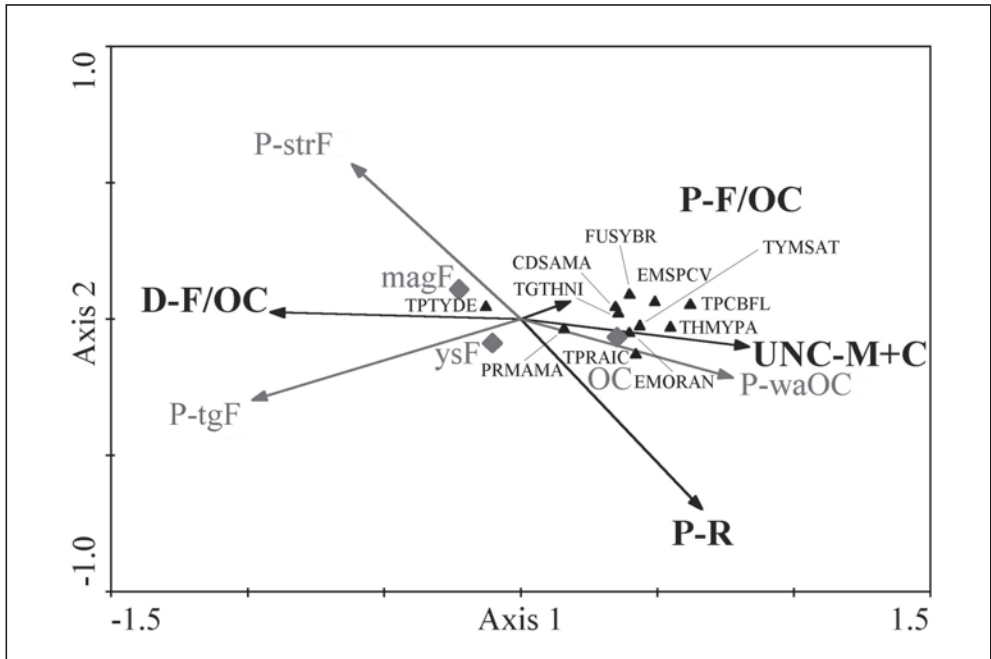


FIG. 43. Detrended Canonical Correspondence Analysis (DCCA) for the mist-netting data. Detrended by 2nd order polynomials. The ordination result for 2 axes explains 11.5% of the entire variance in the data set. Axis 1 explains 10.0% and axis 2 1.5%. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. The point of origin of the arrows represents the average value of the corresponding environmental gradients. Black triangles represent the center of abundance of each bird species in the ordination space. The closer the position of a species's center of abundance to an environmental gradient, the closer the association between the species and the variable. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) environmental variable (active): D-F/OC = distance to forest-open country edge; P-F/OC = proximity to forest-open country edge; UNC-M+C = combined uncovered portion of midstory and canopy; P-R = proximity to river; (c) supplementary variable (passive): P-tgF = proximity to tree-fall gap within forest; P-waOC = proximity to water body in open country; P-strF = proximity to forest stream; (d) bird species: see Appendices 4 or 5.

based on transect mapping (Fig. 46). Also *M. exsul* is evidently edge-tolerant, with a center of abundance at about 60 m from the ecotone. Forest-edge taxa that are more closely associated with disturbed and open habitats are *Cercomacra tyrannina* and *Lophotriccus pileatus* (Fig. 46) as well as *Manacus manacus* and *Arremon aurantiivirostris* (Fig. 45).

Regarding the environmental factor 'combined cover of midstory and canopy,' none of the best-fit forest birds had their center of abundance below a value of 3.5 (87.5%). Of these, *C. olivacea* was the taxon associated with the densest combined cover (Fig. 48).

Species that were most abundant in transect sections with very open or missing midstory and canopy were *Glaucis aeneus*, *Amazilia tzacatl*, *Heliothryx barroti*, *Synallaxis brachyura*, *Taraba major*, *Myrmotherula pacifica*, *Tyrannulus elatus*, *Todirostrum cinereum*, *Myiozetetes cayanensis*, *M. granadensis*, *Pachyrhamphus cinnamomeus*, *Thryothorus nigricapillus*, *Geothlypis auricularis*, *Coereba flaveola*, *Ramphocelus icteronotus*, *Saltator maximus*, and *Sporophila corvina* (Figs. 47 and 48). The center of abundance of many of these species also lay within 40 m or less of the edges of water bodies within open country, like streams, ponds, and artificial channels (Figs. 49 and



50). *Myiobius atricaudus* and *Oryzoborus angolensis* are two other species showing a clear association with watercourses in open country (Fig. 49). However, in the DCCA of the transect-mapping data, *Leptotila pallida* was the only best-fit non-forest bird with a close association with the environmental variable 'proximity to the river' (Fig. 44). Nevertheless, in single variable analysis, the center of abundance of many of the previously mentioned non-forest species also increases with decreasing distance to the river (CCAs not shown).

It should be mentioned that some species show an apparent association with environmental variables of which they are evidently independent. For ex-

ample, according to the transect-mapping data, the center of abundance of some best-fit forest birds seems to be influenced by the distance to water bodies in open country (Fig. 50). Likewise, the distance to forest streams or tree falls within forest apparently influences the abundance of some non-forest species (CCAs not shown). In reality this is not the case, and the reason why some taxa nevertheless appear to be associated with some of these odd variables might be a residual collinearity to the environmental gradient 'distance to forest/open country edge'. As yet it is unclear whether these effects would disappear with larger sample size, or whether they are caused by a methodological artifact of environmental gra-

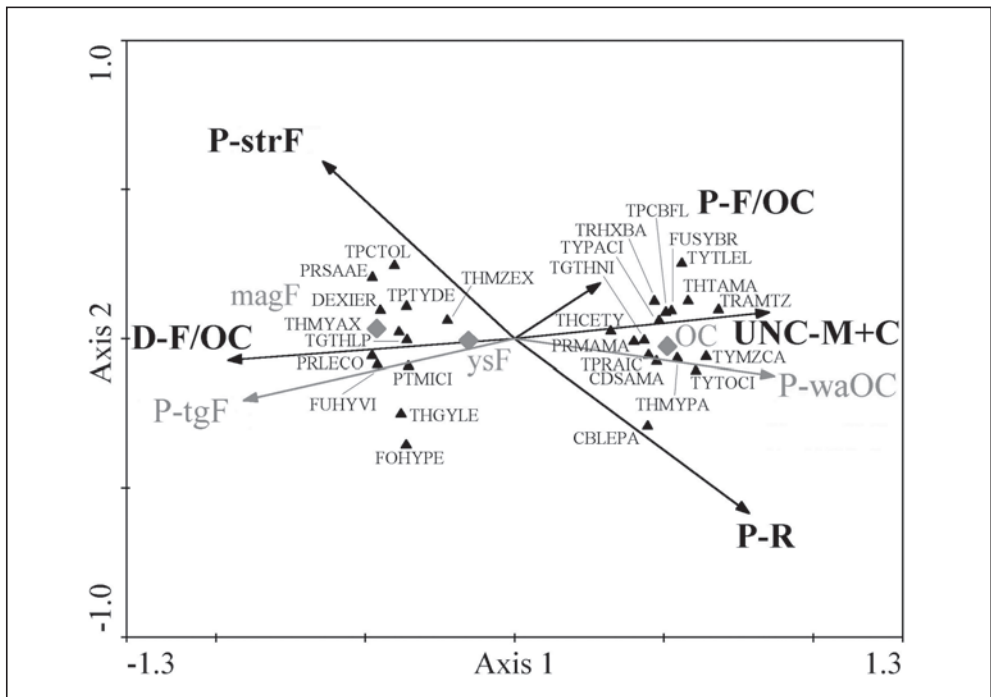


FIG. 44. Detrended Canonical Correspondence Analysis (DCCA) for the transect-mapping data. Detrended by 2nd order polynomials. The ordination result for 2 axes explains 17.3% of the entire variance in the data set. Axis 1 explains 14.8% and axis 2 2.5%. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) environmental variable (active): D-F/OC = distance to forest-open country edge; P-F/OC = proximity to forest-open country edge; UNC-M+C = combined uncovered portion of midstory and canopy; P-R = proximity to river; P-strF = proximity to forest stream; (c) supplementary variable (passive): P-tgF = proximity to tree-fall gap within forest; P-waOC = proximity to water body in open country; (d) bird species: see Appendices 4 or 5.

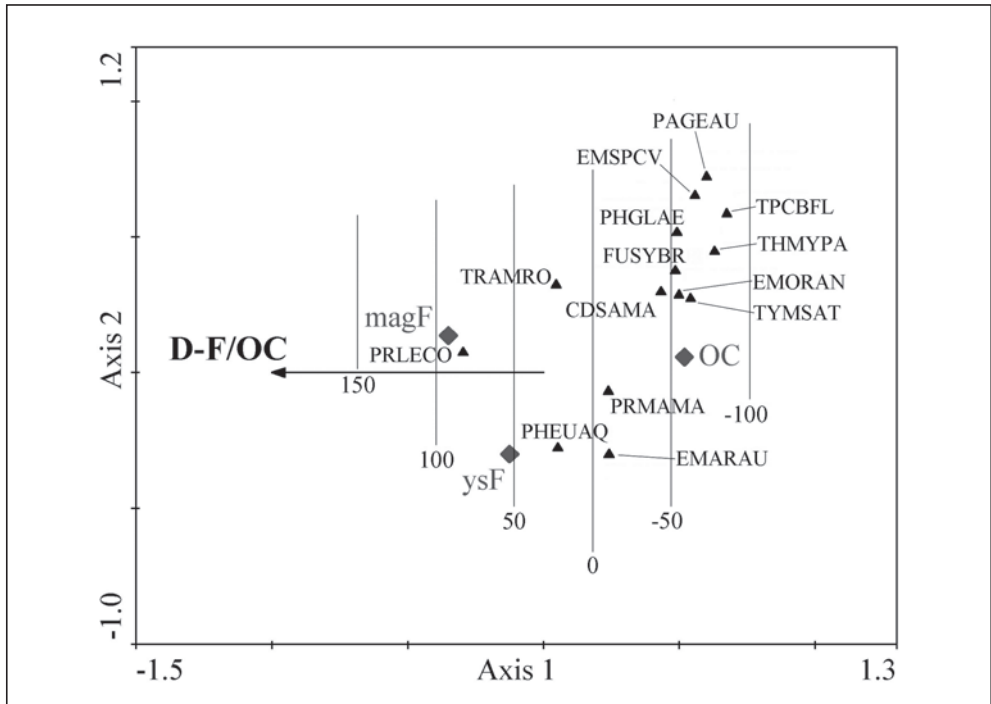


FIG. 45. Canonical Correspondence Analysis (CCA) of the variable 'distance to forest-open country edge' (D-F/OC) for the mist-netting data. The ordination space is subdivided by isolines of the variable obtained via the 'Contour Attribute Plot' function of CANODRAW using the 'Generalized Linear Models' (GLM) option for calculating the species responses to the variable. The gradient explains 8.6% ( $P = 0.008$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5.

dients that acts only in certain portions of habitat mosaics. Of course, the true variance explained by the corresponding variables as well as the probability values are certainly lower than those calculated.

#### Indicator species

The program TWINSpan (Hill 1979) mostly identified abundant bird taxa as indicator species. However, the resulting classifications are not always consistent with the species' habitat selection as observed in the field. One likely reason is that the data sets contain a considerable level of noise. Furthermore, the TWINSpan algorithm is not error free. In general, the probability of misclassification increases with the rising number of divisions. Therefore, I do not

interpret the results of higher divisions in which the identification of indicators might be the product of chance.

In the case of the mist-netting data (Table 48), the first division generated two groups, one containing four abundant open-country and forest-edge species (positive sign), which contrast with those of the second group of two common forest species (negative sign). The second division produced a single group of four species that were most abundant close to forest edges. For the reasons mentioned above, the results of higher divisions were not regarded as meaningful.

If calculated on the basis of transect-mapping data (Table 49), the number of indicator taxa identified by TWINSpan tends to be greater than that for

capture/recapture data. The first and third divisions separated some open-country and forest-inhabiting species rather cleanly. However, divisions 2 and 4 divide several forest birds into distinct groups, without the reasons for the separations being clear. In the case of division 2, *Myiornis atricapillus* and *Hylophilus decurtatus* are subcanopy-dwelling birds (positive sign), whereas the rest mainly inhabit the forest undergrowth. Because the second division may not represent meaningful results, it seems advisable to ignore the higher divisions.

In contrast to TWINSpan, the program IndVal (Dufrene & Legendre 1997) computes indicator groups based on predefined habitat categories. Consequently, the allocation of indicators to certain habitats is unambiguous. Moreover, IndVal also presents the basis for the assignments, i.e., for each

habitat considered, the relationship between abundance and number of sampling units in which the corresponding species was recorded as well as a t-test allowing the significance of the results to be assessed (Tables 50 and 51). Although many of the indicator species determined by IndVal were also identified by TWINSpan, with the latter approach major uncertainties remain whether the results are meaningful or not.

The number of indicator taxa determined on the basis of the transect-mapping sample ( $n = 61$ ; Table 50) was slightly greater than for the mist-netting data ( $n = 47$ ; Table 49). Based on captures, IndVal listed 27 indicator species for open country, 8 for young successional forest, and 12 for medium-age forest. The corresponding numbers for transect-mapping records are 29, 10, and 22, respectively.

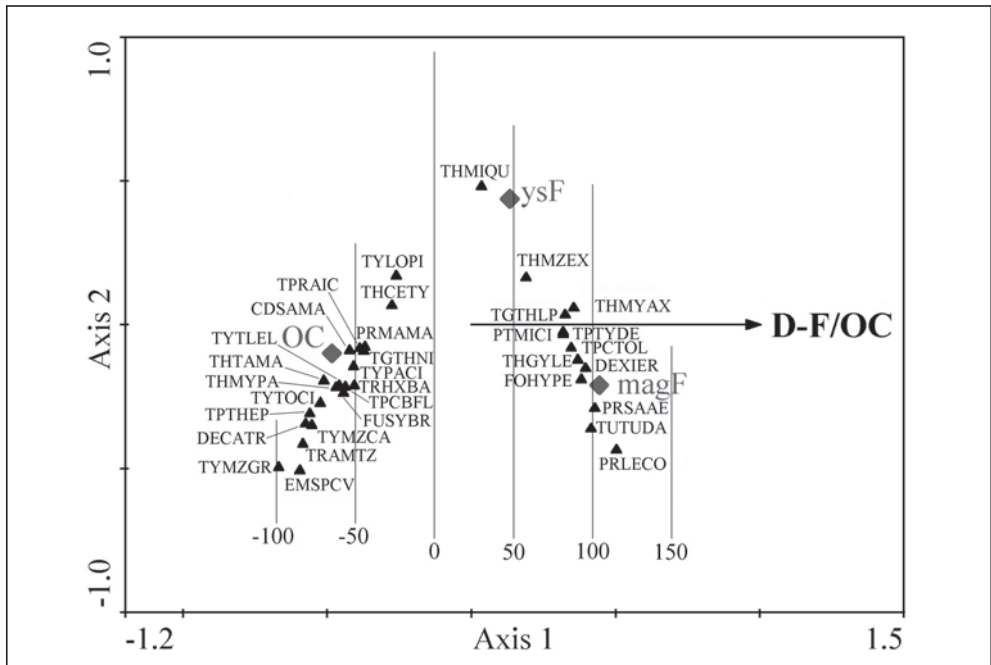


FIG. 46. Canonical Correspondence Analysis (CCA) of the variable 'distance to forest-open country edge' (D-F/OC) for the transect-mapping data. Plot functions and options used as in Fig. 45. The gradient explains 13.7% ( $P = 0.008$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5. Note the distinct 'arch effect' of the data points.

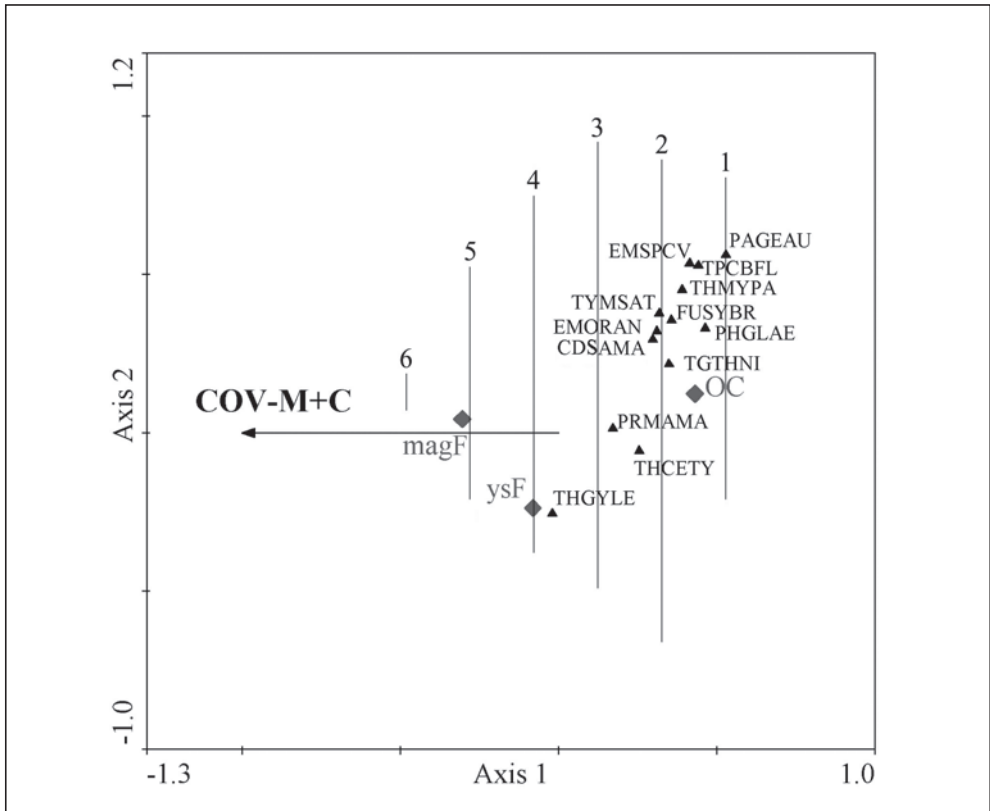


FIG. 47. Canonical Correspondence Analysis (CCA) of the variable 'combined cover of the midstory and canopy' (COV-M+C) for the mist-netting data. Plot functions and options used as in Fig. 45. The gradient explains 7.5% ( $P = 0.008$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5.

Many of the indicators identified for open country and medium-age forest were shared by both data sets, whereas for young successional forest, capture and MTW data didn't even have a single indicator taxon in common. For several potential indicator taxa that were recorded in only one habitat, sample size were too small to result in significant differences in the  $t$ -tests; e.g., based on mist-netting data, *Stelgidopteryx ruficollis*, *Geothlypis semiflava*, *Thraupis episcopus*, and *Molothrus bonariensis* were only recorded in open country, but capture rates were so low that they were not identified as indicators for this habitat by IndVal.

Two taxa, *Gymnophrys leucaspis* and *Chlorothraupis olivacea*, which were determined as indicators for young successional forest based on capture/recapture data, were significant for medium-age forest when computed with MTW data (Tables 50 and 51). Likewise, using mist-netting data, *Amazilia rosenbergi* was identified as an indicator for open country but as an indicator for young successional forest when transect-mapping data were employed. The opposite case, in which a species would be listed as an indicator for a more disturbed habitat in the transect-mapping sample than in the mist-netting data, did not occur.

### Assessment of the conservation value of MNT1 and MNT2

According to standardized MTW surveys, bird species richness was higher at MNT1 than at MNT2, as were all but one of the diversity indices calculated for the modeled bird communities (p. 75-77, Transect-mapping study; p. 142f, Species diversity; and Table 33). However, if we look at the habitat association within the avian assemblages (Table 52), it quickly becomes clear that MNT1 was more species-rich and diverse only because of the greater extent and variety of anthropogenic habitats there. MNT2 held more forest species as well as forest-interior specialists than MNT1, whereas the number of forest-edge and open-country taxa was higher at the latter transect. Forest-interior species present at

MNT2 but not recorded at MNT1 are *Tinamus major*, *Leucopternis plumbeus*, *Megascops centralis*, *Sclerurus mexicanus*, *Campylorhamphus pusillus*, *Phoenicostictus mcleannani*, and *Myiobius sulphureipygius*. Of these, only *M. sulphureipygius* was certainly overlooked at MNT1 due to the low detectability of this species in audiovisual surveys.

Using the data on avian habitat selection, I calculated the bird community index  $BCI_{forest}$ . Although both transects were located in a similarly structured mosaic landscape, the index value for transect MNT1 was considerably lower ( $BCI_{MNT1} = -0.049$ ) than for MNT2 ( $BCI_{MNT2} = 0.541$ ).

Not only was the number of forest-dwelling bird species higher at MNT2 in comparison with MNT1, but so too were the population densities of many of

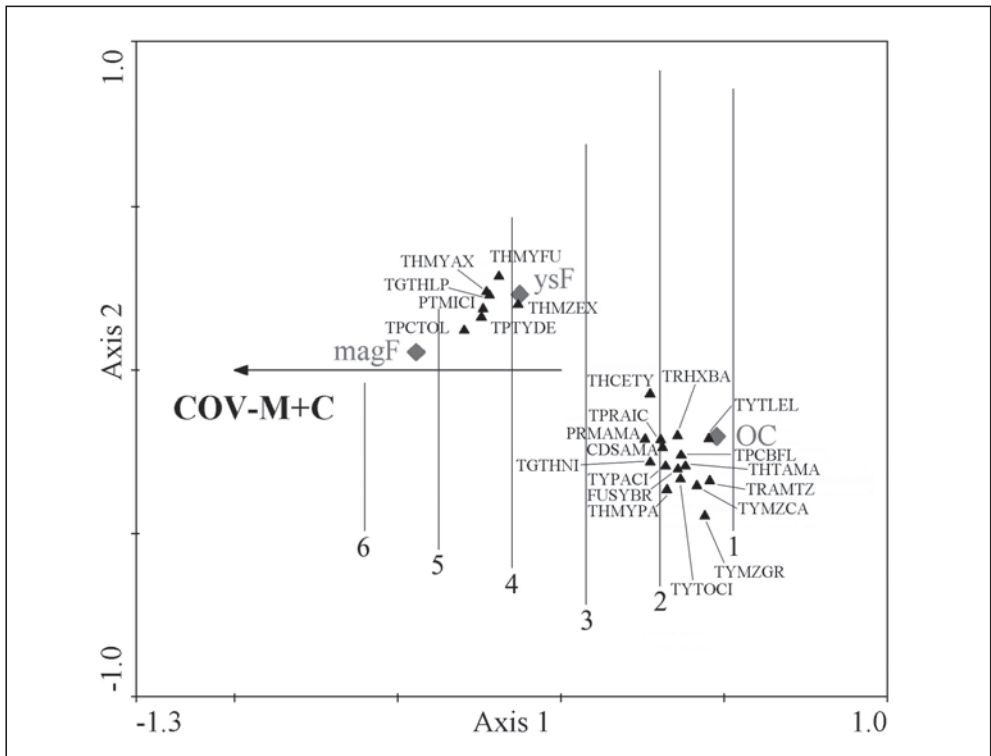


FIG. 48. Canonical Correspondence Analysis (CCA) of the variable 'combined cover of the midstory and canopy' (COV-M+C) for the transect-mapping data. Plot functions and options used as in Fig. 45. The gradient explains 11.0% ( $P = 0.008$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5.

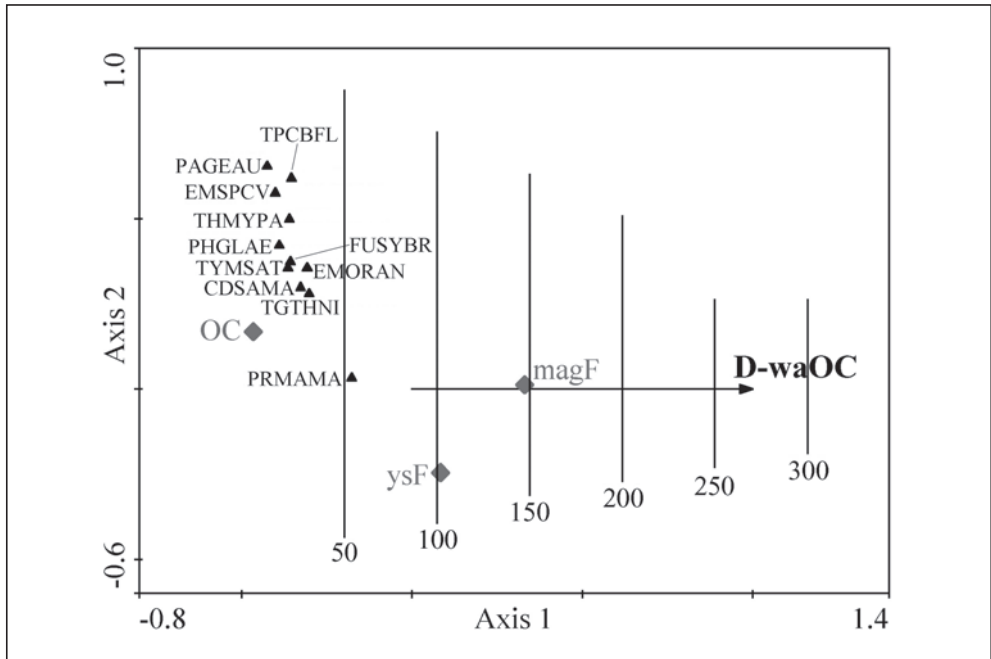


FIG. 49. Canonical Correspondence Analysis (CCA) of the variable 'distance to water body in open country' (D-waOC) for the mist-netting data. Plot functions and options used as in Fig. 45. The gradient explains 6.5% ( $P = 0.01$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5.

those forest taxa noted at both transects (Appendices 18a and 19a). For example, of the four parrot species (*Pionopsitta pulchra*, *Pionus menstruus*, *P. chalcopterus*, and *Amazona farinosa*) recorded during MTW surveys at MNT1 as well as at MNT2, only one, the forest-edge-inhabiting *P. menstruus*, had higher population densities at the former transect.

The total number of globally threatened and near-threatened species was also higher at MNT2 ( $n = 7$ ) than at MNT1 ( $n = 4$ ). This pattern was confirmed by the species' conservation status at the national level, with only 37 taxa at MNT1 but 48 at MNT2. The most noteworthy differences in this context were the presence of *Ara ambiguus* and *Penelope purpurascens* at MNT2. However, the number of endemic bird taxa was basically identical for both transects. During transect-mapping surveys only three endemic species, viz. *Piculus litae*, *Campephilus gayaquilensis*, and *Tangara palmeri*, were recorded at MNT2 but not at MNT1. However, all of them

were also observed at MNT1 during non-standardized observation hours (Appendices 12a and 12b).

## Discussion

Tropical birds as indicators for biodiversity, forest condition, and environmental change

Assessing birds with objective criteria for the selection of indicator taxa

The use of birds (and other vertebrates) as indicators of biodiversity patterns as well as environmental change has been controversially debated in the scientific literature (e.g., Landres *et al.* 1988, Lawton *et al.* 1998, Rodríguez-Estrella *et al.* 1998, Caro & O'Doherty 1999, Andelman & Fagan 2000, Lawler *et al.* 2003). However, many characteristics of birds make them perhaps the most appropriate biological indicators for tropical habitats (Stotz *et al.* 1996), even if we apply very rigorous criteria (e.g., Pearson & Cassola 1992, Pearson 1994):



1. *Taxonomically well known and stable.* – Birds belong to the most stable of all higher taxa, with less than 10% synonymy in recent revisions of regional and world-wide check lists (Pearson 1994). About 10 000 different species have been described (BirdLife International 2004a), and new ones are being added at a very low rate, even for poorly studied areas like the Chocó region in northwestern South America (p. 20f, Biogeographical aspects).

2. *Biology and natural history well understood.* – Although many gaps remain, species-level biology, ecology, and conservation status of birds are far better known than in any other comparable group of organisms (BirdLife International 2004a). For many

tropical regions readily available field guides supply accurate knowledge of identification, behavioral characteristics, ecology, and geographic distribution (Stotz *et al.* 1996). An internationally accepted red list of threatened bird species of the world is available and periodically updated (Collar & Andrew 1988, Collar *et al.* 1994, BirdLife International 2000, 2004b, 2008). Some detailed regional accounts provide additional information on the conservation status and ecology of these threatened species (Collar & Stuart 1985, Collar *et al.* 1992, 1999, 2001).

3. *Populations readily surveyed and manipulated.* – Critics of birds as indicator taxa may point out that they are too expensive to capture and mark, and that

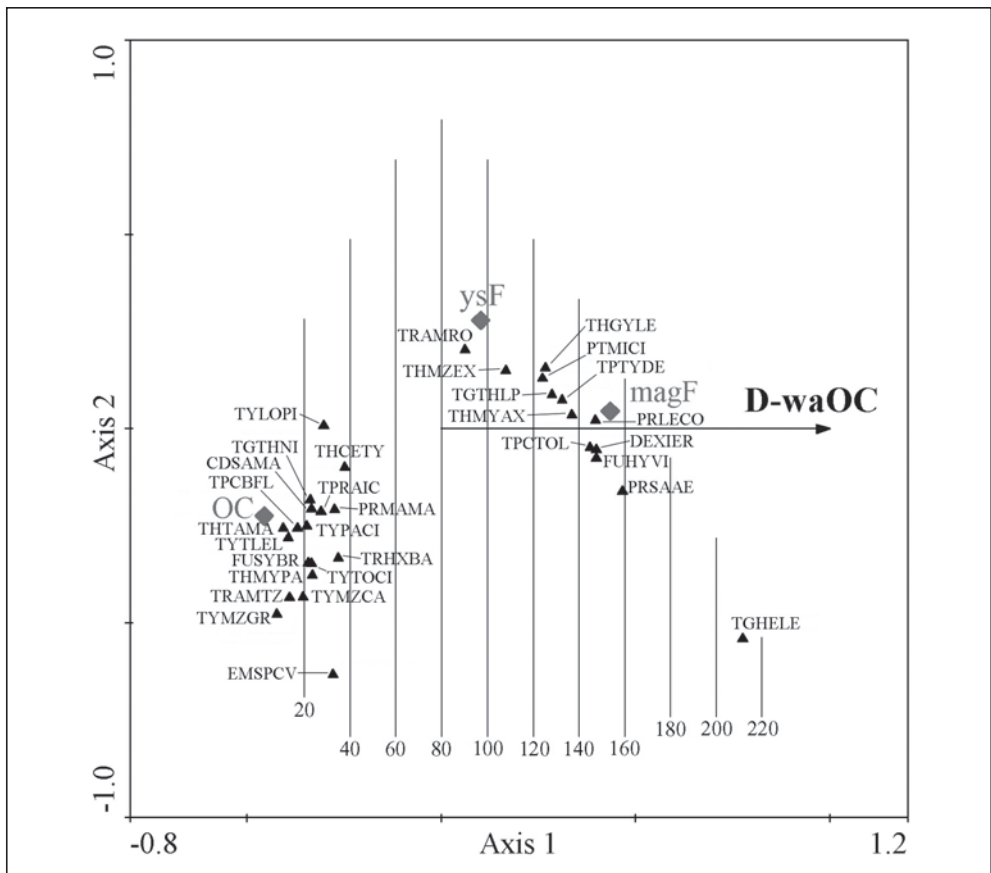


FIG. 50. Canonical Correspondence Analysis (CCA) of the variable 'distance to water body in open country' (D-waOC) for the transect-mapping data. Plot functions and options used as in Fig. 45. The gradient explains 11.7% ( $P = 0.008$ ) of the entire variance in the data set. Only the best-fit species, those with  $\geq 20\%$  variance explained, are shown. Abbreviations used: (a) main habitat type (binary 'dummy' variable; passive): OC = open country; ysF = young successional forest; magF = medium-age forest; (b) bird species: see Appendices 4 or 5.

TABLE 48. Indicator species determined by the program TWINSpan (Hill 1979) on the basis of mist-netting data gathered in habitat mosaics of the upper Río Santiago drainage. Division 1:  $n = 136$ , eigenvalue = 0.436 at iteration 2; division 2:  $n = 101$ , eigenvalue = 0.230 at iteration 3; division 3:  $n = 35$ , eigenvalue = 0.261 at iteration 7; division 4:  $n = 70$ , eigenvalue = 0.172 at iteration 12; division 5:  $n = 31$ , eigenvalue = 0.244 at iteration 5; division 6:  $n = 13$ , eigenvalue = 0.382 at iteration 7; division 7:  $n = 22$ , eigenvalue = 0.314 at iteration 5.

Indicator species	Division	Sign		Indicator species	Division	Sign	
		+	–			+	–
<i>Synallaxis brachyura</i>	1	1		<i>Mionectes olivaceus</i>	4	1	
<i>Manacus manacus</i>	1	1		<i>Sapayoa aenigma</i>	4		1
<i>Saltator maximus</i>	1	1		<i>Henicorhina leucosticta</i>	4		1
<i>Sporophila corvina</i>	1	1		<i>Euphonia xanthogaster</i>	4		1
<i>Pipra mentalis</i>	1		1	<i>Threnetes ruckeri</i>	5	1	
<i>Tachyphonus delatrii</i>	1		1	<i>Phaethornis yaruqui</i>	5	1	
<i>Cercomacra tyrannina</i>	2	1		<i>Mionectes olivaceus</i>	5	1	
<i>Manacus manacus</i>	2	1		<i>Microbates cinereiventris</i>	5		1
<i>Microcerculus marginatus</i>	2	1		<i>Synallaxis brachyura</i>	6	1	
<i>Arremon aurantirostris</i>	2	1		<i>Mionectes oleagineus</i>	6		1
<i>Sporophila corvina</i>	3	1		<i>Androdon aequatorialis</i>	7	1	
<i>Eutoxeres aquila</i>	3		1	<i>Sporophila nigricollis</i>	7	1	
<i>Cercomacra tyrannina</i>	3		1	<i>Sporophila corvina</i>	7		1
<i>Mionectes oleagineus</i>	3		1				
<i>Turdus daguae</i>	3		1				
<i>Tachyphonus delatrii</i>	3		1				

it may take years of training to learn to identify them by audiovisual methods – peculiarities that may impede their broad use in developing countries (Pearson 1994). Although it is evident that mist netting is not a proper survey method for entire tropical bird assemblages, observational methods like transect mapping or point counting are fast and effective in surveying core species (Chapters 4 and 5). The increasing number of high-quality field guides, comprehensive audio publications, and WEB-based sound archives on tropical birds guarantees that future generations of motivated and capable observers will learn to accurately identify entire regional avifaunas in a few months rather than many years. The correct identification of bird sounds can be routinely documented with voucher recordings, and the completeness of bird surveys can be easily assessed through repeated sampling (e.g., Kéry *et al.* 2005) and by comparing observed species richness with existing core species lists for the area, as well as with incidence-based richness estimators, like MMRuns, MMean, and ICE (p. 162f, Performance of species richness estimators). Skeptics may use the fact that in diverse tropical lowland forests an asymptote may not be

reached for several weeks or months, despite intensive surveying (e.g., Figs. 21, 22, and 38), as an argument against the suitability of birds as biological indicators (e.g., Pearson 1994). In my opinion this would be short-sighted. First, if we exclude non-core species (sensu Remsen 1994), migratory taxa, and dispersing birds that are usually recorded in other habitat types, the asymptote may be reached relatively quickly. Second, even if some of the difficult-to-detect or low-density breeding residents still mean that an asymptote is not reached quickly, the wealth of information provided by those species already recorded fully justifies the use of birds as an indicator group. Nevertheless, in order to generate comparable and consistent results, standardized survey methods should be applied, with transect mapping probably being the most appropriate method for tropical landbirds.

4. *Higher taxa occupy a breadth of habitats and a broad geographical range.* – Birds occur in almost all terrestrial and aquatic habitats of our planet. However, the distribution of avian diversity is uneven: c. 97% are landbirds, and most of these occur in tropical latitudes (BirdLife International 2004a). The

Neotropical realm is by far the most species-rich region of the world, harboring c. 3370 (36%) of all known landbird taxa (Stotz *et al.* 1996, Newton 2003). Thus, birds might be especially relevant as indicators in tropical countries.

5. *Species and/or subspecies show a narrow habitat specialization and sensitivity to environmental change.*

– Although birds inhabit all major habitat types, most species show a strong preference for just one or a few of them. Forests are by far the most important habitat for birds, holding no less than 74% of all taxa. In combination, tropical and subtropical lowland and montane moist forests support about 55–60% of global bird species richness (BirdLife International 2004a). The high bird diversity in tropical forests is partly due to a very high degree of ecological specialization among avian taxa. Consequently, many forest-dependent tropical birds are very sensitive to habitat disturbance, making them excellent indicators of environmental change (Stotz *et al.* 1996). Critics, however, have emphasized that birds, as well as other vertebrates, are usually too slow in

reacting to environmental change, as they tend to be rather long-lived, have a low reproductive potential, long generation times, and comparatively low habitat specificity (Landres *et al.* 1988, Murphy 1990, Pearson 1994, Caro & O'Doherty 1999). Therefore, smaller species, especially insects and other arthropods, are often credited with a better sensitivity to environmental disturbance (Pyle *et al.* 1981, Kremen *et al.* 1993, Siemann *et al.* 1996). Although these arguments are valid to some degree, I doubt that arthropods will, at least in the medium term, reach the same importance as indicators of environmental change in tropical forests that birds already have (see below). The enormous species richness of arthropods in tropical forests (Erwin 1983), their high degree of endemism, as well as our poor knowledge of their species-level ecology, general life history, and conservation status, simply does not, in most cases, permit meaningful as well as management-practice-oriented interpretations of their community composition.

6. *Patterns of biodiversity reflected in other related and unrelated taxa.* – Indicator groups will be useful

TABLE 49. Indicator species determined by the program TWINSPAN (Hill 1979) on the basis of transect-mapping data gathered in habitat mosaics of the upper Río Santiago drainage. Division 1:  $n = 94$ , eigenvalue = 0.606 at iteration 2; division 2:  $n = 57$ , eigenvalue = 0.237 at iteration 4; division 3:  $n = 37$ , eigenvalue = 0.278 at iteration 3; division 4:  $n = 30$ , eigenvalue = 0.233 at iteration 5; division 5:  $n = 27$ , eigenvalue = 0.257 at iteration 6; division 6:  $n = 19$ , eigenvalue = 0.235 at iteration 7; division 7:  $n = 18$ , eigenvalue = 0.202 at iteration 16.

Indicator species	Division	Sign		Indicator species	Division	Sign	
		+	–			+	–
<i>Synallaxis brachyura</i>	1	1		<i>Xiphorhynchus erythropygius</i>	4	1	
<i>Cercomacra tyrannina</i>	1	1		<i>Myrmotherula axillaris</i>	4	1	
<i>Pachyramphus cinnamomeus</i>	1	1		<i>Chlorothraupis olivacea</i>	4	1	
<i>Ramphocelus icteronotus</i>	1	1		<i>Mionectes olivaceus</i>	4		1
<i>Saltator maximus</i>	1	1		<i>Turdus daguae</i>	4		1
<i>Myrmeciza exsul</i>	1		1	<i>Cercomacra tyrannina</i>	5	1	
<i>Tachyphonus delatrii</i>	1		1	<i>Hylophylax naevioides</i>	5	1	
<i>Myiornis atricapillus</i>	2	1		<i>Myrmeciza berlepschi</i>	5	1	
<i>Hylophilus decurtatus</i>	2	1		<i>Saltator grossus</i>	5	1	
<i>Gymnopithys leucaspis</i>	2		1	<i>Myrmotherula pacifica</i>	6	1	
<i>Hylopezus perspicillatus</i>	2		1	<i>Todirostrum cinereum</i>	6	1	
<i>Lepidothrix coronata</i>	2		1	<i>Myrmeciza exsul</i>	6		1
<i>Turdus daguae</i>	2		1	<i>Lophotriccus pileatus</i>	6		1
<i>Amazilia tzacatl</i>	3	1		<i>Manacus manacus</i>	6		1
<i>Amazilia rosenbergi</i>	3		1	<i>Tangara larvata</i>	7	1	
<i>Myrmeciza exsul</i>	3		1	<i>Taraba major</i>	7		1
<i>Microcerculus marginatus</i>	3		1	<i>Lophotriccus pileatus</i>	7		1
				<i>Thryothorus nigricapillus</i>	7		1
				<i>Saltator maximus</i>	7		1

TABLE 50. Indicator species determined by the program IndVal (Dufrêne & Legendre 1997) on the basis of mist-netting data gathered in habitat mosaics of the upper Río Santiago drainage. For each habitat the number of captures is shown in front of the slash and the number of nets for which records were obtained behind. Significance levels of the t-test statistics: \* =  $P < 0.05$ , \*\* =  $P < 0.01$ , \*\*\* =  $P \leq 0.001$ . Abbreviations used: IndVal = indicator index value; class = habitat class for which the species was determined to be an indicator species; OC = open country; ysF = young successional forest; magF = medium-age forest.

Species	IndVal	Class	OC	ysF	magF	Mean	SD	t	p
<i>Manacus manacus</i>	54.91	OC	117/38	43/18	15/14	22.84	3.70	8.67	***
<i>Cercomacra tyrannina</i>	44.69	OC	56/28	16/10	4/4	15.26	3.24	9.09	***
<i>Synallaxis brachyura</i>	44.05	OC	31/21	2/2	0/0	9.87	3.07	11.14	***
<i>Threnetes ruckeri</i>	39.74	OC	65/32	20/11	37/23	21.39	3.20	5.74	***
<i>Oryzoborus angolensis</i>	34.73	OC	23/17	2/2	0/0	8.40	2.67	9.86	***
<i>Myiobius atricaudus</i>	33.48	OC	30/16	2/2	0/0	8.17	2.68	9.44	***
<i>Saltator maximus</i>	30.67	OC	31/18	8/5	0/0	9.77	2.92	7.16	***
<i>Sporophila corvina</i>	30.46	OC	29/14	1/1	0/0	7.30	2.69	8.60	***
<i>Ramphocelus icteronotus</i>	29.55	OC	17/13	0/0	0/0	6.47	2.37	9.75	***
<i>Myrmotherula pacifica</i>	27.27	OC	17/12	0/0	0/0	6.25	2.47	8.50	***
<i>Coereba flaveola</i>	27.27	OC	23/12	0/0	0/0	6.50	2.50	8.32	***
<i>Thryothorus nigricapillus</i>	26.85	OC	21/14	3/2	0/0	7.76	2.69	7.11	***
<i>Amazilia rosenbergi</i>	24.36	OC	34/20	4/4	32/24	16.78	3.21	2.36	*
<i>Glaucis aeneus</i>	22.73	OC	11/10	0/0	0/0	5.58	2.19	7.83	***
<i>Leptotila pallida</i>	15.91	OC	8/7	0/0	0/0	4.55	2.04	5.58	***
<i>Arremon aurantirostris</i>	15.16	OC	15/13	11/10	0/0	9.40	2.53	2.28	*
<i>Mionectes oleagineus</i>	13.97	OC	10/9	3/3	1/1	6.44	2.32	3.25	**
<i>Amazilia tzacatl</i>	11.36	OC	5/5	0/0	0/0	3.86	1.89	3.98	**
<i>Pachyrhamphus cinnamomeus</i>	11.36	OC	5/5	0/0	0/0	3.82	1.86	4.05	**
<i>Geothlypis auricularis</i>	11.36	OC	8/5	0/0	0/0	3.81	1.90	3.99	**
<i>Catharus ustulatus</i>	9.87	OC	5/5	0/0	1/1	4.10	1.84	3.14	*
<i>Picumnus olivaceus</i>	9.35	OC	6/5	1/1	0/0	4.03	1.90	2.80	*
<i>Tangara larvata</i>	9.09	OC	4/4	0/0	0/0	3.37	1.64	3.49	*
<i>Platypsaris homochrous</i>	7.89	OC	5/4	0/0	1/1	3.67	1.72	2.46	*
<i>Lophotriccus pileatus</i>	6.87	OC	4/4	1/1	0/0	3.66	1.66	1.94	*
<i>Taraba major</i>	6.82	OC	3/3	0/0	0/0	2.83	1.58	2.53	*
<i>Tiaris obscurus</i>	6.82	OC	3/3	0/0	0/0	2.92	1.63	2.39	*
<i>Myiobius sulphureipygius</i>	35.37	ysF	4/4	32/22	40/31	18.67	2.85	5.87	***
<i>Gymnophithys leucaspis</i>	34.96	ysF	7/5	33/17	15/12	13.08	3.21	6.83	***
<i>Microcerculus marginatus</i>	24.40	ysF	13/8	24/14	11/8	11.63	2.78	4.59	**
<i>Xenops minutus</i>	20.23	ysF	11/10	15/14	12/10	12.92	2.95	2.48	*
<i>Mitrospingus cassini</i>	19.11	ysF	1/1	10/7	0/0	4.85	2.15	6.64	***
<i>Chlorothraupis olivacea</i>	16.15	ysF	0/0	10/10	14/10	8.77	2.55	2.90	*
<i>Terentotriccus erythrurus</i>	16.04	ysF	2/2	11/10	13/13	10.38	2.76	2.05	*
<i>Malacoptila panamensis</i>	14.91	ysF	5/3	10/10	10/7	8.82	2.52	2.42	*
<i>Lepidothrix coronata</i>	36.17	magF	4/4	12/11	49/32	16.57	3.06	6.40	***
<i>Myrmotherula axillaris</i>	34.19	magF	0/0	3/3	32/23	10.49	2.74	8.65	***
<i>Tachyphonus delatrii</i>	33.75	magF	23/12	58/19	108/43	23.52	3.39	3.02	*
<i>Chloropipo holochlora</i>	31.69	magF	1/1	7/7	32/26	12.84	3.10	6.08	***
<i>Hylophilus ochraceiceps</i>	25.86	magF	0/0	0/0	15/15	7.10	2.44	7.68	***
<i>Sapayoa aenigma</i>	24.14	magF	0/0	0/0	18/14	7.00	2.62	6.53	***
<i>Myrmotherula fulviventris</i>	21.35	magF	2/2	10/8	32/20	11.68	2.83	3.42	**
<i>Glyphorhynchus spirurus</i>	19.96	magF	6/4	17/11	41/22	13.91	3.18	1.90	*
<i>Microbates cinereiventris</i>	19.29	magF	0/0	12/10	26/20	11.75	2.90	2.60	*
<i>Henicorhina leucosticta</i>	13.79	magF	0/0	0/0	9/8	4.94	2.28	3.88	**
<i>Xiphorhynchus erythropygius</i>	10.34	magF	0/0	0/0	7/6	4.06	1.88	3.35	*
<i>Platyrinchus coronatus</i>	10.28	magF	0/0	2/2	10/8	5.65	2.12	2.19	*

TABLE 51. Indicator species determined by the program 'IndVal' (Dufrêne & Legendre 1997) on the basis of transect-mapping data gathered in habitat mosaics of the upper Río Santiago drainage. For each habitat the number of records within the 25-m main belt is shown in front of the slash and the number of 25 x 25-m plots for which records were obtained behind. See Table 49 for abbreviations used.

Species	IndVal	Class	OC	ysF	magF	Mean	SD	t	p
<i>Saltator maximus</i>	79.98	OC	65/28	3/2	0/0	16.55	4.20	15.10	***
<i>Ramphocelus icteronotus</i>	73.95	OC	124/27	10/7	0/0	18.27	4.31	12.93	***
<i>Cercomacra tyrannina</i>	70.44	OC	112/29	21/13	0/0	21.34	4.41	11.13	***
<i>Synallaxis brachyura</i>	65.50	OC	74/22	1/1	0/0	13.79	4.01	12.88	***
<i>Myrmotherula pacifica</i>	60.61	OC	51/20	0/0	0/0	12.36	3.76	12.83	***
<i>Todirostrum cinereum</i>	54.55	OC	34/18	0/0	0/0	11.73	3.79	11.31	***
<i>Pachyrhamphus cinnamomeus</i>	53.31	OC	33/19	2/2	0/0	13.15	3.98	10.09	***
<i>Thryothorus nigricapillus</i>	53.08	OC	42/19	2/2	1/1	13.70	4.13	9.54	***
<i>Coereba flaveola</i>	42.71	OC	32/17	5/4	0/0	12.96	3.67	8.10	***
<i>Manacus manacus</i>	40.84	OC	46/18	11/8	1/1	15.48	3.93	6.46	***
<i>Threnetes ruckeri</i>	37.60	OC	61/30	44/19	31/18	29.55	3.56	2.26	*
<i>Amazilia tzacatl</i>	30.30	OC	21/10	0/0	0/0	7.82	2.95	7.61	***
<i>Tyrannulus elatus</i>	27.27	OC	9/9	0/0	0/0	7.42	2.89	6.87	***
<i>Heliothryx barroti</i>	25.54	OC	12/10	1/1	1/1	8.93	3.22	5.16	**
<i>Myiozetetes cayanensis</i>	24.24	OC	12/8	0/0	0/0	6.76	2.67	6.55	***
<i>Lophotriccus pileatus</i>	24.08	OC	26/14	15/8	0/0	13.32	3.88	2.77	*
<i>Taraba major</i>	22.01	OC	13/8	1/1	0/0	7.56	3.07	4.71	***
<i>Laterallus albigularis</i>	21.21	OC	12/7	0/0	0/0	6.20	2.77	5.42	**
<i>Thraupis episcopus</i>	21.21	OC	16/7	0/0	0/0	6.52	3.03	4.84	**
<i>Saltator atripennis</i>	18.18	OC	8/6	0/0	0/0	5.98	2.96	4.12	*
<i>Leptotila pallida</i>	17.60	OC	14/8	4/1	0/0	7.54	3.12	3.23	*
<i>Nyctidromus albicollis</i>	15.15	OC	7/5	0/0	0/0	5.61	2.75	3.47	**
<i>Myiozetetes granadensis</i>	15.15	OC	8/5	0/0	0/0	5.37	2.74	3.57	*
<i>Legatus leucophaeus</i>	15.15	OC	6/5	0/0	0/0	5.43	2.81	3.46	*
<i>Sporophila corvina</i>	15.15	OC	8/5	0/0	0/0	5.39	2.63	3.71	**
<i>Amaurolimnas concolor</i>	13.20	OC	7/6	2/2	0/0	6.97	2.88	2.16	*
<i>Polioptila plumbea</i>	12.42	OC	6/5	1/1	0/0	5.87	2.59	2.53	*
<i>Myiobius atricaudus</i>	12.12	OC	5/4	0/0	0/0	4.92	2.51	2.87	*
<i>Thraupis palmarum</i>	12.12	OC	4/4	0/0	0/0	4.89	2.43	2.98	*
<i>Myrmeciza exsul</i>	45.82	ysF	11/6	43/22	45/29	26.07	3.71	5.32	***
<i>Amazilia rosenbergi</i>	36.15	ysF	20/14	44/18	41/26	26.77	3.76	2.50	*
<i>Saltator grossus</i>	28.09	ysF	3/3	13/9	2/2	9.59	3.21	5.76	**
<i>Microrhopias quixensis</i>	27.69	ysF	2/2	12/9	3/3	9.74	3.33	5.39	***
<i>Myiornis atricapillus</i>	25.75	ysF	3/3	13/11	10/9	13.28	3.20	3.90	**
<i>Thryothorus leucopogon</i>	23.19	ysF	0/0	23/10	24/16	14.80	3.70	2.27	*
<i>Thamnophilus atrinucha</i>	19.56	ysF	3/3	10/6	0/0	7.68	3.15	3.77	**
<i>Ornithion brunneicapillus</i>	13.45	ysF	1/1	4/4	0/0	5.23	2.52	3.26	*
<i>Cymbilaimus lineatus</i>	12.00	ysF	0/0	3/3	0/0	4.07	2.31	3.44	*
<i>Dendrocincla fuliginosa</i>	11.88	ysF	0/0	4/4	2/2	5.76	2.69	2.28	*
<i>Tachyphonus delatrii</i>	60.54	magF	1/1	22/12	70/32	22.16	4.00	9.60	***
<i>Chlorothraupis olivacea</i>	51.08	magF	0/0	6/6	44/22	15.86	4.03	8.74	***
<i>Lepidothrix coronata</i>	47.22	magF	0/0	0/0	33/17	11.48	3.89	9.18	***
<i>Microbates cinereiventris</i>	44.03	magF	4/2	11/7	35/25	17.99	3.90	6.68	***
<i>Sapayoa aenigma</i>	36.85	magF	0/0	1/1	26/14	10.40	3.56	7.42	***
<i>Turdus daguae</i>	33.16	magF	0/0	3/3	25/14	11.39	3.64	5.99	***
<i>Xiphorhynchus erythropygius</i>	31.36	magF	0/0	3/3	18/14	11.04	3.70	5.50	**
<i>Myrmotherula axillaris</i>	28.06	magF	1/1	11/9	29/16	15.09	3.88	3.35	*
<i>Glyphorhynchus spirurus</i>	26.58	magF	0/0	3/3	17/12	10.56	3.72	4.30	**

TABLE 51. Continued.

Species	IndVal	Class	OC	ysF	magF	Mean	SD	t	p
<i>Hylopezus perspicillatus</i>	21.88	magF	0/0	8/6	22/12	11.78	3.74	2.70	*
<i>Gymnophrys leucaspis</i>	21.84	magF	1/1	9/6	18/14	12.93	3.52	2.54	*
<i>Myrmotherula fulviventris</i>	20.47	magF	0/0	10/7	16/14	12.52	3.28	2.42	*
<i>Dysithamnus puncticeps</i>	19.44	magF	0/0	0/0	10/7	6.37	2.94	4.45	**
<i>Hylophilus ochraceiceps</i>	19.44	magF	0/0	0/0	8/7	6.52	3.05	4.24	**
<i>Mionectes olivaceus</i>	19.43	magF	0/0	2/1	20/8	7.11	2.76	4.46	**
<i>Platyrinchus coronatus</i>	18.60	magF	2/2	5/5	19/10	10.99	3.01	2.53	*
<i>Dendrocolaptes sanctithomae</i>	15.10	magF	0/0	2/2	10/7	7.64	2.94	2.54	*
<i>Electron platyrhynchum</i>	14.73	magF	0/0	2/2	9/7	7.23	2.83	2.65	*
<i>Odontophorus erythrops</i>	13.89	magF	0/0	0/0	5/5	5.43	2.52	3.36	*
<i>Henicorhina leucosticta</i>	13.89	magF	0/0	0/0	9/5	5.68	2.93	2.80	*
<i>Androdon aequatorialis</i>	13.78	magF	0/0	2/1	7/7	6.96	3.21	2.13	*
<i>Rhynchocyclus pacificus</i>	11.11	magF	0/0	0/0	4/4	4.80	2.44	2.58	*

surrogates for poorly known biodiversity only if patterns of distribution coincide across higher taxa (Moore *et al.* 2003). Since the status and distribution of birds are far better known than those of any other group of organisms, they play a potentially important role in the identification of key biodiversity areas (KBAs). In an effort to promote the establishment of such a global network of conservation units, BirdLife International has been coordinating the identification of Important Bird Areas (IBAs) all over the world (e.g., Heath *et al.* 2000a, 2000b; Fishpool & Evans 2001, BirdLife International & Conservation International 2005). Ideally, these areas should also contain a large portion of representative wildlife other than birds, especially their threatened and endemic components. Although comparative studies have produced mixed results on how useful birds may be as proxy taxa for the representation of non-avian species (Prendergast *et al.* 1993, Lawton *et al.* 1998, Lawler *et al.* 2003, Moore *et al.* 2003), there are also many encouraging results on their effectiveness as biodiversity indicators (BirdLife International 2004a). For example, Brooks *et al.* (2001) found that the 228 East African IBAs collectively include 97% of the region's endemic mammals ( $n = 97$ ), 90% of globally threatened mammals ( $n = 80$ ), and 92% of endemic snakes and amphibians ( $n = 131$ ). Similarly, Uganda's 30 IBAs together, which, apart from forest, also cover a broad range of savanna and wetland habitats, contain, in merely 8% of the land surface, 74% and 80%, respectively, of all butterfly ( $n = 1247$ ) and dragonfly ( $n = 241$ ) species known to occur in the country. For those species of greatest conservation concern, the proportions are even higher (BirdLife

International 2004a). For various higher taxa, relatively good congruence was also found between the locations of their 'centers of endemism'. More than 25% ( $n = 2623$ ) of all avian species have restricted global breeding ranges of less than 50 000 km<sup>2</sup> (Stattersfield *et al.* 1998). The combined breeding areas of restricted-range species was used to determine 218 separate 'Endemic Bird Areas' (EBAs) across the globe, and the majority of these also coincide with 'centers of endemism' of restricted-range species of other animals and plants; e.g., there is an overlap of 60-70% between EBAs and the 234 'Centers of Plant Diversity' (WWF/IUCN 1994, 1994-1995, 1997; Stattersfield *et al.* 1998, BirdLife International 2004a).

**7. Potential economic importance.** – Recreational and scientific observation of wild birds is tremendously popular. For instance, c. 46 million people in the United States watch and identify birds (USFWS 2003). In 1996, they spent over US\$ 23 billion on birdwatching-related activities, fostering the employment of almost 800 000 people (USDI *et al.* 1996). Although in many tropical countries this development may still be in its early phases, wild birds will gain increasing economic importance as their unique diversity attracts growing numbers of ecotourists. In some tropical countries tourism is already one of the most important sources of foreign exchange, and a high proportion of this income can be credited to bird-related travel; e.g., according to the Costa Rican Tourism Institute (ICT), cited by Sekercioglu (2002b), about 41% of the US\$ 1 billion tourism business for the year 1999 was generated by people watching birds. In addition, for rural people around the world birds still have an enormous socio-economic value as



a source of food. For example, it has been estimated that subsistence hunters in the Brazilian Amazon kill 23.5 million game vertebrates each year, including many birds, yielding 89 224 tons of bushmeat with a market value of US\$ 190.7 million (Peres 2000).

#### Birds as surrogates in biodiversity

In the previous sections we have seen that, at a regional scale, birds as a group are rather effective in capturing the biodiversity of other taxa, e.g., in BirdLife International's IBA approach. However, at a local scale the distribution patterns of birds do not always coincide with those of other groups of organ-

isms (Prendergast *et al.* 1993, Lawton *et al.* 1998, Lawler *et al.* 2003).

It should be emphasized that the utility of single species, such as flagship and umbrella species, as surrogates for regional biodiversity is often limited (Andelman & Fagan 2000). Especially if multiple conservation goals are involved, a single indicator species is unlikely to satisfy them all (Lambeck 1997). Flagships should be used for the promotion of conservation efforts and fundraising, but unless they also occupy an umbrella function their ecological importance should not be overinterpreted (Caro & O'Doherty 1999). The limited use of flagship and

TABLE 52. Assessment of the conservation value of two transects located in human-influenced habitat mosaics in the floodplain and adjacent *terra firme* forest of the Río Santiago, based on transect-mapping data. Number of species (N<sub>spp</sub>) and proportion of total species richness recorded in different classes of main habitats, endemic bird areas, as well as international threat status categories (IUCN 2001). Note: the taxa listed here, according to Ridgely & Greenfield (2001b), as restricted-range species for the Chocó lowlands, the western Andean slope, and the Tumbesian lowlands, were not regarded as endemic species by Stattersfield *et al.* (1998).

Categories	MNT1		MNT2	
	N <sub>spp</sub>	%	N <sub>spp</sub>	%
Species richness (MTW study only)	162	100	144	100
Main habitat				
- Forest	78	48.1	90	62.5
of which forest-interior specialists	10	6.2	17	11.8
- Forest edge	46	28.4	34	23.6
- Open country	38	23.5	19	13.2
- River and streams			1	0.7
IUCN threat status category				
World (BirdLife 2000, 2004b)				
- Endangered (EN)			1	0.7
- Vulnerable (VU)	1	0.6	1	0.7
- Near Threatened (NT)	3	1.9	5	3.5
Sum	4	2.5	7	4.9
Ecuador (Granizo <i>et al.</i> 2002)				
- Critically Endangered (CR)			1	0.7
- Endangered (EN)	3	1.9	4	2.8
- Vulnerable (VU)	15	9.3	22	15.3
- Near Threatened (NT)	19	11.7	21	14.6
Sum	37	22.8	48	33.3
Endemic species				
- Chocó (Stattersfield <i>et al.</i> 1998)	11	6.8	12	8.3
- Chocó lowlands (Ridgely & Greenfield 2001b)	6	3.7	6	4.2
- West slope of Andes (Ridgely & Greenfield 2001b)			1	0.7
- Tumbesian lowlands (Ridgely & Greenfield 2001b)	2	1.2	2	1.4
Sum	19	11.7	21	14.6

umbrella taxa in conservation practice can easily be demonstrated for Playa de Oro and the Ecuadorian Chocó.

The most attractive avian flagship candidates in the study area are *Harpia harpyja*, *Crax rubra*, *Ara ambiguus*, *Penelope orton*i, and *Cephalopterus penduliger*. A top predator like *H. harpyja* could serve as a flagship as well as an umbrella species. In theory, this eagle could be a very successful symbol taxon for biodiversity conservation in the northwestern Ecuadorian lowlands, because for the maintenance of a viable population all remnant blocks of continuous forest would have to be protected or at least managed in a sustainable way. Furthermore, hunting pressure would have to be reduced substantially. However, to be useful in conservation management, the monitoring of indicator taxa should be facilitated through large population size (Caro & O'Doherty 1999) or at least conspicuous behavior. Under these criteria *H. harpyja* might be too inconspicuous to serve as an effective umbrella taxon. In addition, it is also important that target species do not become locally extinct (Caro & O'Doherty 1999). However, *H. harpyja* as well as *C. rubra* are so close to regional extirpation that it might not be wise to employ either of them as a flagship (Guerrero 2002a, Mena & Jahn 2002j).

*Ara ambiguus* might be a more appropriate flagship candidate for Playa de Oro because the species is reasonably easy to observe due to its far-carrying and conspicuous vocalizations. The macaw is also a popular cage bird in western Ecuador. It is already employed successfully as a flagship, dubbed 'Guacamayo de Guayaquil', to promote the conservation of the Bosque Protector Cerro Blanco, a 6000 ha private reserve on the outskirts of Guayaquil (E. Horstman, pers. comm.). Furthermore, in Costa Rica the species is being used as a flagship bird for the establishment of a new national park, Parque Nacional Maquenque (G. Monge & O. Chassot, pers. comm.). However, in western Ecuador *A. ambiguus* is already very patchily distributed and its conservation status is also critical (Benítez *et al.* 2002). Hence its potential use as a surrogate taxon for regional biodiversity is rather limited.

Regarding the endemic bird taxa, *P. orton*i might be sufficiently large, but it is very similar to other *Penelope* guans and so might not be sufficiently distinctive and attractive to serve as a local or regional flagship. However, considering the fact that cracids are intensively hunted in most regions of Ecuador, a

broad conservation and environmental education campaign for *P. orton*i could also be beneficial for other game bird species, like *P. purpurascens* and *Crax rubra*. *Cephalopterus penduliger* is rather small for flagship standard, but of course it is a very exotic Chocó endemic as well as globally threatened by deforestation and subsistence hunting (Jahn *et al.* 1999b). Thus, it might be one of the most appropriate candidates from the avifauna to serve as a symbol for local or regional conservation efforts. However, the distribution of both endemic taxa, *P. orton*i and *C. penduliger*, is mostly restricted to the foothills. As a consequence, their umbrella function for the biodiversity of Chocóan lowland forest is very limited.

#### Birds as indicators of environmental change

Given adequate ecological knowledge, birds may play an important role in the design of local and regional wildlife reserves, adaptive management strategies, mitigating measures, and other conservation planning procedures. In order to integrate avifaunistic data effectively into management projects, it is important to understand how tropical birds react to alterations in forest structure and other environmental changes.

*1. Selective logging.* – It has been shown that some tropical forest bird species are severely affected even by slight changes in the vegetation structure. For example, 42% of the species recorded in primary forest sharply decreased in numbers or disappeared after logging of merely 3 trees/ha in tropical lowland forest in French Guiana, northeastern Amazonia (Thiollay 1992). Of course, not all species reacted in the same way: 34% increased or remained unchanged. Considering that many birds are associated with tree falls, forest edges, or the upper canopy (Thiollay 1994b), this strong response to low-impact logging might be rather surprising. However, logging operations often result in a higher density and greater average size of gaps than those generated by natural tree falls (Thiollay 1990a). Furthermore, logging-induced gaps are generated in a short period of time, whereas the formation of natural tree falls is mostly heterogeneous in space and time. Much of the changes in the structure of selectively logged forests must be attributed to secondary damage, which might affect 40-80% of all trees in forests where only 3-10% of stems were removed for commercial use (Putz *et al.* 2000, 2001). Some silvicultural treatments following harvesting, like enrichment strips

(linear plantations), may further aggravate the situation (Mason 1996).

The fragmented canopy of selectively logged forest allows more light to reach the ground, making the understory hotter, drier, and eventually much denser when regeneration sets in (Mason & Thiollay 2001). As a consequence, understory-dwelling birds tend to be more sensitive to timber management than canopy species (Thiollay 1997). In French Guiana, 24 species of the lower forest strata, corresponding to 9% of the total avian diversity, were not recorded in forests one and ten years after logging (Thiollay 1992). Similarly negative effects of selective logging on terrestrial and understory birds were also reported from Venezuela (Mason 1996), Brazilian Amazonia (Johns 1991), Brazilian Atlantic forest (Aleixo 1999), Malaysia (Johns 1986, 1989, 1992), and Kibale National Park, Uganda (Sekercioglu 2002a), among others.

In Neotropical forests, small insectivorous birds constitute the most adversely affected guild (Thiollay 1992, 1997; Mason 1996, Aleixo 1999). In the following, I list those insectivores that in agreement with other studies might suffer population declines after logging impacts in the Ecuadorian Chocó lowlands as well: small solitary terrestrial taxa, like leaf-tossers (*Sclerurus*) and antpittas (*Hylopezus*); obligate ant followers, e.g., *Hylophylax* and *Gymnophis*; mixed-species understory flock attendants, such as ovenbirds, woodcreepers, antbirds, and undergrowth-dwelling tyrannids. Severely affected might also be terrestrial omnivores and many larger species (e.g., forest eagles, *Leucopternis*, *Ibycter*, *Penelope*, *Crax*, *Ara*, *Ramphastos*), partially due to increased hunting pressure (Jullien & Thiollay 1996, Mason & Thiollay 2001). By contrast, some canopy and treetop-dwelling species apparently tend to increase after logging (Thiollay 1992), especially thraupids, sallying insectivores, foliage-gleaning insectivores, and some woodpeckers. Depending on the magnitude of logging damage (e.g., gap size and width of skidder trails), the presence and abundance of forest-edge and open-country species might also rise considerably.

Comparative analysis of studies from various tropical regions on the magnitude of impacts of selective logging on bird community composition revealed that differences in the avian response might exist between sites (Aleixo 1999). In general, species richness was more severely reduced after selective logging in Amazonian forests than in other biogeographical regions. In some tropical forests (e.g., Brazilian At-

lantic), bird diversity and richness might in fact increase in the years following timber extraction, due to colonization by species typically found at forest edges and in secondary habitats, which coexist with the remaining forest birds. Furthermore, Jaccard's incidence-based similarity index between logged and unlogged forest tracts was only 52-59% in Amazonia (Johns 1991, Thiollay 1992, Mason 1996), but 96-97% in Borneo, Malaysia (Johns 1992, Lambert 1992), with western Malaysia (66%) (Wong 1985) and the Brazilian Atlantic forest (75%) (Aleixo 1999) being intermediate. It is unclear, however, to what extent differences in the magnitude of impacts and in the elapsed time between logging events and the bird surveys (1-11 yrs in Amazonia, 8-25 yrs in Asia, and 12 yrs in Atlantic Forest) were in fact responsible for the patterns found. Different traits in the evolution of avian habitat selection between biogeographic regions might explain why Amazonian bird communities are especially sensitive to changes in the forest structure. According to Stotz *et al.* (1996), 46-47% of all Amazonian forest taxa are restricted to primary habitat, whereas only c. 28% of the Atlantic Forest species belong in the same category. In the Chocó region the proportion of birds restricted to primary habitat is c. 29% (72 of 247 forest species). Thus, it is likely that selective logging affects Chocóan bird communities less severely than those of the Amazon basin. Nevertheless, low-to-moderate-impact timber harvesting might cause population decreases in almost one third of all forest species. However, the planting of exotic trees in enrichment strips after timber extraction of native species, a silvicultural technique now regularly used in some parts of Esmeraldas Province, Ecuador, is expected to cause profound changes in the composition of bird communities (pers. obs.).

*2. Forest fragmentation.* – If selective logging can cause profound changes in the structure of avian communities, the formation of forest fragments of differing sizes is the ultimate test for the ability of tropical birds to survive in human-dominated and rapidly changing landscapes. Thus, there is much to learn about the sensitivity of birds as indicators of habitat alteration as well as for conservation planning for tropical forest bird assemblages.

In newly created forest fragments near Manaus, Brazil, capture rates increased significantly during the first months after isolation due to the immigration of refuge birds from recently cut neighboring forests and to changing foraging behavior of some species

(Bierregaard & Lovejoy 1988, 1989; Bierregaard 1990a). A rapid loss of forest-dependent birds followed, with extinction probabilities greatly differing between taxa and decreasing with larger size of the fragments (Ferraz *et al.* 2003). Obligate army-ant followers (e.g., *Gymnopithys*) and terrestrial insectivores (*Sclerurus*, *Formicarius*, *Hylopezus*, *Cyphorhinus*, and others) belonged to the most sensitive species. Mixed understory flocks tended to disintegrate within about 2–3 yrs of isolation in 10 ha fragments (Bierregaard & Lovejoy 1989, Stouffer & Bierregaard 1995, Stratford & Stouffer 1999).

In central Amazonia, local extinction of about 50% of the original undergrowth-dwelling avifauna took < 15 yrs in fragments of 100 ha, and it seems possible that eventually almost all of these species will disappear (Ferraz *et al.* 2003). Not surprisingly, many forest birds also became locally extinct in the 87 ha humid forest isolate at Río Palenque, Pichincha Province, in the Ecuadorian Chocó (Leck 1979, Ridgely & Greenfield 2001b), among them even some small undergrowth-dwelling frugivores, like *Pipra mentalis* and *Lepidothrix coronata*, which usually belong to the most abundant species in extensively forested areas, such as Playa de Oro (Appendices 18a to 19b) or central Panama (Karr 1990, Karr *et al.* 1990; Table 41). Ground-dwelling insectivores, e.g., *Hylopezus perspicillatus*, as well as army-ant followers, such as *Pittasoma rufopileatum*, *Hylophylax naevioides*, and *Gymnopithys leucaspis*, were again among the first to disappear. In 1996, the latter two species were still present at Barro Colorado Island (BCI), a 1600-ha forest fragment in the artificial Gatun Lake, which was created between 1911 and 1914 during the construction of the Panama Canal (Robinson 1999; see also Table 3). However, the population density of *G. leucaspis* decreased from 3.2 pairs/km<sup>2</sup> in 1961 to 1.5 pairs/km<sup>2</sup> in 1970 (Willis 1974), and numbers may have further declined since, although less dramatically (c. 12.5%) (Robinson 1999). Several other species also present in the Chocó region are already extinct on the island, including *Dendrocolaptes sanctithomae*, *Phaenostictus mcleannani*, *H. perspicillatus* (Willis 1974, 1980), or are evidently close to becoming so, e.g., *Laniocera rufescens*, *Lipaugus unirufus*, and *Salpator grossus* (Robinson 1999).

All in all, 65 avian taxa, composed of 30 forest species and 35 edge and non-forest taxa, have reportedly disappeared from BCI during the first 85 years of isolation. According to Brooks *et al.* (1999), local extinction approximates to an exponential decay

function, with about 50% of the expected total extinctions in 1000-ha fragments occurring within the first 50 years after isolation. Consequently, it can be estimated that about 40–50 forest species might eventually disappear from BCI, which corresponds to 30–40% of all forest-inhabiting avian taxa originally present ( $n = 120+$ , sensu Robinson 1999). Area-time-dependent species-loss curves suggest that even fragments of about 10 000 ha may lose many species when isolated for a century (Ferraz *et al.* 2003). Unfortunately, in some species-rich areas of the planet, forest remnants are already in fragments < 1000 ha (Gascon *et al.* 2000). Furthermore, recent analysis demonstrated that in order to decrease the rate of bird extinctions 10-fold it would be necessary to increase the fragment size c. 1000-fold (Ferraz *et al.* 2003). Considering the current rates of tropical deforestation (FAO 1997, 2001, 2007; Sala *et al.* 2000, Fuller *et al.* 2004), the future of entire forest-dependent avian communities looks rather bleak (Brooks & Balmford 1996, Brooks *et al.* 1997, Ribon *et al.* 2003), including those inhabiting the Ecuadorian Chocó (Granizo *et al.* 2002; p. 21–23, Conservation status of the Ecuadorian Chocó).

There are many reasons why forest-dependent birds in the Neotropics are so sensitive to forest fragmentation. Numerous edge effects, like increased wind disturbance (Lewis 1998), increased tree mortality (Laurance *et al.* 1998a), high density of tree falls (Kapos *et al.* 1993), lower canopy-foliage density (Malcolm 1994), reduced canopy height (Camargo & Kapos 1995), lower relative humidity (Lovejoy *et al.* 1986), or increased air temperature (Kapos 1989, Sizer & Tanner 1999) lead to profound changes in ecological and ecosystem processes (Laurance *et al.* 2002), many of which affect birds directly or indirectly. Elevated levels of predation may result in increased adult mortality (Crooks & Soulé 1999) as well as low reproductive success (Sieving 1992); see also a recent review provided by Chalfoun *et al.* (2002). Most forest birds are specialized in their foraging techniques and habitat use and have, in addition, comparably large territories, making them sensitive to habitat alteration (Willis & Oniki 1978, Remsen & Parker 1984, Munn 1985, Rosenberg 1990a, Terborgh *et al.* 1990, Cody 2000). Obligate army-ant followers, for example, depend on several swarms simultaneously, as the ants undergo asynchronous inactive periods of several months per year (Harper 1989, Stouffer & Bierregaard 1995). Furthermore, ant followers as well as most other terrestrial

and undergrowth insectivores, avoid crossing cleared areas. In central Brazil, clearcuts of as little as 70 m between small fragments and continuous forest were wide enough to virtually interrupt movements of such species to the isolates (Bierregaard 1990a). Playback experiments have demonstrated that roads only 10–30 m wide represent effective barriers for mixed understory flocks in Amazonian moist forest, as soon as trees no longer form a partial canopy connecting the two sides (Develey & Stouffer 2001). Not surprisingly, the habitat matrix surrounding fragments strongly influences bird movements between fragments and continuous forest (Stouffer & Bierregaard 1995, Borges & Stouffer 1999). Likewise, the ability of avian taxa to disperse through deforested countryside habitats is probably decisive for their persistence in or disappearance from small forest fragments (Graham 2001, Sekercioglu *et al.* 2002).

3. *The importance of threatened species as indicators.* – Studies on varying geographic scales have shown that cross-taxon surrogates for biodiversity consistently missed restricted-range and threatened species (Dobson *et al.* 1997, Fjeldsø 2000, Reyers *et al.* 2000). This is unfortunate considering that these groups are of greatest conservation concern. Consequently, endemic and at-risk species should be integrated in any approaches for the site selection of key conservation areas (Moore *et al.* 2003, BirdLife International 2004a). In favor of this argument, it has been demonstrated that narrowly distributed taxa and threatened species themselves might perform well as indicator groups covering large parts of other regional biodiversity (Howard *et al.* 1998, Brooks *et al.* 2001, Lawler *et al.* 2003). However, I am not aware of any study analyzing this important aspect at a local scale.

Globally threatened birds seem especially suited for the identification of key biodiversity areas, considering that 70% of them also have restricted ranges (BirdLife International 2004a), and that habitat loss and degradation are the major causes of threat in 85% ( $n = 1008$ ) of all cases (BirdLife International 2000). However, it must be emphasized that the selection of important sites for the conservation of regional biodiversity should not exclusively be based on globally threatened species. The reason is that a species's extinction risk at the regional level is not always reflected by its global threat status. For example, in the present study neither globally threatened species nor endemic taxa demonstrated the difference

in the conservation values of transects MNT1 and MNT2 as clearly as nationally threatened birds (Table 52). Furthermore, of the avian species recorded in Playa de Oro until Nov. 2004 ( $n = 336$ ), only 18 are considered either threatened or near-threatened at the global scale, whereas no less than 78 taxa are listed in the same categories in Ecuador (Table 45). Of the three Critically Endangered bird species of the Ecuadorian Chocó lowlands, viz. *Harpia harpyja*, *Crax rubra*, and *Ara ambiguus*, only the macaw is considered Endangered at the global level, whereas the other two are listed Near Threatened and Vulnerable, respectively. All three species have in common that they are large-bodied and suffer a combined impact of rapid deforestation and high levels of direct persecution (trophy and subsistence hunting, pet trade) in western Ecuador (Ridgely & Greenfield 2001b, Benítez *et al.* 2002, Guerrero 2002a, Mena & Jahn 2002j).

The divergence between regional and global threat status can be explained by the fact that large-bodied forest animals usually occur at rather low densities but at the same time occupy relatively large geographical areas (Brown & Maurer 1987, Arita *et al.* 1990, Maurer *et al.* 1990, Pagel *et al.* 1991, Ayres & Clutton-Brock 1992). In other words, small species may have small or large range sizes, but large-bodied taxa tend to occupy only large ranges (Gaston & Blackburn 1996). Thus, different mechanisms may explain the global threat status of different higher bird taxa. Owens & Bennett (2000) found that the extinction risk to large and long-lived birds is associated with persecution and introduced predators, whereas the extinction risk to small, habitat-specialized, and restricted-range species is correlated with habitat loss. Thus, considering that the ranges of most bird species inhabiting the Ecuadorian Chocó extend northward to northwestern Colombia or beyond, to areas where deforestation rates or levels of persecution are considerably lower, it is no longer surprising that the threat status of these species seems less dramatic from a world-wide perspective than from a national point of view. Consequently, the global status of threatened birds recorded in Playa de Oro is not associated with body size ( $r_s = 0.252$ ,  $P = 0.328$ ; Fig. 51). By contrast, the status of regionally threatened species shows a strong positive correlation with body size ( $r_s = 0.585$ ,  $P < 0.001$ ).

It seems possible that former and current red lists of globally threatened birds (BirdLife International

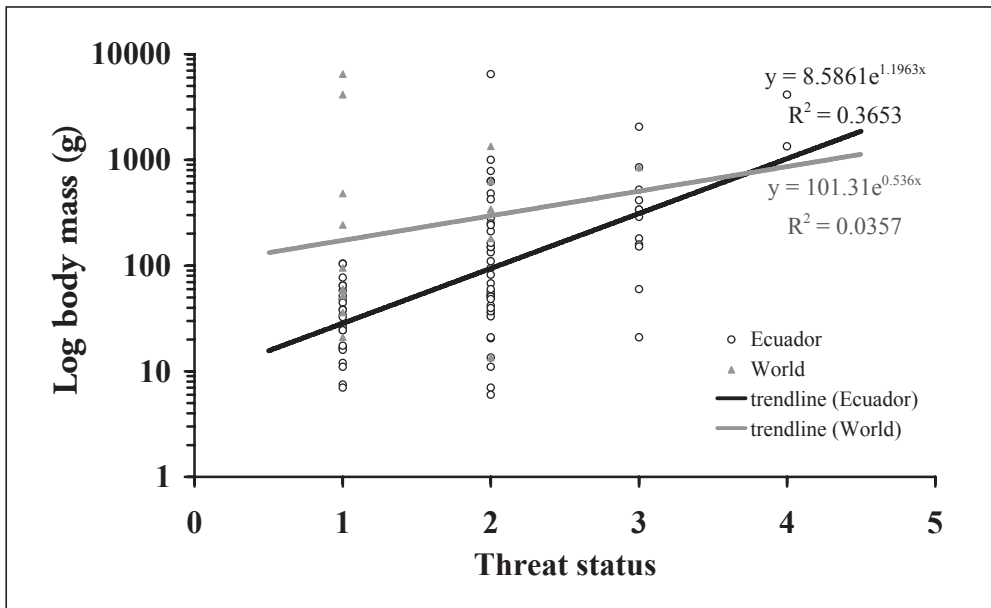


FIG. 51. Threatened bird species of Playa de Oro. Relationship between body size and species threat status in Ecuador (Granizo *et al.* 2002) and in the world (BirdLife International 2000, 2004b; see also Table 45). The relationship is best described by an exponential function. If *Harpia harpyja*, represented by the uppermost point in category 2 (VU), were assigned to the threat category that corresponds to its real conservation status in western Ecuador (category 4 = Critically Endangered), then the relationship would be described by the following trendline function:  $y = 7.2894e^{1.2663x}$ ,  $R^2 = 0.45$ . Status categories according to the IUCN (2001): 1 = Near Threatened (NT); 2 = Vulnerable (VU); 3 = Endangered (EN); 4 = Critically Endangered (CR); 5 = Extinct in the Wild (EW). Data Deficient (DD) species were excluded from analysis.

2000, 2004b, 2008) systematically underestimate the extinction risk to larger birds because the generation length of species was not taken into account in the threat assessments, with the important exception of seabirds (S. Butchart, pers. comm.). According to the official IUCN red list criteria (IUCN 2001), generation length determines the time period against which population declines have to be set. Considering the high deforestation rates in many tropical countries, any ignoring of reasonable generation lengths may thus have severe consequences for the assessment of the true extinction risk to larger birds, especially those facing multiple threats like habitat deterioration and direct persecution. For example, Benítez *et al.* (2002) estimated the generation length of *Ara ambiguus* at nine years, using the relationship between body size and longevity (Lindstedt & Calder 1976). Taking into account additional aspects of the

biology and natural history of this macaw, e.g., maturity is reached after 5–6 yrs (Chassot *et al.* 2002) and the oldest bird in captivity lived for c. 60 yrs (O. Chassot, pers. comm.), this is likely an underestimation. Considering the relationship between longevity of wild and captive birds (Lindstedt & Calder 1976), I estimate the macaw's maximum longevity in the wild at c. 35 yrs. "Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual" (IUCN 2001: 10–11), so it seems reasonable to assume that the generation length of *A. ambiguus* is between about 12 and 18 yrs. However, BirdLife International's (2000, 2004b) threat assessments of this and other large species was based on a generation length of only 3.3 yrs, which is the minimum duration used in many IUCN criteria. Note that the above reasoning in combination with new population estimates final-



ly resulted in a revision of the macaw's threat status from Vulnerable to Endangered in 2005 (BirdLife International 2008).

The 'minimum viable population hypothesis' (Brown & Maurer 1987) might be another argument confirming a systematic underestimation of the true threat status of large-bodied birds. Large animals require, on average, larger territories and home ranges than smaller ones and thus may also depend on larger geographic ranges in order to maintain viable populations (McNab 1963, Armstrong 1965, Schoener 1968, Lindstedt *et al.* 1986, Swihart *et al.* 1988; see also Fig. 49). This is one likely reason for the fact that interspecific geographic range size to body size relationships are approximately triangular (Gaston & Blackburn 1996). In other words, animals of certain body sizes seem not to occupy regions smaller than some lower limit of geographic range size, and this lower boundary is positively correlated with size. Many large species occupy ranges close to the lower boundary, and so any factor that might reduce their geographic range size further could threaten the viability of their populations (Brown & Maurer 1987, Gaston & Blackburn 1996). If we project these macroecological considerations onto small regions with high rates of deforestation, like the Ecuadorian Chocó, then it is to be expected that body size is one of the most important predictors of extinction risk in forest birds (Fig. 51). In agreement with this, a study on the threat status of Nicaraguan birds, using five ecological variables (body weight, habitat specificity, trophic guild, forest preference, and biogeographic range), also came to the result that body size was the best individual variable for predicting proposed threatened-bird lists, followed by habitat specificity (Gillespie 2001). *Harpia harpyja* was identified as the most extinction-prone taxon, in agreement with the fact that this bird had not been recorded in Nicaragua or in neighboring Costa Rica for over two decades.

4. *Climate change.* – Global average surface temperatures have risen by 0.76° C since 1850, and are expected to rise by between 1.1 and 6.4° C (best estimate: 3.0° C) over the 21st century (IPCC 2007). Tropical deforestation may account for up to a quarter of all greenhouse gas emissions, contributing significantly to global warming (Houghton 1991, Fearnside 2000, Bonnie *et al.* 2002). In the northern and central parts of South America, the annual mean warming is likely to be larger than the global mean warming. In northwestern Ecuador the annual mean temperature is expected to rise by between 2.5 and

3.0° C and the annual mean precipitation by up to 10% (0.25–0.5 mm per day) within the next 100 years (Cubasch *et al.* 2001, Gitay *et al.* 2002, Christensen *et al.* 2007).

An increase in global average air temperatures of more than 2° C above pre-industrial levels is predicted to result in catastrophic extinction rates (BirdLife International 2004a). Thus, global climate change might also have severe consequences for terrestrial biodiversity in tropical regions (e.g., Gitay *et al.* 2002, Téllez-Valdés & Dávila-Aranda 2003, Williams *et al.* 2003, Malcolm *et al.* 2006, Williams *et al.* 2007).

Considering the fact that in western Ecuador life zones (*sensu* Holdridge 1967) occur mostly in narrow bands along the coastal cordilleras and Andean slopes (Dodson & Gentry 1991), major shifts in the climate envelope of many bird species should also be expected in Esmeraldas Province. Avian taxa most affected by global warming might be those restricted to only one or a few life zones (Table 46). Of course, any predictions on how changing climate might affect bird community composition should be based on concrete models.

The composition of 'life zone assemblages', and especially the occurrence of taxa that are not assumed to be present, may be helpful for the characterization of the ecological conditions of study areas as well as for the monitoring of climate change. In the wet lowlands of Playa de Oro, certain indicator species that are more typically found in semi-humid or humid forests are usually restricted to disturbed habitats where microclimatic conditions are drier than in continuous forest (*pers. obs.*). For example, *Ortalis erythroptera* is restricted to river-edge vegetation, *Campylorhamphus trochilirostris* is commonest in mixed-culture plantations, and *Automolus ochrolaemus* occurs in young secondary forest and at forest borders. Other humid forest specialists, like *Amazona autumnalis*, *Amazilia amabilis*, and *Notharchus pectoralis*, are only rarely or seasonally recorded in Playa de Oro, and some species that are known to occur about 10–20 km west of the community have not yet been observed there, e.g., *Ara severa*, *Trogon massena*, *T. caligatus*, *Sclerurus guatemalensis*, *Attila torridus*, and *Ramphocaelus melanurus*.

A recent colonizer in the study area is *Cyanocoryps cyanoides*, an indicator for humid forest, found for the first time in July 1999 in secondary forest. In Nov. 2005, which was an extremely dry year not only in the Brazilian Amazon region (Marengo 2006,

Marengo *et al.* 2008) but also in the Ecuadorian Chocó, I observed the Tumbesian endemic *Pachyramphus spodiurus* for the first time in Playa de Oro. This becard was also noted in three other areas in the Ecuadorian Chocó (P. Coopmans, pers. comm.; pers. obs.), and at least one pair subsequently bred at one of these sites close to the Colombian border (B. Palacios, pers. comm.). The same year, *Myiodynastes maculatus*, another indicator for dry habitats and only rarely recorded in the 1990s, was present everywhere in the Ecuadorian Chocó up to at least 600 m a.s.l., even in continuous forest (pers. obs.; P. Mena V., pers. comm.).

Although the above range shifts of some 'life zone specialists' are anecdotal by nature, it is probable that similar changes in species distributions might increase in frequency over the next several decades, a phenomenon that should be closely monitored. However, different environmental changes might cause contradictory responses in some species, e.g., deforestation and warmer average temperatures might cause range expansions of species preferring drier life zones to the northeast, whereas increasing annual precipitation might result in range expansions of wet forest taxa to the southwest. Therefore, complex changes in avian community composition might occur in some areas.

#### Assessing conservation value at the local level

It is a widely held assumption that species-rich, more diverse communities mean higher ecological quality and thus conservation value for an area (Magurran 1988). This is especially the case when referring to assemblages inhabiting tropical forests, which are the epitome of biodiversity per se. Diversity patterns have been widely used to pinpoint conservation value at regional (e.g., Thiollay 2002b) and global scales (e.g., Myers *et al.* 2000). However, the answer to the question whether higher diversity also equals higher conservation value at the local scale is quite complex. Although there is no doubt that species richness and diversity, and thus conservation value, must be expected to decrease dramatically in a wide range of taxonomic groups when a tract of natural forest is converted into agricultural land or a plantation of exotic tree species (Petit *et al.* 1999, Petit & Petit 2003, Donald 2004; cf. p. 211–213, Birds as indicators of environmental change), that does not automatically mean that the conservation priority of two tracts of similar habitat can be ranked simply by comparing their ecological diversity. In fact, species

richness and diversity indices might be rather poor predictors of conservation value at local and regional levels (cf. Winston & Angermeier 1995, Aleixo 1999). Transects MNT1 and MNT2 are an excellent example to demonstrate this.

#### The example of transects MNT1 and MNT2

Although species richness and diversity indices calculated for the modeled avian communities were higher at MNT1 than at MNT2 (Tables 33 and 52), the conservation value of the latter was obviously higher due to the presence of more forest-dependent species, forest-interior specialists, and threatened taxa. The difference between the transects was more pronounced for numbers of regionally threatened species than for globally threatened taxa and endemics.

Of the forest-interior species absent from MNT1, *Megascops centralis* inhabits the undergrowth of continuous forest, often in the vicinity of light gaps or otherwise disturbed tracts, and thus might not be a particularly good indicator of the conservation value of a forest. However, the high hunting pressure in the surroundings of the village is the only plausible explanation for the absence of *Tinamus major* at MNT1. In Playa de Oro this tinamou was uncommon to fairly common in appropriate habitat, with the exception of the most intensively hunted areas. In intact habitat, local extirpation of this secretive bird would probably be impossible if local people did not use so many trip-wire-triggered shotgun traps. The traps are usually set up to hunt 'guanta' *Cuniculus paca* or 'guatusa' *Dasyprocta punctata*, but other medium-to-large-sized ground-dwelling mammals as well as birds are indiscriminately killed by them too. The other five forest-interior species not recorded at MNT1 are known to establish medium to large territories in intact and extensive forest tracts and are certainly sensitive to habitat fragmentation (p. 211–213, Birds as indicators of environmental change). One of these taxa, the diurnal raptor *Leucopternis plumbeus*, is already regarded as Near Threatened at a global level and Vulnerable in Ecuador (Table 45). Local extinctions and population declines due to forest fragmentation, selective logging, and edge effects have already been reported from different Neotropical regions for *Phaenostictus mcleannani* (Willis 1974, Levey & Stiles 1994, Robinson 1999) as well as for various species of the genus *Sclerurus* (Thiollay 1992, Ferraz *et al.* 2003, Ribon *et al.* 2003). The woodcreeper *Campylorhamphus pusillus* might also be prone to withdraw from altered habitat, particularly

under the suboptimal ecological conditions at the species's lower altitudinal range limit.

But even forest-interior species should not be expected to respond uniformly to changes in the structure of their habitat; e.g., *Henicorhina leucosticta*, a tree-fall-gap specialist that virtually never appears at forest edges in the Ecuadorian Chocó lowlands (cf. Figs. 41 and 42), seemingly benefits from traditional low impact logging practices in Playa de Oro (pers. obs.). Critics might use the inconsistent response of group members of 'forest interior, understory-dwelling insectivores' to question the utility of birds as indicators for environmental change (Verner 1984, Landres *et al.* 1988), as population increases in one or a few species may mask the decline or loss of other guild members (Mannan *et al.* 1984). However, this problem can be avoided if all species of an avian community are categorized into functional groups, i.e., habitat assemblages, which are then used to calculate the 'bird community index' (BCI) (Bradford *et al.* 1998, Canterbury *et al.* 2000; p. 181f, Assessment of the conservation value of MNT1 and MNT2). In a pilot study in temperate loblolly-shortleaf pine forests in the USA, avian assemblage members showed consistent responses to variations in disturbance levels (Canterbury *et al.* 2000). Thus, the BCI permits the monitoring of replacement patterns as a consequence of habitat alteration. In the present study, the index clearly reflects the higher value of transect MNT2 for the conservation of forest-dependent birds ( $BCI_{MNT2} = 0.541$  versus  $BCI_{MNT1} = -0.049$ ).

Regarding the threatened species, *Ara ambiguus* is already Critically Endangered in Ecuador, with an estimated wild population of less than 100 mature individuals in the country (Benítez *et al.* 2002). Although the macaw does not breed in the close vicinity of Playa Rica, up to six individuals were regularly observed there during the dry seasons, when they visited fruiting trees. By contrast, in several years of field work it was only once recorded on the outskirts of the village (P. Mena V., pers. comm.). The guan *Penelope purpurascens* is regarded as Endangered in Ecuador due to the high deforestation rates in the coastal lowlands and foothills as well as the intensity of subsistence hunting, but it is not yet listed at a global level. The population of *P. purpurascens* was almost extirpated in the close vicinity of Playa de Oro, whereas one territory persisted during the study period in the area of MNT2.

Recommendations for the use of the 'bird community index'

In contrast to Canterbury *et al.* (2000), I recommend combining all bird species that depend on continuous forest into one functional group, and not only those preferring mature forests. One reason is the high number of tree-fall-gap specialists in tropical forests (Schemske & Brokaw 1981, Levey 1988b). Some of these, like the *Henicorhina* wood-wren mentioned above, are forest-interior taxa that may benefit from low-impact logging but rapidly disappear when habitat alteration reaches certain threshold levels. The same argument applies to many canopy birds that might be edge-tolerant but, nevertheless, depend on continuous forests for their survival. These species function as potential 'buffers' that may be helpful for the differentiation between low- and high-magnitude impacts and, in this way, may improve the indicator performance of the BCI. Of course, it is critical to assign those species that easily survive in semi-open woodland, mixed-culture plantations, or highly fragmented landscapes to the habitat categories 'forest edge' or 'open country'. In the case of poorly studied regions, field experience and accounts of general habitat selection in the literature (e.g., Stotz *et al.* 1996; Appendix 8), as well as the program IndVal (Dufrêne & Legendre 1997; p. 184f, Determination of indicator species), can be used for an adequate categorization. However, the assignment of birds to habitat categories should preferably be based on audiovisual observations and not on mist-netting data for the reasons mentioned below (p. 218f, Influence of the survey methods).

Because the relationship between forest-dependent birds and those that inhabit borders and open country differs from site to site and between forest types, the BCI cannot be directly compared between localities. In other words, a BCI of a certain value may indicate primary forest conditions at one locality but disturbed conditions at another. This problem is also relevant in comparisons between sites that are located in the same region but in different life zones, because a given bird species might occupy different habitats in different life zones. For instance, some of the forest-edge species of Playa de Oro, such as *Thamnophilus atrinucha*, inhabit continuous forest in drier life zones closer to the coast. Therefore it is necessary to define habitat assemblages at least on the level of biogeographic areas (e.g., Tumbesian vs. Chocó). Furthermore, it should always be tested whether different sites are ecologically comparable or not. Of

course, these minor drawbacks do not prevent the BCI from being employed in pre- and post-impact studies as well as in the long-term monitoring of changes in forest condition at a particular locality or in a set of matched transect pairs at different localities (cf. p. 229–238, Transect mapping as a tool for adaptive management).

I also recommend computing the BCI with incidence data and not with the overall abundances of each habitat assemblage. There is a practical reason as well as an ecological argument for using presence/absence data. Firstly, the utility of the BCI in conservation practice would be severely limited if it could not be calculated on the basis of raw field data. There is often not enough time for labor-intensive calculations of relative or absolute abundances. Secondly, total avian densities are usually lower in mature forests than in successional habitats, and this is true in tropical as well as in temperate latitudes (p. 166–169, Comparison of the community structure at MNT1 and MNT2 with other sites). Although the increase in avian abundance in disturbed habitats might be mostly attributable to increasing numbers of non-forest and forest-edge taxa, this would not necessarily be the case in slightly to moderately disturbed forest tracts (pers. obs.). Thus, if we use all bird taxa that depend on continuous forest and not only the few mature forest specialists, then we might face the paradox that some members of the habitat assemblage may well increase in abundance after low magnitude changes in the forest structure. As a consequence, only incidence-based BCI values might provide meaningful results in this situation.

Finally, only breeding species should be taken into account, as non-core species (*sensu* Remsen 1994) and long-distance migrants tend to appear in 'atypical' habitats. Of course, species with no clear habitat preference should always be excluded from analysis (Canterbury *et al.* 2000).

Avian habitat selection and indicators in human-influenced mosaic landscapes

Identified biases and challenges

Before interpreting the results of the multivariate analysis as well as the indicator species and indicator groups determined with the computer programs TWINSPAN and IndVal, it should be remembered that the 'sampling units', nets in the case of mist netting and 25 x 25-m main-belt plots in the case of transect mapping, were not independent of each

other. Furthermore, the corresponding bird data sets contained either recaptures or repeatedly observed individuals. Considering the fact that many species were represented by only a few individuals in the transect areas of MNT1 and MNT2 (Appendices 18a and 19a), the results evidently mirror the habitat selection of these birds rather than of the corresponding populations. As a consequence, the significance levels of the IndVal indicators have to be viewed with caution. Nevertheless, the database of the transect-mapping study is so large for Playa de Oro (Appendix 3), that more conclusive results can be obtained in future analyses. For regularly recorded species it would then be feasible to draw random samples from the data pool, e.g., using only one record at a time for each territory in randomly selected subsets in order to achieve independence of the data and to permit conclusive statistical testing of the patterns found.

At this point it remains unclear why the TWINSPAN results are apparently not interpretable (Tables 48 and 49). The program was written for classifying plant communities (Hill 1979) and so might not work for assemblages of moving animals. Many bird species regularly visit a variety of habitats and ecotones (see below), adding noise to the data set. This situation was aggravated by the wide error margins of the bird positions relative to the habitat gradients (p. 182, Multivariate analysis). Probably of minor importance was the fact that the data were not drawn from random samples. A problem might also be that the indicator value for a given species is not independent of the relative abundance of the other taxa in the sample. Evidently, the IndVal results are much more promising and consistent (Tables 50 and 51). This method could be used to separate open-country and forest-edge birds from those dependent on continuous forest, in order to objectively categorize the species' habitat preferences for the calculations of the bird community index (p. 181f, Assessment of the conservation value of MNT1 and MNT2). With sufficiently large data sets, IndVal could also be used to accurately determine the composition of life zone assemblages (Table 46).

Influence of the survey methods

Discrepancies in various aspects exist between mist-netting and transect-mapping results. In the Detrended Correspondence Analysis (DCA), the centers of abundance of some species do not coincide in their position with respect to the first axis, mirroring

differences in the detectability of certain subpopulations between survey methods (p. 83-85, Influence of breeding/non-breeding status and territory/home-range size). The fact that mist netting detects floaters and breeding individuals of a given species with roughly the same probability, as long as both groups use the scrub level with similar frequency and mobility, is the reason why the centers of abundance of *Mionectes olivaceus* and *Turdus daguae* were located at the forest edge (Fig. 41), and not in the forest interior as in the transect-mapping study (Fig. 42). In these species, floaters and feeding visitors far outnumbered the breeding residents in the transect areas, especially at MNT2 (p. 90f, Species richness and species accumulation). The corresponding subpopulations mainly used the forest borders, and consequently their centers of abundance coincide with this habitat in the mist-netting data. Similarly, the centers of abundance of some elevational migrants, e.g., *Androdon aequatorialis*, were also located close to the forest edge (Fig. 41), although they are in fact forest species that use borders and disturbed habitats only seasonally. In contrast to mist netting, transect mapping mainly detects the vocalizing portion of the populations. Consequently, the centers of abundance of *M. olivaceus*, *T. daguae*, and *A. aequatorialis* coincide with the forest interior where their respective display, breeding, and feeding territories were located (Fig. 42). Another obvious difference between survey methods refers to the consistently lower number of 'best-fit' species for mist netting in comparison with transect mapping in the Detrended Canonical Correspondence Analysis (DCCA; Figs. 43 and 44) and Canonical Correspondence Analysis (CCA; Figs. 45 to 50). Considering that the number of sample units ( $n_{MN} = 136$  vs.  $n_{MTW} = 94$ ), valid records ( $n_{MN} = 2545$  vs.  $n_{MTW} = 2626$ ), and analyzed species ( $n_{MN} = 87$  vs.  $n_{MTW} = 114$ ) were rather similar in both data sets, I assume that these patterns were also caused by survey-method-specific differences in the detectability of birds. Most birds vocalize under distinct circumstances and at distinct localities, e.g., within their territories and at its borders or on conspicuous twigs close to an important food resource. However, if these individuals leave their breeding or feeding territories they usually vocalize less frequently, decreasing their overall detectability in audiovisual surveys. Consequently, with transect mapping birds are recorded mostly in their centers of activity, where habitat quality or abundance of food resources is high enough to make active signaling, display, and defense

energetically worthwhile. By contrast, mist netting records undergrowth birds where they move, and that might also be in habitats where they do not establish territories. Thus, from the perspective of capture data, avian habitat use may appear less specific than from the viewpoint of transect mapping. The fact that many dispersing forest species may feed at borders or in young successional regrowth might explain why they were represented by much fewer best-fit species when analyses were based on mist-netting instead of transect-mapping data. By contrast, most open-country taxa do not disperse through the forest undergrowth but rather move along river edges or forest borders or ascend to canopy level.

It should be emphasized that the data on habitat selection are basically a by-product of transect-mapping and mist-netting studies that can be obtained with relatively low additional effort. However, if habitat selection is the main or single aspect of a study, point counting is probably more appropriate than other methods, as it is easier to establish independent stations in homogeneous habitat and to employ a sound statistical design.

What do we know about the original habitats of open-country species?

Considering that the Ecuadorian Chocó region was almost entirely covered by dense forest for many thousands, perhaps millions of years, it is rather surprising that there are so many open-country species, 25.6% ( $n = 86$ ) of Playa de Oro's known avifauna (Table 14). In contrast to Central America, no hurricanes occur in the doldrums zone near the equator, and unlike central and eastern Amazonia the Chocó is too wet for natural forest fires that can cause extensive clearings in other Neotropical forests (Sanford *et al.* 1985, Uhl *et al.* 1988, Lynch 1991, Will 1991, Yih *et al.* 1991). Before humans colonized the Chocóan lowlands several thousand years ago, thunderstorms and landslides might have been the only important source of disturbance that generated clearings within *terra firme* forest. However, it seems rather doubtful whether such natural openings were frequent and large enough to maintain viable populations of many open-country species. Thus, the original habitats of most birds that depend on disturbed and secondary areas were likely river-created. Meandering rivers and streams were the only natural disturbance factor with sufficient frequency, extension, and force to guarantee a continuing availability of a broad variety of successional vegetation types. Interestingly,



in spite of the historical importance of rivers for the creation of otherwise rare or absent habitats in the trans-Andean lowlands, very few non-aquatic bird species explicitly depend on river and stream edges, e.g., *Basileuterus fulvicauda*. Most Neotropical river systems, apart from the huge Amazon drainage, may have been too small and discontinuous to promote the evolution of a significant riverine habitat avifauna (Remsen & Parker 1983). Nevertheless, many bird taxa that presently thrive in human-created habitats still seem to have their centers of abundance on the floodplains and especially close to river or stream edges (Figs. 49 and 50). Among them are many species that inhabit mosaics of grassy patches, *Gynurium* cane and *Heliconia* stands, young successional regrowth, or periodically flash-flooded river-edge scrub and forest, viz. *Leptotila pallida*, *Glaucis aeneus*, *Amazilia tzacatl*, *Synallaxis brachyura*, *Taraba major*, *Cercomacra tyrannina*, *Myrmotherula pacifica*, *Myio-bius atricaudus*, *Manacus manacus*, *Thryothorus nigricapillus*, *Cyanerpes cyaneus*, *Mitrospingus cassinii*, *Sporophila corvina*, and *Oryzoborus angolensis*. Some typical river-edge generalists like *Pachyrhamphus cinnamomeus* and *Coereba flaveola* also occur at lower densities in the canopy of continuous forest (pers. obs.).

The limited extent of cultivated semi-open landscapes and the scarcity of pasture-like grasslands partially explains why many open-country species were strikingly uncommon or even rare in the study area, for instance, *Coragyps atratus*, *Tapera naevia*, *Nyctidromus albicollis*, *Camptostoma obsoletum*, *Myiozetetes similis*, *Progne chalybea*, *Geothlypis semiflava*, *Tachyphonus rufus*, *Volatinia jacarina*, *Sporophila nigricollis*, *Arremonops conirostris*, and *Molothrus bonariensis*. Of course, at least some of the open-country species, such as *Geothlypis auricularis*, *Rhodospingus cruentus*, *Tiaris obscura*, and *Sporophila telasco*, were originally restricted to drier life zones in western Ecuador and only recently expanded their range northwestward with encroaching deforestation.

Few species show a strong association with secondary forest and edges

In the Detrended Correspondence Analysis (DCA), the centers of abundance of many species coincide with forest-edge habitats (Figs. 41 and 42). However, in the Detrended Canonical Correspondence Analysis (DCCA; Figs. 43 and 44) and Canonical Correspondence Analysis (CCA; Figs. 45 and 46), rather few best-fit species seem to have a close association

with forest borders; e.g., *Eutoxeres aquila*, *Amazilia rosenbergi*, and *Microrhopias quixensis* within forest, *Cercomacra tyrannina*, *Lophotriccus pileatus*, *Manacus manacus*, and *Arremon aurantirostris* outside forest. Analyses of more comprehensive data sets have to demonstrate whether these associations are real, or whether they merely represent an artifact of small sample size; e.g., *M. quixensis* might not be more abundant at borders than in the subcanopy and tree-fall gaps of selectively logged forest. Most other species mentioned here were perhaps associated with river-created habitats before anthropogenic deforestation set in.

Curiously, for young successional forest no IndVal indicators were shared between the mist-netting and transect-mapping data. For some species the assignment as indicators was evidently biased by various factors, including small sample size (regarding either the number of individuals and/or the number of sampling units per habitat type), the length of the habitat gradients, as well as a surplus of repeatedly recorded individuals. In the case of mist netting (Table 50), only *Mitrospingus cassinii* seems to be a valid indicator, whereas most other species might have been captured more frequently in young secondary forest merely by chance; e.g., *Gymnopithys leucaspis* and *Chlorospingus olivacea* were determined as indicators of medium-age forest, when analyses were based on MTW data (Table 51). The number of supposedly valid indicators for young forest was higher for transect-mapping data, e.g., *Dendrocicla fuliginosa*, *Cymbilaimus lineatus*, *Thamnophilus atrinucha*, *Microrhopias quixensis*, *Ornithion brunneicapillus*, and *Saltator grossus*. However, some of these species might be associated with forest edges or tree-fall gaps rather than explicitly with young successional forest. In other words, major changes in the composition of the indicator groups should be expected if data from additional transects were included in the analysis.

#### Forest species

The IndVal program is very helpful for the identification of taxa that are closely associated with good forest condition. Those species that were mostly recorded in medium-age forest, but only rarely in young successional forest or open country, might be potentially sensitive to changes in habitat structure or to forest fragmentation (Tables 50 and 51; p. 210-213, Birds as indicators of environmental change). These species include *Odontophorus erythrops*, *Den-*



*drocolaptes sanctithomae*, *Dysithamnus puncticeps*, *Rhynchocyclus pacificus*, *Sapayoa aenigma*, *Hylophilus ochraceiceps*, and *Henicorhina leucosticta*. Furthermore, successful reproduction of some species that were regularly mist-netted at forest borders or in young regrowth may nevertheless depend on continuous forest; e.g., *Mionectes olivaceus*, *Lepidothrix coronata*, *Chloropipo holochlora*, and *Chlorothraupis olivacea*. Other species, like *Dendrocincla fuliginosa* and *Xiphorhynchus* woodcreepers, regularly disperse along field-wood-like landscape elements and may even breed within mixed-culture plantations (e.g., in dead *Bactris* palms; pers. obs.), but might still depend on continuous forest for foraging. These woodcreeper species at least have moderate to good dispersal abilities, which might considerably lower their extinction risk (cf. Sekercioglu *et al.* 2002).

The relatively low number of birds that showed a close association with tree-fall gaps in the Detrended Canonical Correspondence Analysis (DCCA; Figs. 43 and 44) and Canonical Correspondence Analysis (not shown) might be explained by small sample size as well as by the relatively large error margins regarding the distance measurements between the position of recorded birds and habitat elements. Considering that the median distance between natural gaps ( $> 40 \text{ m}^2$ ) was determined to be only 12 m in primary forest at La Selva, Costa Rica (Sanford *et al.* 1986), an error margin of  $\pm 9 \text{ m}$  for captures and  $\pm 24 \text{ m}$  for MTW observations might be too large for testing associations between the distribution patterns of birds and tree falls. This question should be studied in detail with more comprehensive data sets.

## Conclusion

Due to lack of funds and time, conservation biologists and managers have increasingly used surrogate taxa as a shortcut to monitoring and solving conservation problems. Birds score very high on many objective criteria for the selection of indicators for biodiversity patterns and environmental change (BirdLife International 2004a). Although they are obviously not perfect indicators, as no single group of organisms is, many characteristics make them perhaps the most appropriate biological indicators in tropical habitats (Stotz *et al.* 1996). Birds are well known in comparison with most other taxa and their populations tend to integrate a number of ecological factors. Thus, they should always be included as an indicator group in applied conservation-related re-

search and resource management in tropical countries. Whenever feasible, the entire bird community should be taken into account, instead of only one or a few indicator species, like flagships and umbrellas, which might be doubtful surrogates for the integrity of ecosystems and the ecological functioning of landscapes.

Range-restricted taxa and threatened species themselves might perform well as indicator groups. Consequently, these species should be integrated into any approaches of habitat conservation and landscape planning procedures. Of the 316 avian taxa recorded in Playa de Oro until Nov. 2004, 44 are considered endemics, 18 threatened or near-threatened at the global scale, and 78 are listed in the same threat categories at the national level. Thus, extinction risk at a regional scale is not always reflected by a species's global threat status. Consequently, the availability of adequate national lists is very important for environmental impact assessments and conservation-related planning procedures. Adequate means that all potentially declining species, and not only those already considered globally threatened, should be included in the assessment and be tested for compliance with the official IUCN red list criteria. In regions with high rates of deforestation, like the Ecuadorian Chocó, body size is one of the most important predictors of extinction risk in forest-dependent birds.

Some forest bird species are restricted to relatively narrow environmental conditions regarding mean annual precipitation, temperatures, and their associated vegetation types. These taxa can be grouped in 'life zone assemblages' that may be helpful for the characterization of ecological conditions in study areas as well as for the monitoring of climate change. Observed and predicted shifts in climate zones and bird distributions due to deforestation and global warming make the implementation of monitoring programs an urgent priority in tropical countries, particularly in regions with steep precipitation gradients like western Ecuador.

At the local level, bird species richness and diversity indices are poor predictors of habitat quality. Whereas birds that depend on mature forest tend to decrease considerably after changes in the forest structure, edge and open-country species might colonize the disturbed habitat. Depending on the biogeographic region or biome, the latter group may mask or outnumber species loss suffered by habitat specialists. For instance, in the study area the number of avian taxa was higher at MNT1 ( $n = 162$ ) than at

MNT2 ( $n = 144$ ), as were all but one of the diversity indices calculated for the modeled bird communities. However, the conservation value of the latter transect was higher because it held more forest species, forest-interior specialists, and globally and nationally threatened species than MNT1. The 'bird community index' (BCI) sensu Canterbury *et al.* (2000), which contrasts disturbance-sensitive forest taxa with disturbance-tolerant species, clearly reflected the higher value of transect MNT2 for the conservation of forest-dependent birds ( $BCI_{MNT2} = 0.541$  versus  $BCI_{MNT1} = -0.049$ ). Therefore, the present study demonstrates that the index can also be applied in the humid tropics. One important lesson learned from this example is that the conservation value of study sites should be ranked on the basis of a detailed comparison of habitat association as well as threat status of the bird species present. The central questions of environmental assessments should not be "How many bird species? / How many individuals?" but "Which species? / How regularly in which habitats and at which sites? / How sensitive in the face of habitat alteration and human disturbance?" and "How threatened at regional and global levels?" (Flade 1994, Jahn 2001).

Selective logging can severely affect tropical forest birds by causing changes in the vegetation structure. Although timber harvesting might hit Chocoan bird communities less hard than those of the Amazon basin, this anthropogenic activity might still cause population decreases in almost one third of all forest-

dwelling species. Forest fragmentation is even more threatening for the maintenance of tropical bird diversity. Apart from large-bodied species, such as *Harpia harpyja*, *Penelope ortonii*, *Crax rubra*, or *Ara ambiguus*, that suffer a combination of habitat deterioration and direct persecution, obligate army-ant followers (e.g., *Phaenostictus mcleannani*, *Gymnophrys leucaspis*) and other terrestrial and understory-dwelling insectivores (e.g., *Sclerurus mexicanus*, *Dendrocolaptes sanctithomae*, *Pittasoma rufopileatum*, *Hylopezus perspicillatus*) might belong to the most sensitive taxa of the study area.

Comparisons between mist-netting and transect-mapping data through multivariate analyses revealed that the centers of abundance of some species do not coincide in their position, mirroring differences in the detectability of certain subpopulations between survey methods. From the perspective of capture data, avian habitat use may appear less specific than from the viewpoint of transect mapping.

In the Chocoan lowlands, the original habitats of most birds that depend on disturbed and secondary areas were likely river-created. Before colonization by man, meandering rivers and streams were the only natural disturbance factor with sufficient frequency, extent, and force to guarantee a continuing availability of a broad variety of successional vegetation types. Many bird taxa that currently thrive in anthropogenic habitats still seem to have their centers of abundance on the floodplains, especially close to river or stream edges.

## 7. THE USE OF AVIFAUNISTIC DATA FOR ADAPTIVE MANAGEMENT OF BIOLOGICAL RESOURCES

### Introduction

Although the information on survey methods and ecology presented in the previous chapters certainly has an intrinsic scientific value of its own, the mounting threats for the integrity and functioning of tropical ecosystems, the consequence of human encroachment and over-exploitation, make it ever more important that contemporary biology also provides practical solutions on how the impending biodiversity loss might be avoided, or at least, slowed down. Thus, one overall aim of my work is to demonstrate the use of avifaunistic data in the development of environmentally sound management practices. Here I present an example of how an integrated conservation and development project (ICDP) employed data on globally threatened birds in the zoning of land use and conservation goals in Playa de Oro.

The precepts of ICDPs, such as CARE Ecuador's Sustainable Use of Biological Resources (SUBIR) Project, aim to achieve long-term environmental protection of areas rich in biodiversity through an "improvement of the quality of life of local people by providing tangible benefits that are compatible with the conservation of the natural resource base" (Stallings 2001: 3); see also Ack (1991) and Brown & Wykoff-Baird (1992). ICDPs embrace many of the central ideas of the 'Convention on Biological Diversity' (UNEP 1992), including the sustainable use of natural resources and the implementation of environmental impact assessments in planning procedures (p. 15f, General aims). The SUBIR Project was carried out in the buffer zones of three major protected areas in northern Ecuador (Cotacachi-Cayapas Ecological Reserve, Cayambe-Coca Ecological Reserve, and Yasuni National Park) between 1991 and 2001. To achieve the long-term goal of sustainable use of biological resources, SUBIR performed activities in the following fields: (1) biodiversity research, (2) GIS mapping and remote sensing, (3) ecotourism development, (4) sustainable forestry, (5) improved land-use practices and agroforestry systems, (6) microenterprise development and marketing, and (7) land titling (e.g., Alarcón 2001, León 2001a,b; Morales 2001, Stallings & García 2001). Playa de Oro quickly became a model for the imple-

mentation of SUBIR's strategies. Originally my study was not planned as a complementary measure to this ICDP. However, given the shared conservation interests, SUBIR eventually provided the first opportunity to apply the transect-mapping (MTW) method in development practice. In the following I discuss how avifaunistic data improved the conservation efforts of SUBIR and what lessons can be learned from these experiences. Moreover, I provide practical guidelines that might be helpful for a successful integration of biological data in future projects, permitting an adaptive management of natural resources.

### Methods

See page 66-70, Transect-mapping study, for details on the bird survey method used (see also Appendix 3), and Table 5 for the description of the physical characteristics and habitats of the transects. Transects LT9 and LT10 were located within the initial Community Forest Management Plan I (Fig. 1b) that was established in 1996 by the SUBIR Project in collaboration with the local people.

Although, in the previous chapter (p. 210-216, Birds as indicators of environmental change), I emphasized that national red lists should be taken into account for regional conservation planning in addition to species of global conservation concern, I will here exclusively focus on the latter group in order to simplify the data analysis. This decision can be justified by the high number of globally threatened and near-threatened avian taxa present in the community area of Playa de Oro (Table 45), a prerequisite not necessarily fulfilled at other sites.

In a few cases I complemented my original field notes with identifications based on the tape recordings made during the MTW surveys. This was done whenever I discovered a species of concern on the tapes that I had overlooked while sampling the transect. However, observations made during non-standardized observation hours as well as capture data were omitted from analysis to improve the comparability between transects. Nevertheless, the records obtained in addition to the transect-mapping results were considered in the zoning of the community area.

TABLE 53. Presence of globally threatened species at the transects in Playa de Oro according to the MTW study. See Fig. 1b for the location of the transects and Table 6 for the description of their physical characteristics and habitats. Note that the number of complete transect-mapping surveys performed was twice as high for MNT1, LT9, and LT10 than for the rest of the transects (Appendix 3). Abbreviations used: (a) threat status = international threat status categories sensu IUCN (2001): NT = Near Threatened; VU = Vulnerable; EN = Endangered; considered are the species' global threat status according to BirdLife International (2004b); see Table 45 and BirdLife International (2008, 2009a) for more recent changes in the threat status categories of *A. ambiguus* and *C. quiniticolor*; (b) freq = frequency of presence: number of transects at which the species was recorded; (c) sum 'status values' = in order to estimate the conservation value of the transects, each threat category was assigned a value, which increases exponentially with severity of extinction risk: NT = 1, VU = 2, and EN = 4. Notes: For species and transects with equal frequencies or status values, I assigned tied ranks according to the rules of nonparametric statistics.

Scientific name	Threat status <sup>a</sup>	Transects																Freq. <sup>b</sup>	Rank
		MNT1	MNT2	LT1	LT2a	LT2b	LT3	LT4a	LT4b	LT5	LT6	LT7	LT8a	LT8b	LT9	LT10	LT11a	LT11b	LT11c
<i>Leucopternis plumbeus</i>	NT	+				+	+				+	+			+	+		+	5
<i>Micrastur plumbeus</i>	VU												+		+	+		+	13
<i>Penelope ortoni</i>	EN												+		+	+		+	10
<i>Ara ambiguus</i>	VU	+						+							+	+		+	8.5
<i>Nyctiphrurus rosenbergi</i>	NT	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	18
<i>Capito squamatus</i>	NT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	17
<i>Capito quiniticolor</i>	NT						+							+	+	+	+	+	8
<i>Veniliornis chocoensis</i>	NT			+											+	+		+	11
<i>Campephilus gayaquilensis</i>	NT	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	13
<i>Pittasoma rufopileatum</i>	NT						+		+						+	+		+	4
<i>Cephalopterus penduliger</i>	VU														+	+		+	7
<i>Dacnis berlepschi</i>	VU	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	8.5
<i>Tangara johannae</i>	NT	+	+					+	+	+	+	+	+	+	+	+	+	+	15
Number of species		4	7	4	4	5	6	5	6	4	4	5	6	6	12	12	7	8	11
Rank by number of species		16	5.5	16	16	12	8.5	12	8.5	16	16	12	8.5	8.5	1.5	1.5	5.5	4	3
Sum of 'status values' <sup>c</sup>		5	9	5	5	6	6	7	7	5	4	6	10	7	18	18	11	13	18
Rank by 'status values'		15.5	7	15.5	15.5	12	12	9	9	15.5	18	12	6	9	2	2	5	4	2

Important sources of bias in the comparisons between transects include their varying lengths (Table 5), the different numbers of complete surveys carried out per transect (Appendix 3), as well as the fact that my identification skills improved in the course of the study (p. 75-77, Transect-mapping study of MNT1 and MNT2). The last factor is of relevance because some transects were sampled exclusively during the initial months of the project, whereas others were studied mainly in the second half of the survey period (Appendix 3). Consequently, I decided not to perform statistical tests on the data. However, as demonstrated below, the quality of the data is good enough to draw reliable conclusions about the appropriate zoning of the community area.

## Results

Of the 18 species recorded in Playa de Oro until Nov. 2004 that are considered threatened or near-threatened at the global level (Table 45), 13 were noted during the transect-mapping study (Table 53). Regarding the taxa not detected, *Harpia harpyja* was only recently rediscovered in the community area, *Ortalis erythroptera*, *Crax rubra*, and *Neomorphus radiolosus* were extremely rare and may not always be present in the transect areas, and in the case of *Neocrex colombiana* the probability of detection in audiovisual surveys was very low because the primary vocalizations of this secretive rail remain unknown (cf. Appendix 6).

The at-risk species were not evenly distributed over the study area (Table 53). Their number per transect varied between 4 and 12, with lower values typically obtained in the vicinity of the village and higher figures in the remoter parts of the study area. *Nyctiphrynus rosenbergi* was the only taxon detected at all transects ( $n = 18$ ), followed by *Capito squamatus* (17), *Dacnis berlepschi* (15), and *Campephilus gayaquilensis* (13). However, I assume that the latter three species were also present at those transects for which no records were obtained. For example, *C. gayaquilensis* occurs at rather low densities (e.g., c. 4 individuals/km<sup>2</sup> at MNT2; Appendix 19b) and so the species was likely overlooked at some transects. *C. squamatus* and *D. berlepschi* are canopy-dwelling taxa that, as a group, showed a delayed accumulation in transect-mapping surveys according to the original protocol (p. 98f, Influence of the main survey stratum; and Appendices 17a-17c). The same considerations also apply to other canopy species, like *Capito quinticolor* and *Tangara johannae*, which apparently

were missed at some transects. Likewise, diurnal raptors, such as *Leucopternis plumbeus* and *Micrastur plumbeus*, often went undetected in the pioneer study at Playa de Oro (Chapter 4, Discussion, Influence of Taxonomic affinities; and Appendices 13a-13c). Furthermore, the vocalizations of *Veniliornis chocoensis* were unknown at the time when the study was carried out and all records were based on visual observations. However, the last five species were probably not present at all transects.

All threatened species that are easily detected in audiovisual surveys showed a pronounced heterogeneous distribution pattern. For example, *Ara ambiguus* was predominantly recorded in areas close to the lower base of the Andean foothills at transects LT9, LT10, and LT11a to LT11c. MNT2 and LT4a were the only sites in the rolling lowlands where records of the macaw were obtained during transect-mapping surveys. At most transects this species was recorded only in overflight, and thus it remains uncertain to what degree these areas were of importance for the survival of the populations. The situation was very distinct at LT9 and LT10, where perched as well as flying birds were observed during most MTW samples (Fig. 52). The area of the Forestry Management Plan I evidently embraced very important feeding habitats of *A. ambiguus* and, given the birds' behavior, it may also have included nesting sites. *Penelope ortoni* was restricted to remote transects due to the species's sensitivity to hunting pressure (Jahn & Mena 2002Ä). Several records were obtained within the management plan area. The single lek of *Cephalopterus penduliger* that was detected along the total transect length of 25.15 km was located at LT10. In Playa de Oro, only one other lek of this taxon was found away from the transect network (Jahn *et al.* 1999b). Considering that the display calls of male umbrellabirds are audible for c. 400 m, it can be estimated that the density of display sites in the upper Río Santiago drainage is only c. 5-10 leks per 100 km<sup>2</sup> in an elevational range of between 50 and 400 m.

In order to estimate the conservation value of the single transects, I took into account the severity of extinction risk faced by each species (Table 53). According to this analysis, transects LT9, LT10, and LT11c were the most important sites for populations of globally threatened species, followed by transects LT11a and LT11b. Considering the varying transect lengths (Table 5) as well as the higher survey effort at MNT1, MNT2, LT9, and LT10 (Appendix 3), it can be concluded that LT11c, the most remote of all

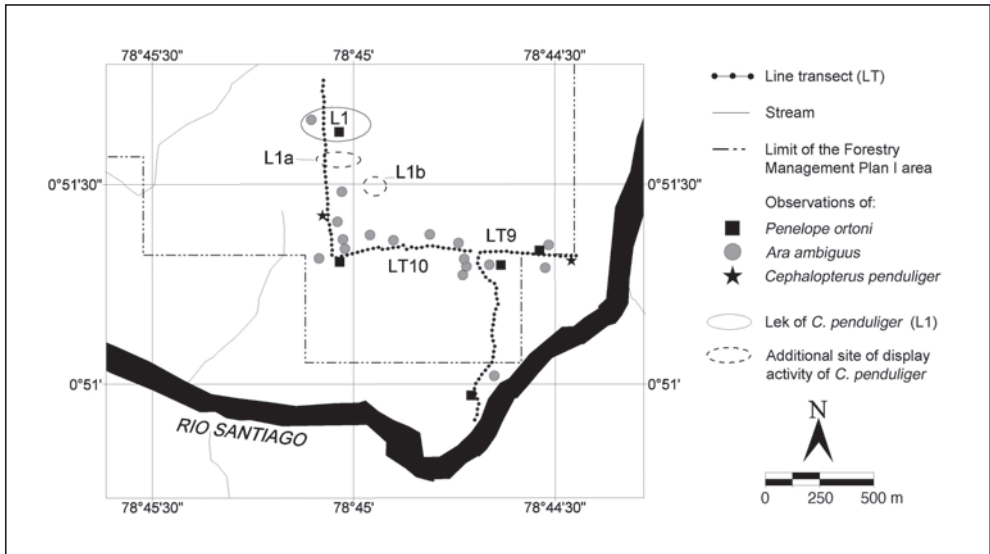


FIG. 52. Threatened birds and forest management in Playa de Oro. Location of transects LT9 and LT10 in the Forestry Management Plan I area and observations made of three globally threatened species (cf. Fig. 1b). Note: In comparison with Fig. 5.2 in Jahn (2001), there are two additional records for *Penelope ortoni*, which were based on recently identified tape recordings made during the MTW surveys.

transects, had a very high conservation value. Nevertheless, the Forestry Management Plan I area (LT9 and LT10) was clearly of critical importance for the populations of at least two globally threatened species, *Ara ambiguus* and *Cephalopterus penduliger*. Furthermore, it must be assumed that the importance of MNT1 for at-risk species was genuinely low, while it should not be deduced that MNT2 really had a higher conservation value than any of the transects LT1 to LT7 or LT8b. For example, the apparent low conservation value of LT6 was probably due to the fact that this transect was exclusively surveyed during the first three months of the MTW study, when my observer experience was still relatively poor.

## Discussion

How transect mapping improved conservation efforts

Data on threatened birds changed the land-use planning in Playa de Oro

At the time when I started the transect-mapping study, the local people, with technical support from the SUBIR Project, had already established the Forestry Management Plan I area. A forest inventory had

been carried out and governmental authorities had already approved the corresponding management plan (Palacios *et al.* 1996). During the study period, first timber exploitation trials were carried out along transect LT9. Consequently, my findings on the importance of the management area for globally threatened birds (Table 53; Fig. 52) came at a truly unsuitable moment.

Although a bird inventory was carried out in the area before the forestry management plan had been set up (Benítez & Matheus 1997), the study was not designed to provide comparative data on the presence or absence of threatened species. Furthermore, the survey methods used, mist netting in combination with some non-standardized visual observations, were clearly not appropriate to produce comprehensive species lists. In consequence, most globally threatened taxa recorded during the transect-mapping study (Table 53) remained undetected in the initial inventory of Benítez & Matheus (1997; cf. Appendix 6).

Although any changes obviously meant that some of the efforts and financial resources already invested in project activities would be written off, my data eventually convinced the managers of the SUBIR



Project, along with the community of Playa de Oro, to restructure the area of the initial management plan and to create a community reserve in the area of the *Cephalopterus penduliger* lek (Fig. 53). This reserve covered approximately 360 ha and included a trail for ecotourist activities, which ends at a beautiful waterfall (Jahn 2001). The idea was to use the umbrella bird lek and the presence of the Great Green Macaw as tourist attractions, thus helping to create an additional income for the local people (Jahn *et al.* 1999b). The selectively logged areas at LT9 were excluded from the reserve.

During the development of a community-wide land-use management plan, the inhabitants of Playa de Oro agreed to establish another much larger reserve. This preserve covered an area of some 3800 ha

and included transects LT11a to LT11c, which were found to embrace important habitats for globally threatened birds in the MTW study. Moreover, it formed a buffer zone for the Cotacachi-Cayapas Ecological Reserve. A third reserve was allocated in the transect areas of MNT2, LT7, LT4b, and LT4a, in order to conserve mature forest stands along the trail that connects the tourist facilities at Playa Rica with the village. Together, the three community reserves covered c. 4400 ha, gave protection to important sites for threatened species, and maintained valuable potential for ecotourist activities in Playa de Oro. Additionally, the area designated for sustainable forest management was extended to about 5100 ha, in order to ensure a regular income for the local people.

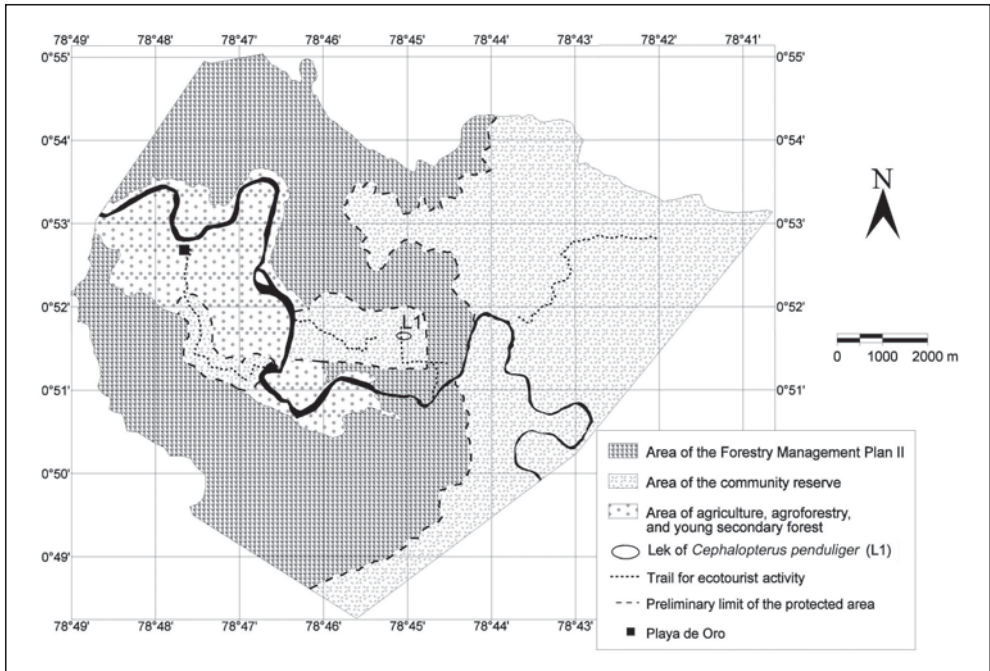


FIG. 53. The allocation of the community area of Playa de Oro in 1998 according to the draft for a community-wide land-use management plan. The area for the new Community Forest Management Plan (II) covered up to 5100 ha. The initial management area embraced only 500 ha (cf. Fig. 1b). A total of c. 1400 ha was allocated for the development of agriculture and agroforestry, mainly in areas that were already covered by secondary forest. Moreover, the zoning included three community reserves (c. 4400 ha) in areas identified as important for the conservation of threatened bird species and the development of ecotourist activities. The limits of the community reserves correspond to contour lines (not shown), which are visible in the field (Jahn 2001). The Cotacachi-Cayapas Ecological Reserve is located to the southeast of the community area.

Transect mapping generated important data at many other sites

The restructuring of the initial Forest Management Plan area in Playa de Oro was a key experience for SUBIR's project managers in two aspects: (1) the transect-mapping (MTW) technique was recognized as an efficient and affordable tool for the identification of areas of critical importance for the survival and reproduction of threatened and other sensitive bird species; (2) it was evident that MTW surveys had to be performed in the early planning phases of activities that might have adverse effects on the integrity of ecosystems, such as forest management, in order to avoid costly rezoning at later stages.

After 1998, SUBIR employed transect mapping as a standard rapid assessment method in all communities where forest management plans or land-use zoning were required. Moreover, between 1999 and 2001 MTW was also used in the biological monitoring of the impacts of forest management activities (Alarcón 2001). Until the conclusion of the SUBIR Project in 2001, transect-mapping surveys were carried out at 16 of the 18 localities shown in Fig. 40. Three additional leks of *Cephalopterus penduliger* were located in the Río Chimbagal drainage, and remnant populations of *Harpia harpyja*, *Penelope ortonii*, *Crax rubra*, *Ara ambiguus*, and many other threatened species were discovered (pers. obs.; P. Mena V., pers. comm.). These data were used for the delimitation of various community reserves as well as for the design of a proposed biosphere reserve in the Ecuadorian Chocó (SUBIR 2000). Moreover, they also provided the baseline information necessary for the determination of mitigating measures in site-specific environmental impact assessments (EIAs), using regionally adapted guidelines (SUBIR 1999). The EIAs were requested by USAID, the principal donor of the SUBIR Project, as a prerequisite for the approval of planned project activities.

Did the land-use zonings survive the end of SUBIR?

The land-use zoning for Playa de Oro (Fig. 53) and other community areas in the Ecuadorian Chocó, as well as the mitigating measures defined in the environmental impact assessments for the forest management plans, were never fully implemented in practice. There are several reasons for this disappointing fact, the most important of which being that SUBIR

simply ceased too soon. Sustainable forest management basically remained in the trial phase in most communities.

Regarding the particular situation of Playa de Oro, it should be added that the forest was still there when I revised the present work in May 2008 (Ruth Muñoz, pers. comm.). Most local people were surprisingly conscious of the exceptional economic value of their forests and the biodiversity maintained by them. It was a late success of environmental education efforts that the *Harpia harpyja* pair was not shot by the local people on its discovery in 2003 (José Arroyo, pers. comm.). Instead, they managed it to attract a small project that studied the Harpy Eagles (Ruth Muñoz, pers. comm.). Of course, local people still intensively hunt for subsistence. For example, an individual of *Crax rubra* was shot as recently as 2004 (José Arroyo, pers. comm.).

Many community members are desperate to improve their quality of life. The income generated by varying, but mostly low, numbers of ecotourists visiting the area, as well as by other small projects, like the one studying the Harpy Eagles, is not enough by far to satisfy the needs of Playa de Oro's 300 inhabitants. As long as sustainable management strategies and/or compensation payments for environmental services (e.g., preservation of biodiversity and avoided carbon emissions through the maintenance of natural forest) do not permit acceptable living conditions, the risk continues to grow that one day in the near future the community will sell its forest to one of the timber companies that continually propose such plans.

Lessons learned for the use of transect mapping

Perhaps the most important lesson learned from the application of transect mapping in a real-world conservation and development project was that the method worked. Areas critical for the conservation of threatened and other sensitive avian species could be accurately and efficiently identified. Moreover, the same observers could survey large mammals, e.g., monkeys, simultaneously with the birds (pers. obs.; P. Mena V., pers. comm.). The data facilitated the design of community reserves and other mitigating measures for planned forest management operations. However, not even the best land-use zoning or management recommendations based on sound biological data will have any real benefit for biodiversity

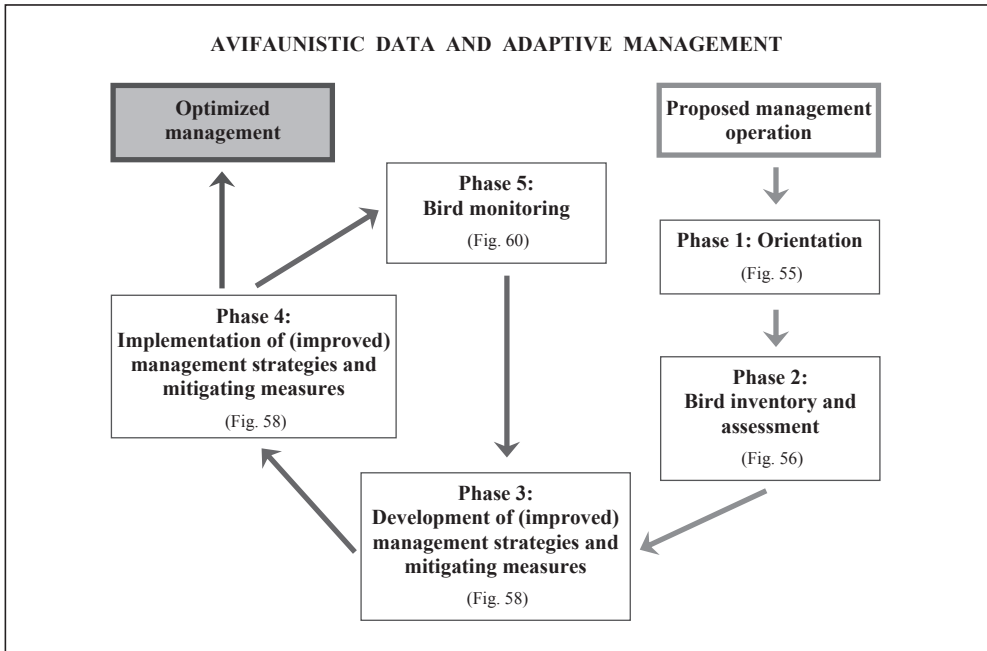


FIG. 54. Block diagram of adaptive management through the integration of avifaunistic data in the development of land-use strategies. The continued monitoring of the impacts of management activities on threatened birds and other sensitive species facilitates the optimized use of biological resources. Note that data on other taxonomic groups should also be considered whenever feasible. See Figs. 55, 56, 58, and 60 for details on each phase.

conservation until these results are fully implemented at the local level and integrated in day-to-day management practice, and as long as the success of these mitigating measures is not appropriately monitored.

#### Transect mapping as a tool for adaptive management

Adaptive management of natural resources is achieved through the systematic acquisition and application of scientifically reliable information over time. In contrast to trial-and-error approaches, which may be characterized as 'reactive learning' or 'crisis management' (Wilhere 2002), active adaptive management schemes are conducted as a deliberate experiment (Walters & Hilborn 1978). Distinct management regimes are implemented through statistically valid experimental design (Hurlbert 1984). Environmentally least damaging strategies are developed through the integration of monitoring and management activities (Wilhere 2002).

To promote an adaptive management of natural resources through the integration of biological data in the design, monitoring, and optimization of strategies for their sustainable use and conservation, I provide guidelines that could be applied in a wide range of operations. The principal objective is to reduce to a minimum the loss of biodiversity in human-managed tropical landscapes. Globally and regionally threatened taxa are the most important target groups in this approach, due to the reasons stated in the previous chapter (p. 213-215, Birds as indicators of environmental change). 'Non-threatened' restricted-range species and other avian taxa that are known to be sensitive to alterations of their pristine habitats should also be considered, since many of them will soon be in trouble if their habitats continue to be destroyed at current rates. Of course, the approach outlined here is not at all restricted to avifaunistic data. On the contrary, threatened and sensitive species of other taxonomic groups should be taken into account whenever feasible. Although I will focus on

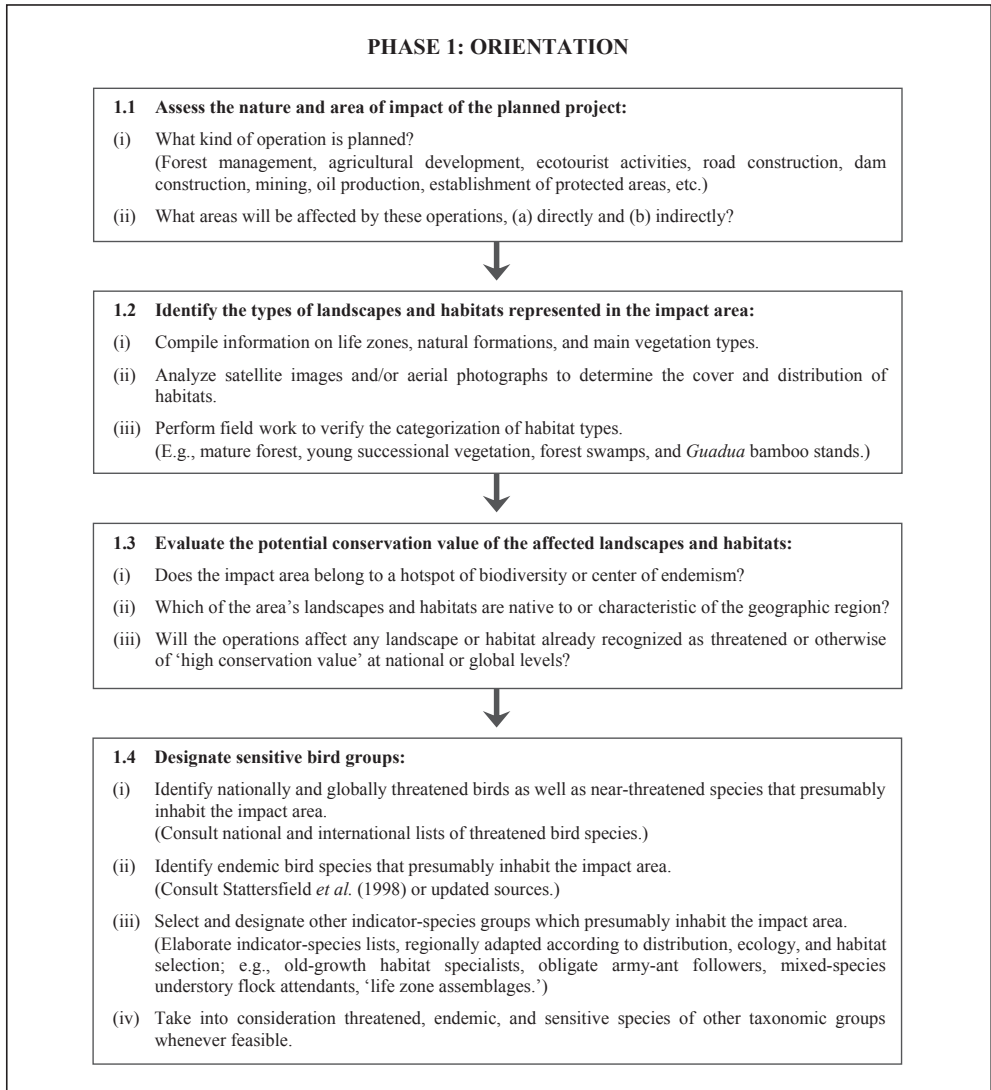


FIG. 55. Investigation and planning scheme for an adaptive management of biological resources through the integration of avifaunistic data in the development of land-use strategies. Phase 1: Orientation (cf. Fig. 54). Adapted and enhanced on the basis of Jahn (2001: 45) and Flade (1994: 610).

the use of transect mapping, because it might be the most effective, efficient, and affordable bird survey method for this task, in theory any other audiovisual method (e.g., spot mapping and point counting) could also be applied (p. 99-103, Comparison of MTW with other potential rapid assessment methods).

The consideration of biological data should begin as early as possible during the project development, in order to avoid costly reevaluations of land-use zonings, planned routes for roads or skidder trails, and management options. In the following, I will discuss each phase of the investigation and planning scheme (Fig. 54) in detail.

*Phase 1: Orientation (Fig. 55)* – The type and magnitude of planned operations evidently has implications for all further steps to be taken. The project characteristics will determine the area directly or indirectly affected by the impacts. Thus, these factors

will be decisive for the scope, design, duration, and costs of the study.

Here I choose the hypothetical example of a timber company that has purchased a tract of 20 000 ha of natural forest in the Ecuadorian Chocó lowlands.

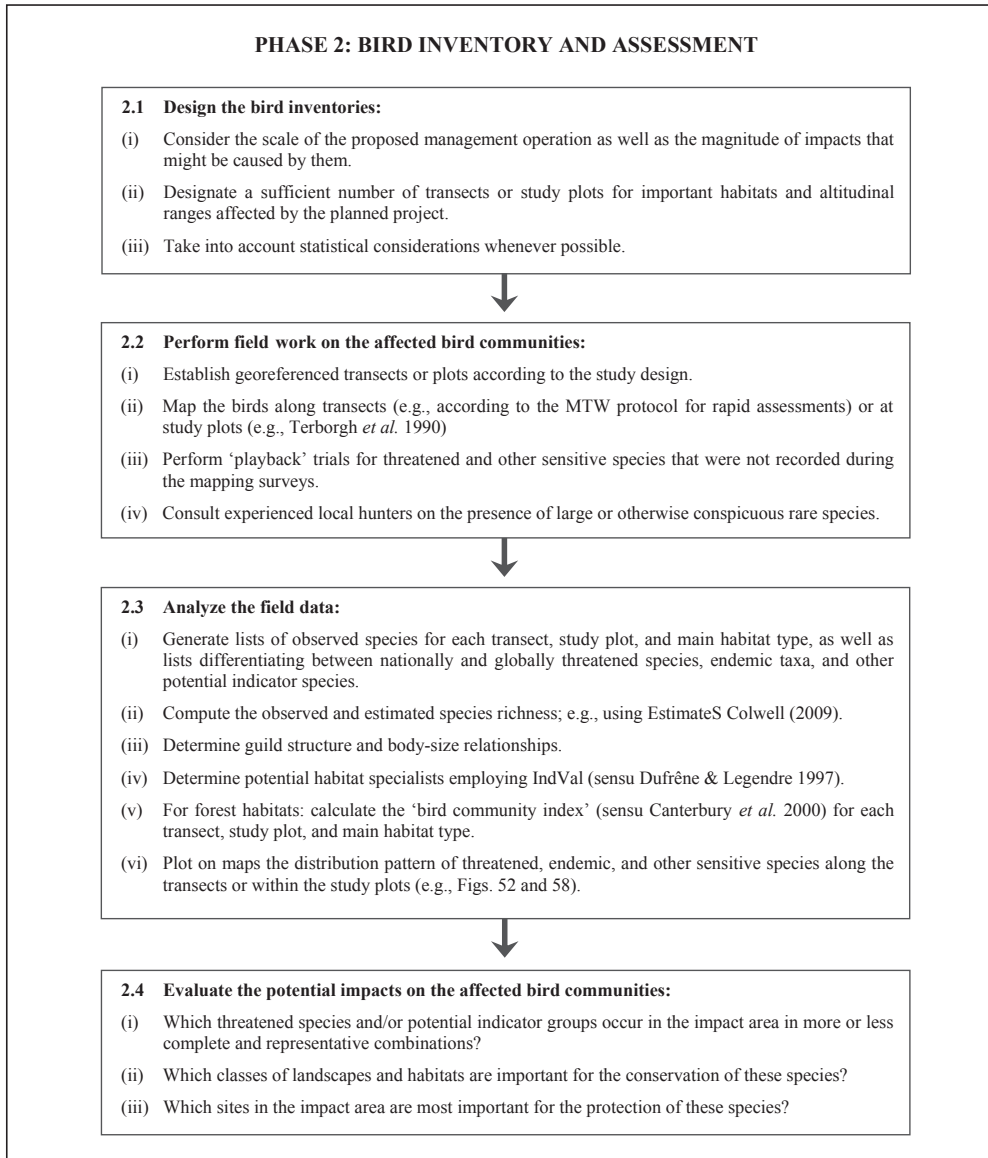


FIG. 56. Investigation and planning scheme for an adaptive management of biological resources through the integration of avifaunistic data in the development of land-use strategies. Phase 2: Bird inventory and assessment (cf. Fig. 54). Adapted and enhanced on the basis of Jahn (2001: 45) and Flade (1994: 610).

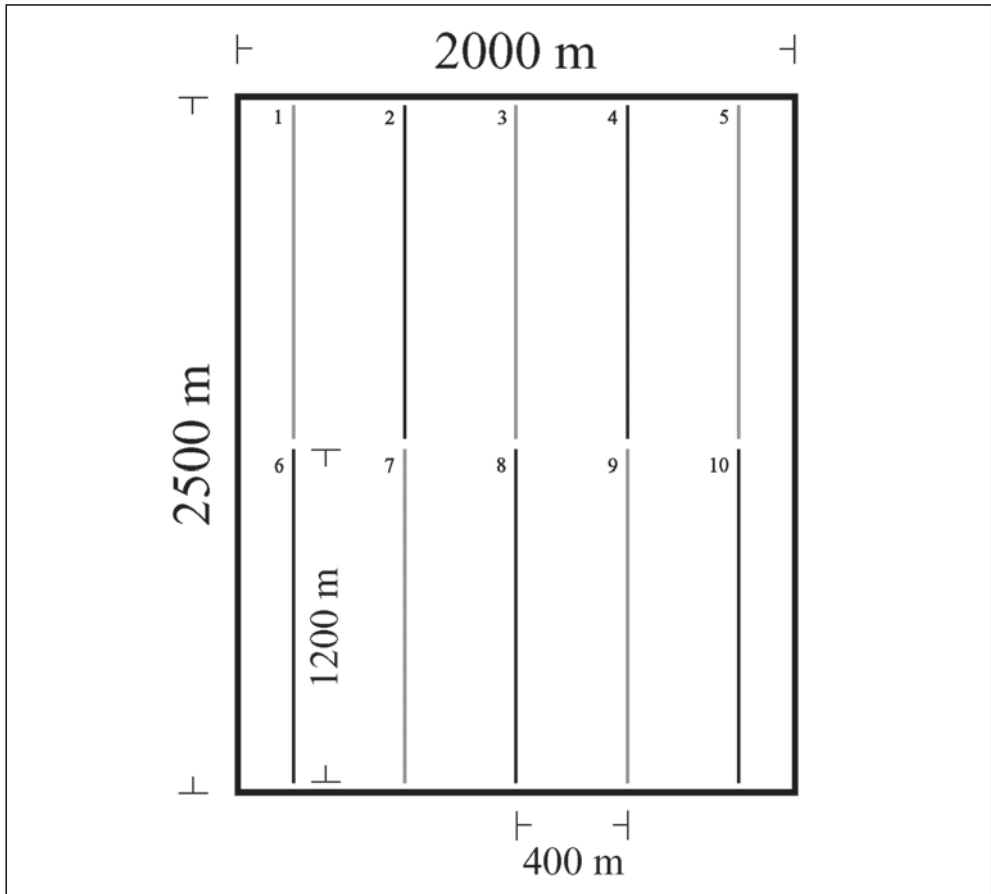


FIG. 57. Schematic design for a bird inventory in a forest plot of 500 ha. Ten transects of 1200 m each are established and surveyed according to the improved transect-mapping (MTW) protocol for rapid assessments (p. 103-106). Large mammals might be surveyed together with the birds. A single experienced observer could cover about five transects (250 ha) per field trip or c. 2000 ha per year, assuming a reasonable number of eight field trips in the same period. Note that in areas with irregular topography it might be impossible to establish 10 transects per 500 ha. In any circumstances the researchers should aim to survey not less than six transects per forest plot of this size.

The company decides to implement a sustainable management regime, and aspires to gain a 'green' certification (e.g., Cauley *et al.* 2001) in order to open up new markets for their products and to improve the profit margins of their operations. Two experienced biologists are hired to ensure that the management activities will comply with the criteria for properly and sustainably managed natural forests, defined by an international certifying organization. In the orientation phase, the biologists learn that the

company plans to harvest c. 500 ha annually using skidders, bulldozers, and trucks (Box 1.1). A geographer assists in setting up a geographic information system (GIS) based on recent satellite images of the property (Box 1.2). The cover and distribution of main habitat types, life zones, and natural formations are determined with the help of the GIS, taking into consideration published information and verifications in the field. It is evident that the management operations will mostly affect primary forest of high



conservation value (Box 1.3), which is already recognized as threatened at national and global levels (e.g., Mittermeier *et al.* 1998, Olson & Dinerstein 1998, Sierra *et al.* 1999a, Myers *et al.* 2000). Lists are compiled of threatened, endemic, and otherwise sensitive bird species, which potentially may occur in the impact areas (Box 1.4). The biologists decide to take large mammals into consideration because *Ateles fusciceps*, a primate recognized as Critically Endangered at global and national levels (Hilton-Taylor 2000, Tirira 2001), might also be present in the forest tract.

*Phase 2: Bird Inventory and Assessment (Fig. 56)*

– The macro design for the inventory study is discussed with the staff of forest managers and engineers and adapted to the proposed size of annual harvesting areas as well as to the sequence in which the forest blocks are to be exploited (Box 2.1). The biologists decide to establish, for each forest tract of 500 ha, 10 transects of 1200 m each, c. 400 m apart (Fig. 57). The transects are surveyed according to the optimized transect-mapping (MTW) protocol for rapid assessments (p. 103-106, Guidelines for an optimized transect-mapping protocol for rapid assessments; Box 2.2). The method permits almost complete coverage of each 500 ha plot for avian species with far-carrying vocalizations, to which many of the larger threatened taxa belong (e.g., *Penelope ortonii*, *Ara ambiguus*, *Cephalopterus penduliger*). If a team of forest workers or field assistants sets up the trails beforehand, a single observer can survey five transects (covering c. 250 ha) per field trip of about three weeks. In this way, the two biologists together could inventory c. 4000 ha of forest per year, supposing that eight field trips per person are performed in the same period. However, at a randomly selected subsample of transects, the study design should include some kind of combined repeated-sampling / double-observer / double-survey approach to assess observer-dependent species-specific detection probabilities and observer bias (cf. p. 173f, Guidelines for the use of transect mapping (MTW) in monitoring studies). For instance, two observers could simultaneously but independently carry out an MTW monitoring survey (24 samples), after one of them has finished an MTW rapid assessment of the same transect. Because these quality controls are very time consuming, it is advisable applying them only at one or two transects per year, alternating surveys between dry and rainy seasons. The actual area inventoried further decreases due to the monitoring study, which is carried

out by the same team of researchers (see below). Consequently, it is a more reasonable approximation that c. 2000 ha are inventoried per year and that the total property could be assessed within about 10 years. The field data, an estimated 8000 to 12 000 observations per complete survey of 10 transects, are transferred to the geographic information system (GIS), and the distribution pattern of threatened, endemic, and other sensitive species along the transects are plotted on digital maps (Box 2.3). Observed and estimated species richness are computed for each transect and forest plot of 500 ha to obtain data on the completeness of the surveys (p. 135-140, Observed and estimated species richness and p. 161-163, Performance of species richness estimators). The 'bird community index' (sensu Canterbury *et al.* 2000) is calculated to identify those transects characterized by a high proportion of forest-dependent species (p. 181f, Assessment of the conservation value of MNT1 and MNT2). The potential impacts of the management operations on the affected bird communities are evaluated on the basis of these data (Box 2.4).

*Phases 3+4: Development and implementation of management strategies and mitigating measures (Fig. 58)* – After the biological information from various neighboring forest blocks has been gathered, analyzed, and pre-assessed, concrete actions can be developed. Several species of conservation concern were found in the bird inventories (Fig. 59). Based on distribution patterns, ecological requirements, and natural history of each threatened bird and mammal species, areas of critical importance for the maintenance of their populations are identified and visualized in digital maps (Box 3.1). These key areas include territories, home ranges, nesting trees, and lek sites of sensitive species, as well as wildlife corridors (Fig. 59). In agreement with the forest managers, they are declared conservation zones, which will be spared from timber harvesting and other impacts (Boxes 3.2 to 3.4b). Nevertheless, the conservation zones are probably not large enough to guarantee the survival of some of the at-risk species. Therefore, additional mitigating measures are developed for the surrounding timber harvesting areas. These management recommendations include reduced-impact logging techniques (e.g., Dykstra & Heinrich 1996, Pinard & Putz 1996, Bertault & Sist 1997), restricting the maximum number of trees harvested per unit area (e.g.,  $\leq 6$  trees/ha) or determining a minimum number of large trees to be retained throughout the logging areas (e.g., Lindenmayer *et al.* 2000). More-

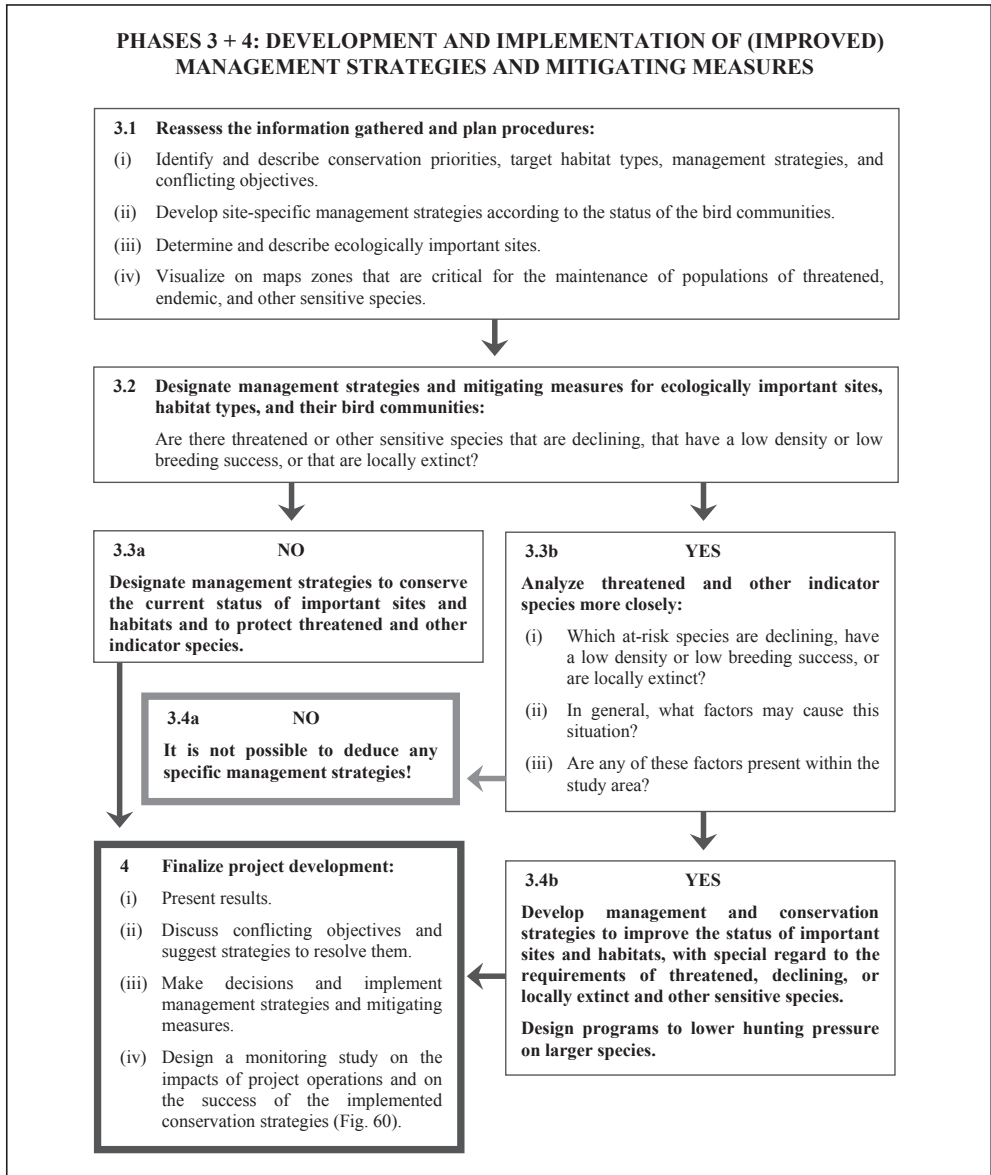


FIG. 58. Investigation and planning scheme for an adaptive management of biological resources through the integration of avifaunistic data in the development of land-use strategies. Phases 3+4: Development and implementation of management strategies (cf. Fig. 54). Adapted and enhanced on the basis of Jahn (2001: 45) and Flade (1994: 610).

over, many of the target species are sensitive to direct persecution, and thus effective measures for the control of hunting are developed (e.g., Redford & Robinson 1987, Robinson *et al.* 1999, Cauley *et al.*

2001). Monitoring programs for the nesting trees of *Harpia harpyja* and *Ara ambiguus* are recommended, which might be performed by an interested NGO or individual, which is why these species-specific studies

are not taken into consideration in the description of the next phase of 'monitoring and reassessment' (Fig. 60).

Other areas, that were found to be relatively poor in threatened and other sensitive species, might be managed with higher intensity than those embracing important populations of at-risk species. In this case, no or fewer reserves and wildlife corridors would be planned and other mitigation measures restricted to basic methods of reduced-impact logging.

In the final step of project development, the conservation plans and management recommendations are presented to the company executives (Box 4). Conflicting objectives are discussed and resolved. Once a compromise is reached, the management

strategies and mitigating measures are implemented, e.g., reserves and movement corridors are georeferenced and unequivocally marked in the field. A monitoring program is designed and implemented before the timber in the relevant forest plots is harvested.

*Phase 5: Bird monitoring and reassessment (Fig. 60)*

– Although the conservation measures are based on the 'best available scientific knowledge', this is no guarantee that they are sufficient to maintain the populations of threatened and other sensitive species in the medium and long term. Thus the biologists design a monitoring project to study the impacts of the management operations and the success of the implemented mitigation measures (Box 5.1). They

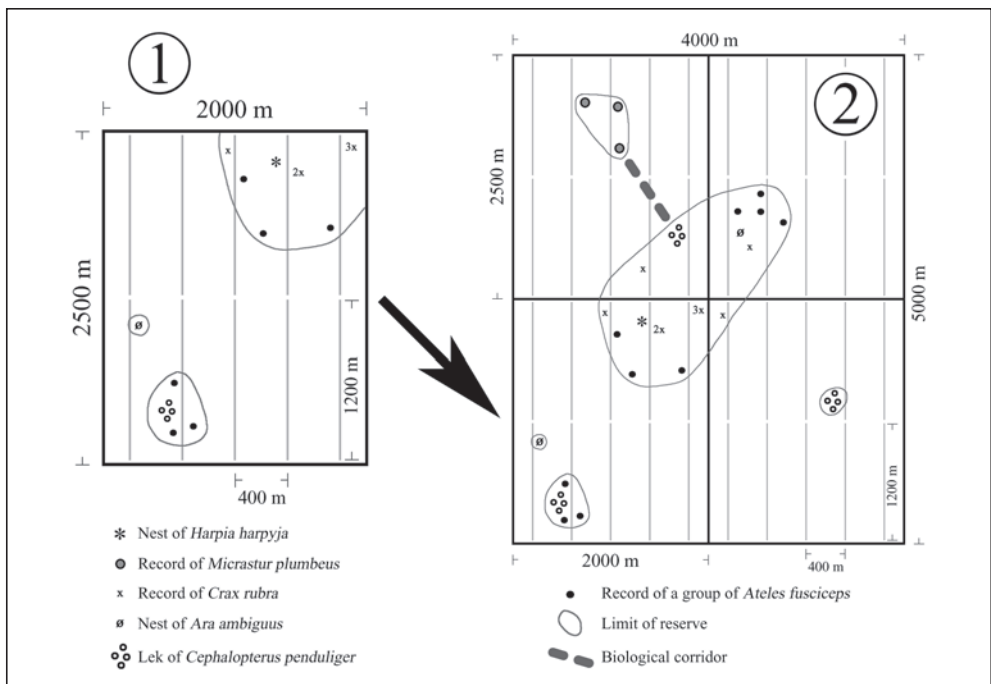


FIG. 59. Hypothetical example for the zoning procedure based on field records of threatened birds and large mammals. (1) Areas of critical importance for the maintenance of populations of at-risk species are identified on the basis of georeferenced transect mapping data. Potential conservation zones are delimited taking account of the ecological requirements and natural history of each species. (2) Areas important for the maintenance of at-risk species are unified between various forest plots to generate larger reserves, which might be more viable than smaller conservation units. Moreover, biological corridors should be established between reserves whenever feasible. The exact limits and extent of each reserve and movement corridor should be determined in the field, using conspicuous elements in the landscape, such as streams, ridges of hills, ravines, and gullies. The reserves should be surrounded by buffer zones (not shown) where low-impact management schemes are implemented.

## PHASE 5: BIRD MONITORING AND REASSESSMENT

### 5.1 Design a monitoring study on the impacts of management strategies and the success of implemented mitigating measures and conservation actions:

- (i) Use the same transects or study plots as established in the bird inventories whenever feasible (Fig. 56; Box 2.2).
- (ii) Alternatively, establish new georeferenced transects or study plots in important habitats in areas that will be affected by productive activities as well as conservation strategies.
- (iii) Establish independent controls in the same habitat types that will not be affected by the management activities and mitigating measures, neither directly nor indirectly.
- (iv) Make sure that the design of the monitoring study allows statistical testing of pre-impact vs. post-impact samples, managed plots vs. controls, and, whenever possible, comparative analyses between various treatments.



### 5.2 Perform monitoring surveys on the affected bird communities:

- (i) Map the birds along transects (e.g., according to the MTW monitoring protocol) or at study plots (e.g., Terborgh *et al.* 1990) at least twice before management impacts occur.
- (ii) Survey the birds shortly after the first management operations were performed and subsequently twice per year or at least twice every second year (cf. Fig. 39).
- (iii) Perform 'playback' trials for threatened and other sensitive species that were not recorded during the mapping surveys.
- (iv) Carry out repeated-sampling, double-observer, and double-survey studies for a randomly selected subsample to account for heterogeneous species detectabilities and observer bias, whenever feasible.
- (v) Gather data on habitat structure (e.g., canopy cover and tree-fall gaps).
- (vi) Survey the controls accordingly; e.g., within a few days or weeks of pre- and post-impact studies.



### 5.3 Analyze the field data:

- (i) Carry out the analyses and tests mentioned in Fig. 56, Box 2.3.
- (ii) Calculate abundance indices (e.g., number of territories per kilometer transect) or absolute population densities whenever feasible.
- (iii) Quantify differences between pre- and post-impact samples and between distinct treatments, as well as between these samples and the controls and perform statistical tests.
- (iv) Plot on maps changes in the distribution pattern of threatened and other sensitive species along the transects or within the study plots.



### 5.4 Assess the impacts on the affected bird communities:

- (i) Which threatened species and other potential indicator taxa show population changes due to the impacts caused by the management activities?
- (ii) Which types of habitats and microhabitats are important for these species?
- (iii) How successful were mitigating measures in maintaining the populations of threatened, endemic, and other sensitive species?
- (iv) Optimize management strategies and mitigating measures following the steps in Fig. 58.

FIG. 60. Investigation and planning scheme for an adaptive management of biological resources through the integration of avifaunistic data in the development of land-use strategies. Phase 5: Bird monitoring and re-assessment (cf. Fig. 54).

decide to implement two monitoring approaches that focus on different scales of change in habitat structure and bird community composition.

The first monitoring study concerns landscape-level changes and employs the same principal design as used in the bird inventories. However, for reasons of practicality not the entire forest plot of 500 ha is monitored but only half, that is, 5 randomly chosen transects covering about 250 ha (Fig. 57). Otherwise, the bird inventories that have to be continued in other forest tracts would suffer delays due to the time effort spent on the monitoring study. The monitoring plots are selected from those forest blocks for which conservation measures are already implemented, according to the processes described above (phases 1 to 4). The most basic experiment includes at least two plots that will be managed in distinct ways as well as a control plot (Box 5.1). Note that for the implementation of more statistically robust experimental designs additional biologists would have to be hired, a prerequisite probably not fulfilled in most real world scenarios for economic reasons. The plots are established in the same forest type and altitudinal range, but are separated from each other by at least 1000 m to ensure independence. The first treatment block, for example, embraces extensive conservation zones (i.e., reserves and wildlife corridors) that are inhabited by a high number of threatened species and other sensitive taxa as well as a reduced-impact management regime within wood production areas (e.g., pre-planned skidder trails, directional felling, high degree of tree retention). The second treatment plot is characterized by few, if any, implemented mitigating measures. In other words, the timber there will be exploited with the high-impact regime conventionally used by the company. All transects of the three plots are surveyed twice before the harvesting impact (Box 5.2), ideally always within a few weeks of each other to minimize the effects of seasonal variations. The surveys are performed according to the transect-mapping protocol for rapid assessments (p. 103-106, Guidelines for an optimized transect-mapping protocol for rapid assessments). At least one randomly chosen transect per treatment should be surveyed, using the aforementioned combined repeated-sampling / double-observer / double-survey approach (Phase 2; see also p. 173f, Guidelines for the use of transect mapping (MTW) in monitoring studies). Habitat information, such as canopy cover, canopy height, stem density, DBH, etc., are collected randomly within the

plots. Moreover, the number and characteristics of tree-fall gaps are determined within the belts of 25 m at each side of the transects or alternatively on the basis of high-spatial-resolution satellite images for the entire study plots (cf. Clark *et al.* 2004a,b). A few months after the harvesting impacts, the transects are reestablished and surveyed again, including those of the control plots (Box 5.2). Monitoring surveys are repeated at least once a year. Comparative statistical analyses are carried out between pre- and post-impact samples, between distinct treatments, and between these samples and the controls, principally through Mann-Whitney U-tests (Box 5.3). Variables compared include numbers of threatened, endemic, and other sensitive species groups, as well as species richness, bird community index, guild structure, body mass relationship, relative abundance, and habitat characteristics. This design permits monitoring of changes that have occurred in forest tracts of 250 ha each. Thus, it also reflects the success of the implemented conservation measures at that scale, i.e., whether populations of threatened and other sensitive species were affected by the management operations or not. If the magnitude of observed changes is compared with the ecological requirements of those species most adversely affected, improved management options as well as mitigating measures can be developed and implemented (Box 5.4; Fig. 58). A new monitoring cycle begins. Obviously, the number of monitored forest plots would increase rapidly over time. To handle this situation, plots for which pronounced changes in bird species composition were confirmed shortly after the management impacts are surveyed with less frequency (e.g., every third year) or excluded from further monitoring. These treatment plots have already demonstrated that implemented management regimes were too destructive and mitigating measures not sufficient. Thus, it is not required to continue monitoring them with the same intensity. However, depending on the magnitude of the impact, alterations in the composition and structure of the bird community may appear only after a certain time lag (e.g., Brooks *et al.* 1999, Ferraz *et al.* 2003). Consequently, all plots where management strategies and conservation measures were seemingly successful in maintaining populations of the target species are monitored continuously.

The second monitoring approach concerns the much finer scale of changes in absolute population density and biomass density. This study requires a more intensive and costly survey method. Therefore,

it is not employed until one or a few optimized management models are available. The most basic design includes at least four transects per treatment (more is better) that are managed according to the adapted strategies, and an equal number of controls that are affected by neither direct nor indirect impacts of the operations (Box 5.1). In the case of limited funds and time, the number of habitats or impact scenarios to be considered as well as the frequency of surveys should be reduced in favor of a rigorous statistical design. All transects are randomly chosen, 1200 m long, and separated by at least 500 m to ensure independence. They are surveyed, according to the transect-mapping protocol for monitoring studies (p. 169-175, Guidelines for the use of transect mapping (MTW) in monitoring studies), at least twice before the management operations are carried out and then twice a year or twice every second year (Fig. 39 and Fig. 60, Box 5.2). Note that in this more detailed MTW monitoring scheme, double surveys should include additional sampling techniques, such as intensive playback trials and capture/recapture mist netting (cf. p. 173-175, last subchapter of Discussion and p. 177, Conclusion). However, in most real world projects heterogeneous species detection probabilities and observer bias would be addressed only through a combined repeated-sampling / double-observer approach (see p. 233, Phase 2), as the costs of more intense methods would be prohibitive in most circumstances. Environmental parameters such as habitat structure are monitored accordingly. Comparative statistical analyses are carried out as described above (Box 5.3). For most species this design allows the detection of even slight long-term changes in absolute population densities that usually remain undetected in the coarse-scale monitoring described above. A fine-tuning of management strategies is possible through testing of cause-and-effect relationships between management activities, changes in ecosystem conditions, and changes in species-specific absolute population densities (Box 5.4). However, the method might be less useful for monitoring the success of landscape-level conservation measures, which is why the first monitoring regime is also continued.

In any monitoring project it should be taken into account that differences between observers exist not only in results of field surveys, i.e., in the number of species and individuals recorded when the same study plots are sampled simultaneously by different workers with the same methods (Conant *et al.* 1981,

Sauer *et al.* 1994), but also in the interpretation of one and the same set of field data (O'Connor 1981, Verner & Milne 1990). Consequently, the same group of researchers should carry out all surveys and data analyses during the study period.

The practice-based approach of adaptive management, explained here with help of a hypothetical example, clearly depends on an intense collaboration between biologists, resource managers, and land-owners. Conflicting objectives, e.g., between economic profits and conservation goals, must be openly discussed, evaluated, and successfully resolved. Recognizing that commercial logging operations always have adverse effects on biodiversity, and that mitigating conservation measures often affect profit margins, all adaptive management decisions necessarily represent compromises. The ideal outcome of this process would be a zoning of the entire management area into wildlife reserves, movement corridors, and (predominantly) production areas with site-specific harvesting strategies and mitigating measures, including less intensively used buffer zones in the vicinity of integrated conservation areas.

#### The challenge of biodiversity conservation in managed tropical forests

Some researchers are skeptical about the feasibility of sustainable natural forest management as a means of achieving biodiversity conservation and regard totally protected areas as the only alternative for maintaining populations of old-growth habitat species (e.g., Robinson 1993, Rice *et al.* 1997, Bawa & Seidler 1998, Bowles *et al.* 1998, Struhsaker 1998). Clearly, extensive and strictly protected wildlife reserves are essential for the maintenance of biodiversity. However, they cannot ensure the continued existence of the majority of tropical forest ecosystems (Putz *et al.* 2001). Even if 10-12% of the Earth's surface were appropriately protected, sited, and managed, up to 50% of all tropical species might still be lost during the next few decades (Soulé & Sanjayan 1998). Thus given the extent of tropical forests outside protected areas, biodiversity-sensitive management is an important option for minimizing the expected wave of extinctions (e.g., Chazdon 1998, Whitmore 1999, Putz *et al.* 2001). Managed natural forests maintain considerably more biodiversity than oil palm and pulpwood plantations, maize fields, or cattle pastures (e.g., Petit & Petit 2003). This makes logging often the least deleterious form of those land uses that are also financially viable on a regional



scale (Pearce *et al.* 1999). However, much remains to be done to put into effect the potential value of managed natural forests for maintenance of tropical biodiversity. Despite numerous studies demonstrating that training workers, pre-planning log-extraction trails, practicing directional felling, and implementing a variety of other well-established forestry practices reduces not only environmental damage but also the financial costs of timber harvesting, destructive logging is still the rule in most parts of the tropics (Poore *et al.* 1989, Johnson & Cabarle 1993). The most important reason is that the cost savings associated with good logging practices relative to unplanned timber extraction by untrained workers may not materialize under some conditions (Putz *et al.* 2000). In most large-scale logging operations, including those in Ecuador (C. Carrera, pers. comm.), fellers and skidder drivers are paid on the basis of the extracted timber volume. Consequently, training in reduced-impact logging practices might reduce the risk of accidents for fellers and decrease the likelihood of log breakage during felling but, on the other hand, restricted access to steep slopes or wet-weather shut-downs negatively affect income. Moreover, tropical timber companies rarely own the forests they harvest but rather operate on the basis of short-term leases from governments. Considering that some financial benefits of reduced-impact logging appear in the long term rather than immediately, logging contractors have little incentive to practice reduced-impact logging or to care about biodiversity conservation (Poore *et al.* 1989, Bawa & Seidler 1998). The resulting 'forest mining' depresses local and regional timber prices, affecting the perceived overall value of tropical forests. These and other conditions help explain why conventional destructive logging persists in tropical areas where regulations are nonexistent or unenforced (Putz *et al.* 2000, 2001).

## Conclusion

Large protected areas are essential for biodiversity conservation; however, even under the most optimal conditions they will not help to avoid the extinction of many tropical forest species. Given the extent of

tropical forests outside protected areas, biodiversity-sensitive management is an important option for minimizing the expected wave of extinctions. Managed natural forests might play a significant role in biodiversity conservation if accurate data on local distribution patterns and the ecological requirements of threatened species and other sensitive taxa can be integrated in the development of adaptive management strategies. However, large-scale sustainable management will not be achieved until the true benefits of natural tropical forests (e.g., biodiversity conservation, protection of watersheds, and carbon sequestration) are realized, and the costs associated with these environmental services are spread widely and eventually carried by the consumers of tropical forest products.

Transect mapping (MTW) might be the most effective, efficient, and affordable method of generating conservation- and management-relevant information for tropical birds. On the basis of avifaunistic data, site-specific land-use strategies and mitigating measures can be developed. By monitoring the impacts of these management operations and the success of accompanying mitigating measures, it is possible to improve strategies and conservation action plans. Such a cycle of monitoring and adjusting could facilitate an optimized management of natural resources. The ideal outcome would be a zoning of the entire management area into wildlife reserves, movement corridors, and (predominantly) production areas with site-specific harvesting strategies and mitigating measures, including less intensively used buffer zones in the vicinity of integrated conservation areas.

Transect mapping could be a tool for adaptive management in a wide range of other operations and projects, like agricultural development, ecotourist projects, road construction, or design and maintenance of protected areas. Moreover, the potential use of transect mapping is not restricted to birds but could be adapted for other taxa with distinct vocalizations, such as some mammals and amphibians. Its use is not limited to *terra firme* forest either but could be adjusted for forest streams, small rivers, lakes, and mangroves, whenever the absence of strong currents permits data collection from electric-engine-powered boats.



## 8. SUMMARY

Effective and affordable rapid assessment methods are an important prerequisite for the consideration of biological data in the development of management strategies for natural resources. For this reason, I have developed the 'Multi Time-Window Transect-Mapping' (MTW) technique for audiovisual surveys of tropical bird communities. In many aspects the method is similar to the 'plot-mapping' approach of Emlen (1977) and, particularly, Thompson *et al.* (1992) but differs, among other things, in adapting the mean observer speed to the activity level of the birds as well as to topography, weather conditions, observer skills, and other factors. The research was performed in Playa de Oro (0°52'35"N, 78°47'40"W; 45–590 m a.s.l.), Esmeraldas Province, northwestern Ecuador. I sampled 18 transects, using the MTW method. The transects had a total length of 25.14 km and varied in length between 550 and 1700 m. According to the original protocol, one complete MTW survey consisted of six individual samples at different periods of the day. The position of each bird is mapped by means of 25-m distance markers, revealing the distribution pattern of species and flocks along the transect route. The method is highly effective, even in structurally complex and biodiverse tropical forests. In order to perform a comparative study of the effectiveness of mist-netting and transect-mapping protocols, I chose two independent transects, MNT1 (625 m) and MNT2 (550 m). They were located in a similarly structured habitat mosaic of managed and abandoned plantations, young successional vegetation, and selectively logged forest. The greater variability of human-managed habitats on the outskirts of Playa de Oro village was the principal reason why, according to standardized mist netting (MN) as well as MTW surveys, the avifauna was more species-rich and diverse at transect MNT1 ( $n_{MN} = 117$ ;  $n_{MTW} = 162$ ) than at MNT2 ( $n_{MN} = 96$ ;  $n_{MTW} = 144$ ). Nevertheless, the number of forest-dependent bird species and threatened taxa was higher at the latter transect, likely due to the lower degree of fragmentation and higher foliage complexity of the upper strata, as well as to lower levels of hunting pressure. In conclusion, the conservation value of study sites should not be ranked on the basis of bird species richness or diversity indices, but rather through an analysis of species composition. For example, the 'bird community index' (BCI) sensu Canterbury *et al.* (2000) contrasts disturbance-

sensitive forest taxa with disturbance-tolerant species. This index clearly reflected the higher value of MNT2 in comparison with MNT1 for the conservation of forest-dependent birds when calculated using MTW data ( $BCI_{MNT1} = -0.049$  versus  $BCI_{MNT2} = 0.541$ ). Considering comparative effectiveness and efficiency, the results indicate that in only 8–9% (21–23 h) of the study time, 39–50% (45 and 48) more bird species were recorded by transect mapping than by mist netting. With a study effort of only 44.5 h, 88% of all breeding bird species in the area were registered by MTW. By comparison, only 58% of the breeding residents were mist-netted in 544 h (4817 MNH, mist-net hours). The costs of a transect-mapping study are approximately only 5% of a comparable mist-netting project, with the former simultaneously producing greater accuracy and relevance of results. Proportions found in MTW data sets for major taxonomic groups (non-passerines, suboscines, and oscines), body mass classes, and habitat and stratum categories are similar to those found in the complete breeding bird communities of the transect areas. By contrast, mist-netting data are heavily biased towards small (< 64 g) and active species that inhabit the lower growth. With the exception of hummingbirds, most non-passerine families are underrepresented in mist-netting samples. High costs, low time efficiency, and inaccurate representation of entire bird groups make the use of mist netting prohibitive for most survey purposes, unless the status and habitat selection of altitudinal and latitudinal migrants are concerned. Transect mapping is highly effective at detecting avian taxa that regularly vocalize, e.g., breeding species in all territory-size classes. However, dispersing birds, floaters, long-distance migrants on passage, and very silent breeding residents were overlooked or underestimated. Thus I developed an optimized MTW rapid assessment protocol to further increase bird species detectability. Eight samples are carried out in as little as two days, from pre-dawn to after-dusk periods, with highest effort during early morning hours. A single worker can accurately assess the distribution pattern of threatened and other bird species in an area of c. 2000 ha per year. Observers need, of course, an excellent knowledge of the sound repertoire and other field characters of the local avifauna. Transect mapping is also a powerful tool for monitoring purposes. Implementing a specifically designed MTW monitoring protocol, a well-trained

observer might record c. 70% of the total species richness and 80-90% of all breeding residents present in the transect area within as little as six days. For transects of up to 1200 m, sufficient data for rough estimations of absolute population and biomass densities can be obtained in the same period. MTW survey data can be georeferenced with minimal effort, and thus provide valuable information for conservation-related landscape planning at local and regional levels. Site-specific management strategies and mitigating measures can be developed and monitored. Transect mapping could be a tool for adaptive management in a wide range of operations, like management of natural tropical forests, agricultural development, ecotourism projects, road construction, mining, oil production, or design and maintenance of protected areas. Moreover, its potential use is not restricted to birds but could be adapted for other taxa with distinct vocalizations, such as some mammals and amphibians.

Between June 1993 and November 2000, a total of 336 bird species, belonging to 48 families and 243 genera, were recorded in Playa de Oro at elevations between c. 50 and 450 m. Eight additional species were confirmed since November 2004. The final count is expected to increase to > 400 species when the foothill zone up to 590 m has been inten-

sively studied. Of the birds recorded before November 2004, non-passerines ( $n = 137$ ) were more species-rich than the suboscine (102) and oscine (97) passerines. About 82% ( $n = 276$ ) of the species certainly or possibly breed in the area. Forest- or forest-edge-inhabiting birds make up 74.4% ( $n = 250$ ). No less than 231 (68.8%) bird species may participate in foraging flocks. Non-passerines (48.2%;  $n = 66$ ) are less gregarious than suboscines (76.5%;  $n = 78$ ) and oscines (89.7%;  $n = 87$ ). Almost all suboscine passerines that attend flocks do so in mixed-species flocks (93.6%;  $n = 73$ ), whereas about 44.8% (39) of the oscines form single-species groups or join single-species as well as mixed-species flocks. A total of 44 avian taxa are considered to be endemics, 18 are threatened or near-threatened on the global scale, and 78 are listed in the same threat categories at the national level. Based on transect-mapping data, I extrapolated the bird populations for habitat mosaics of 100 ha each in the transect areas of MNT1 and MNT2. Although some clear differences existed between the sites, with regard to species richness and composition, the biomass density was almost identical, with an estimated 193 kg/km<sup>2</sup> for MNT1 and 198 kg/km<sup>2</sup> for MNT2. The number of breeding 'pairs' was roughly 2000 /km<sup>2</sup> and 1800 /km<sup>2</sup>, and the average biomass per individual 36 g and 41 g, respectively.

## 9. RESUMEN

Métodos de evaluación rápida eficaces y económicos son un prerequisite importante para que los datos biológicos se tomen en cuenta en el desarrollo de estrategias de manejo para los recursos naturales. Por esta razón, desarrollé la técnica audio visual “Mapeo de Transectos en Múltiples Períodos de Tiempo” (MTW por sus siglas en inglés) para muestrear comunidades de aves tropicales. En muchos aspectos el método es similar al planteamiento de ‘mapeo de parcelas’ (plot mapping) según Emlen (1977) y, particularmente, Thompson *et al.* (1992), pero se distingue, entre otros, en que el observador adapta su velocidad promedio al caminar al nivel de actividad de las aves, así como a la topografía, las condiciones climáticas, sus conocimientos y otros factores. La investigación se realizó en Playa de Oro (0°52'35"N, 78°47'40"O; 45-590 m sobre el nivel del mar), provincia de Esmeraldas, en el noroeste de Ecuador. Estudié 18 transectos, usando el método MTW. Los transectos tuvieron una longitud total de 25,14 km y variaron en longitud entre 550 y 1700 m. De acuerdo con el protocolo original un muestreo MTW completo consistió de seis recorridos individuales en diferentes períodos del día. La posición de cada ave es mapeada con la ayuda de marcas de distancia cada 25 m, revelando así el patrón de distribución de las especies y bandadas a lo largo de la ruta del transecto. El método es altamente eficaz aún en bosques tropicales biodiversos y estructuralmente complejos. Para realizar un estudio comparativo de la eficacia de protocolos de captura con redes de neblina y mapeo de transectos, escogí dos transectos independientes, MNT1 (625 m) y MNT2 (550 m). Estos estuvieron ubicados en un mosaico de hábitat similarmente estructurado de plantaciones manejadas y abandonadas, vegetación joven de sucesión y bosque selectivamente talado. En las cercanías del pueblo de Playa de Oro, la mayor variabilidad del hábitat manejado por el hombre fue la causa principal para que, de acuerdo a los muestreos estandarizados de redes de neblina (MN) así como MTW, la avifauna fue más rica en especies y más diversa en el transecto MNT1 ( $n_{MN} = 117$ ;  $n_{MTW} = 162$ ) en comparación con MNT2 ( $n_{MN} = 96$ ;  $n_{MTW} = 144$ ). Sin embargo, en el último transecto el número de especies de aves dependientes de bosque y de taxones amenazados fue más alto, probablemente debido al menor grado de fragmentación, mayor complejidad de los estratos superiores de follaje, así como menores niveles de persecución. En conclusión, el valor de

conservación de los sitios de estudio no debería ser alineado en base a los índices de la riqueza o a la diversidad de especies de aves, si no a través de un análisis profundo de la composición de especies. Por ejemplo, el índice de comunidades de aves (BCI por sus siglas en inglés) según Canterbury *et al.* (2000) contrasta las especies que son sensitivas a las alteraciones de la estructura del bosque con aquellas que son tolerantes a dichos cambios. Este índice reflejó claramente un valor más alto de MNT2 en comparación con MNT1 para la conservación de aves dependientes del bosque, cuando fue calculado con los datos de MTW ( $BCI_{MNT1} = -0,049$  versus  $BCI_{MNT2} = 0,541$ ). Respecto a la eficacia y eficiencia comparativa, los resultados indican que en solo el 8 al 9% (21 a 23 h) del tiempo de estudio, se detectó entre el 39 y 50% (45 y 48) más especies de aves con el método mapeo de transectos que en redes de neblina. Con un esfuerzo de estudio de solo 44,5 h, se registró con MTW el 88% de todas las especies de aves reproductivas del área. En comparación, con redes de neblina se capturó solo el 58% de las residentes reproductivas en 544 h (4817 MNH = horas-red). El costo de un estudio de mapeo de transectos es aproximadamente solo el 5% en comparación con un proyecto de redes de neblina. Simultáneamente los resultados tienen una mayor precisión y relevancia. Proporciones encontradas en el conjunto de datos de MTW para los grupos taxonómicos mayores (no-paserinos, suboscines y oscines), clases de masa corporal, y categorías de hábitat y estratos, son similares a los encontrados en comunidades completas de aves reproductivas de las áreas de los transectos. En contraste, los datos de redes de neblina son muy erróneos, sobre valorando a las especies pequeñas (< 64 g) y activas que habitan el sotobosque. Con la excepción de los colibríes, muchas familias de los no-paserinos están mal representadas en las muestras de redes de neblina. Los altos costos, baja eficiencia, así como la representación imprecisa de grupos enteros de aves hacen que el uso de redes de neblina no sea apto para muchos propósitos de muestreo, a menos que le concierna el estado y selección del hábitat de aves migratorias altitudinales y latitudinales. Mapeo de transectos es altamente efectivo en detectar aves que regularmente vocalizan, ej., especies reproductivas en toda clase de tamaños de territorios. Sin embargo, aves en dispersión, itinerantes, migratorias de larga distancia en traspaso, así como residentes reproductivos muy silenciosos, fueron pas-

ados por alto o subestimados. Por lo tanto desarrollé un protocolo MTW de evaluaciones rápidas optimizado para incrementar la detectabilidad de las especies de aves aún más. Se realizan ocho recorridos en tan solo dos días en periodos que van desde antes del amanecer hasta el anochecer. Un solo observador puede determinar con precisión el patrón de distribución de especies amenazadas y otras en un área de cerca de 2000 ha por año. Por supuesto, los observadores necesitan un excelente conocimiento de los repertorios de sonidos y otras características de la avifauna local. Mapeo de transectos es también una herramienta poderosa para propósitos de monitoreo. Al implementar un protocolo MTW desarrollado específicamente para este fin, un observador bien entrenado podría registrar cerca del 70% del total de la riqueza de las especies y entre el 80 y 90% de todas las aves residentes reproductivas presentes en el área del transecto en tan solo seis días. En el mismo período y para transectos de hasta 1200 m se pueden obtener datos suficientes para estimar de manera aproximada las densidades poblacionales absolutas y de biomasa. Los datos de muestreo MTW pueden ser georeferenciados con un mínimo esfuerzo, y así proveer a nivel local y regional información valiosa relacionada con el ordenamiento paisajístico enfocado en la conservación. Estrategias de manejo y medidas de mitigación, específicas para cada sitio, pueden ser desarrolladas y monitoreadas. Mapeo de transectos puede ser una herramienta para el manejo adaptativo en un amplio rango de operaciones, como el manejo de bosques tropicales naturales, desarrollo agrícola, proyectos de ecoturismo, construcción de caminos, minería, producción petrolera, o diseño y mantenimiento de áreas protegidas. Por otra parte, su uso potencial no se restringe a aves si no también podría ser adaptado para otros taxones con distintas vocalizaciones, tales como algunos mamíferos y anfibios.

En Playa de Oro se registraron un total de 336 especies de aves, pertenecientes a 48 familias y 243 géneros, entre junio de 1993 y noviembre de 2000 en altitudes entre 50 y 450 m. Desde noviembre 2004, se confirmaron ocho especies adicionales. Se espera que el número final se incremente a más de 400 especies si se estudia intensivamente la zona de estribaciones hasta los 590 m. De las aves registradas antes de noviembre 2004, los no-paserinos ( $n = 137$ ) tubieron más especies que los suboscines (102) y los oscines (97). Alrededor del 82% ( $n = 276$ ) de las especies ciertamente o posiblemente se reprodujeron en el área. Las aves que habitan el bosque o sus bordes representan el 74,4% ( $n = 250$ ). No menos que 231 (68,8%) de las especies de aves pueden participar en bandadas de forrajeo. Los no-paserinos (48,2%;  $n = 66$ ) son menos gregarios que los suboscines (76,5%;  $n = 78$ ) y oscines (89,7%;  $n = 87$ ). Casi todos los suboscines que participan en bandadas lo hacen en bandadas mixtas (93,6%;  $n = 73$ ), mientras que alrededor del 44,8% (39) de los oscines forman bandadas monotípicas o se unen a grupos monotípicos así como a bandadas mixtas. Un total de 44 taxones de aves son considerados endémicos, 18 amenazados o casi amenazados a nivel global, y 78 constan en la lista de las mismas categorías de amenaza a nivel nacional. En base a los datos de mapeo de transectos, extrapolé las poblaciones de aves para los mosaicos de hábitat de 100 ha para cada área de los transectos MNT1 y MNT2. Aunque existieron algunas diferencias pronunciadas entre los sitios respecto a la riqueza y composición de las especies, la densidad de la biomasa fue casi idéntica, con un estimado de 193 kg/km<sup>2</sup> para MNT1 y 198 kg/km<sup>2</sup> para MNT2. El número de parejas reproductivas fue aproximadamente 2000 /km<sup>2</sup> y 1800 /km<sup>2</sup> y el promedio de la biomasa por individuo fue 36 g y 41 g respectivamente.



## 10. ZUSAMMENFASSUNG

Effektive und ökonomische Schnellerfassungsmethoden organischer Daten sind eine Grundvoraussetzung für die Entwicklung von Nutzungs- und Schutzstrategien für natürliche Ressourcen. Daher habe ich die *Multi Time-window Transect-Mapping* (MTW) Technik für die audiovisuelle Erfassung tropischer Vögel entwickelt. In vielen Aspekten ist die Methode dem 'Parzellenkartierungs-' (plot mapping) Ansatz nach Emlen (1977) und insbesondere Thompson *et al.* (1992) ähnlich, unterscheidet sich unter anderem aber dadurch, dass für jeden Begehungszeitraum die Beobachtergeschwindigkeit an das Aktivitätsniveau der Vögel, als auch an die Topographie, Wetterbedingungen, Beobachterkenntnisse und anderen Faktoren angepasst wird. Die Forschungsarbeiten wurden in Playa de Oro (0°52'35"N, 78°47'40"W; 45-590 m), Esmeraldas Provinz im Nordwesten Ecuadors, durchgeführt. Insgesamt untersuchte ich 18 Transekte mit der MTW-Methode. Die Transekte hatten eine Gesamtlänge von 25,14 km und ihre Einzellängen variierten zwischen 550 und 1700 m. Eine vollständige MTW-Untersuchung bestand aus sechs Einzelerfassungen zu unterschiedlichen Tageszeiten. Die Position eines jeden Vogels wurde mit Hilfe von 25 m-Distanzmarkern kartiert, um die Verteilungsmuster der Arten und Vogelschwärme entlang der Transekttroute zu bestimmen. Diese Methode ist selbst in strukturell komplexen und artenreichen tropischen Wäldern gut durchführbar und effizient. Um die Effektivität von Netzfangstudien und Transektkartierungen direkt vergleichen zu können, wählte ich zwei unabhängige Transekte, MNT1 (625 m) und MNT2 (550 m). Diese befanden sich in ähnlich strukturierten Habitatmosaiken von bewirtschafteten und brachliegenden Subsistenzplantagen, junger Sukzessionsvegetation sowie mittelaltem Wald mit selektiver Holznutzung. Die größere Vielfalt vom Menschen beeinflusster Lebensräume in der Umgebung des Dorfes Playa de Oro war der Hauptgrund dafür, dass entsprechend standardisierter Netzfänge (MN) und MTW-Erfassungen, die Vogelwelt im Gebiet des Transekts MNT1 ( $n_{MN} = 117$ ;  $n_{MTW} = 162$ ) artenreicher und diverser war als in der Umgebung von MNT2 ( $n_{MN} = 96$ ;  $n_{MTW} = 144$ ). Nichtsdestoweniger, die Anzahl von Waldvogelarten und gefährdeten Spezies war höher für den letzteren Transekt, wahrscheinlich wegen des geringeren Fragmentierungsgrades, einer höheren Laubkomplexität der oberen Vegetationsschichten

und des geringeren Jagddruckes. In Schlussfolgerung sollte der Naturschutzwert von Gebieten nicht auf Grundlage des Artenreichtums oder Diversitätsindizes bewertet werden, sondern eher durch eine Analyse der Artenzusammensetzung. Zum Beispiel unterscheidet der Vogelgemeinschaftsindex (BCI) nach Canterbury *et al.* (2000) zwischen störungsempfindlichen und störungstoleranten Waldvogelarten. Auf Grundlage der MTW-Daten gab der Index die im Vergleich zu MNT1 erhöhte Bedeutung von MNT2 für den Schutz von waldabhängigen Arten deutlich wieder ( $BCI_{MNT1} = -0.049$  versus  $BCI_{MNT2} = 0.541$ ). Betreffend der vergleichenden Effektivität und Effizienz zeigen die Ergebnisse, dass in einer Untersuchungszeit von nur 8-9% (21-23 h) 39-50% (45 und 48) mehr Vogelarten durch Transektkartierungen nachgewiesen wurden als durch Netzfänge. Durch MTW wurden 88% aller Brutvogelarten des Gebiets mit einem Aufwand von nur 44,5 h nachgewiesen. Im Vergleich dazu wurden in 544 h (4817 MNH, Netzstunden) nur 58% aller Brutvogelarten gefangen. Die ökonomischen Kosten einer Transektkartierungsstudie betragen dabei nur etwa 5% einer vergleichbaren Netzfanguntersuchung bei gleichzeitig größerer Genauigkeit und Aussagekraft der Ergebnisse. In MTW-Datensätzen sind die Proportionen für höhere taxonomische Gruppen (Nichtsingvögel, suboscine und oscine Singvögel), als auch für Körpermassen-, Lebensraum- und Vegetationsschichtklassen, denen der vollständigen Brutvogelgemeinschaften der Transektgebiete sehr ähnlich. Im Gegensatz dazu sind die Netzfangdaten in Richtung kleiner (< 64 g) und aktiver, den Unterwuchs bewohnenden Arten verzerrt. Mit Ausnahme der Kolibris sind die meisten Nichtsingvogelfamilien in Netzfangproben unterrepräsentiert. Hohe Kosten, geringe Zeiteffizienz als auch ungenaue Repräsentation verschiedener Vogelgruppen sprechen gegen eine Verwendung von Japannetzen für die meisten Erfassungsaufgaben. Eine Ausnahme stellen jene Studien dar, in denen der Status und die Habitatselektion von Kurz- und Langstrecken ziehenden Vögeln von Bedeutung sind. Transektkartierungen sind hoch effizient in der Erfassung von Vogelarten, die regelmäßig singen bzw. rufen, insbesondere von Brutvögeln. Umherstreifende Vögel, Langstreckenzieher, als auch überwiegend stille Brutvogelarten wurden jedoch oft übersehen. Daher habe ich ein verbessertes MTW-Schnellerfassungsprotokoll ent-

wickelt, um die Nachweiswahrscheinlichkeit von Vögeln weiter zu verbessern. Acht Begehungen wurden zu unterschiedlichen Tageszeiten und innerhalb von zwei Tagen durchgeführt. Der größte Kartierungsaufwand fiel dabei auf die frühen Morgenstunden. Ein Kartierer kann das Verteilungsmuster gefährdeter und anderer Vogelarten in einem Gebiet von etwa 2000 ha pro Jahr erfassen. Voraussetzung ist, dass Datenerfasser eine ausgezeichnete Kenntnis der Lautäußerungen und anderer Feldmerkmale der lokalen Avifauna haben. Transektkartierung ist auch ein potentes Hilfsmittel für Monitoring-Studien. Mit einem für diesen Zweck optimierten MTW-Protokoll kann ein trainierter Beobachter innerhalb von nur sechs Tagen etwa 70% der gesamten Artenvielfalt und 80-90% aller Brutvogeltaxa eines Transektgebietes erfassen. Für Transektlängen von bis zu 1200 m können im selben Zeitraum sogar genügend Daten für eine grobe Schätzung der absoluten Populations- und Biomassendichten erhoben werden. Da die geographischen Positionen der MTW-Beobachtungen mit minimalen Aufwand bestimmt werden können, stellen diese eine wertvolle Grundlage für die naturschutzorientierte Landschaftsplanung auf lokaler und regionaler Ebene dar. Ortsspezifische Nutzungsstrategien sowie Ausgleichs- und Ersatzmaßnahmen können entwickelt und kontrolliert werden. Transektkartierung könnte ein wichtiges Hilfsmittel in einem weiten Spektrum von Eingriffen darstellen, z.B. in der Bewirtschaftung von Tropenwäldern, in der Landwirtschaftsentwicklung, bei Ökotourismusprojekten, im Straßen- und Bergbau, in der Erdölproduktion, und auch für die Planung und Pflege von Naturschutzgebieten. Darüber hinaus ist der potentielle Nutzen nicht nur auf Vögel beschränkt. Die Methode könnte auch für die Erfassung anderer Tiergruppen, die artspezifische Laute ausstoßen, angepasst werden, z.B. für einige Säugetiere und Amphibien.

Zwischen Januar 1993 und November 2000 wurden in Playa de Oro, in einem Höhenbereich zwischen 50 und 450 m, 336 Vogelarten erfasst, die sich aus 48 Familien und 243 Gattungen zusammensetzten. Seit November 2004 wurden acht weitere Arten festgestellt. Es wird damit gerechnet, dass diese Zahl auf > 400 Arten ansteigen könnte, wenn die Andenabhänge bis zu einer Höhe von 590 m genauer untersucht würden. Von den bis November 2004 registrierten Taxa waren die Nichtsingvögel ( $n = 137$ ) artenreicher als suboscine Singvögel (102) und oscine Singvögel (97). Etwa 82% ( $n = 276$ ) der Arten brüten sicherlich oder wahrscheinlich im Gebiet. Wald- und Waldrandarten stellen ca. 74,4% ( $n = 250$ ) dar. Nicht weniger als 231 (68,8%) Vogelarten nehmen an nahrungssuchenden Vogelschwärmen teil. Nichtsingvögel (48,2%;  $n = 66$ ) sind weniger gesellig als suboscine Singvögel (76,5%;  $n = 78$ ) oder oscine Singvögel (89,7%;  $n = 87$ ). Fast alle suboscinen Singvögel, die Vogelschwärme begleiten, tun dies in artgemischten Gruppen (93,6%;  $n = 73$ ), während 44,8% (39) der oscinen Singvögel monotypische Gruppen bilden oder sowohl an artreinen als auch an gemischten Schwärmen teilnehmen. Im Untersuchungsgebiet waren insgesamt 44 Vogelarten endemisch, 18 sind auf globaler Ebene als gefährdet oder nahezu gefährdet eingestuft und 78 befinden sich auf nationaler Ebene in den gleichen Gefährdungskategorien. Auf Grundlage der Transektkartierungsdaten habe ich die Vogelpopulationen für Habitatmosaiken von je 100 ha in den Transektgebieten von MNT1 und MNT2 extrapoliert. Obgleich zwischen den Gebieten einige klare Unterschiede bezüglich der Artenvielfalt als auch Artenzusammensetzung existierten, war die geschätzte Biomassendichte annähernd gleich, mit 193 kg/km<sup>2</sup> für MNT1 und 198 kg/km<sup>2</sup> für MNT2. Die entsprechende Anzahl von „Brutpaaren“ war etwa 2000 /km<sup>2</sup> und 1800 /km<sup>2</sup> und die durchschnittliche Biomasse pro Individuum 36 g und 41 g.

## 11. REFERENCES

- Ack, B.L. 1991. Towards success in integrated conservation and development. *Wildlands and human needs*. Paper No. 1, WHN Technical Paper Series. World Wildlife Fund, Washington, USA.
- Aide, T.M., Zimmerman, J.K., & L. Herrera. 1995. Forest recovery in abandoned tropical pastures in Puerto Rico. *Forest Ecology and Management* 77: 77–86.
- Alarcón, R. 2001. Biological monitoring: a key tool in conservation and development projects. Pp. 23–32 in Rhoades, R., & J. Stallings (eds.). *Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies*. SANREM CRSP and CARE-SUBIR, Athens, USA.
- Aleixo, A. 1999. Effects of selective logging on a bird community in the Brazilian Atlantic forest. *Condor* 101: 537–548.
- Alvarez-Buylla, E.R., & R. García-Barrios. 1991. Seed and forest dynamics: a theoretical framework and an example from the Neotropics. *American Naturalist* 137: 133–154.
- Alvarez-Buylla, E.R., García-Barrios, R., Lara-Moreno, C., & M. Martínez-Ramos. 1996. Demographic and genetic models in conservation biology: applications and perspectives for tropical rain forest tree species. *Annual Review of Ecology and Systematics* 27: 387–421.
- Alvarez-Buylla, E.R., & M. Martínez-Ramos. 1990. Seed bank versus seed rain in the regeneration of a tropical pioneer tree. *Oecologia* 84: 314–325.
- Andelman, S.J., & W.F. Fagan. 2000. Umbrellas and flagships: efficient conservation surrogates or expensive mistakes? *Proceedings of the National Academy of Sciences of the USA* 97: 5954–5959.
- Anderson, B.W., & R.D. Ohmart. 1981. Comparisons of avian census results using variable distance transect and variable circular plot techniques. *Studies in Avian Biology* 6: 186–192.
- Andrade, G.I., & H. Rubio. 1994. Sustainable use of tropical rainforest: evidence from the avifauna in a shifting-cultivation mosaic in the Colombian Amazon. *Conservation Biology* 8: 545–554.
- Anjos, L. dos, & R. Boçon. 1999. Bird communities in natural forest patches in southern Brazil. *Wilson Bulletin* 111: 397–414.
- Archard, F., Eva, H.D., Stibig, H.-J., Mayaux, P., Gallego, J., Richards, T., & J.-P. Malingreau. 2002. Determination of deforestation rates of the world's humid tropical forests. *Science* 297: 999–1002.
- Arita, H.T., Robinson, J.G., & K.H. Redford. 1990. Rarity in Neotropical forest mammals and its ecological correlates. *Conservation Biology* 4: 181–192.
- Armstrong, J.T. 1965. Breeding home range in the night-hawk and other birds: its evolutionary and ecological significance. *Ecology* 46: 619–629.
- Askins, R.A., Lynch, J.F., & R. Greenberg. 1990. Population declines in migratory birds in eastern North America. *Current Ornithology* 7: 1–57.
- Aylor, D. 1972. Noise reduction by vegetation and ground. *J. Acoust. Soc. Amer.* 51: 197–205.
- Ayres, J.M., & T.H. Clutton-Brock. 1992. River boundaries and species range size in Amazonian primates. *American Naturalist* 140: 531–537.
- Baker, J.D. 2004. Evaluation of closed capture – recapture methods to estimate abundance of Hawaiian Monk Seals. *Ecological Applications* 14: 987–998.
- Baker, J.R. 1938. The relation between latitude and breeding seasons in birds. *Proc. Zool. Soc. A* 108: 557–582.
- Baldock, J.W. 1982. Geología del Ecuador – Boletín de la explicación del mapa geológico de la República del Ecuador, Escala 1:1.000.000. Quito, Ecuador.
- Balmford, A., Green, R.E., & M. Jenkins. 2003. Measuring the changing state of nature. *Trends in Ecology and Evolution* 18: 326–330.
- Balslev, H., Luteyn, J., Øllgaard, B., & L.B. Holm-Nielsen. 1987. Composition and structure of adjacent unflooded and floodplain forest in Amazonian Ecuador. *Opera Botanica* 92: 37–57.
- Banks, R.C., Chesser, R.T., Cicero, C. Dunn, J.L., Kratter, A.W., Rasmussen, P.C., Remsen, J.V., Jr. Rising, J.D., & D.F. Stotz. 2008. Forty-ninth supplement to the American Ornithologists' Union check-list of North American Birds. *Auk* 125: 758–768.
- Banks, R.C., Cicero, C., Dunn, J.L., Kratter, A.W., Rasmussen, P.C., Remsen, J.V., Jr., Rising, J.D., & D.F. Stotz. 2003. Forty-fourth supplement to the American Ornithologists' Union check-list of North American birds. *Auk* 120: 923–931.
- Barker, F.K., Barrowclough, G.F., & J.G. Groth. 2002. A phylogenetic hypothesis for passerine birds: taxonomic and biogeographic implications of an analysis of nuclear DNA sequence data. *Proceedings of The Royal Society of London B (Biological Sciences)* 269: 295–308.
- Barker, F.K., & S.M. Lyon. 2000. The impact of parsimony weighting schemes on inferred relationships among toucans and Neotropical barbets (Aves: Piciformes). *Molecular Phylogenetics and Evolution* 15: 215–234.
- Bawa, K.S., & R. Seidler. 1998. Natural forest management and conservation of biodiversity in tropical forests. *Conservation Biology* 12: 46–55.
- Bart, J., Droege, S., Geissler, P., Peterjahn, B., & C.J. Ralph. 2004. Density estimation in wildlife surveys. *Wildlife Society Bulletin* 32: 1242–1247.
- Benítez, V., Canaday, C., & J.C. Matheus. 1997. Diversidad y abundancia relativa de las aves en dos localidades en San Miguel, zona de amortiguamiento de la Reserva

- Ecología Cotacachi-Cayapas, Esmeraldas, Ecuador. Pp. 125–145 in Mena, P.A., Soldi, A., Alarcón, R., Chiriboga, C., & L. Suárez (eds.). Estudios biológicos para la conservación. Diversidad, ecología y etnobiología. EcoCiencia, Quito, Ecuador.
- Benítez, V., Jahn, O., Mena, V. P., & K.S. Berg. 2002. Guacamayo Verde Mayor (*Ara ambigua*). Pp. 83–84 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN. Quito, Ecuador.
- Benítez, V., & J.C. Matheus. 1997. Diversidad y abundancia relativa de las aves en dos localidades en Playa de Oro, zona de amortiguamiento de la Reserva Ecológica Cotacachi-Cayapas, Esmeraldas, Ecuador. Pp. 87–107 in Mena, P.A., Soldi, A., Alarcón, R., Chiriboga, C., & L. Suárez (eds.). Estudios biológicos para la conservación. Diversidad, ecología y etnobiología. EcoCiencia, Quito, Ecuador.
- Benítez-Malvido, J. 1998. Impact of forest fragmentation on seedling abundance in a tropical forest. *Conservation Biology* 12: 380–389.
- Berger, J. 1997. Population constraints associated with the use of Black Rhinos as an umbrella species for desert herbivores. *Conservation Biology* 11: 69–78.
- Bertault, J.G., & P. Sist. 1997. An experimental comparison of different harvesting intensities with reduced-impact and conventional logging in East Kalimantan, Indonesia. *Forest Ecology and Management* 94: 209–218.
- Best, B., & M. Kessler. 1995. Biodiversity and conservation of Tumbesian Ecuador and Peru. BirdLife International, Cambridge, UK.
- Beurlen, K. 1970. *Geologie von Brasilien*. Berlin, Germany.
- Bibby, C.J., Burgess, N.D., & D.A. Hill. 1992. Bird census techniques. London, UK.
- Bibby, C.J., Burgess, N.D., Hill, D.A., & S.A. Mustoe. 2000. Bird census techniques, 2nd edition. London, UK.
- Bibby, C.J., Jones, M., & S. Marsden. 1998. Expedition field techniques: bird surveys. Expedition Advisory Center, Royal Geographical Society, London, UK.
- Bierregaard, R.O., Jr. 1990a. Avian communities in the understory of Amazonian forest fragments. Pp. 333–343 in Keast, A. (ed.). Biogeography and ecology of forest bird communities. The Hague, The Netherlands.
- Bierregaard, R.O., Jr. 1990b. Species composition and trophic organization of the understory bird community in a central Amazonian *terra firme* forest. Pp. 217–236 in Gentry, A.H. (ed.). Four Neotropical Rainforests. New Haven, USA.
- Bierregaard, R.O., Jr. 1994. Harpy Eagle (*Harpia harpyja*). Pp. 179 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- Bierregaard, R.O., Jr., & T.E. Lovejoy. 1988. Birds in Amazonian forest fragments: effects of insularization. Int. Ornith. Cong. Ottawa, Canada.
- Bierregaard, R.O., Jr., & T.E. Lovejoy. 1989. Effects of forest fragmentation on Amazonian understory bird communities. *Acta Amazônica* 19: 215–241.
- Bierregaard, R.O., Jr., & T.E. Lovejoy. 1992. The biological dynamics of tropical rainforest fragments. *BioScience* 42: 859–866.
- BirdLife International. 2000. Threatened birds of the world. Barcelona, Spain.
- BirdLife International. 2004a. State of the world's birds 2004: indicators for our changing world. BirdLife International, Cambridge, UK.
- BirdLife International. 2004b. Threatened birds of the world 2004. CD-ROM. BirdLife International, Cambridge, UK.
- BirdLife International. 2008. Threatened birds of the world 2008. CD-ROM. BirdLife International, Cambridge, UK.
- BirdLife International. 2009a. Data zone: species search. Online at: <http://www.birdlife.org/datazone/species/search>, last accessed: 20 March 2011.
- BirdLife International. 2009b. Species factsheet: *Capito quinticolor*. Online at: <http://www.birdlife.org/datazone/speciesfactsheet.php?id=828>, last accessed: 20 March 2011.
- BirdLife International. 2009c. Species factsheet: *Crax rubra*. Online at: <http://www.birdlife.org/datazone/speciesfactsheet.php?id=103>, last accessed: 20 March 2011.
- BirdLife International. 2009d. Species factsheet: *Neomorphus radiolatus*. Online at: <http://www.birdlife.org/datazone/speciesfactsheet.php?id=1332>, last accessed: 20 March 2011.
- BirdLife International & Conservation International. 2005. Áreas importantes para la conservación de las aves en los Andes tropicales: sitios prioritarios para la conservación de la biodiversidad. BirdLife International, Serie de Conservación de BirdLife No. 14, Quito, Ecuador.
- Blackburn, T.M., & K.J. Gaston. 1996. Spatial patterns in the species richness of birds in the New World. *Ecography* 19: 369–376.
- Blake, J.G. 1989. Birds of primary forest undergrowth in western San Blas, Panama. *Journal of Field Ornithology* 60: 178–189.
- Blake, J.G. 1992. Temporal variation in point counts of birds in a lowland wet forest in Costa Rica. *Condor* 94: 265–275.
- Blake, J.G. 2007. Neotropical forest bird communities: a comparison of species richness and composition at local and regional scales. *Condor* 109: 237–255.
- Blake, J.G., & B.A. Loiselle. 1991. Variation in resource abundance affects capture rates of birds in three lowland habitats in Costa Rica. *Auk* 108: 114–127.

- Blake, J.G., & B.A. Loiselle. 2000. Diversity of birds along an elevational gradient in the Cordillera Central, Costa Rica. *Auk* 117: 663–686.
- Blake, J.G., & B.A. Loiselle. 2001. Bird assemblages in second-growth and old-growth forests, Costa Rica: perspectives from mist-nets and point counts. *Auk* 118: 304–326.
- Blake, J.G., Niemi, G.J., & J.M. Hanowski. 1992. Drought and annual variation in bird populations. Pp. 419–430 in Hagan, J.M., III & D.W. Johnston (eds.). *Ecology and conservation of Neotropical migrant landbirds*. Washington.
- Blake, J.G., & M. Rougès. 1997. Variation in capture rates of understory birds in El Rey National Park, northwestern Argentina. *Ornitologia Neotropical* 8: 185–193.
- Bloch, H., Poulsen, M.K., Rahbek, C., & J.F. Rasmussen. 1991. A survey of the montane forest avifauna of the Loja Province, southern Ecuador. Expedition report, International Council for Bird Preservation, Cambridge, UK.
- Boinski, S., & N.L. Fowler. 1989. Seasonal patterns in a tropical lowland forest. *Biotropica* 21: 223–233.
- Bollinger, E.K., Gavin, T.A., & D.C. McIntyre. 1988. Comparison of transects and circular plots for estimating Bobolink densities. *Journal of Wildlife Management* 52: 777–786.
- Bonham, C.D., Bousquin, S.G., & D. Tazik. 2001. Protocols and models for inventory, monitoring, and management of threatened and endangered plants. Colorado State University, Department of Rangeland Ecosystem Science, Fort Collins, USA.
- Bonnie, R., Carey, M., & C.A. Peterson. 2002. Protecting terrestrial ecosystems and the climate through a global carbon market. *Philosophical Transactions of the Royal Society of London* 360: 1853–1873.
- Borchsenius, F. 1997. Patterns of plant species endemism in Ecuador. *Biodiversity and Conservation* 6: 379–399.
- Borges, S.H., & P.C. Stouffer. 1999. Bird communities in two types of anthropogenic successional vegetation in central Amazonia. *Condor* 101: 529–536.
- Boucher, D.H. 1990. Growing back after hurricanes: catastrophes may be critical to rain forest dynamics. *BioScience* 40: 163–166.
- Boulinier, T., Nichols, J.D., Sauer, J.R., Hines, J.E., & K.H. Pollock. 1998. Estimating species richness: the importance of heterogeneity in species detectability. *Ecology* 79: 1018–1028.
- Bourlière, F., & M.L. Harmelin-Vivien. 1988. Species diversity in tropical vertebrates: an ecosystem perspective. *Ecological Studies* 69: 169–183.
- Bowles, I., Rice, R., Mittermeier, R.M., & A. da Fonseca. 1998. Logging and tropical forest conservation. *Science* 280: 1899–1900.
- Bradford, D.F., Franson, S.E., Neale, A.C., Heggem, D.T., Miller, G.R., & G.E. Canterbury. 1998. Bird species assemblages as indicators of biological integrity in Great Basin rangeland. *Environmental Monitoring and Assessment* 49: 1–22.
- Brokaw, N.V.L. 1982. Treefalls: frequency, timing, and consequences. Pp. 101–108 in Leigh, E.G., Jr., Rand, A.S., & D.M. Windsor (eds.). *The ecology of a tropical forest: seasonal rhythms and long-term changes*. Washington, USA.
- Brokaw, N.V.L. 1985. Gap-phase regeneration in a tropical forest. *Ecology* 66: 682–687.
- Bromley, R. 1981. The colonization of humid tropical areas in Ecuador. *Singapore Journal of Tropical Geography* 2: 15–26.
- Brooks, T.M., & A. Balmford. 1996. Atlantic forest extinctions. *Nature* 380: 115.
- Brooks, T.M., Balmford, A., Burgess, N.D., Hansen, L.A., Moore, J.L., Rahbek, C., Williams, P., Bennun, L.A., Byaruhanga, A., Kasoma, P., Njoroge, P., Pomeroy, D., & M. Wondafra. 2001. Conservation priorities for birds and biodiversity: do East African Important Bird Areas represent species diversity in other terrestrial vertebrate groups? *Ostrich Supplement*: 3–12.
- Brooks, T.M., Pimm, S.L., & N.J. Collar. 1997. Deforestation predicts the number of threatened birds in insular Southeast Asia. *Conservation Biology* 11: 382–394.
- Brooks, T.M., Pimm, S.L., & J.O. Oyugi. 1999. Time lag between deforestation and bird extinction in tropical forest fragments. *Conservation Biology* 13: 1140–1150.
- Brose, U., Martinez, N.D., & R.J. Williams. 2003. Estimating species richness: sensitivity to sample coverage and insensitivity to spatial patterns. *Ecology* 84: 2364–2377.
- Brosset, A. 1990. A long-term study of the rain forest birds in M'Passa (Gabon). Pp. 57–89 in Keast, A. (ed.). *Biogeography and ecology of forest bird communities*. The Hague, The Netherlands.
- Brown, J.H. 1995. *Macroecology*. Chicago, USA.
- Brown, J.H., & B.A. Maurer. 1987. Evolution of species assemblages: effects of energetic constraints and species dynamics on the diversification of the American avifauna. *American Naturalist* 130: 1–17.
- Brown, K.S., Jr., & G.T. Prance. 1987. Soils and Vegetation. Pp. 19–45 in Whitmore, T.C., & G.T. Prance (eds.). *Biogeography and Quaternary history in tropical America*. New York, USA.
- Brown, M., & B. Wyckoff-Baird. 1992. Designing integrated conservation and development projects. Biodiversity Support Program, PVO-NGO/NRMS Project, Washington, USA.
- Buckland, S.T., Anderson, D.R., Burnham, K.P., & J.L. Laake. 1993. Distance sampling: estimating abundance of biological populations. London, UK.



- Buckland, S.T., Anderson, D.R., Burnham, K.P., & J.L. Laake. 1998. Distance sampling. Figures 2 and 3, p. 1192 in Armitage, P., & T. Colton (eds.). Encyclopedia of Biostatistics. Chichester, UK.
- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., & L. Thomas. 2001. Distance sampling: estimating abundance of biological populations, 2nd edition. Oxford, UK.
- Burnham, K.P., & W.S. Overton. 1978. Estimation of the size of a closed population when capture probabilities vary among animals. *Biometrika* 65: 623–633.
- Burnham, K.P., & W.S. Overton. 1979. Robust estimation of population size when capture probabilities vary among animals. *Ecology* 60: 927–937.
- Burns, K.J., Hackett, S.J., & N.K. Klein. 2002. Phylogenetic relationships and morphological diversity in Darwin's finches and their relatives. *Evolution* 56: 1240–1252.
- Cabot, J. 1992. Family Tinamidae (tinamous). Pp. 112–138 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 1: Ostrich to ducks. Barcelona, Spain.
- Cairns, J., Jr. 1986. The myth of the most sensitive species. *BioScience* 36: 670–672.
- Camargo, J.L.C., & V. Kapos. 1995. Complex edge effects on soil moisture and microclimate in central Amazonian forest. *Journal of Tropical Ecology* 11: 205–211.
- Cañadas C., L. 1983. El mapa bioclimático y ecológico del Ecuador. Banco Central, Quito.
- Canterbury, G.E., Martin, T.E., Petit, D.R., Petit, L.J., & D.F. Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. *Conservation Biology* 14: 544–558.
- Cárdenas, A. 2007. Análisis multitemporal de cobertura vegetal y uso del suelo para la ventana binacional Ecuador, período 1998–2007, Proyecto “Diseño del SIMSA – CCCM”. EcoCiencia, Quito.
- Caro, T.M., & G. O'Doherty. 1999. On the use of surrogate species in conservation biology. *Conservation Biology* 13: 805–814.
- Carroll, J.P. 1994. Family Odontophoridae (New World quails). Pp. 412–433 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 2: New World vultures to guineafowl, Barcelona, Spain.
- Carroll, S.S., & D.L. Pearson. 1998. Spatial modeling of butterfly species richness using tiger beetles (Cicindelidae) as a bioindicator taxon. *Ecological Applications* 8: 531–543.
- Casagrande, D.G., & S.R. Beissinger. 1997. Evaluation of four methods for estimating parrot population size. *Condor* 99: 445–457.
- Case, J.E., Duran S., L.G., Lopez R., A., & W.R. Moore. 1971. Tectonic investigations in western Colombia and eastern Panama. *Bull. Geol. Soc. Amer.* 82: 2685–2712.
- Cauley, H.A., Peters, C.M., Donovan, R.Z., & J.M. O'Connor. 2001. Forest Stewardship Council forest certification. *Conservation Biology* 15: 311–312.
- Cerón, C., Palacios, W., Valencia, R., & R. Sierra. 1999. Las formaciones naturales de la Costa del Ecuador. Pp. 55–78 in Sierra, R. (ed.). Propuesta preliminar de un sistema de clasificación de vegetación para el Ecuador continental. Proyecto INEFAN/GEF-BIRF & Eco-Ciencia, Quito, Ecuador.
- Chalfoun, A.D., Thompson, F.R., III & M.J. Ratnaswamy. 2002. Nest predators and fragmentation: a review and meta-analysis. *Conservation Biology* 16: 306–318.
- Chantler, P. 1999. Family Apodidae (swifts). Pp. 388–457 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- Chantler, P., & G. Driessens. 1995. Swifts: a guide to the swifts and treeswifts of the world. Mountfield, UK.
- Chao, A. 1984. Non-parametric estimation of the number of classes in a population. *Scandinavian Journal of Statistics* 11: 265–270.
- Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* 43: 783–791.
- Chao, A., Chazdon, R.L., Colwell, R.K., & T.-J. Shen. 2005. A new statistical approach for assessing similarity of species composition with incidence and abundance data. *Ecology Letters* 8: 148–159.
- Chao, A., Hwang, W.H., Chen, Y.-C., & C.Y. Kuo. 2000. Estimating the number of shared species in two communities. *Statistica Sinica* 10: 227–246.
- Chao, A., Ma, M.-C., & M.C.K. Yang. 1993. Stopping rules and estimation for recapture debugging with unequal failure rates. *Biometrika* 80: 193–201.
- Chapman, F.M. 1917. The distribution of bird-life in Colombia: a contribution to a biological survey of South America. Bulletin of the American Museum of Natural History 36: 1–169.
- Charles-Dominique, P. 1986. Inter-relations between frugivorous vertebrates and pioneer plants: *Cecropia*, birds and bats in French Guyana. Pp. 119–135 in Estrada, A., & T.H. Fleming (eds.). Frugivores and seed dispersal. Dordrecht, The Netherlands.
- Chassot, O., Monge, G., Alemán, U., Powell, G.V.N., & S. Palminteri. 2002. Lapa Verde – estable pero inviable. *Ambientales* 24: 18–23.
- Chazdon, R.L. 1998. Tropical forests: log 'em or leave 'em? *Science* 281: 1295–1296.
- Chazdon, R.L., Colwell, R.K., Denslow, J.S., & M.R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of NE Costa Rica. Pp. 285–309 in Dallmeier, F., & J.A. Comiskey (eds.). Biodiversity research, monitoring and modeling: conceptual background and Old World case studies. Paris, France.



- Chen, Y.-C., Hwang, W.H., Chao, A., & C.Y. Kuo. 1995. Estimating the number of common species. Analysis of the number of common bird species in Ke-Yar Stream and Chung-Kang Stream. (In Chinese with English abstract). *Journal of the Chinese Statistical Association* 33: 373–393.
- Christensen, J.H., Hewitson, B., Busuioic, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., La-prise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A., & P. Whetton. 2007. Regional climate projections. Pp. 847–940 in Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., & H.L. Miller (eds.). *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK.
- Christman, S.P. 1984. Plot mapping: estimating densities of breeding bird territories by combining spot mapping and transect techniques. *Condor* 86: 237–241.
- CIA. 2003. *The world factbook 2003*. Central Intelligence Agency, Office of Public Affairs, Washington, USA.
- Cicero, C., & N.K. Johnson. 2001. Higher-level phylogeny of New World vireos (Aves: Vireonidae) based on sequences of multiple mitochondrial DNA genes. *Molecular Phylogenetics and Evolution* 20: 27–40.
- Clark, D.A. 1994. Plant demography. Pp. 90–105 in McDade, L.A., Bawa, K.S., Hespenheide, H.A., & G.S. Hartshorn (eds.). *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- Clark, D.A. 2002. Are tropical forests an important carbon sink? Reanalysis of the long-term plot data. *Ecological Application* 12: 3–7.
- Clark, D.A., Clark, D.B., Sandoval M., R., & M.V. Castro C. 1995. Edaphic and human effects on landscape-scale distributions of tropical rain forest palms. *Ecology* 76: 2581–2594.
- Clark, D.B., & D.A. Clark. 2000. Landscape-scale variation in forest structure and biomass in a tropical rain forest. *Forest Ecology and Management* 137: 185–198.
- Clark, D.B., Read, J.M., Clark, M.L., Murillo C., A, Fallas, D., M., & D.A. Clark. 2004a. Application of 1-m and 4-m resolution satellite data to ecological studies of tropical rain forest. *Ecological Applications* 14: 61–74.
- Clark, D.B., Soto C., C., Alfaro A., L.D., & J.M. Read. 2004b. Quantifying mortality of tropical rain forest trees using high-spatial-resolution satellite data. *Ecology Letters* 7: 52–59.
- Cleere, N. 1999. Family Caprimulgidae (nightjars). Pp. 302–386 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- Cody, M.L. 1966. A general theory of clutch size. *Evolution* 20: 174–184.
- Cody, M.L. 2000. Antbird guilds in the lowland Caribbean rainforest of southeast Nicaragua. *Condor* 102: 784–794.
- Cohen, A.C.J. 1959. Simplified estimators for the normal distribution when samples are singly censored or truncated. *Technometrics* 1: 217–237.
- Cohen, A.C.J. 1961. Tables for maximum likelihood estimates: singly truncated and singly censored sample. *Technometrics* 3: 535–541.
- Colinvaux, P.A. 1989. Ice-age Amazon revisited. *Nature* 340: 188–189.
- Collar, N.J. 1997. Family Psittacidae (parrots). Pp. 280–477 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 4: sandgrouse to cuckoos. Barcelona, Spain.
- Collar, N.J. 2001. Family Trogonidae (trogons). Pp. 80–127 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 6: mousebirds to hornbills. Barcelona, Spain.
- Collar, N.J., Andreev, A.V., Chan, S., Crosby, M.J., Subramanya, S., & J.A. Tobias. 2001. *Threatened birds of Asia: the BirdLife International Red Data Book*. BirdLife International, Cambridge, UK.
- Collar, N.J., & P. Andrew. 1988. *Birds to watch: the ICBP check-list of threatened birds*. ICBP, Cambridge, UK.
- Collar, N.J., Crosby, M.J., & A.J. Stattersfield (eds.). 1994. *Birds to watch 2: the world list of threatened birds*. BirdLife International, Cambridge, UK.
- Collar, N.J., Gonzaga, L.P., Krabbe, N., Madroño Nieto, A., Naranjo, L.G., Parker, T.A., III & D.C. Wege. 1992. *Threatened birds of the Americas*. ICBP, Cambridge, UK.
- Collar, N.J., Mallari, N.A.D., & B.R. Tabaranza, Jr. 1999. *Threatened birds of the Philippines: the Haribon Foundation/BirdLife International Red Data Book*. Bookmark, Makati City, Philippines.
- Collar, N.J., & S.N. Stuart. 1985. *Threatened birds of Africa and related islands*. ICBP/IUCN, Cambridge, UK.
- Colwell, R.K. 2000. EstimateS: statistical estimation of species richness and shared species from samples, version 6.0b. Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA.
- Colwell, R.K. 2001. User's guide to EstimateS: statistical estimation of species richness and shared species from samples. Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA.
- Colwell, R.K. 2009. EstimateS: statistical estimation of species richness and shared species from samples, version 8.2.0. Downloadable at: <http://viceroy.eeb.uconn.edu/estimates>, last accessed on 20 March 2011.
- Colwell, R.K., & J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London B* 345: 101–118.

- Conant, S., Collins, M.S., & C.J. Ralph. 1981. Effects of observers using different methods upon the total population estimates of two resident island birds. *Studies in Avian Biology* 6: 377–381.
- Connell, J.H. 1978. Diversity in tropical rain forests and coral reefs. *Science* 199: 1302–1310.
- Conover, W.J. 1980. Practical non-parametric statistics. Wiley & Sons, New York, USA and Toronto, Canada.
- Cooperrider, A.Y., Boyd, R.J., & H.R. Stuart (eds.). 1986. Inventory and monitoring of wildlife habitat. Service Center, Bureau of Land Management, U.S. Department of the Interior, Denver, USA.
- Coopmans, P., Moore, J.V., Krabbe, N., Jahn, O., Berg, K.S., Lysinger, M., Navarrete, L., & R.S. Ridgely. 2004. The Birds of Southwest Ecuador. John V. Moore Nature Recordings, San Jose, USA.
- Corrales, L. 2000. FRA 2000: bibliografía comentada – cambios en la cobertura forestal – Ecuador. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- Cortés-Diogo, A., Ortega, L.A., Mazariegos-Hurtado, L., & A.-A. Weller. 2007. A new species of *Eriocnemis* (Trochilidae) from southwest Colombia. *Ornitología Neotropical* 18: 161–170.
- Cracraft, J. 1985. Historical biogeography and patterns of differentiation within the South American avifauna: areas of endemism. Pp. 49–85 in Buckley, P.A., Foster, M.S., Morton, E.S., Ridgely, R.S., & F.G. Buckley (eds.). *Neotropical Ornithology. Ornithological Monographs* No. 36, AOU, Washington, USA.
- Cracraft, J. 2001. Avian evolution, Gondwana biogeography and the Cretaceous–Tertiary mass extinction event. *Proceedings of The Royal Society of London B (Biological Sciences)* 268: 459–469.
- Cracraft, J., & R.O. Prum. 1988. Patterns and processes of diversification: speciation and historical congruence in some Neotropical birds. *Evolution* 42: 603–620.
- Cresswell, W., Hughes, M., Mellanby, R., Bright, S., Catry, P., Chaves, J., Freile, J., Gabela, A., Martineau, H., MacLeod, R., McPhie, F., Anderson, N., Holt, S., Barabas, S., Chapel, C., & T. Sanchez. 1999. Densities and habitat preferences of Andean cloud-forest birds in pristine and degraded habitats in north-eastern Ecuador. *Bird Conservation International* 9: 129–145.
- Crisp, P.N., Dickinson, K.J.M., & G.W. Gibbs. 1998. Does native invertebrate diversity reflect native plant diversity? A case study from New Zealand and implications for conservation. *Biological Conservation* 83: 209–220.
- Crooks, K.R., & M.E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400: 563–566.
- Cubasch, U., Meehl, G.E., Boer, G.J., Stouffer, R.J., Dix, M., Noda, A., Senior, C.A., Raper, S., & K.S. Yap. 2001. Projections of future climate change. Pp. 881 in IPCC (ed.). *Climate change 2001: the scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K. & C.A. Johnson (eds.)]. Intergovernmental Panel on Climate Change, Cambridge, UK.
- Czaplewski, R.L. 2002. FRA 2000: on sampling for estimating global tropical deforestation. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- da Silva, J.M.C., Uhl, C., & G. Murray. 1996. Plant succession, landscape management, and the ecology of frugivorous birds in abandoned Amazonian pastures. *Conservation Biology* 10: 491–503.
- Daily, G.C., Ceballos, C., Pacheco, J., Suzán, G., & A. Sánchez-Azofeifa. 2003. Countryside biogeography of Neotropical mammals: conservation opportunities in agricultural landscapes of Costa Rica. *Conservation Biology* 17: 1814–1826.
- Daily, G.C., Ehrlich, A.H., & P.R. Ehrlich. 1994. Optimum human population size. *Population and Environment* 15: 469–475.
- David, N., & M. Gosselin. 2002a. Gender agreement of avian species names. *Bulletin British Ornithologists' Club* 122: 14–49.
- David, N., & M. Gosselin. 2002b. The grammatical gender of avian genera. *Bulletin British Ornithologists' Club* 122: 257–282.
- Davis, D.E. 1945. The annual cycle of plants, mosquitoes, birds, and mammals in two Brazilian forests. *Ecological Monographs* 15: 243–295.
- Dawson, D.K. 1981. Sampling in rugged terrain. *Studies in Avian Biology* 6: 311–315.
- DeJong, M.J., & J.T. Emlen. 1985. The shape of the auditory detection function and its implications for songbird censusing. *Journal of Field Ornithology* 56: 213–320.
- del Hoyo, J. 1994. Family Cracidae (chachalacas, guans, and curassows). Pp. 310–363 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & D. Christie (eds.). 2003. *Handbook of the birds of the world*, vol. 8: broadbills to manakins. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 1992. *Handbook of the birds of the world*, vol. 1: Ostrich to ducks. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 1994. *Handbook of the birds of the world*, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 1996. *Handbook of the birds of the world*, vol. 3: hoatzin to auks. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 1997. *Handbook of the birds of the world*, vol. 4: sandgrouse to cuckoos. Barcelona, Spain.

- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 1999. Handbook of the birds of the world, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 2001. Handbook of the birds of the world, vol. 6: mousebirds to hornbills. Barcelona, Spain.
- del Hoyo, J., Elliott, A., & J. Sargatal (eds.). 2002. Handbook of the birds of the world, vol. 7: jacamars to woodpeckers. Barcelona, Spain.
- Dengo, G. 1985. Mid America: tectonic setting for the Pacific margin from southern Mexico to north-western Colombia. Pp. 123–180 in Nairn, A.E., Stehli, F.G., & S. Uyeda (eds.). The ocean basins and margins. New York, USA.
- DeSante, D.F. 1981. A field test of the variable circular-plot censusing technique in a California coastal scrub breeding bird community. *Studies in Avian Biology* 6: 177–185.
- Develey, P.F., & P.C. Stouffer. 2001. Effects of roads on movements by understory birds in mixed-species flocks in central Amazonian Brazil. *Conservation Biology* 15: 1416–1422.
- Diamond, J. 1980. Patchy distributions of tropical birds. Pp. 57–74 in Soulé, M.E., & B.A. Wilcox (eds.). *Conservation biology: an evolutionary-ecological approach*. Sunderland, USA.
- Diehl, B. 1981. Bird populations consist of individuals differing in many respects. *Studies in Avian Biology* 6: 225–229.
- Dietz, J.M., Dietz, A.L., & E.Y. Nagagata. 1994. The effective use of flagship species for conservation of biodiversity: the example of lion tamarins in Brazil. Pp. 32–49 in Olney, P.J.S., Mace, G.M., & A.T.C. Feistner (eds.). *Creative conservation: interactive management of wild and captive animals*. London, UK.
- Digby, P.G.N., & R.A. Kempton. 1987. *Multivariate Analysis of Ecological Communities*. London, UK.
- Dinerstein, E., Olson, D.M., Graham, D.J., Webster, A.L., Primm, S.A., Bookbinder, M.P., & G. Ledec. 1995. A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. World Bank, Washington, USA.
- Dingle, C., Lovette, I.J., Canaday, C., & T.B. Smith. 2006. Elevational zonation and the phylogenetic relationships of the *Henicorhina* woodwrens. *Auk* 123: 119–134.
- DO-G. 1995. Qualitätsstandards für den Gebrauch vogelkundlicher Daten in raumbedeutsamen Planungen. Projektgruppe "Ornithologie und Landschaftsplanung" der Deutschen Ornithologen-Gesellschaft. NFN Medien-Service Natur, Minden, Germany.
- Dobson, A.P., Rodriguez, J.P., Roberts, W.M., & D.S. Wilcove. 1997. Geographic distribution of endangered species in the United States. *Science* 275: 750–752.
- Dodson, C.H., & A.H. Gentry. 1991. Biological extinction in western Ecuador. *Annals of the Missouri Botanical Garden* 78: 273–295.
- Donald, P.F. 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology* 18: 17–37.
- Dooling, R.J. 1982. Auditory perception in birds. Pp. 95–130 in Kroodsma, D.E., & E.H. Miller (eds.). *Acoustic communication in birds*. New York, USA.
- Dorazio, R.M., & J.A. Royle. 2005. Estimating size and composition of biological communities by modeling the occurrence of species. *Journal of the American Statistical Association* 100: 389–398.
- Dow, D.D. 1970. Indexing population densities of the Cardinal with tape-recorded song. *Wilson Bulletin* 82: 83–91.
- Droege, S. 1990. The North American Breeding Bird Survey. Pp. 1–4 in Sauer, J.R., & S. Droege (eds.). *Survey designs and statistical methods for the estimation of avian population trends*. Biological Report 90 (1), Fish and Wildlife Service, U.S. Department of the Interior, Washington, USA.
- Duelli, P., & M.K. Obrist. 1998. In search of the best correlates for organismal biodiversity in cultivated areas. *Biodiversity and Conservation* 7: 97–309.
- Dufrene, M., & P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* 67: 345–366.
- Dunning, J.B., Jr. 1993. *Avian body masses*. Boca Raton, USA.
- Dykstra, D.P., & R. Heinrich. 1996. *FAO model code of forest harvesting practice*. Food and Agriculture Organization (FAO), Rome, Italy.
- Dyrce, A. 1990. Understory bird assemblages in various types of lowland tropical forest in Tambopata Reserve, SE Peru (with faunistic notes). *Acta Zool. Cracov* 33: 215–233.
- Eberhardt, L.L. 1968. A preliminary appraisal of line transects. *Journal of Wildlife Management* 32: 82–88.
- Eberhardt, L.L. 1978. Transect methods for population studies. *Journal of Wildlife Management* 42: 1–31.
- EcoCiencia. 1996. Mapa de uso actual y uso potencial – comuna Playa de Oro. EcoCiencia, INEFAN, USAID, SUBIR, Quito, Ecuador (unpubl.).
- Edwards, D.K., Dorsey, G.L., & J.A. Crawford. 1981. A comparison of three avian census methods. *Studies in Avian Biology* 6: 170–176.
- Ehrlich, P.R. 1988. The loss of biodiversity: causes and consequences. Pp. 21–27 in E.O. Wilson (ed.). *Biodiversity*. Washington, USA.
- Eisenmann, E. 1952. Annotated list of birds of Barro Colorado Island, Panama Canal Zone. *Smithsonian Misc. Coll.* 117: 1–62.
- Ellenberg, H. 1979. Zeigerwerte der Gefäßpflanzen Mitteleuropas. *Scripta Geobotanica* 9: 39–122.
- Emlen, J.T. 1971. Population densities of birds derived from transect counts. *Auk* 88: 323–342.
- Emlen, J.T. 1977. Land bird communities of Grand Bahama Island: the structure and dynamics of an avifauna. *Ornithological Monographs* 24: 1–129.

- Emlen, J.T., & M.J. DeJong. 1981. The application of song detection threshold distance to census operations. *Studies in Avian Biology* 6: 346–352.
- Endler, J.A., & M. Théry. 1996. Interacting effects of lek placement, display behavior, ambient light, and color patterns in three Neotropical forest dwelling birds. *American Naturalist* 148: 421–452.
- Ericson, G.P., Christidis, L., Cooper, A., Irestedt, M., Jackson, J., Johansson, U.S., & J.A. Norman. 2002. A Gondwanan origin of passerine birds supported by DNA sequences of the endemic New Zealand wrens. *Proceedings of The Royal Society of London B (Biological Sciences)* 269: 235–241.
- European Union for Bird Ringing. 2008. Euring – Coordinating bird ringing throughout Europe. Online at: <http://www.euring.org>, last accessed on 20 March 2011.
- Erwin, R.M. 1982. Observer variability in estimating numbers: an experiment. *Journal of Field Ornithology* 53: 159–167.
- Erwin, T.L. 1983. Beetles and other insects of tropical forest canopies at Manaus, Brazil, sampled by insecticidal fogging. Pp. 59–75 in Sutton, S.L., Whitmore, T.C., & A.C. Chadwick (eds.). *Tropical rain forest: ecology and management*. Edinburgh, UK.
- Estrada, A., Coates-Estrada, R., & C. Vázquez-Yáñez. 1984. Observations of fruiting and dispersers of *Cecropia obtusifolia* at Los Tuxtlas, Mexico. *Biotropica* 16: 315–318.
- Ewel, J., Berish, C., Brown, B., Price, N., & J. Raich. 1981. Slash and burn impacts on a Costa Rican wet forest site. *Ecology* 62: 816–829.
- Faanes, C., & D. Bystrak. 1981. The role of observer bias in the North American Breeding Bird Survey. *Studies in Avian Biology* 6: 353–359.
- Faber-Langendoen, D., & A.H. Gentry. 1991. The structure and diversity of rain forests at Bajo Calima, Chocó region, western Colombia. *Biotropica* 23: 2–11.
- FAO. 1995. Forest resources assessment 1990: global synthesis. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- FAO. 1997. State of the world's forests 1997. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- FAO. 2001. Global forest resources assessment 2000: main report. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- FAO. 2007. State of the world's forests 2007. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- Fearnside, P.M. 2000. Global warming and tropical land-use change: greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation. *Climate Change* 46: 115–158.
- Feininger, T., & C.R. Bristow. 1980. Cretaceous and paleogene geologic history of coastal Ecuador. *Geologische Rundschau* 69: 849–874.
- Ferguson, B.C., Vandermeer, J., Morales, H., & D.M. Griffith. 2003. Post-agricultural succession in El Petén, Guatemala. *Conservation Biology* 17: 818–828.
- Fernandes, D.N., & R.L. Sanford, Jr. 1995. Effects of recent land-use practices on soil nutrients and succession under tropical wet forest in Costa Rica. *Conservation Biology* 9: 915–922.
- Fernandes, E.N., & G.D. Vinha. 1984. Floral recomposition of the zoobotanical park at the Cacao Research Center, Bahia, Brazil. *Revista Theobroma* 14: 1–26.
- Ferraz, G., Russell, G.J., Stouffer, P.C., Bierregaard, R.O., Jr., Pimm, S.L., & T.E. Lovejoy. 2003. Rates of species loss from Amazonian forest fragments. *Proceedings of the National Academy of Sciences of the USA* 100: 14069–14073.
- Ferreira, L.V., & W.F. Laurance. 1997. Effects of forest fragmentation on mortality and damage of selected trees in central Amazonia. *Conservation Biology* 11: 797–801.
- FGDC. 1997. Vegetation classification standard. Federal Geographic Data Committee, U.S. Geological Survey, Reston, USA.
- Fishpool, L.D.C., & M.I. Evans (eds.). 2001. *Important Bird Areas in Africa and associated islands: priority sites for conservation*. Pisces Publications and BirdLife International, Newbury and Cambridge, UK.
- Fitzpatrick, J.W. 1981. Search strategies of tyrant flycatchers. *Animal Behaviour* 29: 810–821.
- Fjeldså, J. 1999. The impact of human forest disturbance on the endemic avifauna of the Udzungwa Mountains, Tanzania. *Bird Conservation International* 9: 47–62.
- Fjeldså, J. 2000. The relevance of systematics in choosing priority areas for global conservation. *Environmental Conservation* 27: 67–75.
- Fjeldså, J., Zuccon, D., Irestedt, M., Johansson, U.S., & G.P. Ericson. 2003. *Sapayoa aenigma*: a New World representative of 'Old World suboscines'. *Proceedings of The Royal Society of London B (Biological Sciences)* 270 (supplement): 238–241.
- Flade, M. 1994. Die Brutvogelgemeinschaften Mittel- und Norddeutschlands: Grundlagen für den Gebrauch vogelkundlicher Daten in der Landschaftsplanung. IHW-Verlag, Eching, Germany.
- Flather, C.H., Wilson, K.R., Dean, D.J., & W.C. McComb. 1997. Identifying gaps in conservation networks: on indicators and uncertainty in geographic-based analyses. *Ecological Applications* 7: 531–542.
- Fleischer, R.C., Tarr, C.L., Morton, E.S., Sangmeister, A., & K.C. Derrickson. 1997. Mating system of the Dusky Antbird, a tropical passerine, as assessed by DNA fingerprinting. *Condor* 99: 512–514.
- Fletcher, R.J., Jr., & R.L. Hutto. 2006. Estimating detection probabilities of river birds using double surveys. *Auk* 123: 695–707.

- Fogden, M.P.L. 1972. The seasonality and population dynamics of equatorial forest birds in Sarawak. *Ibis* 114: 307–343.
- Foster, R.B. 1990. Long-term change in the successional forest community of the Rio Manu floodplain. Pp. 565–572 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Fowler, J., & L. Cohen. 1986. *Statistics for Ornithologists*. British Trust for Ornithology, Hertfordshire, UK.
- Franzreb, K.E. 1981. A comparative analysis of territorial mapping and variable-strip transect censusing methods. *Studies in Avian Biology* 6: 164–169.
- Freile, J.F. 2002. Tapaculo del Chocó (*Scytalopus chocoensis*). Pp. 169–170 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCienca, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Freile, J.F., & T. Santander (eds.). 2005. Cayapas-Santiago-Wimbi (EC004). Pp. 302–303 in *BirdLife International & Conservation International. Áreas importantes para la conservación de las aves en los Andes tropicales: sitios prioritarios para la conservación de la biodiversidad*. BirdLife International, Serie de Conservación de BirdLife No. 14, Quito, Ecuador.
- Frost, T.M., Carpenter, S.R., & T.K. Kratz. 1992. Choosing ecological indicators: effect of taxonomic aggression on sensitivity to stress and natural variability. Pp. 215–228 in McKenzie, D.H., Hyatt, D.E., & V.J. McDonald (eds.). *Ecological indicators*. New York, USA.
- Fuller, D.O., Jessup, T.C., & A. Salim. 2004. Loss of forest cover in Kalimantan, Indonesia, since the 1997–1998 El Niño. *Conservation Biology* 18: 249–254.
- Gaddis, P. 1980. Mixed flocks, Accipiters, and antipredator behavior. *Condor* 82: 348–349.
- García-Moreno, J., Ohlson, J., & J. Fjeldså. 2001. MtDNA sequences support monophyly of *Hemipingus* tanagers. *Molecular Phylogenetics and Evolution* 21: 424–435.
- Gärdenfors, U., Hilton-Taylor, C., Mace, G.M., & J.P. Rodríguez. 2001. The application of IUCN red list criteria at regional levels. *Conservation Biology* 15: 1206–1212.
- Garwood, N.C. 1983. Seed germination in a seasonal tropical forest in Panama: a community study. *Ecological Monographs* 53: 159–181.
- Gascon, C., Williamson, G.B., & G.A.B. Fonseca. 2000. Receding edges and vanishing reserves. *Science* 288: 1356–1358.
- Gaston, K.J. 2000. Global patterns in biodiversity. *Nature* 405: 220–227.
- Gaston, K.J., & T.M. Blackburn. 1996. Conservation implications of geographical range size – body size relationships. *Conservation Biology* 10: 638–646.
- Gauch, H.G., Jr. 1982. *Multivariate analysis in community ecology*. Cambridge, UK.
- Gedeon, K., Mitschke, A., & C. Sudfeldt. 2007. *Brutvögel in Deutschland: zweiter Bericht*. Dachverband Deutscher Avifaunisten und Stiftung Vogelmonitoring, Hohenstein-Ernstthal, Germany.
- Gentry, A.H. 1982. Phytogeographic patterns as evidence for a Chocó refuge. Pp. 112–136 in Prance, G.T. (ed.). *Biological diversification in the tropics*. New York, USA.
- Gentry, A.H. 1986. Species richness and floristic composition of Chocó region plant communities. *Caldasia* 15: 71–91.
- Gentry, A.H. 1988a. Changes in plant community diversity and floristic composition on environmental gradients. *Annals of the Missouri Botanical Garden* 75: 1–34.
- Gentry, A.H. 1988b. Tree species richness of upper Amazonian forests. *Proceedings of the National Academy of Sciences of the USA* 85: 156–159.
- Gentry, A.H. 1989. Northwest South America (Colombia, Ecuador and Peru). Pp. 391–400 in Campbell, D., & H. Hammond (eds.). *Floristic inventory of tropical forests*. New York Botanical Garden, Bronx, New York, USA.
- Gentry, A.H. 1990a. Floristic similarities and differences between southern Central America and upper and central Amazonia. Pp. 141–157 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Gentry, A.H. (ed.). 1990b. *Four Neotropical rainforests*. New Haven, USA.
- Gentry, A.H. 1990c. Introduction. Pp. 1–5 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Gentry, A.H. 1990d. Tropical forests. Pp. 35–43 in Keast, A. (ed.). *Biogeography and ecology of forest bird communities*. The Hague, The Netherlands.
- Gentry, A.H. 1993. A field guide to the families and genera of woody plants of northwest South America. Conservation International, Washington, USA.
- Gentry, A.H., & J.W. Terborgh. 1990. Composition and dynamics of the Cocha Cashu 'mature' floodplain forest. Pp. 542–564 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Gilardi, J.D., & C.A. Munn. 1998. Patterns of activity, flocking, and habitat use in parrots of the Peruvian Amazon. *Condor* 100: 641–653.
- Gillespie, T.W. 2001. Application of extinction and conservation theories for forest birds in Nicaragua. *Conservation Biology* 15: 699–709.
- Gitay, H., Suárez, A., Watson, R.T., & D.J. Dokken. 2002. *Climate Change and Biodiversity*. Intergovernmental Panel on Climate Change (IPCC), WMO, UNEP.
- Goldsmith, F.B. (ed.). 1991. *Monitoring for Conservation and Ecology*. London, UK.
- Goodman, D. 1975. The theory of diversity-stability relations in ecology. *Q. Rev. Biol.* 50: 237–266.
- Gotelli, N.J., & R.K. Colwell. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4: 379–391.



- Gotelli, N.J., & G.R. Graves. 1996. Null models in ecology. Washington, USA.
- Goulding, M. 1980. The fishes and the forest: explorations in Amazonian natural history. Berkeley, USA.
- Graham, C.H. 2001. Factors influencing movement patterns of Keel-billed Toucans in a fragmented tropical landscape in southern Mexico. *Conservation Biology* 15: 1789–1798.
- Gram, W.R., & J. Faaborg. 1997. The distribution of Neotropical migrant birds wintering in the Cielo Biosphere Reserve, Tamaulipas, Mexico. *Condor* 99: 658–670.
- Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). 2002. Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Graves, G.R., & N.J. Gotelli. 1993. Assembly of avian mixed-species flocks in Amazonia. *Proceedings of the National Academy of Sciences of the USA* 90: 1388–1391.
- Graves, G.R., Robbins, M.B., & J.V. Remsen, Jr. 1983. Age and sexual difference in spatial distribution and mobility in manakins (Pipridae): inferences from mist netting. *Journal of Field Ornithology* 54: 407–412.
- Gray, J.S. 1987. Species abundance patterns. Pp. 53–67 in Gee, J.H.R., & P.S. Giller (eds.). *Organisation of Communities: Past and Present*. Oxford, UK.
- Greenberg, R., & J. Gradwohl. 1986. Constant density and stable territoriality in some tropical insectivorous birds. *Oecologia* 69: 618–625.
- Greenfield, P.J. 2002. Cuco Hormiguero Franjeado (*Neomorphus radiolus*). Pp. 146–147 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Gregory, R.D., Gibbons, D.W., & P.F. Donald. 2004. Bird census and survey techniques. Pp. 17–56 in Sutherland, W.J., Newton, I., & R.E. Green (eds.). *Bird ecology and conservation: a handbook of techniques*. Cambridge University Press, Cambridge, UK.
- Guerrero, M. 2002a. Águila Arpia (*Harpia harpyja*). Pp. 206–207 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Guerrero, M. 2002b. Colagris Alibandeado (*Xenerpestes minlosi*). Pp. 277 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Guevara, S., & J. Laborde. 1993. Monitoring seed dispersal at isolated standing trees in tropical pastures: consequences for local species availability. Pp. 319–338 in Fleming, T.H., & A. Estrada (eds.). *Frugivory and seed dispersal: ecological and evolutionary aspects*. Dordrecht, The Netherlands.
- Guevara, S., Laborde, J., & G. Sánchez. 1998. Are isolated remnant trees in pastures a fragmented canopy? *Selbyana* 19: 34–43.
- Guevara, S., Purata, S.E., & E. Van der Maarel. 1986. The role of remnant forest trees in tropical succession. *Veg-etatio* 66: 77–84.
- Haffer, J. 1967. Speciation in Colombian forest birds west of the Andes. *American Museum Novitates* 2294: 1–57.
- Haffer, J. 1969. Speciation in Amazonian forest birds. *Science* 165: 603–620.
- Haffer, J. 1974. Avian speciation in tropical South America. Nuttall Ornithological Club, Cambridge, USA.
- Haffer, J. 1975. Avifauna of northwestern Colombia, South America. *Bonner zoologische Monographien* 7: 5–182.
- Haffer, J. 1987. Quaternary history of tropical America. Pp. 1–18 in Whitmore, T.C., & G.T. Prance (eds.). *Biogeography and Quaternary history in tropical America*. New York, USA.
- Haffer, J. 1990. Avian species richness in tropical South America. *Studies on Neotropical Fauna and Environment* 25: 157–183.
- Haffer, J. 1991. Mosaic distribution patterns of Neotropical forest birds and underlying cyclic disturbance processes. *Ecological Studies* 85: 83–105.
- Haffer, J. 1993. Time's cycle and time's arrow in the history of Amazonia. *Biogeographica* 69: 15–45.
- Hagan, J.M., III, & D.W. Johnston (eds.). 1992. Ecology and conservation of Neotropical migrant landbirds. Washington, USA.
- Hallé, F. 1990. Tropical rain forests: structure and growth dynamics relative to utilization of birds. Pp. 27–33 in Keast, A. (ed.). *Biogeography and ecology of forest bird communities*. The Hague, The Netherlands.
- Hammond, P.M. 1992. Species inventory. Pp. 17–39 in Groombridge, B. (ed.). *Global biodiversity: status of the earth's living resources*. London, UK.
- Harper, L.H. 1989. The persistence of ant-following birds in small Amazonian forest fragments. *Acta Amazônica* 19: 249–263.
- Hart, R.D. 1980. A natural ecosystem analog approach to the design of a successional crop system for tropical forest environments. *Biotropica* 12: 73–82.
- Hartshorn, G.S. 1978. Treefalls in tropical dynamics. Pp. 617–638 in Tomlinson, P.B., & M.H. Zimmerman (eds.). *Tropical trees as living systems*. Cambridge, UK.
- Hartshorn, G.S. 1983. Plants. Pp. 118–157 in Janzen, D.H. (ed.). *Costa Rica Natural History*. Chicago, USA.
- Hartshorn, G.S. 1990. An overview of Neotropical forest dynamics. Pp. 585–599 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.



- Hartshorn, G.S., & B.E. Hammel. 1994. Vegetation types and floristic patterns. Pp. 73–89 in McDade, L.A., Bawa, K.S., Hespeneheide, H.A., & G.S. Hartshorn (eds.). *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- Haselmayer, J., & J.S. Quinn. 2000. A comparison of point counts and sound recording as bird survey methods in Amazonian southeast Peru. *Condor* 102: 887–893.
- Hayek, L.C., & M.A. Buzas. 1996. *Surveying natural populations*. New York, USA.
- Heath, M.F., Evans, M.I., Hoccom, D.G., Payne, A.J., & N.B. Peet (eds.). 2000a. Important Bird Areas in Europe: priority sites for conservation. Vol. 1: Northern Europe. BirdLife International, Cambridge, UK.
- Heath, M.F., Evans, M.I., Hoccom, D.G., Payne, A.J., & N.B. Peet (eds.). 2000b. Important Bird Areas in Europe: priority sites for conservation. Vol. 2: Southern Europe. BirdLife International, Cambridge, UK.
- Heimerdinger, M.A., & R.C. Lebermann. 1966. The comparative efficiency of 30 and 36 mm mesh in mist nets. *Bird-Banding* 37: 280–285.
- Helshe, J., & N.E. Forrester. 1983. Estimating species richness using the jackknife procedure. *Biometrics* 39: 1–11.
- Herzog, S.K., & M. Kessler. 2002. Biogeography and composition of dry forest bird communities in Bolivia. *Journal für Ornithologie* 143: 171–204.
- Herzog, S.K., Kessler, M., & T.M. Cahill. 2002. Estimating species richness of tropical bird communities from rapid assessment data. *Auk* 119: 749–769.
- Heyer, W.R., Donnelly, M.A., McDiarmid, R.W., Hayek, L.-A., & M.S. Foster (eds.). 1994. *Measuring and monitoring biological diversity: standard methods for amphibians*. Washington, USA.
- Hildén, O. 1981. Source of error involved in the Finnish line-transect method. *Studies in Avian Biology* 6: 152–159.
- Hilgert, N., & V. Benavides. 2002. Halcón Peregrino (*Falco peregrinus*). Pp. 211–212 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Hill, M.O. 1979. TWINSPLAN – a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. Ithaca, USA.
- Hill, M.O., Bunce, R.G.H., & M.W. Shaw. 1975. Indicator species analysis, a divisive polythetic method of classification, and its application to survey of native pine-woods in Scotland. *Journal of Ecology* 63: 597–613.
- Hill, M.O., & H.G. Gauch. 1980. Detrended correspondence analysis, an improved ordination technique. *Veg-etatio* 42: 47–58.
- Hilton-Taylor, C. 2000. 2000 IUCN red list of threatened species. IUCN, Gland, Switzerland.
- Hilty, S.L., & W.L. Brown. 1986. *A guide to the birds of Colombia*. Princeton, New Jersey, USA.
- Hinkelmann, C., & K.-L. Schuchmann. 1997. Phylogeny of the hermit hummingbirds (Trochilidae: Phaethornithinae). *Studies on Neotropical Fauna and Environment* 32: 142–163.
- Holdridge, L.R. 1967. *Life zone ecology*. Tropical Science Center, San José, Costa Rica.
- Holmes, R.T. 1990. The structure of a temperate deciduous forest bird community: variability in time and space. Pp. 121–139 in Keast, A. (ed.). *Biogeography and ecology of forest bird communities*. The Hague, The Netherlands.
- Holmes, R.T., Sherry, T.W., & F.W. Sturges. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. *Ecological Monographs* 56: 201–220.
- Holmes, R.T., & F.W. Sturges. 1975. Avian community dynamics and energetics in a northern hardwoods ecosystem. *Journal of Animal Ecology* 44: 175–200.
- Holmgren, P., & R. Davis. 2000. FRA 2000: on definitions of forest and forest change. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
- Houghton, R.A. 1991. Tropical deforestation and atmospheric carbon dioxide. *Climate Change* 19: 99–118.
- Houston, D.C. 1994. Family Cathartidae (New World vultures). Pp. 24–41 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- Howard, P.C., Viskanic, P., Davenport, T.R.B., Kigneniyi, F.W., Baltzer, M., Dickinson, C.J., Lwanga, J.S., Matthews, R.A., & A. Balmford. 1998. Complementarity and the use of indicator groups for reserve selection in Uganda. *Nature* 394: 472–475.
- Howe, H.F., & J. Smallwood. 1982. Ecology of seed dispersal. *Annual Review of Ecology and Systematics* 13: 201–228.
- Howell, S.N.G., & S. Webb. 1995. *A guide to the birds of Mexico and northern Central America*. Oxford, UK.
- Hubbell, S.P., & R.B. Foster. 1990. Structure, dynamics, and equilibrium status of old-growth forest on Barro Colorado Island. Pp. 522–541 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54: 187–211.
- Hutto, R.L., Pletschet, S.M., & P. Hendricks. 1986. A fixed-radius point count method for non-breeding and breeding season use. *Auk* 103: 593–602.
- INEFAN-GEF. 1998. *Guía de parques nacionales y reservas del Ecuador*. Proyecto INEFAN-GEF, Quito, Ecuador.

- International Bird Census Committee (IBCC). 1969. Recommendations for an international standard for a mapping method in bird census work. *Bird Study* 16: 248–255.
- International Bird Census Committee (IBCC). 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. *Audubon Field Notes* 24: 722–726.
- International Bird Census Committee (IBCC). 1977. Censusing breeding birds by the I.P.A. method. *Polish Ecological Studies* 3: 15–17.
- IPCC. 2007. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., & H.L. Miller (eds.)]. Cambridge, UK.
- Irestedt, M., Fjeldså, J., Johansson, U.S., & P.G.P. Ericson. 2002. Systematic relationships and biogeography of the tracheophone suboscines (Aves: Passeriformes). *Molecular Phylogenetics and Evolution* 23: 499–512.
- Irving, E.M. 1975. Structural evolution of the northernmost Andes, Colombia. *U.S. Geol. Surv. Prof. Pap.* 846.
- Isler, M.L., & P.R. Isler. 2003. Species limits in the pygmy antwren complex (Aves: Passeriformes: Thamnophilidae): 1. The taxonomic status of *Myrmotherula brachyura ignota*. *Proc. Biol. Soc. Wash.* 116: 23–28.
- IUCN. 1992. Protected areas of the world: a review of national systems. IUCN, Gland, Switzerland.
- IUCN. 2001. IUCN red list categories and criteria, version 3.1. IUCN, Species Survival Commission, Gland, Switzerland.
- Jahn, O. 2001. Integrating biological data into development projects: threatened bird species and management plans for sustainable forestry in the Province of Esmeraldas, Ecuador. Pp. 41–53 in Rhoades, R., & J. Stallings (eds.). *Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies*. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- Jahn, O. 2008. Rediscovery of Black-breasted Puffleg *Eriocnemis nigrivestis* in the Cordillera de Toisán, north-west Ecuador, and reassessment of its conservation status. *Cotinga* 129: 31–39.
- Jahn, O., Jara Viteri, M.E., & K.-L. Schuchmann. 1999a. Connecticut Warbler, a North American migrant new to Ecuador. *Wilson Bulletin* 111: 281–282.
- Jahn, O., & P. Mena V. 2002a. Arasari Piquirrayado (*Pteroglossus sanguineus*). Pp. 262–263 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002b. Autillo del Chocó (*Otus centralis*). Pp. 361 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002c. Barbudo Cinco Colores (*Capito quinticolor*). Pp. 153–154 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002d. Barbudo Frentinaranja (*Capito squamatus*). Pp. 374 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002e. Batarito Coronipunteado (*Dysithamnus puncticeps*). Pp. 384 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002f. Cacique Lomiescarlata (*Cacicus microrhynchus*). Pp. 418 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002g. Calzonario Patirrojo (*Chalybura urochrysa*). Pp. 253–254 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002h. Carpintero Canelo (*Celeus loricatus*). Pp. 379 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002i. Carpintero del Chocó (*Veniornis chocoensis*). Pp. 272–273 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002j. Carpintero Guayaquileño (*Campephilus guayaquilensis*). Pp. 274–275 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.

- Jahn, O., & P. Mena V. 2002k. Colibrí Piquidentado (*Anodrodon aequatorialis*). Pp. 363 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002l. Copetón Plañidero Rufo (*Rhytipterna holerythra*). Pp. 394 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002m. Corcovado Frenticolorado (*Odontophorus erythrops*). Pp. 218–219 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002n. Cotinga Azul (*Cotinga nattererii*). Pp. 318–319 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002o. Cotinga Blanca (*Carpodectes hopkei*). Pp. 320–321 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002p. Dacnis Musliescarlata (*Dacnis venusta*). Pp. 405 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002q. Eufonia Ventrileonada (*Euphonia fulvicrissa*). Pp. 407 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002r. Hormiguerito de Griscom (*Myrmotherula ignota*). Pp. 385 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002s. Hormiguero Colimocho (*Myrmeciza berlepschi*). Pp. 389 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002t. Hormiguero Inmaculado (*Myrmeciza immaculata*). Pp. 387 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002u. Hormiguero Moteado (*Hylophylax naevioides*). Pp. 386 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002v. Hormiguero Ocelado (*Phoenostictus mcleannani*). Pp. 293–294 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002w. Loro Alibronceado (*Pionus chalcopterus*). Pp. 244–245 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002x. Loro Cachetirrosa (*Pionopsitta pulchra*). Pp. 242–243 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002y. Mochuelo Cabecigris (*Glauucidium griseiceps*). Pp. 246–247 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002z. Mosquero Aureola (*Conopias albovittata*). Pp. 395 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002#. Oropéndola Cabecicastaña (*Zarhynchus wagleri*). Pp. 345–346 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002\*. Pájaro-Paraguas Longuipéndulo (*Cephalopterus penduliger*). Pp. 177–178 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.

- Jahn, O., & P. Mena V. 2002†. Paloma Oscura (*Columba goodsoni*). Pp. 230–231 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002¥. Paloma Perdiz Corona Indigo (*Geotrygon purpurata*). Pp. 232–233 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002π. Paloma Perdiz Dorsioliva (*Geotrygon veraguensis*). Pp. 132–133 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Ä. Pava Bronceada (*Penelope ortonii*). Pp. 120–121 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Å. Perlita Pechipizarrosa (*Polioptila schistaceigula*). Pp. 327–328 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Ç. Picoplano del Pacífico (*Rhynchocyclus pacificus*). Pp. 391 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002É. Piha Rojiza (*Lipaugus unirufus*). Pp. 314–315 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Ñ. Pitasoma Coronirrufa (*Pittasoma rufopileatum*). Pp. 295–296 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Ö. Plañidera Moteada (*Laniocera rufescens*). Pp. 314–315 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Ü. Rondamusgos Occidental (*Hyloctistes virgatus*). Pp. 381 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002Á. Siristes Occidental (*Sirystes albogriseus*). Pp. 310–311 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002à. Soterrey Canoro (*Cyphorhinus phaeocephalus*). Pp. 404 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002â. Soterrey Golirrayado (*Thryothorus leucopogon*). Pp. 403 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ä. Tangara Alirrufa (*Tangara lavinia*). Pp. 409 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002â. Tangara Bigotiazul (*Tangara johannae*). Pp. 333–334 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002â. Tangara Cejiescarlata (*Heterospingus xanthopygius*). Pp. 410 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ç. Tangara Doradigris (*Tangara palmeri*). Pp. 408 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002é. Tangara Escarlatiblanca (*Erythrothlypis salmoni*). Pp. 406 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.

- Jahn, O., & P. Mena V. 2002è. Tangara Ojeralimón (*Chlorothraupis olivacea*). Pp. 340–341 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ê. Tangara Pechidorada (*Bangsia rothschildi*). Pp. 337–338 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ë. Tororoi Pechirrayado (*Hylopezus perspicillatus*). Pp. 299–300 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002í. Trepatroncos Barreteado Norteño (*Dendrocolaptes sanctithomae*). Pp. 286–287 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002i. Trepatroncos Manchado (*Xiphorhynchus erythropygius*). Pp. 382 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002j. Trepatroncos Pinto (*Xiphorhynchus lachrymosus*). Pp. 288–289 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002k. Trogón del Chocó (*Trogon comptus*). Pp. 371 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ñ. Tucán de Swainson (*Ramphastos swainsonii*). Pp. 268–269 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ó. Tucán del Chocó (*Ramphastos brevis*). Pp. 266–267 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., & P. Mena V. 2002ò. Tucancillo Orejiamarillo (*Selenidena spectabilis*). Pp. 427 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Jahn, O., Moore, J.V., Coopmans, P., Mena V., P., Krabbe, N., Lysinger, M., Navarrete, L., Nilsson, J., & R.S. Ridgely. 2008. The birds of northwest Ecuador, volume I: the upper foothills and subtropics – revised and expanded edition. John V. Moore Nature Recordings, San Jose, USA.
- Jahn, O., Moore, J.V., Mena V., P., Krabbe, N., Coopmans, P., Lysinger, M., & R.S. Ridgely. 2002. The birds of northwest Ecuador, volume II: the lowlands and lower foothills – summary edition. John V. Moore Nature Recordings, San Jose, USA.
- Jahn, O., Palacios, B., & P. Mena V. 2007. Ecology, population and conservation status of the Chocó Vireo *Vireo masteri*, a species new to Ecuador. Bulletin British Ornithologists' Club 127: 161–166.
- Jahn, O., Robbins, M.B., Mena V., P., Coopmans, P., Ridgely, R.S., & K.-L. Schuchmann. 2000. Status, ecology, and vocalizations of the Five-coloured Barbet *Capito quinticolor* in Ecuador, with notes on the Orange-fronted Barbet *C. squamatus*. Bulletin British Ornithologists' Club 120: 16–22.
- Jahn, O., Vargas G., E.E., & K.-L. Schuchmann. 1999b. The life history of the Long-wattled Umbrellabird *Cephalopterus penduliger* in the Andean foothills of northwest Ecuador: leks, behaviour, ecology and conservation. Bird Conservation International 9: 81–94.
- Janzen, D.H. 1975. Ecology of plants in the tropics. London, UK.
- Järvinen, O., Koskimies, P., & R.A. Väisänen. 1991. Line transect census of breeding land birds. Pp. 33–40 in Koskimies, P., & R.A. Väisänen (eds.). Monitoring bird populations: a manual of methods applied in Finland. Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland.
- Järvinen, O., & R.A. Väisänen. 1975. Estimating relative densities of breeding birds by the line transect method. Oikos 26: 316–322.
- Järvinen, O., & R.A. Väisänen. 1981. Methodology for censusing land bird faunas in large regions. Studies in Avian Biology 6: 146–151.
- Järvinen, O., & R.A. Väisänen. 1983a. Confidence limits for estimates of population density in line transects. Ornis Scandinavica 14: 129–134.
- Järvinen, O., & R.A. Väisänen. 1983b. Correction coefficients for line transect censuses of breeding birds. Ornis Fennica 60: 97–104.
- Jenkins, M., Green, R.E., & J. Madden. 2003. The challenge of measuring global change in wild nature: are things getting better or worse? Conservation Biology 17: 20–23.



- Jenks, W.F. 1956. Handbook of South American geology: an explanation of the geologic map of South America. Geol. Soc. Amer. Mem. 65.
- Jennings, S.B., Brown, N.D., & D. Sheil. 1999. Assessing forest canopies and understorey illumination: canopy closure, canopy cover and other measures. *Forestry* 72: 59–73.
- Jiménez, I., Londoño, G.A., & C.D. Cadena. 2003. Efficiency, bias, and consistency of visual and aural surveys of curassows (Cracidae) in tropical forests. *Journal of Field Ornithology* 74: 210–216.
- Johns, A.D. 1986. Effects of selective logging on the ecological organization of a peninsular Malaysian rainforest avifauna. *Forktail* 1: 65–79.
- Johns, A.D. 1989. Recovery of a peninsular Malaysian rainforest avifauna following selective timber logging: the first twelve years. *Forktail* 4: 89–105.
- Johns, A.D. 1991. Responses of Amazonian rain forest birds to habitat modification. *Journal of Tropical Ecology* 7: 417–437.
- Johns, A.D. 1992. Vertebrate response to selective logging: implications for the design of logging systems. *Philosophical Transactions of the Royal Society of London B* 335: 437–442.
- Johnson, K.P., de Kort, S., Dinwoodey, K., Mateman, A.C., Ten Cate, C., Lessells, C.M., & D.H. Clayton. 2001. Phylogeny and systematics of the dove genera *Streptopelia* and *Columba*. *Auk* 118: 874–887.
- Johnson, N., & B. Cabarle. 1993. Surviving the cut: natural forest management in the humid tropics. World Resource Institute, New York and Washington, USA.
- Johnson, N.K., Zink, R.M., & J.A. Marten. 1988. Genetic evidence for relationships in the avian family Vireonidae. *Condor* 90: 428–445.
- Johnson, R.R., Brown, B.T., Haight, L.T., & J.M. Simpson. 1981. Playback recordings as a special avian censusing technique. *Studies in Avian Biology* 6: 68–75.
- Johnson, R.R., & J.J. Dinsmore. 1986. The use of tape-recorded calls to count Virginia Rails and Soras. *Wilson Bulletin* 98: 303–306.
- Johnson, R.R., Haight, L.T., & J.M. Simpson. 1979. Owl populations and species status in the southwestern United States. Pp. 40–59 in Schaeffer, P.P., & S.M. Ehlers (eds.). Proceedings of symposium on owls of the west: their ecology and conservation. Natl. Aud. Soc. West. Ed. Center, Tiburon, USA.
- Jongman, R.H.G., ter Braak, C.J.F., & O.F.R. van Tongeren (eds.). 1987. Data Analysis in Community and Landscape Ecology. Pudoc, Wageningen, The Netherlands.
- Jullien, M., & J.-M. Thiollay. 1996. Effects of rain forest disturbance and fragmentation: comparative changes of the raptor community along natural and man-made gradients in French Guiana. *Journal of Biogeography* 23: 7–25.
- Kaeslin, E.A. 2002. Die Einflüsse von Waldrand, Ökotourismus und kleinflächiger Walddnutzung auf die Diversität und Abundanz der Avifauna eines neotropischen Tiefland-Regenwaldes am Río Napo, Ecuador. Ph.D. Thesis, Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany (unpubl.).
- Kapos, V. 1989. Effects of isolation on the water status of forest patches in the Brazilian Amazon. *Journal of Tropical Ecology* 5: 173–185.
- Kapos, V., Ganade, G., Matsuli, E., & R.L. Victoria. 1993.  $\delta^{13}\text{C}$  as an indicator of edge effects in tropical rainforest reserves. *Journal of Ecology* 81: 425–432.
- Karr, J.R. 1971. Structure of avian communities in selected Panama and Illinois habitats. *Ecological Monographs* 41: 207–233.
- Karr, J.R. 1975. Production, energy pathways, and community diversity in forest birds. *Ecological Studies* 11: 161–176.
- Karr, J.R. 1976a. Seasonality, resource availability, and community diversity in tropical bird communities. *American Naturalist* 110: 973–994.
- Karr, J.R. 1976b. Within- and between-habitat avian diversity in African and Neotropical lowland habitats. *Ecological Monographs* 46: 457–481.
- Karr, J.R. 1977. Ecological correlates of rarity in a tropical forest bird community. *Auk* 94: 240–247.
- Karr, J.R. 1979. On the use of mist nets in the study of bird communities. *Inland Bird Banding* 51: 1–10.
- Karr, J.R. 1980a. Geographical variation in the avifaunas of tropical forest undergrowth. *Auk* 97: 283–298.
- Karr, J.R. 1980b. History of the habitat concept in birds and the measurement of avian habitats. Pp. 991–997 in Acta Proc. XVII International Congress of Ornithology, Berlin, Germany.
- Karr, J.R. 1981a. Surveying birds in the tropics. *Studies in Avian Biology* 6: 548–553.
- Karr, J.R. 1981b. Surveying birds with mist-nets. *Studies in Avian Biology* 6: 62–67.
- Karr, J.R. 1990. The avifauna of Barro Colorado Island and the Pipeline Road, Panama. Pp. 183–198 in Gentry, A.H. (ed.). Four Neotropical rainforests. New Haven, USA.
- Karr, J.R., Robinson, S.K., Blake, J.G., & R.O. Bierregaard, Jr. 1990. Birds of four Neotropical forests. Pp. 237–269 in Gentry, A.H. (ed.). Four Neotropical rainforests. New Haven, USA.
- Karr, J.R., & R.R. Roth. 1971. Vegetation structure and avian diversity in several New World areas. *American Naturalist* 105: 423–435.
- Keast, A., & E.S. Morton (eds.). 1980. Migrant birds in the Neotropics: ecology, behavior, distribution and conservation. Washington, USA.
- Keating, K.A., & J.F. Quinn. 1998. Estimating species richness: the Michaelis-Menten model revisited. *Oikos* 81: 411–416.



- Kellmann, M. 1980. Geographic patterning in tropical weed communities and early secondary succession. *Biotropica* 12: 34–39.
- Kempton, R.A. 2002. Species diversity. Pp. 2086–2092 in El-Shaarawi, A.H., & W.W. Piegorsch (eds.). *Encyclopedia of Environmetrics*. Chichester, UK.
- Kempton, R.A., & L.R. Taylor. 1974. Log-series and log-normal parameters as diversity determinants for the Lepidoptera. *Journal of Animal Ecology* 43: 381–399.
- Kennerley, J.B. 1980. Outline of the geology of Ecuador. *Overseas Geology and Mineral Resources* 55: 1–17.
- Kepler, C.B., & J.M. Scott. 1981. Reducing count variability by training observers. *Studies in Avian Biology* 6: 366–371.
- Kerr, J.T., Sugar, A., & L. Packer. 2000. Indicator taxa, rapid biodiversity assessment, and nestedness in an endangered ecosystem. *Conservation Biology* 14: 1726–1734.
- Kéry, M., J. Royle, A., & H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. *Ecological Applications* 15: 1450–1461.
- Kéry, M., & H. Schmid. 2004. Monitoring programs need to take into account imperfect species detectability. *Basic and Applied Ecology* 5: 65–73.
- Kéry, M., & H. Schmid. 2006. Estimating species richness: calibrating a large avian monitoring programme. *Journal of Applied Ecology* 43: 101–110.
- King, D.I., & J.H. Rappole. 2000. Winter flocking of insectivorous birds in montane pine-oak forests in Middle America. *Condor* 102: 664–672.
- Klein, B. 1989. Effects of forest fragmentation on dung and carrion beetle communities in Central Amazonia. *Ecology* 70: 1715–1725.
- Kleinman, D.G., & J.J.C. Mallinson. 1998. Recovery and management committees for lion tamarins: partnerships in conservation planning and implementation. *Conservation Biology* 12: 27–38.
- Klicka, J., Johnson, K.P., & S.M. Lanyon. 2000. New World nine-primaried oscine relationships: constructing a mitochondrial DNA framework. *Auk* 117: 321–326.
- Klinge, H., Rodrigues, W.A., Bruning, E., & E.J. Fittkau. 1975. Biomass and structure in a central Amazonian rain forest. *Ecological Studies* 11: 115–122.
- Koskimies, P., & R.A. Väisänen. 1991a. Mapping census of breeding land birds. Pp. 63–74 in Koskimies, P., & R.A. Väisänen (eds.). *Monitoring bird populations: a manual of methods applied in Finland*. Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland.
- Koskimies, P., & R.A. Väisänen (eds.). 1991b. *Monitoring bird populations: a manual of methods applied in Finland*. Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland.
- Krabbe, N., & J. Nilsson. 2003. *Birds of Ecuador: sounds and photographs*. Bird Songs International BV, Westerland, The Netherlands.
- Krabbe, N., & T.S. Schulenberg. 1997. Species limits and natural history of *Scytalopus tapaculos* (Rhinocryptidae), with descriptions of the Ecuadorian taxa, including three new species. Pp. 47–88 in Remsen, J.V., Jr. (ed.). *Studies in Neotropical ornithology honoring Ted Parker*. Ornithological Monographs, No. 48, AOU.
- Krebs, C.J. 1989. *Ecological methodology*. New York, USA.
- Kremen, C., Colwell, R.K., Erwin, T.L., Murphy, D.D., Noss, R.F., & M.A. Sanjayan. 1993. Terrestrial arthropod assemblages: their use in conservation planning. *Conservation Biology* 7: 796–808.
- Kroodsma, D.E., Viellard, J.M.E., & F.G. Stiles. 1996. Study of bird sounds in the Neotropics: urgency and opportunity. Pp. 269–281 in Kroodsma, D.E., & E.H. Miller (eds.). *Ecology and evolution of acoustic communication in birds*. Ithaca, USA.
- Kruskal, J.B. 1964. Nonmetric multidimensional scaling: a numerical method. *Psychometrika* 29: 115–129.
- Kulesza, G. 1990. An analysis of clutch-size in New World passerine birds. *Ibis* 132: 407–422.
- Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. *Conservation Biology* 11: 849–856.
- Lambert, F.R. 1992. The consequences of selective logging for Bornean lowland forest birds. *Philosophical Transactions of the Royal Society of London B* 335: 443–457.
- Landres, P.B. 1992. Ecological indicators: panacea or liability? Pp. 1295–1318 in McKenzie, D.H., Hyatt, D.E., & V.J. McDonald (eds.). *Ecological indicators*. New York, USA.
- Landres, P.B., Verner, J., & J.W. Thomas. 1988. Ecological uses of vertebrate indicator species: a critique. *Conservation Biology* 2: 316–329.
- Lanfer, N. 1995. *Wasserbilanz und Bestandsklima als Grundlage einer agrarklimatischen Differenzierung in der COSTA Ecuador*. Verlag Erich Goltze GmbH & Co. KG, Göttingen, Germany.
- Lang, G.E., & D.H. Knight. 1983. Tree growth, mortality, recruitment, and canopy gap formation during a ten-year period in a tropical moist forest. *Ecology* 64: 1075–1080.
- Lanyon, S.M., & K.E. Omland. 1999. A molecular phylogeny of the blackbirds (Icteridae): five lineages revealed by cytochrome-b sequence data. *Auk* 116: 629–639.
- Lanyon, W.E. 1988. Phylogenetic affinities of the flycatcher genera *Myiobius* Darwin and *Terenotriccus* Ridgway. *American Museum Novitates* 2915: 1–15.
- Lauer, W. 1952. Humide und aride Jahreszeiten in Afrika und Südamerika und ihre Beziehung zu den Vegetationsgürteln. *Bonner Geographische Abhandlungen* 9: 15–98.
- Laurance, W.F. 1994. Rainforest fragmentation and the structure of small mammal communities in tropical Queensland. *Biological Conservation* 69: 23–32.

- Laurance, W.F., Delamonica, P., Laurance, S.G., Vasconcelos, H.L., & T.E. Lovejoy. 2000. Rainforest fragmentation kills big trees. *Nature* 404: 836.
- Laurance, W.F., Ferreira, L.V., Rankin-de Merona, J.M., & S.G. Laurance. 1998a. Rain forest fragmentation and the dynamics of Amazonian tree communities. *Ecology* 79: 2032–2040.
- Laurance, W.F., Ferreira, L.V., Rankin-de Merona, J.M., Laurance, S.G., Hutchings, R.W., & T.E. Lovejoy. 1998b. Effects of forest fragmentation on recruitment patterns in Amazonian tree communities. *Conservation Biology* 12: 460–464.
- Laurance, W.F., Lovejoy, T.E., Vasconcelos, H.L., Bruna, E.M., Didham, R.K., Stouffer, P.C., Gascon, C., Bierregaard, R.O., Jr., Laurance, S.G., & E. Sampaio. 2002. Ecosystem decay of Amazonian forest fragments: a 22-year investigation. *Conservation Biology* 16: 605–618.
- Laurance, W.F., & E. Yensen. 1991. Predicting the impacts of edge effects in fragmented habitats. *Biological Conservation* 55: 77–92.
- Lawler, J.J., White, D.W., Sifneos, J.C., & L.L. Master. 2003. Rare species and the use of indicator groups for conservation planning. *Conservation Biology* 17: 875–882.
- Lawton, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., Hodda, M., Holt, R.D., Larsen, T.B., Mawdsley, N.A., Stork, N.E., Srivastava, D.S., & A.D. Watt. 1998. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature* 391: 72–76.
- Leck, C.F. 1979. Avian extinctions in an isolated tropical wet-forest reserve, Ecuador. *Auk* 96: 343–352.
- Lee, S.-M., & A. Chao. 1994. Estimating population size via sample coverage for closed capture-recapture models. *Biometrics* 50: 88–97.
- Lefebvre, G., Poulin, B., & R. McNeil. 1994. Temporal dynamics of mangrove bird communities in Venezuela with special reference to migrant warblers. *Auk* 111: 405–415.
- Legendre, P., & L. Legendre. 1998. *Numerical Ecology*. Amsterdam, The Netherlands.
- Leger, D.W., & D.J. Mountjoy. 2003. Geographic variation in song of the Bright-rumped Attila (Tyrannidae: *Attila spadiceus*): implications for species status. *Auk* 120: 69–74.
- Leigh, E.G., Jr., & S.J. Wright. 1990. Barro Colorado Island and tropical biology. Pp. 28–47 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Lemmon, P.E. 1957. A new instrument for measuring forest overstory density. *Journal of Forestry* 55: 667–668.
- León J., M. 2001a. The community forest network: A tool for strengthening community capacity. Pp. 179–189 in Rhoades, R., & J. Stallings (eds.). *Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies*. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- León J., M. 2001b. Problems associated with the sale of timber in the buffer zone of the Cotacachi-Cayapas Ecological Reserve. Pp. 169–177 in Rhoades, R., & J. Stallings (eds.). *Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies*. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- Leutfeld, M. 1992. Abundanzan regenwaldbewohnender Vogelarten. M.Sc. Thesis, Rheinischen Friedrich-Wilhelms-Universität, Bonn, Germany (unpubl.).
- Levene, H. 1960. Robust tests for equality of variance. Pp. 278–292 in Olkin, I., Ghurye, S.G., Hoefding, W., Madow, W.G., & H.B. Mann (eds.). *Contributions to probability and statistics: essays in honor of Harold Hotelling*. Stanford, USA.
- Levey, D.J. 1988a. Spatial and temporal variation in Costa Rica fruit and fruit-eating bird abundance. *Ecological Monographs* 58: 251–269.
- Levey, D.J. 1988b. Tropical wet forest treefall gaps and distributions of understory birds and plants. *Ecology* 69: 1076–1089.
- Levey, D.J., & E.G. Stiles. 1992. Resource availability and movement patterns in Neotropical landbirds: evolutionary precursors of long-distance migration. *American Naturalist* 140: 447–476.
- Levey, D.J., & E.G. Stiles. 1994. Birds: ecology, behavior, and taxonomic affinities. Pp. 217–227 in McDade, L.A., Bawa, K.S., Hespeneheide, H.A., & G.S. Hartshorn (eds.). *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- Levin, S.A. 1992. The problem of pattern and scale in ecology: the Robert H. MacArthur award lecture. *Ecology* 73: 1943–1967.
- Levin, S.A., & R.T. Paine. 1974. Disturbance, patch formation, and community structure. *Proceedings of the National Academy of Sciences of the USA* 71: 2744–2747.
- Levy, S.H., Levy, J.J., & R.A. Bishop. 1966. Use of tape recorded female quail calls during the breeding season. *Journal of Wildlife Management* 30: 426–428.
- Lewin, R. 1984. Parks: How big is big enough? *Science* 225: 611–612.
- Lewis, S. 1998. Treefall gaps and regeneration: a comparison of continuous forest and fragmented forest in Central Amazonia. Ph.D., University of Cambridge, Cambridge, UK (unpubl.).
- Lieberman, D., Hartshorn, G.S., Lieberman, M., & R. Peralta. 1990. Forest dynamics at La Selva Biological Station, 1969–1985. Pp. 509–521 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Lieberman, D., & M. Lieberman. 1987. Forest tree growth and dynamics at La Selva, Costa Rica (1969–1982). *Journal of Tropical Ecology* 3: 347–358.

- Lindenmayer, D.B., Margules, C.R., & D.B. Botkin. 2000. Indicators of biodiversity for ecologically sustainable forest management. *Conservation Biology* 14: 941–950.
- Lindstedt, S.L., & W.A. Calder. 1976. Body size and longevity in birds. *Condor* 78: 91–94.
- Lindstedt, S.L., Miller, B.J., & S.W. Buskirk. 1986. Home range, time, and body size in mammals. *Ecology* 67: 413–418.
- Little, E.L., & R.G. Dixon. 1969. Árboles comunes de la provincia de Esmeraldas. Programa de las Naciones Unidas para el Desarrollo, Organización de las Naciones Unidas para la Agricultura y Alimentación (FAO), Rome, Italy.
- Loiselle, B.A., & J.G. Blake. 1990. Diets of understory fruit-eating birds in Costa Rica: seasonality and resource abundance. *Studies in Avian Biology* 13: 91–103.
- Loiselle, B.A., & J.G. Blake. 1991a. Resource abundance and temporal variation in fruit-eating birds along a wet forest elevational gradient in Costa Rica. *Ecology* 72: 494–500.
- Loiselle, B.A., & J.G. Blake. 1991b. Temporal variation in birds and fruits along an elevational gradient in Costa Rica. *Ecology* 72: 180–193.
- Loiselle, B.A., & J.G. Blake. 1992. Population variation in a tropical bird community: implications for conservation. *BioScience* 42: 838–845.
- Lougheed, S.C., Freeland, J.R., Handford, P., & P.T. Boag. 2000. A molecular phylogeny of warbling-finches (*Pooecetes*): parapatry in a Neotropical emberizid genus. *Molecular Phylogenetics and Evolution* 17: 367–378.
- Lovejoy, T.E. 1974. Bird diversity and abundance in Amazon forest communities. *Living Bird* 13: 127–191.
- Lovejoy, T.E., Bierregaard, R.O., Jr., Rankin, J.M., & H. O.R. Schubart. 1983. Ecological dynamics of tropical forest fragments. Pp. 377–384 in Sutton, S.L., Whitmore, T.C., & A.C. Chadwick (eds.). *Tropical rain forest: ecology and management*. Special Publication no. 2, British Ecological Society and Blackwell Scientific Publications, Oxford, UK.
- Lovejoy, T.E., Bierregaard, R.O., Jr., Rylands, A.B., Malcolm, J.R., Quintela, C.E., Harper, L.H., Brown, K.S., Jr., Powell, A.H., Powell, G.V.N., Schubart, H.O.R., & M.B. Hays. 1986. Edge and other effects of isolation on Amazon forest fragments. Pp. 257–283 in Soulé, M.E. (ed.). *Conservation biology: the science of scarcity and diversity*. Sunderland, USA.
- Lovejoy, T.E., & R.O. Bierregaard, Jr. 1990. Central Amazonian forests and the Minimum Critical Size of Ecosystem Project. Pp. 60–71 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Lovette, I.J., & E. Bermingham. 2002. What is a wood-warbler? Molecular characterization of a monophyletic Parulidae. *Auk* 119: 695–714.
- Lugo, A.E. 1992. Composition of tropical tree plantations with secondary forests of similar age. *Ecological Monographs* 62: 1–41.
- Lynch, J.D. 1979. The amphibians of the lowland tropical forest. Pp. 189–215 in Duellman, W.E. (ed.). *The South American herpetofauna: its origin, evolution, and dispersal*. University of Kansas, Museum of Natural History, Kansas City.
- Lynch, J.F. 1989. Distribution of overwintering Nearctic migrants in the Yucatan Peninsula, I: General patterns of occurrence. *Condor* 91: 515–544.
- Lynch, J.F. 1991. Effects of hurricane Gilbert on birds in a dry tropical forest in the Yucatan Peninsula. *Biotropica* 23: 488–496.
- Lynch, J.F. 1992. Distribution of overwintering Nearctic migrants in the Yucatan, Peninsula, II: use of native and human-modified vegetation. Pp. 178–196 in Hagan, J.M., III & D.W. Johnston (eds.). *Ecology and conservation of Neotropical migrant landbirds*. Washington, USA.
- Lynch, J.F. 1995. Effects of point count duration, time-of-day, and aural stimuli on detectability of migratory and resident bird species in Quintana Roo, Mexico. Pp. 1–6 in Ralph, C.J., Sauer, J.R., & S. Droege (eds.). *Monitoring Bird Populations by Point Counts*. United States Department of Agriculture, USDA, Forest Service Gen. Tech. Rep. PSW-GTR-149, Albany, USA.
- MacArthur, R.A., & J.T. MacArthur. 1974. On the use of mist nets for population studies of birds. *Proceedings of the National Academy of Sciences of the USA* 71: 3230–3233.
- MacArthur, R.H., Recher, H., & M.L. Cody. 1966. On the relation between habitat selection and species diversity. *American Naturalist* 100: 319–327.
- MacArthur, R.H., & E.O. Wilson. 1967. *The theory of island biogeography*. Princeton, USA.
- Macellari, C. 1984. Late Tertiary tectonic history of the Tachira Depression, southwestern Venezuelan Andes. *Geol. Soc. Amer. Mem.* 162: 333–341.
- MacKinnon, S., & K. Phillipps. 1993. *A Field Guide to the Birds of Borneo, Sumatra, Java and Bali*. Oxford, UK.
- MAE. 2007. Plan de manejo de la Reserva Cotacachi-Cayapas. Proyecto GEF Ecuador: Sistema Nacional de Áreas Protegidas (SNAP-GEF). Ministerio del Ambiente del Ecuador, Quito, Ecuador.
- Magurran, A.E. 1988. *Ecological diversity and its measurement*. London, UK.
- Malcolm, J.R. 1994. Edge effects in central Amazonian forest fragments. *Ecology* 75: 2438–2445.
- Malcolm, J.R., Liu, C., Neilson, R.P., Hansen, L., & L. Hannah. 2006. Global warming and extinctions of endemic species from biodiversity hotspots. *Conservation Biology* 20: 538–548.

- Mannan, R.W., Morrison, M.L., & E.C. Meslow. 1984. The use of guilds in forest bird management. *Wildlife Society Bulletin* 12: 426–430.
- Marcotullio, P.J., & F.B. Gill. 1985. Use of time and space by Chestnut-backed Antbirds. *Condor* 87: 187–191.
- Marengo, J.A. 2006. Drought in Amazonia. P. S70 in Shein, K. (ed.). *State of the climate in 2005*, volume 87. *Bulletin of the American Meteorological Society*, Washington, USA.
- Marengo, J.A., Nobre, C.A., Tomasella, J., & M.F. Cardoso. 2008. Hydro-climatic and ecological behaviour of the drought of Amazonia in 2005. *Philosophical Transactions of the Royal Society of London B* 363: 1773–1778.
- Marín A., M., & F.G. Stiles. 1992. On the biology of five species of swifts (Apodidae, Cypseloidinae) in Costa Rica. *Proceedings of the Western Foundation of Vertebrate Zoology* 4: 287–351.
- Marion, W.R., O'Meara, T.E., & D.S. Maehr. 1981. Use of playback recordings in sampling elusive or secretive birds. *Studies in Avian Biology* 6: 81–85.
- Marks, J.S., Cannings, R.J., & H. Mikkola. 1999. Family Strigidae (typical owls). Pp. 76–242 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- Marshall, L.G., Webb, S.D., Sepkowski, J.J., & D.M. Raup. 1982. Mammalian evolution and the great American interchange. *Science* 215: 1351–1357.
- Marten, K., & P. Marler. 1977. Sound transmission and its significance for animal vocalization. I. Temperate habitats. *Behav. Ecol. Sociobiol.* 2: 271–290.
- Marten, K., Quine, D., & P. Marler. 1977. Sound transmission and its significance for animal vocalization. II. Tropical forest habitats. *Behav. Ecol. Sociobiol.* 2: 291–302.
- Martin, T.E. 2001. Abiotic vs. biotic influences on habitat selection of coexisting species: climate change impacts? *Ecology* 82: 175–188.
- Martin, T.E., & D.M. Finch (eds.). 1995. *Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues*. New York, USA.
- Martínez-Morales, M.A. 1999. Conservation status and habitat preferences of the Cozumel Curassow. *Condor* 101: 14–20.
- Martínez-Vilalta, A., & A. Motis. 1992. Family Ardeidae (herons). Pp. 376–429 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 1: Ostrich to ducks. Barcelona, Spain.
- Mason, D.J. 1996. Responses of understory birds to selective logging, enrichment strips, and vine cutting. *Biotropica* 28: 296–309.
- Mason, D.J., & J.-M. Thiollay. 2001. Tropical forestry and the conservation of Neotropical birds. Pp. 167–191 in Fimbel, R.A., Grajal, A., & J.E. Robinson (eds.). *The Cutting Edge: Conserving Wildlife in Logged Tropical Forest*. New York, USA.
- Mather, P.M. 1976. *Computational methods of multivariate analysis in physical geography*. London, UK.
- Matthews, E. 2001. *Understanding the FRA 2000*. Forest Briefing No. 1, World Resources Institute, Washington, USA.
- Maurer, B.A., Ford, H.A., & E.H. Rapoport. 1990. Extinction rate, body size, and avifaunal diversity. Pp. 826–834 in *Proc. Congressus Internationalis Ornithologici*, Christchurch, New Zealand.
- May, R.M. 1975. Pattern of species abundance and diversity. Pp. 81–120 in Cody, M.L., & J.M. Diamond (eds.). *Ecology and evolution of communities*. Cambridge, USA.
- May, R.M. 1988. How many species are there on Earth? *Science* 241: 1441–1449.
- May, R.M., Lawton, J.H., & N.E. Stork. 1995. Assessing extinction rates. Pp. 1–24 in Lawton, H., & R.M. May (eds.). *Extinction Rates*. New York, USA.
- Mayfield, H.F. 1981. Problems in estimating population size through counts of singing males. *Studies in Avian Biology* 6: 220–224.
- Mayr, E. 1963. *Animal species and evolution*. Cambridge, USA.
- Mayr, G., & J. Clarke. 2003. The deep divergences of neornithine birds: a phylogenetic analysis of morphological characters. *Cladistics* 19: 527–553.
- McClanahan, T.R., & R.W. Wolfe. 1993. Accelerating forest succession in fragmented landscape: the role of birds and perches. *Conservation Biology* 7: 279–288.
- McCune, B., & J.B. Grace. 2002. *Analysis of ecological communities*. MjM Software Design, Gleneden Beach, Oregon, USA.
- McCune, B., & M.J. Mefford. 1999. *PC-ORD: Multivariate analysis of ecological data*, version 4. MjM Software Design, Gleneden Beach, Oregon, USA.
- McDade, L.A., Bawa, K.S., Hespeneide, H.A., & G.S. Hartshorn (eds.). 1994. *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- McDade, L.A., & G.S. Hartshorn. 1994. La Selva biological station. Pp. 6–14 in McDade, L.A., Bawa, K.S., Hespeneide, H.A., & G.S. Hartshorn (eds.). *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- McDonnell, M.J., & E.W. Stiles. 1983. The structural complexity of old field vegetation and the recruitment of bird-dispersed plant species. *Oecologia* 56: 109–116.
- McGeoch, M.A., & S.L. Chown. 1998. Scaling up the value of bioindicators. *Trends in Ecology and Evolution* 13: 47–48.
- McNab, B.K. 1963. Bioenergetics and the determination of home range size. *American Naturalist* 97: 133–139.

- Mena V., P., & O. Jahn. 2002a. Carpintero de Lita (*Piculus litae*). Pp. 270–271 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002b. Chotacabras del Chocó (*Nyctiphrynus rosenbergi*). Pp. 249–250 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002c. Codorniz Carrirufa (*Rhyrchortyx cinctus*). Pp. 124–125 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002d. Dacnis Pechiescarlata (*Dacnis berlepschi*). Pp. 329–330 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002e. Gavilán Barreteado (*Leucopternis princeps*). Pp. 200–201 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002f. Gavilán Plomizo (*Leucopternis plumbea*). Pp. 198–199 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002g. Gavilán Semiplomizo (*Leucopternis semiplumbea*). Pp. 112–113 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002h. Mirlo Dagua (*Turdus daguae*). Pp. 401 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002i. Pava Crestada (*Penelope purpurascens*). Pp. 122–123 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002j. Pavón Grande (*Crax rubra*). Pp. 76–77 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002k. Sapayoa (*Sapayoa aenigma*). Pp. 322–323 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., & O. Jahn. 2002l. Tinamú de Berlepsch (*Crypturellus berlepschi*). Pp. 98–99 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Mena V., P., Jahn, O., Berg, K.S., & V. Benítez. 2002. Amazona Frentirroja (*Amazona autumnalis*). Pp. 143–144 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Microsoft. 2001. Microsoft Office, version X for Macintosh. Microsoft Corp., Redmond, USA.
- Mitschke, A., Sudfeldt, C., Heidrich-Riske, H., & R. Dröschmeister. 2007. Monitoring häufiger Brutvögel in der Normallandschaft Deutschlands. Pp. 129–147 in Bege, F., Schröder, S., Wenkel, K.-O., & H.-J. Weigel (eds.). Monitoring und Indikatoren der Agrobiodiversität: Tagungsband eines Symposiums am 7. und 8. November 2006 in Königswinter (Agrobiodiversität Band 27). Bundesanstalt für Landwirtschaft und Ernährung, Bonn, Germany.
- Mittermeier, R.A., Myers, N., Thomsen, J.B., Da Fonseca, G.A.B., & S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology* 12: 516–520.
- Monastersky, R. 1999. Hidden threats take toll in Amazon. *Science News* 155: 228.
- Moore, J.E., Scheiman, D.M., & R.K. Swihart. 2004. Field comparison of removal and modified double-observer modeling for estimating detectability and abundance of birds. *Auk* 121: 865–876.
- Moore, J.L., Balmford, A., Brooks, T.M., Burgess, N.D., Hansen, L.A., Rahbek, C., & P.H. Williams. 2003. Performance of sub-Saharan vertebrates as indicator groups for identifying priority areas for conservation. *Conservation Biology* 17: 207–218.
- Morales F., M. 2001. Community paralegals and land tenure. Pp. 119–132 in Rhoades, R., & J. Stallings (eds.). Integrated conservation and development in tropical



- America: experiences and lessons in linking communities, projects and policies. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- Morton, E.S. 1971. Nest predation affecting the breeding season of the Clay-colored Robin, a tropical song bird. *Science* 181: 920–921.
- Morton, E.S., Young, K., & M.A. Ramos (eds.). 1994. Growing points in Neotropical migratory bird conservation. Papers from the Neotropical Ornithological Congress, Quito, Ecuador, November 1991. *Bird Conservation International* 4 (2/3) – Special Issue. Cambridge, UK.
- Mosher, J.A., Fuller, M.R., & M. Kopeny. 1990. Surveying woodland raptors by broadcast of conspecific vocalizations. *Journal of Field Ornithology* 61: 453–461.
- Munn, C.A. 1985. Permanent canopy and understory flocks in Amazonia: species composition and population density. *Ornithological Monographs* 36: 683–712.
- Munn, C.A., & J.W. Terborgh. 1979. Multi-species territoriality in Neotropical foraging flocks. *Condor* 81: 338–347.
- Munn, R.E. 1988. The design of integrated monitoring systems to provide early indications of environmental/ecological changes. *Environmental Monitoring and Assessment* 11: 203–217.
- Murphy, D.D. 1990. Conservation biology and scientific method. *Conservation Biology* 4: 123–125.
- Myers, N. 1986. Tackling mass extinction of species: a great creative challenge. Albright Lecture in Conservation, University of California, Berkeley, USA.
- Myers, N. 1987. The extinction spasm impending: synergisms at work. *Conservation Biology* 1: 14–21.
- Myers, N. 1988a. Threatened biotas: 'hotspots' in tropical forests. *Environmentalist* 8: 187–208.
- Myers, N. 1988b. Tropical forests and their species: Going, Going...? Pp. 28–35 in Wilson, E.O. (ed.). *Biodiversity*. Washington, USA.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.
- Naka, L.N. 2004. Structure and organization of canopy bird assemblages in Central Amazonia. *Auk* 121: 88–102.
- Nations, J.D. 1988. The Lacandon Maya. Pp. 86–88 in Denslow, J.S., & C. Padoch (eds.). *People of the tropical rain forest*. Berkeley, USA.
- Navarro S., A.G. 1992. Altitudinal distribution of birds in the Sierra Madre del Sur, Guerrero, Mexico. *Condor* 94: 29–39.
- Nepstad, D.C., Uhl, C., & E.A.S. Serrão. 1991. Recuperation of a degraded Amazonian landscape: forest recovery and agricultural restoration. *Ambio* 20: 248–255.
- Nepstad, D.C., Uhl, C., Pereira, C.A., & J.M.C. Da Silva. 1996. A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. *Oikos* 76: 25–39.
- Newton, I. 2003. *The speciation and biogeography of birds*. London, UK.
- Nichols, J.D., Boulenger, T., Hines, J.E., Pollock, K.H., & J.R. Sauer. 1998. Inference methods for spatial variation in species richness and community composition when not all species are detected. *Conservation Biology* 12: 1390–1398.
- Nichols, J.D., Hines, J.E., Sauer, J.R., Fallon, F.W., Fallon, J.E., & P.J. Heglund. 2000. A double-observer approach for estimating detection probability and abundance from point counts. *Auk* 117: 393–408.
- NIST/SEMATECH. 2003. *E-Handbook of statistical methods*. National Institute of Standards and Technology, USA. Online at: <http://www.itl.nist.gov/div898/handbook>, last accessed 21 November, 2003.
- Nocedal, J. 1994. Local migrations of insectivorous birds in western Mexico: implications for the protection and conservation of their habitats. *Bird Conservation International* 4: 129–142.
- Nores, M. 1992. Bird speciation in subtropical South America in relation to forest expansion and retraction. *Auk* 109: 346–357.
- O'Connor, R.J. 1981. The influence of observer and analyst efficiency in mapping method censuses. *Studies in Avian Biology* 6: 372–376.
- Oelke, H. 1981a. Limitations of estimating bird populations because of vegetation structure and composition. *Studies in Avian Biology* 6: 316–321.
- Oelke, H. 1981b. Limitations of mapping methods. *Studies in Avian Biology* 6: 114–118.
- Oelklaus, W.F. 1976. Chukar Partridge dispersion along the middle and lower Snake and Columbia Rivers. M.Sc. thesis, University of Idaho, Moscow, USA (unpubl.).
- Okanoya, K., & R.J. Dooling. 1988. Hearing in the Swamp Sparrow, *Melospiza georgiana*, and the Song Sparrow, *Melospiza melodia*. *Animal Behaviour* 36: 726–732.
- Oldeman, R.A.A. 1974. *L'architecture de la forêt guyanaise*. Orstom, Paris, France.
- Oldeman, R.A.A. 1978. Architecture and energy of dicotyledonous trees in the forest. Pp. 535–560 in Tomlinson, P.B., & M.H. Zimmerman (eds.). *Tropical trees as living systems*. Cambridge, UK.
- Oldeman, R.A.A. 1989. Dynamics in tropical rain forests. Pp. 3–21 in Holm-Nielsen, L.B., Nielsen, I.C., & H. Balslev (eds.). *Tropical forests: botanical dynamics, speciation and diversity*. London, UK.
- Olson, D.M., & E. Dinerstein. 1998. The Global 200: a representation approach to conserving the earth's most biologically valuable ecoregions. *Conservation Biology* 12: 502–515.
- Ornelas, J.F., Arizmendi, M.C., Márquez-Valdelamar, L., Navarajo, M.L., & H.A. Berlanga. 1993. Variability profiles for line transect bird censuses in a tropical dry forest in Mexico. *Condor* 95: 422–441.



- Owens, I.P.F., & P.M. Bennett. 2000. Ecological basis of extinction risk in birds: habitat loss versus human persecution and introduced predators. *Proceedings of the National Academy of Sciences of the USA* 97: 12144–12148.
- Pacheco, C. 2002a. Halcón Montés Plomizo (*Micrastur plumbeus*). Pp. 117 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Pacheco, C. 2002b. Chachalaca Cabecirrufa (*Orientalis erythroptera*). Pp. 213–214 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). Libro rojo de las aves del Ecuador. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Pagel, M.D., May, R.M., & A.R. Collie. 1991. Ecological aspects of the geographic distribution and diversity of mammal species. *American Naturalist* 137: 791–815.
- Palacios, W., Cerón, C., Valencia, R., & R. Sierra. 1999. Las formaciones naturales de la Amazonía del Ecuador. Pp. 109–119 in Sierra, R. (ed.). Propuesta preliminar de un sistema de clasificación de vegetación para el Ecuador Continental. Proyecto INEFAN/GEF-BIRF & EcoCiencia, Quito, Ecuador.
- Palacios, W., Peter, C., & I. Estupiñán. 1996. Plan piloto de manejo forestal comunitario (PMFC) en Playa de Oro, Provincia de Esmeraldas, Ecuador. Jatun Sacha/SUBIR. Quito, Ecuador (unpubl.).
- Palmer, M.W. 1990. The estimation of species richness by extrapolation. *Ecology* 71: 1195–1198.
- Palmer, M.W. 1991. Estimating species richness: the second-order jackknife reconsidered. *Ecology* 72: 1512–1513.
- Palmer, M.W. 2004. Ordination methods for ecologists. Oklahoma State University, USA. Online at: <http://www.okstate.edu/artsci/botany/ordinate>, last accessed 3 March 2004.
- Pardieck, K., & R.B. Waide. 1992. Mesh size as a factor in avian community studies using mist nets. *Journal of Field Ornithology* 63: 250–255.
- Parker, T.A., III. 1991. On the use of tape recordings in avifaunal surveys. *Auk* 108: 443–444.
- Parker, T.A., III & B. Bailey (eds.). 1991. A biological assessment of the Alto Madidi region and adjacent areas of northwest Bolivia, May 18 – June 15, 1990. RAP Working Papers, No. 1. Conservation International, Washington, USA.
- Parker, T.A., III & J.L. Carr (eds.). 1992. Status of forest remnants in the Cordillera de la Costa and adjacent areas of southwestern Ecuador. RAP Working Papers, No. 2. Conservation International, Washington, USA.
- Parker, T.A., III, Gentry, A.H., Foster, R.B., Emmons, L.H., & J.V. Remsen, Jr. (eds.). 1993. The lowland dry forests of Santa Cruz, Bolivia: a global conservation priority. RAP Working Papers, No. 4. Conservation International, Washington, USA.
- Payne, R.B. 1997. Family Cuculidae (cuckoos). Pp. 508–607 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 4: sandgrouse to cuckoos, Barcelona, Spain.
- Pearce, D., Putz, F.E., & J. Vancley. 1999. A sustainable forest future. Working Paper GEC 99–15. Centre for Social and Economic Research on the Global Environment, Norwich, UK.
- Pearson, D.L. 1971. Vertical stratification of birds in a tropical dry forest. *Condor* 73: 46–55.
- Pearson, D.L. 1975. The relation of foliage complexity to ecological diversity of three Amazonian bird communities. *Condor* 77: 453–466.
- Pearson, D.L. 1977. A pantropical comparison of bird community structure on six lowland forest sites. *Condor* 79: 232–244.
- Pearson, D.L. 1980. Patterns of foraging ecology for common and rarer bird species in tropical lowland forest communities. Pp. 974–978 in Acta Proc. International Congress of Ornithology, Berlin, Germany.
- Pearson, D.L. 1994. Selecting indicator taxa for the quantitative assessments of biodiversity. *Phil. Trans. R. Soc. Lond.* 345: 75–79.
- Pearson, D.L., & F. Cassola. 1992. World-wide species richness patterns of tiger beetles (Coleoptera: Cicindelidae): indicator taxon for biodiversity and conservation studies. *Conservation Biology* 6: 376–391.
- Peet, R.K. 1974. The measurement of species diversity. *Annual Review of Ecology and Systematics* 5: 285–307.
- Peres, C.A. 2000. Effects of subsistence hunting on vertebrate community structure in Amazonian forests. *Conservation Biology* 14: 240–253.
- Petit, D.R., Lynch, J.F., Hutto, R.L., Blake, J.G., & R.B. Waide. 1995. Habitat use and conservation in the Neotropics. Pp. 145–197 in Martin, T.E., & D.M. Finch (eds.). Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues. New York, USA.
- Petit, D.R., Petit, L.J., & K.G. Smith. 1992. Habitat associations of migratory birds overwintering in Belize, Central America. Pp. 247–256 in Hagan, J.M., III & D.W. Johnston (eds.). Ecology and conservation of Neotropical migrant landbirds. Washington, USA.
- Petit, L.J., Petit, D.R., Christian, D.G., & H.D.W. Powell. 1999. Bird communities of natural and modified habitats in Panama. *Ecography* 22: 292–304.
- Petit, L.J., & D.R. Petit. 2003. Evaluating the importance of human-modified lands for Neotropical bird conservation. *Conservation Biology* 17: 687–694.
- Pielou, E.C. 1984. The interpretation of ecological data: a primer on classification and ordination. New York, USA.

- Pimm, S.I., Russell, G.J., Gittleman, J.L., & T.M. Brooks. 1995. The future of biodiversity. *Science* 269: 347–350.
- Pinard, M.A., & F.E. Putz. 1996. Retaining forest biomass by reducing logging damage. *Biotropica* 28: 278–295.
- Pires, J.M. 1978. The forest ecosystems of the Brazilian Amazon: description, function and research needs. *Natural Resource Research* 14: 607–627.
- Pitman, N.C.A., Jørgensen, P.M., Williams, R.S.R., León-Yáñez, S., & R. Valencia. 2002. Extinction-rate estimates for a modern Neotropical flora. *Conservation Biology* 16: 1427–1431.
- Platnick, N.I. 1991. Patterns of biodiversity: tropical *vs* temperate. *J. Nat. Hist.* 25: 1083–1088.
- Platt, H.M., Shaw, K.M., & P.J.D. Lamshead. 1984. Nematode species abundance patterns and their use in the detection of environmental perturbations. *Hydrobiologia* 118: 59–66.
- Plotkin, J.B., & H.C. Muller-Landau. 2002. Sampling the species composition of a landscape. *Ecology* 83: 3344–3356.
- Poore, D., Burges, P., Palmer, J., Rietbergen, J., & T. Synnott. 1989. No timber without trees: sustainability in the tropical forest. Earthscan Publications, London, UK.
- Poulsen, B.O. 1994. Mist netting as a census method for determining species richness and abundance in an Andean cloud forest bird community. *Le Gerfaut* 84: 39–49.
- Poulsen, B.O., Krabbe, N., Frølander, A., Hinojosa, M.B., & C.O. Quiroga. 1997. A rapid assessment of Bolivian and Ecuadorian montane avifaunas using 20-species lists: efficiency, biases and data gathered. *Bird Conservation International* 7: 53–67.
- Poulsen, B.O., & N. Krabbe. 1998. Avifaunal diversity of five high-altitude cloud forests on the Andean western slope of Ecuador: testing a rapid assessment method. *Journal of Biogeography* 25: 83–93.
- Powell, A.H., & G.V.N. Powell. 1987. Population dynamics of male euglossine bees in Amazonian forest fragments. *Biotropica* 19: 176–179.
- Powell, G.V.N. 1985. Sociobiology and adaptive significance of interspecific foraging flocks in the Neotropics. *Ornithological Monographs* 36: 713–732.
- Powell, G.V.N., & R.D. Bjork. 1994. Implications of altitudinal migration for conservation strategies to protect tropical biodiversity: a case study of the Resplendent Quetzal *Pharomachrus mocinno* at Monteverde, Costa Rica. *Bird Conservation International* 4: 161–174.
- Powell, G.V.N., & R.D. Bjork. 2004. Habitat linkages and the conservation of tropical biodiversity as indicated by seasonal migrations of Three-wattled Bellbirds. *Conservation Biology* 18: 500–509.
- Prance, G.T. 1990. The floristic composition of the forests of central Amazonian Brazil. Pp. 112–140 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Prendergast, J.R., Quinn, R.M., Lawton, J.H., Eversham, B.C., & D.W. Gibbons. 1993. Rare species, the coincidence of diversity hotspots and conservation strategies. *Nature* 365: 335–337.
- Preston, D.A., & G.A. Taveras. 1976. Características de la emigración rural en la Sierra. *Revista Geográfica* 84: 23–31.
- Price, J.J., & S.M. Lanyon. 2002. A robust phylogeny of the oropendolas: polyphyly revealed by mitochondrial sequence data. *Auk* 119: 335–348.
- Prum, R.O. 1988. Phylogenetic interrelationships of the barbets (Aves: Capitonidae) and toucans (Aves: Ramphastidae) based on morphology with comparisons to DNA-DNA hybridization. *Zoological Journal of the Linnean Society* 92: 313–343.
- Prum, R.O. 1992. Syringial morphology, phylogeny, and evolution of the Neotropical manakins (Aves: Pipridae). *American Museum Novitates* 3043: 1–65.
- Putz, F.E., Blate, G.M., Redford, K.H., Fimbel, R., & J. Robinson. 2001. Tropical forest management and conservation of biodiversity: an overview. *Conservation Biology* 15: 7–20.
- Putz, F.E., Dykstra, D.P., & R. Heinrich. 2000. Why poor logging practices persist in the tropics. *Conservation Biology* 14: 951–956.
- Pyle, P., Howell, S.N.G., Yunick, R.P., & D.F. DeSante. 1987. Identification guide to North American passerines. Bolinas, USA.
- Pyle, R., Bentzien, M., & P. Opler. 1981. Insect conservation. *Annual Review of Entomology* 26: 233–258.
- Raaijmakers, J.G.W. 1987. Statistical analysis of the Michaelis-Menten equation. *Biometrics* 43: 793–803.
- Rahbek, C., & G.R. Graves. 2001. Multiscale assessment patterns of avian species richness. *Proceedings of the National Academy of Sciences of the USA* 98: 4534–4539.
- Raich, J.W., Rastetter, E.B., Melillo, J.M., Kicklighter, D.W., Steudler, P.A., Peterson, B.J., Grace, A.L., Moore, B., III & C.J. Vorosmarty. 1991. Potential net primary productivity in South America: application of a global model. *Ecological Applications* 1: 399–429.
- Ralph, C.J., Sauer, J.R., & S. Droege (eds.). 1995. Monitoring Bird Populations by Point Counts. United States Department of Agriculture, USDA, Forest Service Gen. Tech. Rep. PSW-GTR-149, Albany, USA.
- Ralph, C.J., & J.M. Scott (eds.). 1981. Estimating numbers of terrestrial birds. *Studies in Avian Biology* 6. The Cooper Ornithological Society.
- Rankin-de-Merona, J.M., Hutchings H., R.W., & T.E. Lovejoy. 1990. Tree mortality and recruitment over a five-year period in undisturbed upland rainforest of the central Amazon. Pp. 573–584 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.

- Rao, M., Terborgh, J.W., & P. Nuñez. 2001. Increased herbivory in forest isolates: implications for plant community structure and composition. *Conservation Biology* 15: 624–633.
- Rappole, J.H., King, D.I., & W.C. Barrow, Jr. 1999. Winter ecology of the endangered Golden-cheeked Warbler. *Condor* 101: 762–770.
- Rappole, J.H., King, D.I., & J. Diez. 2003. Winter *versus* breeding habitat limitation for an endangered avian migrant. *Ecological Applications* 13: 735–742.
- Rappole, J.H., & M.V. McDonald. 1994. Cause and effect in population declines of migratory birds. *Auk* 111: 652–660.
- Rappole, J.H., Winker, K., & G.V.N. Powell. 1998. Migratory bird habitat use in southern Mexico: mist nets versus point counts. *Journal of Field Ornithology* 69: 635–643.
- Raven, P.H., & E.O. Wilson. 1992. A fifty-year plan for biodiversity surveys. *Science* 258: 1099–1100.
- Redford, K.H., & J.G. Robinson. 1987. The game of choice: patterns of Indian and colonist hunting in the Neotropics. *American Anthropologist* 89: 650–657.
- Reichholf, J. 1974. Artenreichtum, Häufigkeit und Diversität der Greifvögel in einigen Gebieten von Südamerika. *Journal für Ornithologie* 115: 381–397.
- Remmert, H. 1991. The mosaic-cycle concept of ecosystems – an overview. *Ecological Studies* 85: 1–21.
- Remsen, J.V., Jr. 1994. Use and misuse of bird lists in community ecology and conservation. *Auk* 111: 225–227.
- Remsen, J.V., Jr., Cadena, C.D., Jaramillo, A., Nores, M., Pacheco, J.F., Pérez-Emán, J., Robbins, M.B., Stiles, F.G., Stotz, D.F., & K.J. Zimmer. 2004. A classification of the bird species of South America. South American Classification Committee / American Ornithologists' Union. Online at: [www.museum.lsu.edu/~Remsen/SACCBaseline.html](http://www.museum.lsu.edu/~Remsen/SACCBaseline.html), last accessed 18 January 2004.
- Remsen, J.V., Jr., Cadena, C.D., Jaramillo, A., Nores, M., Pacheco, J.F., Pérez-Emán, J., Robbins, M.B., Stiles, F.G., Stotz, D.F., & K.J. Zimmer. 2011. A classification of the bird species of South America. South American Classification Committee / American Ornithologists' Union. Online at: [www.museum.lsu.edu/~Remsen/SACCBaseline.html](http://www.museum.lsu.edu/~Remsen/SACCBaseline.html), last accessed 25 November 2011.
- Remsen, J.V., Jr., & D.A. Good. 1996. Misuse of data from mist-net captures to assess relative abundances in bird populations. *Auk* 113: 381–398.
- Remsen, J.V., Jr., & T.A. Parker, III. 1983. Contribution of river-created habitats to bird species richness in Amazonia. *Biotropica* 15: 223–231.
- Remsen, J.V., Jr., & T.A. Parker, III. 1984. Arboreal dead-leaf-searching birds of the Neotropics. *Condor* 86: 36–41.
- Reyers, B., van Jaarsveld, A.S., & M. Kruger. 2000. Complementarity as a biodiversity indicator strategy. *Proceedings of The Royal Society of London B (Biological Sciences)* 267: 505–513.
- Reynolds, R.T., Scott, J.M., & R.A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. *Condor* 82: 309–313.
- Ribadeneira, C., M.B. 2002. Periquito Frentiazul (*Touit dilectissima*). Pp. 359 in Granizo, T., Pacheco, C., Ribadeneira, M.B., Guerrero, M., & L. Suárez (eds.). *Libro rojo de las aves del Ecuador*. SIMBIOE, Conservation International, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Ribon, R., Simon, J.E., & G. Theodoro de Mattos. 2003. Bird extinctions in Atlantic forest fragments of the Viçosa region, southeastern Brazil. *Conservation Biology* 17: 1827–1839.
- Rice, R., Gullison, R., & J. Reed. 1997. Can sustainable management save tropical forests? *Scientific American* 276: 34–39.
- Richards, D.G. 1981. Environmental acoustics and censuses of singing birds. *Studies in Avian Biology* 6: 297–300.
- Richards, P.W. 1952. *The tropical rainforest*. Cambridge, UK.
- Ricklefs, R.E. 1966. The temporal component of diversity among species of birds. *Evolution* 20: 235–242.
- Ridgely, R.S., & P.J. Greenfield. 2001a. *The birds of Ecuador: field guide*. Ithaca, New York, USA.
- Ridgely, R.S., & P.J. Greenfield. 2001b. *The birds of Ecuador: status, distribution, and taxonomy*. Ithaca, New York, USA.
- Ridgely, R.S., & G. Tudor. 1989. *The birds of South America: the oscine passerines*. Volume I. Oxford, UK.
- Ridgely, R.S., & G. Tudor. 1994. *The birds of South America: the suboscine passerines*. Volume II. Oxford, UK.
- Riesing, M.J., Kruckenhauser, L., Gamauf, A., & E. Haring. 2003. Molecular phylogeny of the genus *Buteo* (Aves: Accipitridae) based on mitochondrial marker sequences. *Molecular Phylogenetics and Evolution* 27: 328–342.
- Risser, A.C. 1971. A technique for performing laparotomy on small birds. *Condor* 73: 376–379.
- Rivera-Milán, F.F. 1992. Distribution and relative abundance patterns of columbids in Puerto Rico. *Condor* 94: 224–238.
- Rivera-Milán, F.F. 1995a. Distribution and abundance of raptors in Puerto Rico. *Wilson Bulletin* 107: 452–462.
- Rivera-Milán, F.F. 1995b. Spatial and temporal variation in the detectability and density of columbids in Puerto Rico and on Vieques Island. *Ornitologia Neotropical* 6: 1–17.
- Robbins, M.B., & F.G. Stiles. 1999. A new species of Pygmy-Owl (Strigidae: *Glaucidium*) from the Pacific slope of the northern Andes. *Auk* 116: 305–315.
- Robinson, J.G. 1993. The limits to caring: sustainable living and the loss of biodiversity. *Conservation Biology* 7: 20–28.

- Robinson, J.G., Redford, K.H., & E.L. Bennett. 1999. Wildlife harvest in logged tropical forest. *Science* 284: 595–596.
- Robinson, S.K., & J.W. Terborgh. 1990. Bird communities of the Cocha Cashu Biological Station in Amazonian Peru. Pp. 199–216 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Robinson, S.K., Terborgh, J.W., & C.A. Munn. 1990. Lowland tropical forest bird communities of a site in Western Amazonia. Pp. 229–258 in Keast, A. (ed.). *Biogeography and ecology of forest bird communities*. The Hague, The Netherlands.
- Robinson, S.K., & J.W. Terborgh. 1997. Bird community dynamics along primary successional gradients of an Amazonian whitewater river. Pp. 641–672 in Remsen, J.V., Jr. (ed.). *Studies in Neotropical Ornithology Honoring Ted Parker*. Ornithological Monographs, No. 48, AOU, Washington, USA.
- Robinson, W.D. 1999. Long-term changes in the avifauna of Barro Colorado Island, Panama, a tropical forest isolate. *Conservation Biology* 13: 85–97.
- Robinson, W.D., Brawn, J.D., & S.K. Robinson. 2000. Forest bird community structure in central Panama: influence of spatial scale and biogeography. *Ecological Monographs* 70: 209–235.
- Rodrigues, J.P., Pearson, D.L., & R. Barrera. 1998. A test for the adequacy of bioindicator taxa: are tiger beetles (Coleoptera: Cicindelidae) appropriate indicators for monitoring the degradation of tropical forests in Venezuela? *Biological Conservation* 83: 69–76.
- Rodríguez-Estrella, R., Donazar, J.A., & F. Hiraldo. 1998. Raptors as indicators of environmental change in the scrub habitat of Baja California Sur, Mexico. *Conservation Biology* 12: 921–925.
- Roller, E. 1974. *L'architecture des forêts denses humides sempervirentes de plaine*. CTFT, Nogent sur Marne, France.
- Rosenberg, G.H. 1990a. Habitat specialization and foraging behavior by birds of Amazonian river islands in northeastern Peru. *Condor* 92: 427–443.
- Rosenberg, K.V. 1990b. Dead-leaf foraging specialization in tropical forest birds: measuring resource availability and use. *Studies in Avian Biology* 13: 360–368.
- Rosenstock, S.S., Anderson, D.R., Giesen, K.M., Leukering, T., & M.F. Carter. 2002. Landbird counting techniques: current practices and an alternative. *Auk* 119: 46–53.
- Rosenzweig, M.L. 1995. *Species diversity in space and time*. Cambridge, UK.
- Rosselli, L. 1994. The annual cycle of the White-ruffed Manakin *Corapipo leucorhoa*, a tropical frugivorous altitudinal migrant, and its food plants. *Bird Conservation International* 4: 143–160.
- Routledge, R.D. 1979. Diversity indices: which ones are admissible. *Journal of Theoretical Biology* 76: 503–515.
- Rylands, A.B., & A. Keuroghlian. 1988. Primate populations in continuous forest and forest fragments in central Amazonia. *Acta Amazônica* 18: 291–307.
- Sala, O.E., Chapin, F.S., III, Armesto, J.J., Berlow, R., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M., & D.H. Wall. 2000. Global biodiversity scenarios for the year 2100. *Science* 287: 1770–1774.
- Salaman, P.G.W. (ed.). 1994. *Surveys and conservation of biodiversity in the Chocó, south-west Colombia*. Bird-Life International, Cambridge, UK.
- Salaman, P.G.W. 2001. *The study of an understorey avifauna community in an Andean premontane pluvial forest*. Ph.D. Thesis, University of Oxford, Oxford, UK (unpubl.).
- Salaman, P.G.W., Coopmans, P., Donegan, T.M., Mulligan, M., Cortés, A., Hilty, S.L., & L.A. Ortega. 2003. A new species of wood-wren (Troglodytidae: *Henicorhina*) from the Western Andes of Colombia. *Ornitología Colombiana* 1: 4–21.
- Salaman, P.G.W., & T.M. Donegan (eds.). In prep. *Surveys and conservation of Serranía de los Churumbelos, Cauca, Colombia*. Conservation International, Washington, USA.
- Salaman, P.G.W., & F.G. Stiles. 1996. A distinctive new species of vireo (Passeriformes: Vireonidae) from the Western Andes of Colombia. *Ibis* 138: 610–619.
- Sanford, R.L., Jr., Braker, H.E., & G.S. Hartshorn. 1986. Canopy openings in a primary Neotropical lowland forest. *Journal of Tropical Ecology* 2: 277–282.
- Sanford, R.L., Jr., Paaby, P., Luvall, J.C., & E. Phillips. 1994. Climate, geomorphology, and aquatic systems. Pp. 19–33 in McDade, L.A., Bawa, K.S., Hespenheide, H.A., & G.S. Hartshorn (eds.). *La Selva: ecology and natural history of a Neotropical rain forest*. Chicago, USA.
- Sanford, R.L., Jr., Saldarriaga, J., Clark, K., Uhl, C., & R. Herrera. 1985. Amazonian rain-forest fires. *Science* 227: 53–55.
- Sato, A., Tichy, H., O'Huigin, C., Grant, P.R., Grant, B.R., & J. Klein. 2001. On the origin of Darwin's finches. *Molecular Biology and Evolution* 18: 299–311.
- Sauer, J.R., Peterjohn, B.G., & W.A. Link. 1994. Observer differences in the North American Breeding Bird Survey. *Auk* 111: 50–62.
- Sauer, W. 1971. *Geologie von Ecuador*. Gebrüder Bornträger, Berlin, Germany.
- Schemske, D.W., & N. Brokaw. 1981. Treefalls and the distribution of understory birds in a tropical forest. *Ecology* 62: 938–945.
- Schieck, J. 1997. Biased detection of bird vocalizations affects comparisons of bird abundance among forested habitats. *Condor* 99: 179–190.

- Schmid, H., Burkhardt, M., Keller, V., Knaus, P., Volet, B., & N. Zbinden. 2001. Die Entwicklung der Vogelwelt in der Schweiz. Avifauna Report Sempach 1: 1–444.
- Schmid, H., Zbinden, N., & V. Keller. 2004. Überwachung der Bestandsentwicklung häufiger Brutvögel in der Schweiz. Schweizerische Vogelwarte, Sempach, Switzerland.
- Schoener, T.W. 1968. Size of feeding territories among birds. *Ecology* 49: 123–141.
- Schuchmann, K.-L. 1999. Family Trochilidae (hummingbirds). Pp. 468–680 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- Schupp, E.W., Howe, H.F., Augspurger, C.K., & D.J. Levey. 1989. Arrival and survival in tropical treefall gaps. *Ecology* 70: 562–564.
- Secretariat of the Convention on Biological Diversity. 2006. *Global Biodiversity Outlook 2*. Montreal, Canada.
- Sekercioglu, C.H. 2002a. Effects of forestry practices on vegetation structure and bird community of Kibale National Park, Uganda. *Biological Conservation* 107: 229–240.
- Sekercioglu, C.H. 2002b. Impacts of birdwatching on human and avian communities. *Environmental Conservation* 29: 282–289.
- Sekercioglu, C.H., Ehrlich, P.R., Daily, G.C., Aygen, D., Goehring, D., & R.F. Sandt. 2002. Disappearance of insectivorous birds from tropical forest fragments. *Proceedings of the National Academy of Sciences of the USA* 99: 263–267.
- Shapiro, S.S., & M.B. Wilk. 1965. An analysis of variance test for normality (complete samples). *Biometrika* 52: 591–611.
- Sheldon, F.H., & F.B. Gill. 1996. A reconsideration of songbird phylogeny, with emphasis on the evolution of titmice and their sylvioid relatives. *Syst. Biol.* 45: 473–495.
- Sherry, T.W. 1984. Comparative dietary ecology of sympatric, insectivorous Neotropical flycatchers. *Ecological Monographs* 54: 313–338.
- Short, L.L., & J.F.M. Horne. 2002. Family Ramphastidae (toucans). Pp. 220–272 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 7: jacamars to woodpeckers. Barcelona, Spain.
- Sibley, C.G., & J.E. Ahlquist. 1990. *Phylogeny and classification of birds: a study in molecular evolution*. New Haven, USA.
- Siemann, E., Tilman, D., & J. Haarsrad. 1996. Insect species diversity, abundance and body size relationships. *Nature* 380: 704–706.
- Sierra, R. 1996. La deforestación en el noroccidente del Ecuador 1983–1993. EcoCiencia, Quito, Ecuador.
- Sierra, R. 1999. Vegetación remanente del Ecuador continental. Proyecto INEFAN/GEF, Wildlife Conservation Society, Quito, Ecuador.
- Sierra, R., Campos, F., & F. Chamberlin. 1999a. Areas prioritarias para la conservación de la biodiversidad en el Ecuador continental: un estudio basado en la diversidad de ecosistemas y su ornitofauna. Ministerio del Medio Ambiente, Proyecto INEFAN/GEF-BIRF, EcoCiencia, Wildlife Conservation Society, Quito, Ecuador.
- Sierra, R., Cerón, C., Palacios, W., & R. Valencia. 1999b. Criterios para la clasificación de la vegetación del Ecuador. Pp. 29–54 in Sierra, R. (ed.). *Propuesta preliminar de un sistema de clasificación de vegetación para el Ecuador continental*. Proyecto INEFAN/GEF-BIRF, EcoCiencia, Quito, Ecuador.
- Sierra, R., Céron, C., Palacios, W., & R. Valencia. 1999c. Mapa de Vegetación del Ecuador Continental, Proyecto INEFAN/GEF-BIRF, Wildlife Conservation Society y EcoCiencia, Quito, Ecuador.
- Sieving, K.E. 1992. Nest predation and differential insular extinction among birds of central Panama. *Ecology* 73: 2310–2328.
- Silman, M.R. 1996. Regeneration from seed in a Neotropical rain forest. Ph.D. dissertation, Duke University (unpubl.).
- Simberloff, D.S. 1986. Are we on the verge of a mass extinction in tropical rain forests? Pp. 75–89 in Elliot, D.K. (ed.). *Dynamics of Extinction*. New York, USA.
- Simberloff, D.S., & L.G. Able. 1976. Island biogeography theory and conservation practice. *Science* 191: 285–286.
- Sizer, N., & E.V.J. Tanner. 1999. Responses of woody plant seedlings to edge formation in a lowland tropical rainforest, Amazonia. *Biological Conservation* 91: 135–142.
- Skutch, A.F. 1950. The nesting seasons of Central American birds in relation to climate and food supply. *Ibis* 92: 185–222.
- Skutch, A.F. 1985. Clutch size, nesting success, and predation on nests of Neotropical birds, reviewed. *Ornithological Monographs* 36: 575–594.
- Sliwa, A., & T.W. Sherry. 1992. Surveying wintering warbler populations in Jamaica: point counts with and without broadcast vocalizations. *Condor* 94: 924–936.
- Slud, P. 1960. The birds of Finca 'La Selva', Costa Rica: a tropical wet forest locality. *Bull. Am. Mus. Nat. Hist.* 121: 53–148.
- Smith, B. 1986. Evaluation of different similarity indices applied to data from the Rothamsted insect survey. M.Sc., University of York, UK (unpubl.).
- Smith, D.G. 1981. Accommodation of screech owls to play back of tape recorded calls. *Cassinia* 59: 77.
- Smith, E.P., & G. van Belle. 1984. Nonparametric estimation of species richness. *Biometrics* 40: 119–129.
- Smith, R.L. 1974. *Ecology and field biology*. Harper and Row, New York, USA.



- Smythe, N. 1982. The seasonal abundance of night-flying insects in a Neotropical forest. Pp. 309–318 in Leigh, E.G., Jr., Rand, A.S., & D.M. Windsor (eds.). The ecology of a tropical forest: seasonal rhythms and long-term changes. Washington, USA.
- Snow, D.W. 1962. A field study of the Black-and-white Manakin *Manacus manacus* in Trinidad, W.I. Zoologica 47: 65–104.
- Snow, D.W. 1966. A possible selective factor in the evolution of fruiting seasons in tropical forest. Oikos 15: 274–281.
- Snow, D.W. 1968. The singing assemblies of Little Hermits. Living Bird 7: 47–55.
- Soulé, M.E., & M.A. Sanjayan. 1998. Conservation targets: do they help? Science 279: 2060–2061.
- Southwood, T.R.E. 1978. Ecological methods. London, UK.
- SOVON. 1985. Broedvogel – Monitoringproject Hand-leiding. Samenwerkende Organisaties Vogelonderzoek Nederland (SOVON), Arnhem, The Netherlands.
- SPSS. 2003. SPSS, version 11.0.2 for Macintosh. SPSS Inc., Chicago, USA.
- Stallings, J. 2001. An ICDP implementation paradigm of crossed lines: south-south and north-north. Pp. 3–12 in Rhoades, R., & J. Stallings (eds.). Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- Stallings, J., & M. Garcia. 2001. The double task of institutional strengthening and executing project activities simultaneously with local partners. Pp. 145–151 in Rhoades, R., & J. Stallings (eds.). Integrated conservation and development in tropical America: experiences and lessons in linking communities, projects and policies. SANREM CRSP and CARE-SUBIR, Athens, Georgia, USA.
- Stattersfield, A.J., Crosby, M.J., Long, A.J., & D.C. Wege. 1998. Endemic Bird Areas of the world: priorities for biodiversity conservation. BirdLife International, Cambridge, UK.
- Stevens, G.C. 1989. The latitudinal gradient in geographical range: how so many species co-exist in the tropics. American Naturalist 133: 240–256.
- Stiles, F.G. 1975. Ecology, flowering phenology, and hummingbird pollination of some Costa Rican *Heliconia* species. Ecology 56: 285–301.
- Stiles, F.G. 1977. Coadapted competitors: the flowering season of hummingbird-pollinated plants in a tropical forest. Science 198: 1177–1178.
- Stiles, F.G. 1981. Geographical aspects of bird-flower co-evolution, with particular reference to Central America. Annals of the Missouri Botanical Garden 68: 323–351.
- Stiles, F.G. 1985. On the role of birds in the dynamics of Neotropical forests. Pp. 49–59 in Diamond, A.W., & T.A. Lovejoy (eds.). Conservation of tropical forest birds. ICBP, Cambridge, UK.
- Stiles, F.G. 1988. Altitudinal movements of birds on the Caribbean slope of Costa Rica: implications for conservation. Pp. 243–258 in Almeda, F., & C.M. Pringle (eds.). Tropical rainforests: diversity and conservation. California Academy of Science, San Francisco, USA.
- Stiles, F.G. 1996. When black plus white equals gray: the nature of variation in the Variable Seedeater complex (Emberizinae: *Sporophila*). Ornithologia Neotropica 7: 75–107.
- Stiles, F.G., & D.A. Clark. 1989. Conservation of tropical rain forest birds: a case study from Costa Rica. American Birds 43: 420–428.
- Stiles, F.G., & L. Rosselli. 1998. Inventario de las aves de un bosque altoandino: comparación de dos metodos. Caldasia 20: 29–43.
- Stiles, F.G., & A.F. Skutch. 1989. A guide to the birds of Costa Rica. London, UK.
- Stokstad, E. 2001. U.N. report suggests slowed forest loss. Science 291: 2294.
- Stork, N.E. 1997. Measuring global biodiversity and its decline. Pp. 41–68 in Reaka-Kudla, M.L., Wilson, D.E., & E.O. Wilson (eds.). Biodiversity II: understanding and protecting our biological resources. Washington, USA.
- Stotz, D.F., Fitzpatrick, J.W., Parker, T.A., III & D.K. Moskovits. 1996. Neotropical birds: ecology and conservation. Chicago, USA and London, UK.
- Stouffer, P.C., & R.O. Bierregaard, Jr. 1995. Use of Amazonian forest fragments by understory insectivorous birds. Ecology 76: 2429–2445.
- Stratford, J.A., & P.C. Stouffer. 1999. Local extinctions of terrestrial insectivorous birds in a fragmented landscape near Manaus, Brazil. Conservation Biology 18: 1416–1423.
- Struhsaker, T.T. 1998. A biologist's perspective on the role of sustainable harvest in conservation. Conservation Biology 12: 930–932.
- Stutchbury, B.J.M. 1998. Female mate choice of extra-pair males: breeding synchrony is important. Behav. Ecol. Sociobiol. 43: 213–215.
- Stutchbury, B.J.M., & E.S. Morton. 2001. Behavioral ecology of tropical birds. London, UK.
- SUBIR. 1999. Guía de evaluaciones ambientales para planes de manejo forestal comunitario. Proyecto SUBIR, CARE Ecuador, Quito, Ecuador (unpubl.).
- SUBIR. 2000. Identificación y caracterización preliminar de áreas importantes para la conservación. Proyecto Conservación de la Biodiversidad del Chocó Ecuatoriano, GEF-Ministerio del Ambiente, ECU/98/G32, Septiembre de 2000, Quito, Ecuador (unpubl.).



- Südbeck, P., Andretzke, H., Fischer, S., Gedeon, K., Schiokore, T., Schröder, K., & C. Sudfeldt. 2005. Methodenstandards zur Erfassung der Brutvögel Deutschlands. Radolfzell, Germany.
- Svensson, S.E. 1981. Do transect counts monitor abundance trends in the same way as territory mapping in study plots? *Studies in Avian Biology* 6: 209–214.
- Svensson, S.E. 1992. Experience with the Swedish breeding-bird monitoring programme. *Vogelwelt* 135: 182–196.
- Swaine, M.D., & J.B. Hall. 1983. Early succession on cleared land in Ghana. *Journal of Ecology* 71: 601–628.
- Swihart, R.K., Slade, N.A., & B.J. Bergstrom. 1988. Relating body size to the rate of home range use in mammals. *Ecology* 69: 393–399.
- Tanner, E.V.J., Kapos, V., & J.R. Healy. 1991. Hurricane effects on forest ecosystems in the Caribbean. *Biotropica* 23: 513–521.
- Tardif, B., & J. DesGranges. 1998. Correspondence between bird and plant hotspots of the St. Lawrence River and influence of scale on their location. *Biological Conservation* 84: 53–63.
- Taylor, L.R. 1978. Bates, Williams, Hutchinsons – a variety of diversities. Pp. 1–18 in Mound, L.A., & N. Warloff (eds.). *Diversity of Insect Faunas: 9th Symposium of the Royal Entomological Society*. Oxford, UK.
- Téllez-Valdés, O., & P. Dávila-Aranda. 2003. Protected areas and climate change: a case study of the cacti in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico. *Conservation Biology* 17: 846–853.
- ter Braak, C.J.F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology* 67: 1167–1179.
- ter Braak, C.J.F. 1987. The analysis of vegetation-environment relationships by canonical correspondence analysis. *Vegetatio* 69: 69–77.
- ter Braak, C.J.F., & I.C. Prentice. 1988. A theory of gradient analysis. *Advances in Ecological Research* 18: 271–313.
- ter Braak, C.J.F., & P. Smilauer. 2002. CANOCO reference manual and CANODRAW for Windows user's guide: software for canonical community ordination, version 4.5. Microcomputer Power, Ithaca, New York, USA.
- Terborgh, J.W. 1971. Distribution on environmental gradients: theory and a preliminary interpretation of distributional patterns in the avifauna of the Cordillera Vilcabamba, Peru. *Ecology* 52: 23–40.
- Terborgh, J.W. 1980. The conservation status of Neotropical migrants: present and future. Pp. 21–30 in Keast, A., & E.S. Morton (eds.). *Migrant birds in the Neotropics: ecology, behavior, distribution and conservation*. Washington, USA.
- Terborgh, J.W. 1985. Habitat selection in Amazonian birds. Pp. 311–338 in Cody, M.L. (ed.). *Habitat selection in birds*. Orlando, USA.
- Terborgh, J.W. 1989. Where have all the Birds gone? Princeton, USA.
- Terborgh, J.W. 1990. An overview of research at Cocha Cashu biological station. Pp. 48–59 in Gentry, A.H. (ed.). *Four Neotropical rainforests*. New Haven, USA.
- Terborgh, J.W., Robinson, S.K., Parker, T.A., III, Munn, C.A., & N. Pierpont. 1990. Structure and organization of an Amazonian forest bird community. *Ecological Monographs* 60: 213–238.
- Terborgh, J.W., & J.S. Weske. 1969. Colonization of secondary habitats by Peruvian birds. *Ecology* 50: 765–782.
- Terborgh, J.W., & J.S. Weske. 1975. The role of competition in the distribution of Andean birds. *Ecology* 56: 562–576.
- Terborgh, J.W., & B. Winter. 1983. A method for siting parks and reserves with special reference to Colombia and Ecuador. *Biological Conservation* 27: 45–58.
- The Institute for Bird Populations. 2008a. The Monitoring Avian Productivity and Survivorship (MAPS) Program: continent-wide demographic monitoring. Online at: <http://www.birdpop.org/maps.htm>, last accessed on 21 March 2011.
- The Institute for Bird Populations. 2008b. MoSI: Monitoreo de Sobrevivencia Invernal. Online at: <http://www.birdpop.org/MoSI/MoSI.htm>, last accessed on 21 March 2011.
- Thiollay, J.-M. 1986. Structure comparée du peuplement avien dans trois sites de forêt primaire en Guyane. *Revue d'Ecologie (Terre et Vie)* 41: 59–105.
- Thiollay, J.-M. 1988. Comparative foraging success of insectivorous birds in tropical and temperate forests: ecological implications. *Oikos* 53: 17–30.
- Thiollay, J.-M. 1989a. Censusing of diurnal raptors in a primary rain forest: comparative methods and species detectability. *J. Raptor Res.* 23: 72–84.
- Thiollay, J.-M. 1989b. Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation Biology* 3: 128–137.
- Thiollay, J.-M. 1990a. Comparative diversity of temperate and tropical forest bird communities: the influence of habitat heterogeneity. *Acta Oecologica* 11: 887–911.
- Thiollay, J.-M. 1990b. Food limitation in tropical bird populations. Pp. 1576–1583 in *Acta Proc. Congressus Internationalis Ornithologici*, Christchurch, New Zealand.
- Thiollay, J.-M. 1990c. Tropical rain forest bird communities: emerging patterns and processes of organization. Pp. 938–945 in *Acta Proc. Congressus Internationalis Ornithologici*, Christchurch, New Zealand.
- Thiollay, J.-M. 1992. Influence of selective logging on bird species diversity in a Guianan rain forest. *Conservation Biology* 6: 47–63.
- Thiollay, J.-M. 1994a. Family Accipitridae (hawks and eagles). Pp. 52–205 in del Hoyo, J., Elliott, A., & J. Sargatal

- (eds.). Handbook of the birds of the world, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- Thiollay, J.-M. 1994b. Structure, density and rarity in an Amazonian rainforest bird community. *Journal of Tropical Ecology* 10: 449–481.
- Thiollay, J.-M. 1997. Disturbance, selective logging and bird diversity: a Neotropical forest study. *Biodiversity and Conservation* 6: 1155–1173.
- Thiollay, J.-M. 2002a. Avian diversity and distribution in French Guiana: patterns across a large forest landscape. *Journal of Tropical Ecology* (2002), 18: 471–498.
- Thiollay, J.-M. 2002b. Bird diversity and selection of protected areas in a large Neotropical forest tract. *Biodiversity and Conservation* 11: 1377–1395.
- Thomas, B.T. 1999. Family Steatornithidae (Oilbird). Pp. 244–251 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). Handbook of the birds of the world, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- Thomas, D.W., Cloutier, D., Provencher, M., & C. Houle. 1988. The shape of bird- and bat-generated seed shadows around a tropical fruiting tree. *Biotropica* 20: 347–348.
- Thomas, L., Buckland, S.T., Burnham, K.P., Anderson, D.R., Laake, J.L., Borchers, D.L., & S. Strindberg. 2002a. Distance sampling. Pp. 544–552 in El-Shaarawi, A.H., & W.W. Piegorsch (eds.). *Encyclopedia of Environmetrics*. Wiley & Sons, Chichester, UK.
- Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., & J.H. Pollard. 2002b. Distance, version 4.0. Research Unit for Wildlife Population Assessment, University of St. Andrews, St. Andrews, UK.
- Thompson, F.R., III, Dijak, W.D., Kulowiec, T.G., & D.A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. *J. Wildl. Manage.* 56: 23–29.
- Thompson, W.L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. *Auk* 119: 18–25.
- Tirira S., D. 2001. Mono Araña de Cabeza Café (*Ateles fusciceps*). Pp. 105–106 in Tirira S., D. (ed.). *Libro rojo de los mamíferos del Ecuador*. SIMBIOE, EcoCiencia, Ministerio del Ambiente, UICN, Quito, Ecuador.
- Tokeshi, M. 1993. Species abundance patterns and community structure. *Advances in Ecological Research* 24: 111–186.
- Tomiałojć, L. 1981. On the census accuracy in the line transect. Pp. 87ff in VII. Int. Con. Bird Census, Lyon, France.
- Tomiałojć, L., & T. Wesołowski. 2004. Diversity of the Białowieża forest avifauna in space and time. *J. Orn.* 145: 81–92.
- Taylor, M.A., Jr., & J.W. Fitzpatrick. 1982. A survey of the tyrant flycatchers. *Living Bird* 19: 7–45.
- Tucker, C.J., & J.R.G. Townshend. 2000. Strategies for monitoring tropical deforestation using satellite data. *International Journal of Remote Sensing* 21: 1561–1572.
- Tukey, J. 1977. *Exploratory data analysis*. Addison-Wesley, Reading, USA.
- U.S. Census Bureau. 2003. Total midyear population for the world: 1950–2050. U.S. Bureau of the Census, International Data Base, Washington, USA.
- U.S. Census Bureau. 2004. Global population profile: 2002. International Population Reports WP/02, U.S. Government Printing Office, Washington, USA.
- U.S. Census Bureau. 2008. Total midyear population for the world: 1950–2050. U.S. Bureau of the Census, International Data Base, Washington, USA.
- Uhl, C. 1987. Factors controlling succession following slash and burn agriculture in Amazonia. *Ecology* 75: 377–407.
- Uhl, C. 1988. Restoration of degraded lands in the Amazon basin. Pp. 326–332 in Wilson, E.O. (ed.). *Biodiversity*. Washington, USA.
- Uhl, C., Kauffman, J.B., & D.L. Cumings. 1988. Fire in the Venezuelan Amazon 2: environmental conditions necessary for forest fires in the evergreen rainforest of Venezuela. *Oikos* 53: 176–184.
- Uhl, C., Nepstad, D., Buschbacher, R., Clark, K., Kauffman, B., & S. Subler. 1990. Studies of ecosystem response to natural and anthropogenic disturbances provide guidelines for designing sustainable land-use systems in Amazonia. Pp. 24–42 in Anderson, A.B. (ed.). *Alternatives to deforestation: steps toward sustainable use of the Amazon rain forest*. New York, USA.
- UNEP. 1992. Convention on biological diversity, 5 June 1992. United Nations Environment Programme.
- UNEP. 1999. *Global environment outlook 2000*. United Nations Environment Programme, London, UK.
- UNEP. 2000. *GEO – Latin America and the Caribbean: environment outlook 2000*. United Nations Environment Programme, Regional Office for Latin America and the Caribbean, México City, México.
- UNEP. 2002. *Global environment outlook 3: past, present and future perspective*. United Nations Environment Programme, London, UK.
- UNEP. 2007. *Global environmental outlook 4: environment for development*. Progress Press LTD, Valetta, Malta.
- USDI. 1980a. Habitat as a basis for environmental assessment. *Ecological Services Manual* 101. Division of Ecological Services, U.S. Department of the Interior, Fish and Wildlife Service, Washington, USA.
- USDI. 1980b. Habitat evaluation procedures. *Ecological Services Manual* 102. Division of Ecological Services, U.S. Department of the Interior, Fish and Wildlife Service, Washington, USA.

- USDI. 1981. Standards for the development of habitat suitability index model. Ecological Services Manual 103. Division of Ecological Services, U.S. Department of the Interior, Fish and Wildlife Service, Washington, USA.
- USDI, USFWS & USDC. 1996. National survey of fishing, hunting and wildlife-associated recreation. US Department of the Interior, Fish and Wildlife Service, US Department of Commerce, Bureau of the Census, Washington, USA.
- USFWS. 2003. Birding in the United States: a demographic and economic analysis. Fish and Wildlife Service, Division of Federal Aid, Washington, USA.
- Usher, M.B. (ed.). 1986. Wildlife conservation evaluation. London, UK.
- Verner, J. 1984. The guild concept applied to management of bird populations. *Environmental Management* 8: 1–4.
- Verner, J. 1985. Assessment of counting techniques. *Current Ornithology* 2: 247–257.
- Verner, J., & K.A. Milne. 1990. Analyst and observer variability in density estimates from spot mapping. *Condor* 92: 313–325.
- Verner, J., & L.V. Ritter. 1985. A comparison of transect and point counts in Oak-Pine woodlands of California. *Condor* 87: 47–68.
- Vollmar, R. 1971. Die Entwicklungsregion von Santo Domingo de los Colorados, Ecuador. *Die Erde* 102: 208–226.
- Wackernagel, M., Schulz, N.B., Deumling, D., Callejas L., A., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Myers, N., Norgaard, R., & J. Randers. 2002. Tracking the ecological overshoot of the human economy. *Proceedings of the National Academy of Sciences of the USA* 99: 9266–9271.
- Waide, R.B. 1991. Summary of the response of animal populations to hurricanes in the Caribbean. *Biotropica* 23: 508–512.
- Waide, R.B., & P.M. Narins. 1988. Tropical forest bird counts and the effect of sound attenuation. *Auk* 105: 296–302.
- Walankiewicz, W. 1977. A comparison of the mapping method and I.P.A. results in Bialowieza National Park. *Polish Ecological Studies* 3: 119–125.
- Wallace, G.E., González A., H., McNicholl, M.K., Rodríguez B., D., Oviedo P., R., Llanes S., A., Sánchez O., B., & E.A.H. Wallace. 1996. Winter surveys of forest-dwelling Neotropical migrant and resident birds in three regions of Cuba. *Condor* 98: 745–768.
- Walters, C.J., & R. Hilborn. 1978. Ecological optimization and adaptive management. *Annual Review of Ecology and Systematics* 9: 157–188.
- Walther, B.A., & J.-L. Martin. 2001. Species richness estimation of bird communities: how to control for sampling effort. *Ibis* 143: 413–419.
- Walther, B.A., & S. Morand. 1998. Comparative performance of species richness estimation methods. *Parasitology* 116: 395–405.
- Webb, J.L. 1958. Cyclones as an ecological factor in tropical lowland rainforest, North Queensland. *Australian Journal of Botany* 6: 220–228.
- WEHAB. 2002. A framework for action on biodiversity and ecosystem management. United Nations Environment Programme, World Summit on Sustainable Development, Johannesburg, South Africa.
- Weller, A.-A. 1999. Blue-chested Hummingbird (*Polyerata amabilis*). Pp. 601–602 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 5: barn-owls to hummingbirds. Barcelona, Spain.
- White, C.M., Olsen, P.D., & L.F. Kiff. 1994. Family Falconidae (falcons and caracaras). Pp. 216–275 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 2: New World vultures to guineafowl. Barcelona, Spain.
- Whitman, A.A., Hagan, J.M., & N.V.L. Brokaw. 1997. A comparison of bird survey techniques used in a subtropical forest. *Condor* 99: 955–965.
- Whitmore, T.C. 1991. Tropical rainforest dynamics and its implications for management. Pp. 67–89 in Gómez-Pompa, A., Whitmore, T.C., & M. Hadley (eds.). *Rain forest regeneration and management*. United Nations Educational, Scientific, and Cultural Organization, Paris, France.
- Whitmore, T.C. 1999. Arguments on the forest frontier. *Biodiversity and Conservation* 8: 865–868.
- Whittaker, R.H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs* 30: 279–338.
- Whittaker, R.H. 1977. Evolution of species diversity in land communities. Pp. 1–67 in Hecht, M.K., Steere, W.C., & B. Wallace (eds.). *Evolutionary biology*, vol. 10. New York, USA.
- Whittaker, R.H., & S.A. Levin. 1977. The role of mosaic phenomena in natural communities. *Theoretical Population Biology* 12: 117–139.
- Wicox, B.A. 1984. In *situ* conservation of genetic resources: determinants of minimum area requirements. Pp. 639–647 in McNeely, J.A., & K.R. Miller (eds.). *National parks: conservation and development*. Washington, USA.
- Wiens, J.A. 1989. Spatial scaling in ecology. *Functional Ecology* 3: 385–397.
- Wiley, R.H., & D.G. Richards. 1978. Physical constraints on acoustic communication in the atmosphere: implications for the evolution of animal vocalizations. *Behav. Ecol. Sociobiol.* 3: 69–94.
- Wiley, R.H., & D.G. Richards. 1982. Adaptation for acoustic communication in birds: sound transmission and signal detection. Pp. 130–181 in Kroodsma, D.E., & E.H. Miller (eds.). *Acoustic communication in birds*. New York, USA.

- Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. *Conservation Biology* 16: 2002.
- Will, T. 1991. Birds of a severely hurricane-damaged Atlantic coast rain forest of Nicaragua. *Biotropica* 23: 497–507.
- Williams, S.E., Bolitho, E.E., & S. Fox. 2003. Climate change in Australian tropical rainforest: an impending environmental catastrophe. *Proceedings of The Royal Society of London B (Biological Sciences)* 270: 1887–1892.
- Williams, J.W., Jackson, S.T., & J.E. Kutzbach. 2007. Projected distributions of novel and disappearing climates by 2100 AD. *Proceedings of The National Academy of Sciences of the USA* 104: 5738–5742.
- Williams-Linera, G. 1990. Vegetation structure and environmental conditions of forest edges in Panama. *Journal of Ecology* 78: 356–373.
- Willig, M.R., Kaufman, D.M., & R.D. Stevens. 2003. Latitudinal gradients of biodiversity: pattern, process, scale and synthesis. *Annual Review of Ecology, Evolution, and Systematics* 34: 273–309.
- Willis, E.O. 1967. The behavior of Bicolored Antbirds. *Univ. California Publ. Zool.* 79: 1–132.
- Willis, E.O. 1972. The behavior of Spotted Antbirds. *Ornithological Monographs* 10: 1–161.
- Willis, E.O. 1974. Populations and local extinctions of birds on Barro Colorado Island, Panama. *Ecological Monographs* 44: 153–169.
- Willis, E.O. 1976. Seasonal changes in the invertebrate litter fauna on Barro Colorado Island, Panama. *Revista Brasileira de Biologia* 36: 643–657.
- Willis, E.O. 1977. Lista preliminar das aves da parte nordeste e áreas vizinhas da Reserva Ducke. *Revista Brasileira de Biologia* 37: 585–601.
- Willis, E.O. 1980. Ecological roles of migratory and resident birds on Barro Colorado Island, Panama. Pp. 205–225 in Keast, A., & E.S. Morton (eds.). *Migrant birds in the Neotropics: ecology, behavior, distribution and conservation*. Washington, USA.
- Willis, E.O., & E. Eisenmann. 1979. A revised list of birds on Barro Colorado Island, Panama. *Smithson. Contrib. Zool.* 291: 1–31.
- Willis, E.O., & Y. Oniki. 1972. Ecology and nesting behavior of the Chestnut-backed Antbird (*Myrmeciza exsul*). *Condor* 74: 87–98.
- Willis, E.O., & Y. Oniki. 1978. Birds and army ants. *Annual Review of Ecology and Systematics* 9: 243–263.
- Willson, M.F., & D.J. Moriarty. 1976. Bird species diversity in forest understory: analysis of mist-net samples. *Oecologia* 25: 373–379.
- Wilson, E.O. (ed.). 1988a. *Biodiversity*. Washington, USA.
- Wilson, E.O. 1988b. The current state of biological diversity. Pp. 3–18 in Wilson, E.O. (ed.). *Biodiversity*. Washington, USA.
- Wilson, E.O. 1992. *The diversity of life*. London, UK.
- Winston, M.R., & P.L. Angermeier. 1995. Assessing conservation value using centers of population density. *Conservation Biology* 9: 1518–1527.
- Wolda, H. 1981. Similarity indices, sample size and diversity. *Oecologia* 50: 296–302.
- Wong, M. 1985. Understory birds as indicators of regeneration in a patch of selectively logged west Malaysian rainforest. Pp. 249–263 in Diamond, A.W., & T.A. Lovejoy (eds.). *Conservation of tropical forest birds*. ICBP, Cambridge, UK.
- Woodall, P.F. 2001. Family Alcedinidae (kingfishers). Pp. 130–249 in del Hoyo, J., Elliott, A., & J. Sargatal (eds.). *Handbook of the birds of the world*, vol. 6: mousebirds to hornbills. Barcelona, Spain.
- Wunder, S. 1996. Aspectos socioeconómicos y valoración del bosque en la comunidad de Playa de Oro – zona de amortiguamiento de la Reserva Ecológica Cotacachi-Cayapas, Provincia de Esmeraldas, Ecuador. *EcoCiencia*, Quito, Ecuador (unpubl.).
- Wunderle, J.M., Jr. 1995. Responses of bird populations in a Puerto Rican forest to hurricane Hugo: the first 18 months. *Condor* 97: 879–896.
- Wunderle, J.M., Jr. 1997. The role of animal seed dispersal in accelerating native forest regeneration on degraded tropical lands. *Forest Ecology and Management* 99: 223–235.
- Wunderle, J.M., Jr. 1999. Avian distribution in Dominican shade coffee plantations: area and habitat relationships. *Journal of Field Ornithology* 70: 58–70.
- Wunderle, J.M., Jr., & S.C. Latta. 1996. Avian abundance in sun and shade coffee plantations and remnant pine forest in the Cordillera Central, Dominican Republic. *Ornitología Neotropical* 7: 19–34.
- WWF/IUCN. 1994. Centres of plant diversity: a guide and strategy for their conservation, 1: Europe, Africa, South West Asia, and the Middle East. World Wide Fund for Nature, International Union for Conservation of Nature and Natural Resources, Cambridge, UK.
- WWF/IUCN. 1994–1995. Centres of plant diversity: a guide and strategy for their conservation, 2: Asia, Australasia, and the Pacific. World Wide Fund for Nature, International Union for Conservation of Nature and Natural Resources, Cambridge, UK.
- WWF/IUCN. 1997. Centres of plant diversity: a guide and strategy for their conservation, 3: North America, South America, and the Caribbean Islands. World Wide Fund for Nature, International Union for Conservation of Nature and Natural Resources, Cambridge, UK.
- Wyndham, E. 1986. Length of birds' breeding season. *American Naturalist* 128: 155–164.
- Yahner, R.H., & B.D. Ross. 1995. Seasonal response of Wood Thrushes to taped-playback songs. *Wilson Bulletin* 107: 738–741.
- Yarranton, G.A., & R.G. Morrison. 1974. Spatial dynamics of a primary succession: nucleation. *Journal of Ecology* 62: 417–428.

- Yih, K., Boucher, D.H., Vandermeer, J.H., & N. Zamora. 1991. Recovery of the rain forest of southeastern Nicaragua after destruction by hurricane Juan. *Biotropica* 23: 106–113.
- Young, T.P., & S.P. Hubbell. 1991. Crown asymmetry, treefalls, and repeat disturbance of broad-leaved forest gaps. *Ecology* 72: 1464–1471.
- Yuri, T., & D.P. Mindell. 2002. Molecular phylogenetic analysis of Fringillidae, 'New World nine-primaried oscines' (Aves: Passeriformes). *Molecular Phylogenetics and Evolution* 23: 229–243.
- Zahawi, R.A., & C.K. Augspurger. 1999. Early plant succession in abandoned pastures in Ecuador. *Biotropica* 31: 549–552.
- Zimmer, K.J., Parker, T.A., III, Isler, M.L., & P.R. Isler. 1997. Survey of a southern Amazonian avifauna: the Alta Floresta Region, Mato Grosso, Brazil. Pp. 887–918 *in* Remsen, J.V., Jr. (ed.). *Studies in Neotropical ornithology honoring Ted Parker*. Ornithological Monographs, No. 48, AOU.

## 12. PLATES

PLATE 1a. A presumed male Berlepsch's Tinamou *Crypturellus berlepschi* incubating a single egg. This species inhabits the forest interior and is becoming increasingly threatened by the ongoing conversion of its habitat to agricultural land (LT10, elev. 170 m, 23 Jan. 98).

PLATE 1b. A Uniform Crane *Amaurolimnas concolor guatemalensis* with three pulli (only two of which are visible) on the nest platform in dense undergrowth of an overgrown clearing. Once thought to be rare in Ecuador, but recent field work revealed it to be widespread and common in Esmeraldas from the humid lowlands up to at least 450 m a.s.l in the foothills (MNT2, elev. 66 m, 4 Aug. 97, photo taken before sunrise).

PLATE 1c. The Colombian Crane *Neocrex colombiana colombiana* is so poorly known to science that BirdLife International (2008) regarded it to be Data Deficient. In Playa de Oro the species is not uncommon in traditional mixed-culture plantations and young successional scrub, so it seems not to be genuinely at risk. However, nothing is known about the ecological relationship between this and the closely related Paint-billed Crane *Neocrex erythrops*, which inhabits similar habitats from southern Esmeraldas southward (MNT1, elev. 50 m, 29 Jun. 96).

PLATE 1d. A male Olive-backed Quail-Dove *Geotrygon veraguensis* brooding its two fledglings (not visible). During transect-mapping surveys slowly moving observers might regularly detect the species, usually when the birds are walking on the forest floor in search of seeds, fruits, worms, and insects (MNT2, elev. 75 m, 27 Jun. 96).

PLATE 1e. The Band-tailed Barbthroat *Threnetes ruckeri ruckeri* is the most common hummingbird in habitat mosaics of the Río Santiago floodplain, with an estimated population density of 120-140 individuals per km<sup>2</sup>, according to transect-mapping data (MNT2, elev. 66 m, 14 Apr. 96).

PLATE 1f. The bill morphology of the White-tipped Sicklebill *Eutoxeres aquila heterura* is well adapted to harvest the nectar of similarly curved *Heliconia* flowers. In northwestern Ecuador the species is frequently encountered in *Heliconia* thickets along rivers and streams, at forest borders, and in damp patches inside forest. Males establish display territories or small leks to attract females (TC1, elev. 80 m, 26 Aug. 95).





PLATE 2a. In Esmeraldas the Tooth-billed Hummingbird *Androdon aequatorialis* (male shown) forms leks in the forest undergrowth of the lowermost foothills (between c. 150 and 800 m a.s.l.). In the dry season it disperses widely to lower (and sometimes higher) altitudes, where it may defend feeding territories at flowering ericaceous epiphytes. Only males develop hooks at their bill tips and tooth-like serrations at the anterior ends of their mandibles to catch small arthropods in hovering flight (MNT1, elev. 60 m, 15 Mar. 96).

PLATE 2b. A perched Lanceolated Monklet *Micromonacha lanceolata* close to the entrance of its nest cavity. This inconspicuous puffbird is very difficult to detect, both in mist-netting and audiovisual surveys. The species mostly feeds on large insects and their larvae, which are caught in the forest midstory and subcanopy (MNT2, elev. 75 m, 4 Nov. 96).

PLATE 2c and 2d. Playa de Oro is located in the hybridization zone between populations of *Pteroglossus sanguineus* and *P. erythropygius*, which extends at least from northern Esmeraldas south to extreme northern Pichincha. PLATE 2c shows the typical bill coloration of a Stripe-billed Araçari *P. sanguineus*, whereas PLATE 2d represents a presumed hybrid of which the bill coloration comes close to that which is typical for Pale-mandibled Araçari *P. erythropygius*. Individuals having entirely black and varying amounts of pale areas in their lower mandibles often move in the same flocks, which is why many authors regard them to be subspecies of the similar Collared Araçari *P. torquatus* of Central and northern South America. The vocalizations of the three taxa seem to be very similar if not identical (PLATE 2c: TC1, elev. 80 m, 26 Aug. 95; PLATE 2d: MNT2, elev. 75 m, 30 May 96).

PLATE 2e. Ridgely & Greenfield (2001b) regarded the Scarlet-backed Woodpecker *Veniliornis callonotus* (female shown) as endemic to the Tumbesian lowlands. However, a population also occurs in the arid Patía valley, Nariño, southwestern Colombia. In recent years the species has spread to more humid areas in western Ecuador, likely in response to deforestation (MNT1, elev. 50 m, 20 Nov. 96).

PLATE 2f. The Spot-crowned Antvireo *Dysithamnus puncticeps flemmingi* (male shown) is a core species of mixed understory flocks. It is most abundant in wet foothill forest, but is also present, at lower densities, in the humid lowlands (MNT2, elev. 75 m, 30 Nov. 95).



PLATE 3a. The Purple-chested Hummingbird *Amazilia rosenbergi* (male shown) is a Chocó endemic and one of the most common birds within forest at altitudes below 600 m. Males form small and large leks in the midstory and sometimes at forest borders. The true abundance of the species is only revealed by mist netting or when observers have learned its distinctive calls and songs (MNT2, elev. 66 m, 1 Mar. 96).

PLATE 3b. Some authors continue to list the Western Woodhaunter *Hyloctistes virgatus assimilis* as only a subspecies of the Eastern Woodhaunter *H. subulatus*, calling the combined species Striped Woodhaunter. However, marked differences in their plumage colorations, in combination with their distinct songs and calls, indicate that two valid species almost certainly are involved. The Western Woodhaunter regularly accompanies mixed-species flocks (MNT2, elev. 66 m, 25 Nov. 95).

PLATE 3c. In Ecuador the Black-striped Woodcreeper *Xiphorhynchus lachrymosus lachrymosus* is restricted to altitudes below about 500 m and has been experiencing a rapid decrease in population size due to large-scale conversion of tropical lowland forest to oil palm plantations and cattle pastures. However, the species has a high dispersal ability and tolerance to habitat alteration. In consequence, it persists until today even in severely disturbed forest fragments (MNT1, elev. 70 m, 11 Oct. 96).

PLATE 3d. The Stub-tailed Antbird *Myrmeciza berlepschi* (male shown) is the only species of antbird (Thamnophilidae) that is endemic to the Chocó lowlands of western Ecuador and Colombia. As distinguished from the blackish males, females have some distinct white spotting on their breasts and wing covers (MNT2, elev. 66 m, 1 Mar. 96).

PLATE 3e. In northwestern Ecuador the confusing Green Manakin *Chloropipo holochlora litae* is separated from other “true” manakins (e.g., *Pipra*, *Lepidothrix*, and *Manacus*) by its slightly larger size, dark legs, and yellowish center of belly. Population densities of this mostly silent species might be considerably underestimated in audiovisual surveys (MNT2, elev. 75 m, 29 Nov. 95).

PLATE 3f. Since its scientific description in 1903, the Broad-billed Sapayoa *Sapayoa aenigma* (female shown) has confused taxonomists for an entire century. Long thought to be a manakin (Pipridae), it did not really fit in this family as it forms monogamous pairs, builds globular hanging nests, is an insectivore, and frequently accompanies mixed-species understory flocks. Genetic studies finally demonstrated it to be a phylogenetic relict of the Old World Suboscines dating back to the Gondwanic and Late Cretaceous origin of the passerine birds (Fjeldså *et al.* 2003). Today it is placed either within the broadbills (Eurylaimidae) of the Old World tropics or in its own family (Sapayoidae) (MNT2, elev. 75 m, 1 Dec. 95).





PLATE 4a. In extensively forested areas like the Ecuadorian Chocó, river-edge vegetation was the original habitat of the Pacific Antwren *Myrmotherula pacifica* (female shown). From there it has spread into cleared upland habitats such as plantations, shrubby forest borders, and overgrown pastures, although it remains most numerous in the floodplains (MNT1, elev. 50 m, 21 Nov. 96).

PLATE 4b. In northwestern Ecuador the abundance of the Streak-chested Antpitta *Hylopezus perspicillatus periophthalmicus* (juvenile shown) is highest in forest of advanced stages of succession on level ground. Like many other ground-dwelling insectivores, the species is sensitive to changes in the habitat structure and has suffered severe population declines due to unsustainable timber harvesting practices (MNT2, elev. 75 m, 7 Apr. 96).

PLATE 4c. The Ruddy-tailed Flycatcher *Terenotriccus erythrurus fulvicularis* is closely related to the *Myiobius* flycatchers. However, the former vocalizes much more frequently than the latter, increasing its probability of detection in audiovisual surveys (MNT2, elev. 75 m, 14 Apr. 96).

PLATE 4d. The Sulphur-rumped Flycatcher *Myiobius sulphureipygius aureatus* (a presumed male shown) is one of the few core species of the bird community that is much more easily detected by mist netting than by audiovisual survey techniques. However, the species often accompanies mixed understory flocks, in which it might be spotted through intensive searching. Sometimes it may draw attention to itself through its weak and indistinct calls (MNT2, elev. 66 m, 25 Nov. 95).

PLATE 4e. Adult male Red-capped Manakin *Pipra mentalis minor*. In Playa de Oro leks of this species used to be frequently encountered in young successional stages of forest. However, in many other areas of northwestern Ecuador the species's population has been rapidly decreasing after mechanized timber harvests altered the forest structure (MNT2, elev. 66 m, 25 Nov. 96).

PLATE 4f. With increasing age adult females of Red-capped Manakin *P. mentalis minor* may develop a grey iris (instead of the brown one in younger birds) and some red feathers on the head. At the beginning of the present study these individuals were misidentified as immature males, until some were (re)captured with well-developed brood patches (TC2, elev. 60 m, 20 Aug. 95).





PLATE 5a. A female Blue-crowned Manakin *Lepidothrix coronata minuscula* incubating its clutch of two eggs. In comparison with *Pipra mentalis* this species usually establishes its leks in forest stands of more advanced succession. Although Blue-crowned Manakin is more sensitive to habitat alteration than the latter, both species reportedly disappeared from small forest fragments, like Río Palenque, only a few decades after their isolation (MNT2, elev. 75 m, 4 Nov. 96).

PLATE 5b. The endemic Club-winged Manakin *Machaeropterus deliciosus* (male shown) breeds during the first half of the year (rainy season) at elevations between about 600 and 1500 m on the western Andean slope. In the non-breeding period it performs pronounced altitudinal migrations, when substantial numbers of all sexes and age classes may be detected below 100 m in Playa de Oro (MNT1, elev. 50 m, 30 Jun. 96).

PLATE 5c. In the study area the Tawny-crowned Greenlet *Hylophilus ochraceiceps bulunensis* is the only member of its family that inhabits the forest understory, where it is a core species of mixed flocks. In consequence, it is very sensitive to alterations of the forest structure and its populations have been rapidly declining in recent years (MNT2, elev. 75 m, 1 Dec. 95).

PLATE 5d. The Dagua Thrush *Turdus daguae* is still treated as only a subspecies of *T. assimilis* by most authors (e.g., Remsen *et al.* 2011). However, its song closely resembles that of the cis-Andean White-necked Thrush *T. albicollis* (Ridgely & Greenfield 2001b). It is the only resident forest-dependent thrush in the wet lowlands and lower foothills of Esmeraldas, with breeding taking place only below about 500 m, although dispersing birds sometimes occur at higher elevations. In the mid-1990s it was common and widespread, even at forest borders, but in recent years it has been rapidly retreating from severely logged areas (TC2, elev. 60 m, 22 Aug. 95).

PLATE 5e. Until the mid-1990s the Stripe-throated Wren *Thryothorus leucopogon leucopogon* remained poorly known in the South American portion of its range. Recent field work, like the one presented here, has demonstrated that the species is widespread and fairly common in northwestern Ecuador, particularly in the wet forest belt along the lower base of the Andes below about 750 m. There it is a core species of mixed understory flocks (MNT2, elev. 75 m, 30 Nov. 95).

PLATE 5f. In comparison with other subspecies of the White-breasted Wood-Wren *Henicorhina leucosticta*, the taxon *inornata* of southwestern Colombia and northwestern Ecuador is rather distinct in having a brown (not black) crown as well as a grey (not white) belly and sides of the breast, which is why it is easily confused with the Grey-breasted Wood-Wren *H. leucophrys*. Its vocalizations are also very distinct from those of cis-Andean populations of *H. leucosticta*. Genetic studies have shown that *inornata* is, in fact, more closely related to Bar-winged Wood-Wren *H. leucoptera* (Dingle *et al.* 2006), which means it probably represents a valid species (MNT2, elev. 75 m, 5 Mar. 96).



PLATE 6a. In audiovisual surveys the Tawny-faced Gnatwren *Microbates cinereiventris cinereiventris* is easily detected due to its frequently emitted songs and calls. However, observers need some training in separating its most frequently heard vocalization, a single-noted territorial call that is repeated every few seconds, from similar calls of Stripe-throated Wren *Thryothorus leucopogon* and Tawny-crowned Greenlet *Hylophilus ochraceiceps*. All three species frequently accompany the same mixed understory flocks and may call simultaneously (MNT2, elev. 75 m, 4 Mar. 96).

PLATE 6b. An immature Connecticut Warbler *Oporornis agilis* represents the first confirmed record of this Nearctic-Neotropical migrant for Ecuador (Jahn *et al.* 1999a). In 2005 I observed another individual in northern Esmeraldas, indicating that the species might be of more regular occurrence in the country than previously thought (MNT1, elev. 50 m, 21 Nov. 96).

PLATE 6c. Some authors regard the Black-lored Yellowthroat *Geothlypis auricularis auricularis* (male shown) as only a subspecies of Masked Yellowthroat *G. aequinoctialis*. The former taxon is endemic to the Tumbesian lowlands of Ecuador and northwestern Peru, but has been spreading into more humid areas due to deforestation (MNT1, elev. 50 m, 31 Aug. 96).

PLATE 6d. Until the early 1990s the endemic Scarlet-breasted Dacnis *Dacnis berlepschi* was known from only a handful of museum specimens and visual observations. The present study demonstrated that the species is not as rare as previously thought. However, its population is threatened by deforestation, which is why it is listed as Vulnerable at the global level (MNT2, elev. 66 m, 1 Mar. 96).

PLATE 6e. Once a common bird in the wet lowlands of northern Esmeraldas, the Lemon-spectacled Tanager *Chlorothraupis olivacea* has seen its populations collapsing in recent years due to high-impact logging practices and conversion of forest to other land uses. The species breeds at altitudes below about 400 m, with dispersing birds occurring somewhat higher. Above that elevation it is replaced by a fierce competitor, the Ochre-breasted Tanager *C. stolzmanni* (TC1, elev. 80 m, 29 Aug. 95).

PLATE 6f. The Tawny-crested Tanager *Tachyphonus delatrii* (male shown) forms noisy flocks of up to 20 birds that roam through the forest understory, sometimes ascend briefly to midstory or subcanopy levels, and regularly join or attract mixed-species flocks. Although it is frequently observed at forest borders it might not be able to survive in small forest fragments in the long term (MNT2, elev. 66 m, 25 Nov. 96).





## 13. APPENDICES

## APPENDIX 1

Summary of complete (not standardized) mist-netting study: locality, date, time, effort, and number of birds captured. List of localities mist-netted in Playa de Oro from Aug. 95 to Nov. 96. See Chapter 4 for details on the methodology. Abbreviations used: (a) locality: PdO: outskirts of village of Playa de Oro; PR: Playa Rica, c. 3 km SE of village; (b) transect: TT1: test transect 1, c. 650 m S of village; TT2: test transect 2, c. 900 m NW of Playa Rica; MNT1: mist-netting transect 1; MNT2: mist-netting transect 2; (c) netting hours: op1, op2, op3: nets opened; cl1, cl2, cl3: nets closed; (d) netting effort: NMH: net-meter-hours; NSMH: net-square-meter-hours [1 MNH (mist-net hour) = 1 NSMH + 36]; (e) number of captures: FC: first captures; R2: recaptures type 2; birds already netted in another section or study; R1: recaptures type 1; individuals already trapped in the same sample and section; R2: recaptures type 2; birds already netted in another section or in earlier samples of the same section. Notes: the total number of individuals recorded might be slightly smaller than indicated by the sum of first captures, because not all species and individuals could be permanently marked. The total number of species mist-netted was 146.

Locality <sup>a</sup>	Transect <sup>b</sup>	Section	Sample	Date	Netting hours <sup>c</sup>				Time effort (h)	Nets		Netting effort <sup>d</sup>		Number of captures <sup>e</sup>			
					op1	cl1	op2	cl2		op3	cl3	no.	length (m)	(NMH)	(NSMH)	FC	R1
PR	TT2			19.08.95	08:30	11:00	13:00	16:30	6.0	10	62.50	375.0	1125.0	25	0	0	25
PR	TT2			20.08.95	06:30	17:00			10.5	8	50.00	525.0	1575.0	33	1	0	34
PR	TT2			21.08.95	12:30	14:00			1.5	10	62.50	93.8	281.3	2	0	0	2
PR	TT2			22.08.95	07:00	16:00			9.0	10	62.50	562.5	1687.5	29	0	0	29
PdO	TT1			26.08.95	06:30	16:00			9.5	12	75.00	712.5	2137.5	31	1	0	32
PdO	TT1			27.08.95	06:00	14:30			8.5	14	87.50	743.8	2231.3	19	2	0	21
PdO	TT1			29.08.95	07:00	12:00			5.0	14	87.50	437.5	1312.5	13	3	0	16
PdO	TT1			30.08.95	06:00	15:30			9.5	14	87.50	831.3	2493.8	9	5	0	14
PR	MNT2	B	1	24.11.95	06:30	14:00			7.5	17	106.25	796.9	2390.6	70	1	0	71
PR	MNT2	B	1	25.11.95	06:30	16:30			10.0	17	106.25	1062.5	3187.5	49	7	0	56
PR	MNT2	B	1	26.11.95	06:30	17:00			10.5	17	106.25	1115.6	3346.9	38	7	0	45
PR	MNT2	C	1	29.11.95	07:00	17:00			10.0	17	106.25	1062.5	3187.5	45	3	10	58
PR	MNT2	C	1	30.11.95	06:30	17:00			10.5	17	106.25	1115.6	3346.9	29	6	4	39
PR	MNT2	C	1	01.12.95	06:30	16:30			10.0	17	106.25	1062.5	3187.5	33	10	5	48
PR	MNT2	A	1	29.02.96	06:30	15:30			9.0	17	106.25	956.3	2868.8	64	7	6	77
PR	MNT2	A	1	01.03.96	07:00	16:30			9.5	17	106.25	1009.4	3028.1	51	16	7	74
PR	MNT2	A	1	02.03.96	07:00	14:00	17:00	18:00	8.0	17	106.25	850.0	2550.0	42	9	2	53
PR	MNT2	C	2	04.03.96	06:30	17:00			10.5	17	106.25	1115.6	3346.9	20	0	26	46
PR	MNT2	C	2	05.03.96	11:30	18:00			6.5	17	106.25	690.6	2071.9	13	2	16	31
PR	MNT2	C	2	06.03.96	06:30	16:30			10.0	17	106.25	1062.5	3187.5	30	5	10	45
PdO	MNT1	A	1	10.03.96	16:00	17:00			1.0	17	106.25	106.3	318.8	7	0	0	7
PdO	MNT1	A	1	11.03.96	06:30	17:30			11.0	17	106.25	1168.8	3506.3	74	5	1	80
PdO	MNT1	A	1	12.03.96	06:30	11:30			5.0	17	106.25	531.3	1593.8	28	4	0	32
PdO	MNT1	C	1	13.03.96	10:30	17:00			6.5	17	106.25	690.6	2071.9	29	2	0	31
PdO	MNT1	C	1	14.03.96	06:30	17:00			10.5	17	106.25	1115.6	3346.9	63	18	4	85
PdO	MNT1	C	1	15.03.96	09:00	15:00			6.0	17	106.25	637.5	1912.5	12	2	0	14
PR	MNT2	B	2	07.04.96	07:00	13:00	14:30	15:30	7.0	17	106.25	743.8	2231.3	24	2	20	46
PR	MNT2	B	2	08.04.96	06:30	14:30			8.0	17	106.25	850.0	2550.0	26	6	12	44
PR	MNT2	B	2	09.04.96	07:00	15:00			8.0	17	106.25	850.0	2550.0	10	10	9	29



## APPENDIX 1. Continued.

Locality <sup>a</sup>	Transect <sup>b</sup>	Section	Sample	Date	Netting hours <sup>c</sup>				Time effort (h)	Nets		Netting effort <sup>d</sup>		Number of captures <sup>e</sup>				
					op1	cl1	op2	cl2		op3	cl3	no.	length (m)	(NMH)	(NSMH)	FC	R1	R2
PR	MNT2	D	1	14.04.96	07:00	15:00			8.0	17	106.25	850.0	2550.0	41	3	12	56	
PR	MNT2	D	1	15.04.96	07:00	17:00			10.0	17	106.25	1062.5	3187.5	25	8	13	46	
PR	MNT2	D	1	16.04.96	06:30	07:00	07:30	14:00	7.0	17	106.25	743.8	2231.3	13	9	4	26	
PdO	MNT1	B	1	21.04.96	06:30	16:00			9.5	17	106.25	1009.4	3028.1	43	6	11	60	
PdO	MNT1	B	1	22.04.96	06:30	07:00	08:00	14:30	7.0	17	106.25	743.8	2231.3	26	5	5	36	
PdO	MNT1	B	1	23.04.96	07:00	13:30			6.5	17	106.25	690.6	2071.9	15	8	4	27	
PdO	MNT1	D	1	25.04.96	06:30	12:30			6.0	17	106.25	637.5	1912.5	20	1	10	31	
PdO	MNT1	D	1	26.04.96	06:30	07:00	08:30	16:00	8.0	17	106.25	850.0	2550.0	21	9	7	37	
PdO	MNT1	D	1	27.04.96	06:30	17:30			11.0	17	106.25	1168.8	3506.3	12	5	8	25	
PdO	MNT1	D	1	28.04.96	06:30	07:15	07:45	14:30	7.5	17	106.25	796.9	2390.6	8	6	3	17	
PR	MNT2	A	2	25.05.96	06:00	10:00	14:00	18:00	8.0	17	106.25	850.0	2550.0	86	6	13	105	
PR	MNT2	C	3	28.05.96	06:30	09:00	11:00	16:00	7.5	17	106.25	796.9	2390.6	23	1	24	48	
PR	MNT2	C	3	30.05.96	06:30	16:30			10.0	17	106.25	1062.5	3187.5	21	8	10	39	
PR	MNT2	C	3	31.05.96	06:30	16:00			9.5	17	106.25	1009.4	3028.1	18	3	11	32	
PdO	MNT1	A	2	04.06.96	06:30	16:00			9.5	17	106.25	1009.4	3028.1	41	1	11	53	
PdO	MNT1	A	2	05.06.96	06:30	16:00			9.5	17	106.25	1009.4	3028.1	39	4	5	48	
PdO	MNT1	A	2	06.06.96	06:30	08:00			1.5	17	106.25	159.4	478.1	4	1	0	5	
PdO	MNT1	C	2	08.06.96	06:30	16:00			9.5	17	106.25	1009.4	3028.1	17	3	6	26	
PdO	MNT1	C	2	09.06.96	07:30	15:00			7.5	17	106.25	796.9	2390.6	12	1	11	24	
PdO	MNT1	C	2	10.06.96	06:30	12:00	13:00	15:30	8.0	17	106.25	850.0	2550.0	10	2	7	19	
PdO	MNT1	C	2	11.06.96	06:30	13:30			7.0	17	106.25	743.8	2231.3	9	3	3	15	
PR	MNT2	D	2	23.06.96	06:30	15:30			9.0	17	106.25	956.3	2868.8	32	6	23	61	
PR	MNT2	D	2	24.06.96	06:30	08:00	09:30	10:30	2.5	17	106.25	265.6	796.9	3	1	5	9	
PR	MNT2	D	2	25.06.96	06:30	17:00			10.5	17	106.25	1115.6	3346.9	17	6	5	28	
PR	MNT2	D	2	26.06.96	06:30	10:30			4.0	17	106.25	425.0	1275.0	12	7	8	27	
PdO	MNT1	A	2	29.06.96	06:30	16:30			10.0	17	106.25	1062.5	3187.5	26	2	16	44	
PdO	MNT1	A	2	30.06.96	06:30	15:00			8.5	17	106.25	903.1	2709.4	26	4	11	41	
PdO	MNT1	A	2	01.07.96	06:30	14:30			8.0	17	106.25	850.0	2550.0	11	5	4	20	
PdO	MNT1	A	2	02.07.96	06:30	08:30			2.0	17	106.25	212.5	637.5	11	2	3	16	
PdO	MNT1	D	2	24.08.96	06:30	14:00			7.5	17	106.25	796.9	2390.6	31	0	10	41	
PdO	MNT1	D	2	26.08.96	06:30	15:00			8.5	17	106.25	903.1	2709.4	22	0	6	28	
PdO	MNT1	D	2	27.08.96	06:30	14:30			8.0	17	106.25	850.0	2550.0	17	3	9	29	
PdO	MNT1	D	2	28.08.96	06:30	12:00			5.5	17	106.25	584.4	1753.1	5	4	2	11	
PdO	MNT1	A	3	30.08.96	06:30	13:30			7.0	17	106.25	743.8	2231.3	39	1	18	58	
PdO	MNT1	A	3	31.08.96	06:30	15:30			9.0	17	106.25	956.3	2868.8	47	5	10	62	
PdO	MNT1	A	3	02.09.96	07:30	08:00	09:00	09:30	10:30	15:00	17	106.25	584.4	1753.1	12	4	3	19
PdO	MNT1	A	3	03.09.96	07:00	10:30			3.5	17	106.25	371.9	1115.6	17	2	4	23	
PR	MNT2	B	3	28.09.96	07:00	09:00	10:00	13:30	15:00	16:30	17	106.25	743.8	2231.3	22	3	15	40
PR	MNT2	B	3	29.09.96	06:30	16:30			10.0	17	106.25	1062.5	3187.5	26	9	13	48	
PR	MNT2	B	3	30.09.96	06:30	11:30	13:30	15:00	6.5	17	106.25	690.6	2071.9	12	8	4	24	
PR	MNT2	B	3	01.10.96	06:30	13:30			7.0	17	106.25	743.8	2231.3	6	8	3	17	
PR	MNT2	A	3	02.10.96	08:30	15:00			6.5	17	106.25	690.6	2071.9	27	6	17	50	
PR	MNT2	A	3	03.10.96	06:30	13:00	14:30	17:00	9.0	17	106.25	956.3	2868.8	33	8	11	52	

## APPENDIX 1. Continued.

Locality <sup>a</sup>	Transect <sup>b</sup>	Section	Sample	Date	Netting hours <sup>c</sup>				Time effort (h)	Nets		Netting effort <sup>d</sup>				Number of captures <sup>e</sup>		
					op1	cl1	op2	cl2	op3	cl3	no.	length (m)	(NMH)	(NSMH)	FC	R1	R2	Sum
PR	MNT2	A	3	04.10.96	06:30	15:00					17	106.25	903.1	2709.4	14	8	8	30
PdO	MNT1	C	3	10.10.96	06:30	16:30					17	106.25	1062.5	3187.5	14	0	6	20
PdO	MNT1	C	3	11.10.96	06:30	16:00					17	106.25	1009.4	3028.1	9	0	6	15
PdO	MNT1	C	3	12.10.96	07:30	16:00					17	106.25	903.1	2709.4	4	3	5	12
PdO	MNT1	C	3	13.10.96	06:30	10:30					17	106.25	425.0	1275.0	8	2	5	15
PR	MNT2	D	3	01.11.96	06:30	15:30					17	106.25	956.3	2868.8	22	4	15	41
PR	MNT2	D	3	02.11.96	07:00	15:30					17	106.25	903.1	2709.4	19	10	12	41
PR	MNT2	D	3	03.11.96	06:00	13:00					17	106.25	743.8	2231.3	16	8	19	43
PdO	MNT1	A	3	07.11.96	06:30	07:30	08:30	15:30			17	106.25	850.0	2550.0	18	2	17	37
PdO	MNT1	A	3	08.11.96	06:00	15:00					17	106.25	956.3	2868.8	15	4	8	27
PdO	MNT1	A	3	09.11.96	06:30	15:30					17	106.25	956.3	2868.8	16	6	13	35
PdO	MNT1	A	3	12.11.96	06:30	10:00					17	106.25	371.9	1115.6	12	5	4	21
PdO	MNT1	D	3	13.11.96	07:30	15:30					17	106.25	850.0	2550.0	13	4	22	39
PdO	MNT1	D	3	16.11.96	06:00	15:00					17	106.25	956.3	2868.8	20	5	15	40
PdO	MNT1	D	3	18.11.96	06:00	13:00					17	106.25	743.8	2231.3	22	6	12	40
PdO	MNT1	A	4	20.11.96	06:00	15:00					17	106.25	956.3	2868.8	31	1	21	53
PdO	MNT1	A	4	21.11.96	06:00	14:00					17	106.25	850.0	2550.0	18	4	4	26
PdO	MNT1	A	4	22.11.96	06:00	11:00					17	106.25	531.3	1593.8	14	1	5	20
PdO	MNT1	A	4	23.11.96	06:00	08:00					17	106.25	212.5	637.5	4	1	4	9
PR	MNT2	A	4	26.11.96	06:00	15:00					17	106.25	956.3	2868.8	52	7	24	83
PR	MNT2	A	4	27.11.96	06:30	15:30					17	106.25	956.3	2868.8	52	14	9	75
PR	MNT2	A	4	28.11.96	06:30	12:30					17	106.25	637.5	1912.5	14	10	5	29
Sum											724		74 884.4	224 653.1	2283	426	749	3458

## APPENDIX 2

Summary of standardized mist-netting study of MNT1 and MNT2: locality, date, effort, and number of birds captured. Mist-netting samples standardized by time effort (net length c. 106.25 m), obtained in Playa de Oro between Nov. 95 and Nov. 96. See Chapter 4 for details on the methodology. Abbreviations used: (a) locality: PdO: outskirts of village of Playa de Oro; PR: Playa Rica, c. 3 km SE of village; (b) transect: MNT1: mist-netting transect 1; MNT2: mist-netting transect 2; (c) effort: NSMH: net-square-meter-hours [1 MNH (mist-net hour) = 1 NSMH ÷ 36]; (d) number of captures: FC: first captures; birds netted for the first time in the standardized study; R1: recaptures type 1; individuals already trapped in the same sample and section; R2: recaptures type 2; birds already captured in another section during the same survey. R3: recaptures type 3; individuals already netted in earlier surveys. Note: the total number of individuals recorded might be slightly smaller than indicated by the sum of first captures, because not all species and individuals could be permanently marked.

Locality <sup>a</sup>	Transect <sup>b</sup>	Section	Sample	Survey	Date	Effort <sup>c</sup>		Number of captures <sup>d</sup>				SUM
						(h)	(NSMH)	FC	R1	R2	R3	
PdO	MNT1	A	2	I	04.06.96	9.5	3028.1	47	1	5		53
PdO	MNT1	A	2	I	05.06.96	9.5	3028.1	43	4	1		48
PdO	MNT1	A	2	I	06.06.96	1.5	478.1	4	1			5
Subtotal						20.5	6534.4	94	6	6	0	106
PdO	MNT1	B	1	I	21.04.96	9.5	3028.1	47	6	7		60
PdO	MNT1	B	1	I	22.04.96	7.0	2231.3	29	5	2		36
PdO	MNT1	B	1	I	23.04.96	6.5	2071.9	19	8			27
Subtotal						23.0	7331.3	95	19	9	0	123
PdO	MNT1	C	1	I	13.03.96	6.5	2071.9	29	2			31
PdO	MNT1	C	1	I	14.03.96	10.5	3346.9	67	18			85
PdO	MNT1	C	1	I	15.03.96	6.0	1912.5	12	2			14
Subtotal						23.0	7331.3	108	22	0	0	130
PdO	MNT1	D	1	I	25.04.96	6.0	1912.5	20	1	10		31
PdO	MNT1	D	1	I	26.04.96	8.0	2550.0	21	9	7		37
PdO	MNT1	D	1	I	27.04.96	8.5	2709.4	12	4	6		22
Subtotal						22.5	7171.9	53	14	23	0	90
Sum sample						89.0	28 368.8	350	61	38	0	449
PdO	MNT1	A	3	II	30.08.96	7.0	2231.3	45	1	4	8	58
PdO	MNT1	A	3	II	31.08.96	9.0	2868.8	49	5	2	6	62
PdO	MNT1	A	3	II	02.09.96	5.5	1753.1	13	4	2		19
PdO	MNT1	A	3	II	03.09.96	1.0	318.8	3	1			4
Subtotal						22.5	7171.9	110	11	8	14	143
PdO	MNT1	B	2	II	29.06.96	10.0	3187.5	26	2	2	14	44
PdO	MNT1	B	2	II	30.06.96	8.5	2709.4	28	4	2	7	41
PdO	MNT1	B	2	II	01.07.96	4.5	1434.4	7	2	1	3	13
Subtotal						23.0	7331.3	61	8	5	24	98
PdO	MNT1	C	2	II	08.06.96	9.5	3028.1	17	3		6	26
PdO	MNT1	C	2	II	09.06.96	7.5	2390.6	13	1		10	24
PdO	MNT1	C	2	II	10.06.96	5.5	1753.1	9	1		5	15
Subtotal						22.5	7171.9	39	5	0	21	65
PdO	MNT1	D	2	II	24.08.96	7.5	2390.6	32		5	4	41
PdO	MNT1	D	2	II	26.08.96	8.5	2709.4	23		1	4	28
PdO	MNT1	D	2	II	27.08.96	6.5	2071.9	14	3	1	8	26
Subtotal						22.5	7171.9	69	3	7	16	95
Sum sample						90.5	28 846.9	279	27	20	75	401
PdO	MNT1	A	4	III	20.11.96	9.0	2868.8	35	1	4	13	53
PdO	MNT1	A	4	III	21.11.96	8.0	2550.0	19	4		3	26
PdO	MNT1	A	4	III	22.11.96	5.0	1593.8	15	1	1	3	20
PdO	MNT1	A	4	III	23.11.96	1.0	318.8	1		1	2	4
Subtotal						23.0	7331.3	70	6	6	21	103
PdO	MNT1	B	3	III	07.11.96	8.0	2550.0	18	2	4	13	37
PdO	MNT1	B	3	III	08.11.96	9.0	2868.8	16	4	1	6	27
PdO	MNT1	B	3	III	09.11.96	5.5	1753.1	10	6	1	6	23
Subtotal						22.5	7171.9	44	12	6	25	87
PdO	MNT1	C	3	III	10.10.96	10.0	3187.5	14			6	20
PdO	MNT1	C	3	III	11.10.96	9.5	3028.1	10			5	15
PdO	MNT1	C	3	III	12.10.96	3.5	1115.6	4	1		2	7
Subtotal						23.0	7331.3	28	1	0	13	42

## APPENDIX 2. Continued.

Locality <sup>a</sup>	Transect <sup>b</sup>	Section	Sample	Survey	Date	Effort <sup>c</sup>		Number of captures <sup>d</sup>				
						(h)	(NSMH)	FC	R1	R2	R3	SUM
PdO	MNT1	D	3	III	13.11.96	8.0	2550.0	14	4	3	18	39
PdO	MNT1	D	3	III	16.11.96	9.0	2868.8	21	5	3	11	40
PdO	MNT1	D	3	III	18.11.96	6.0	1912.5	21	6	1	10	38
Subtotal						23.0	7331.3	56	15	7	39	117
Sum sample						91.5	29 165.6	198	34	19	98	349
Sum MNT1						271.0	86 381.3	827	122	77	173	1199
PR	MNT2	A	1	I	29.02.96	9.0	2868.8	64	7	6		77
PR	MNT2	A	1	I	01.03.96	9.5	3028.1	55	16	3		74
PR	MNT2	A	1	I	02.03.96	4.0	1275.0	24	6			30
Subtotal						22.5	7171.9	143	29	9	0	181
PR	MNT2	B	1	I	24.11.95	7.5	2390.6	70	1			71
PR	MNT2	B	1	I	25.11.95	10.0	3187.5	49	7			56
PR	MNT2	B	1	I	26.11.95	5.5	1753.1	19	3			22
Subtotal						23.0	7331.3	138	11	0	0	149
PR	MNT2	C	1	I	29.11.95	10.0	3187.5	45	3	10		58
PR	MNT2	C	1	I	30.11.95	10.5	3346.9	29	6	4		39
PR	MNT2	C	1	I	01.12.95	2.5	796.9	12	3	3		18
Subtotal						23.0	7331.3	86	12	17	0	115
PR	MNT2	D	1	I	14.04.96	8.0	2550.0	43	3	6	4	56
PR	MNT2	D	1	I	15.04.96	10.0	3187.5	26	8	11	1	46
PR	MNT2	D	1	I	16.04.96	5.0	1593.8	10	7	2	1	20
Subtotal						23.0	7331.3	79	18	19	6	122
Sum sample						91.5	29 165.6	446	70	45	6	567
PR	MNT2	A	3	II	02.10.96	6.5	2071.9	29	6	4	11	50
PR	MNT2	A	3	II	03.10.96	9.0	2868.8	34	8	3	7	52
PR	MNT2	A	3	II	04.10.96	7.5	2390.6	13	6	2	4	25
Subtotal						23.0	7331.3	76	20	9	22	127
PR	MNT2	B	2	II	07.04.96	7.0	2231.3	24	2	6	14	46
PR	MNT2	B	2	II	08.04.96	8.0	2550.0	26	6	2	10	44
PR	MNT2	B	2	II	09.04.96	8.0	2550.0	11	10	6	2	29
Subtotal						23.0	7331.3	61	18	14	26	119
PR	MNT2	C	2	II	04.03.96	10.5	3346.9	21			25	46
PR	MNT2	C	2	II	05.03.96	6.5	2071.9	13	2	1	15	31
PR	MNT2	C	2	II	06.03.96	5.5	1753.1	23	2		6	31
Subtotal						22.5	7171.9	57	4	1	46	108
PR	MNT2	D	2	II	23.06.96	9.0	2868.8	33	6	9	13	61
PR	MNT2	D	2	II	24.06.96	2.5	796.9	4	1		4	9
PR	MNT2	D	2	II	25.06.96	10.5	3346.9	17	6	1	4	28
PR	MNT2	D	2	II	26.06.96	0.5	159.4	3	1	2	1	7
Subtotal						22.5	7171.9	57	14	12	22	105
Sum sample						91.0	29 006.3	251	56	36	116	459
PR	MNT2	A	4	III	26.11.96	9.0	2868.8	56	7	7	13	83
PR	MNT2	A	4	III	27.11.96	9.0	2868.8	54	14	3	4	75
PR	MNT2	A	4	III	28.11.96	4.5	1434.4	13	8	2	2	25
Subtotal						22.5	7171.9	123	29	12	19	183
PR	MNT2	B	3	III	28.09.96	7.0	2231.3	23	3	1	13	40
PR	MNT2	B	3	III	29.09.96	10.0	3187.5	29	9	3	7	48
PR	MNT2	B	3	III	30.09.96	5.5	1753.1	9	7	1	3	20
Subtotal						22.5	7171.9	61	19	5	23	108
PR	MNT2	C	3	III	28.05.96	7.5	2390.6	25	1		22	48
PR	MNT2	C	3	III	30.05.96	10.0	3187.5	23	8		8	39
PR	MNT2	C	3	III	31.05.96	5.5	1753.1	12	2		5	19
Subtotal						23.0	7331.3	60	11	0	35	106
PR	MNT2	D	3	III	01.11.96	9.0	2868.8	23	4	8	6	41
PR	MNT2	D	3	III	02.11.96	8.5	2709.4	20	10	1	10	41
PR	MNT2	D	3	III	03.11.96	5.0	1593.8	8	3	1	10	22
Subtotal						22.5	7171.9	51	17	10	26	104
Sum sample						90.5	28 846.9	295	76	27	103	501
Sum MNT2						273.0	87 018.8	992	202	108	225	1527

## APPENDIX 3

Summary of transect-mapping study: transects, date and time of sampling, effort, number of records, and number of birds and species recorded in the complete MTW study. List of transects surveyed in Playa de Oro from Feb. 97 to Jan. 98. See Chapter 4 for details on the methodology. The results for transects LT1 through LT11c are preliminary, as it was not possible to proofread these data due to time restraints. They are written in italics to emphasize this fact. For the same reason the total number of species recorded in the complete MTW study is not precisely known. However, I estimate that the final count will be close to 300 species. Abbreviations used: MNT: mist-netting transect; LT: line transect, see Fig. 1b for the location of the transects and Table 5 for a description of the habitats covered. Notes: (a) sample 1B had to be stopped between 07:55 h and 08:15 h due to rain; (b) late start of sample 3A due to rain; (c) sample 2A had to be stopped between 08:05 h and 08:30 h due to rain; (d) sample 3A had to be stopped from 15:35 h to 15:55 h and again from 16:21 h to 16:29 h due to rain; (e) samples 3A and 3B could not be carried out because the camp was destroyed during a severe inundation. The number of samples cancelled does not include the numerous sampling runs that had to be stopped after a few minutes or could not be initiated at all due to heavy rainfall (particularly in pre-dawn hours or in late afternoons).

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)			Number of birds recorded	species
									records	birds	species		
MNT1	625	MNT1/1		MNT1/1/1A	04.03.97	05:26	05:55	29	4.6	2	2	2	2
MNT1	625	MNT1/1	1	MNT1/1/1B	04.03.97	06:07	07:34	87	13.9	160	235	73	73
MNT1	625	MNT1/1		MNT1/1/2A	20.02.97	06:00	06:58	58	9.3	85	110	49	49
MNT1	625	MNT1/1		MNT1/1/2B	20.02.97	08:30	09:42	72	11.5	110	163	63	63
MNT1	625	MNT1/1	1	MNT1/1/3A	03.03.97	17:28	18:27	59	9.4	70	99	44	44
MNT1	625	MNT1/1		MNT1/1/3B	03.03.97	18:40	19:09	29	4.6	0	0	0	0
MNT1	625	MNT1/1	2					334	53.4	427	609	105	105
MNT1	625	MNT1/2		MNT1/2/1A	18.04.97	05:30	05:55	25	4.0	16	24	10	10
MNT1	625	MNT1/2		MNT1/2/1B	18.04.97	05:59	07:13	74	11.8	144	232	70	70
MNT1	625	MNT1/2		MNT1/2/2A	17.04.97	05:55	07:02	67	10.7	142	209	66	66
MNT1	625	MNT1/2		MNT1/2/2B	17.04.97	08:25	09:44	79	12.6	152	232	69	69
MNT1	625	MNT1/2		MNT1/2/3A	16.04.97	17:26	18:20	54	8.6	69	104	42	42
MNT1	625	MNT1/2		MNT1/2/3B	16.04.97	18:27	18:57	30	4.8	2	2	1	1
MNT1	625	MNT1/2	0					329	52.6	525	803	111	111
MNT1	625	MNT1/1+2	2					663	53.0	952	1412	130	130
MNT1	625	MNT1/3		MNT1/3/1A	17.08.97	05:30	05:55	25	4.0	4	4	3	3
MNT1	625	MNT1/3		MNT1/3/1B	17.08.97	05:55	07:05	70	11.2	155	280	70	70
MNT1	625	MNT1/3		MNT1/3/2A	14.08.87	05:55	07:14	79	12.6	139	260	66	66
MNT1	625	MNT1/3		MNT1/3/2B	14.08.97	08:55	10:13	78	12.5	153	237	74	74
MNT1	625	MNT1/3		MNT1/3/3A	14.08.97	17:01	17:58	57	9.1	92	169	48	48
MNT1	625	MNT1/3		MNT1/3/3B	14.08.97	18:02	18:44	42	6.7	31	71	20	20
MNT1	625	MNT1/3	0					351	56.2	574	1021	120	120
MNT1	625	MNT1/4		MNT1/4/1A	21.11.97	05:29	05:53	24	3.8	34	52	17	17
MNT1	625	MNT1/4		MNT1/4/1B	21.11.97	05:54	07:36	102	16.3	207	345	87	87
MNT1	625	MNT1/4		MNT1/4/2A	22.11.97	05:40	06:59	79	12.6	177	274	78	78

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	Number of	
										records	birds recorded
MNT1	625	MNT1/4		MNT1/4/2B	22.11.97	08:47	10:12	85	13.6	165	281
MNT1	625	MNT1/4		MNT1/4/3A	20.11.97	16:55	17:58	63	10.1	92	151
MNT1	625	MNT1/4		MNT1/4/3B	20.11.97	18:00	18:30	30	4.8	22	33
MNT1	625	MNT1/4	0					383	61.3	697	1136
MNT1	625	MNT1/3+4	0					734	58.7	1271	2157
MNT1	625	MNT1/1-4	2					1397	55.9	2223	3569
MNT2	550	MNT2/1		MNT2/1/1A	11.03.97	05:27	05:54	27	4.9	0	0
MNT2	550	MNT2/1		MNT2/1/1B	11.03.97	06:00	07:24	84	15.3	115	161
MNT2	550	MNT2/1		MNT2/1/2A	12.03.97	06:05	07:24	79	14.4	125	198
MNT2	550	MNT2/1	1	MNT2/1/2B	12.03.97	08:25	09:30	65	11.8	99	139
MNT2	550	MNT2/1		MNT2/1/3A	09.03.97	17:30	18:27	57	10.4	78	116
MNT2	550	MNT2/1		MNT2/1/3B	09.03.97	18:41	19:08	27	4.9	0	0
MNT2	550	MNT2/1	1					339	61.6	417	614
MNT2	550	MNT2/2		MNT2/2/1A	21.04.97	05:37	05:54	17	3.1	8	13
MNT2	550	MNT2/2		MNT2/2/1B	21.04.97	05:57	07:17	80	14.5	134	201
MNT2	550	MNT2/2		MNT2/2/2A	20.04.97	05:55	07:06	71	12.9	117	170
MNT2	550	MNT2/2		MNT2/2/2B	20.04.97	08:25	09:36	71	12.9	93	133
MNT2	550	MNT2/2		MNT2/2/3A	18.04.97	17:35	18:19	44	8.0	46	69
MNT2	550	MNT2/2		MNT2/2/3B	18.04.97	18:24	18:49	25	4.5	1	1
MNT2	550	MNT2/2	0					308	56.0	399	587
MNT2	550	MNT2/1+2	1					647	58.8	816	1201
MNT2	550	MNT2/3		MNT2/3/1A	04.08.97	05:33	05:57	24	4.4	14	28
MNT2	550	MNT2/3		MNT2/3/1B	04.08.97	05:58	07:10	72	13.1	135	246
MNT2	550	MNT2/3		MNT2/3/2A	31.07.97	05:58	07:05	67	12.2	141	236
MNT2	550	MNT2/3		MNT2/3/2B	31.07.97	08:50	10:07	77	14.0	128	197
MNT2	550	MNT2/3		MNT2/3/3A	31.07.97	17:16	18:22	66	12.0	78	130
MNT2	550	MNT2/3		MNT2/3/3B	31.07.97	18:23	18:49	26	4.7	20	21
MNT2	550	MNT2/3	0					332	60.4	516	858
MNT2	550	MNT2/4		MNT2/4/1A	23.11.97	05:30	05:51	21	3.8	19	33
MNT2	550	MNT2/4		MNT2/4/1B	23.11.97	05:52	06:54	62	11.3	131	203
MNT2	550	MNT2/4		MNT2/4/2A	25.11.97	05:45	06:53	68	12.4	136	195
MNT2	550	MNT2/4		MNT2/4/2B	25.11.97	08:37	09:43	66	12.0	101	175
MNT2	550	MNT2/4		MNT2/4/3A	24.11.97	17:02	17:56	54	9.8	72	107
MNT2	550	MNT2/4		MNT2/4/3B	24.11.97	17:58	18:20	22	4.0	23	25
MNT2	550	MNT2/4	0					293	53.3	482	738
MNT2	550	MNT2/3+4	0					625	56.8	998	1596
MNT2	550	MNT2/1-4	1					1272	57.8	1814	2797
LT1	1550	LT1/1		LT1/1/1A	06.03.97	04:39	05:51	72	4.6	6	6
LT1	1550	LT1/1		LT1/1/1B	06.03.97	06:05	08:52	167	10.8	262	381



## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	records	Number of birds recorded	species
LT1	1550	LT1/1		LT1/1/2A	07.03.97	06:01	08:23	142	9.2	231	280	78
LT1	1550	LT1/1		LT1/1/2B	07.03.97	08:35	10:55	140	9.0	203	263	86
LT1	1550	LT1/1		LT1/1/3A	04.03.97	16:05	18:20	135	8.7	162	250	70
LT1	1550	LT1/1		LT1/1/3B	04.03.97	18:40	19:36	56	3.6	0	0	0
LT1	1550	LT1/1	0					712	45.9	864	1180	143
LT1	1550	LT1/2		LT1/2/1A	14.04.97	05:02	05:56	54	3.5	11	15	11
LT1	1550	LT1/2		LT1/2/1B	14.04.97	06:00	08:55	175	11.3	264	392	97
LT1	1550	LT1/2		LT1/2/2A	13.04.97	05:55	08:10	135	8.7	216	289	80
LT1	1550	LT1/2		LT1/2/2B	13.04.97	08:25	10:56	151	9.7	200	293	78
LT1	1550	LT1/2		LT1/2/3A	15.04.97	16:05	18:07	122	7.9	181	256	85
LT1	1550	LT1/2		LT1/2/3B	15.04.97	18:30	19:28	58	3.7	4	4	3
LT1	1550	LT1/2	0					695	44.8	876	1249	138
LT1	1550	LT1/1+2	0					1407	45.4	1740	2429	174
LT2a	1500	LT2a/1		LT2a/1/1A	14.06.97	04:53	05:51	58	3.9	15	15	9
LT2a	1500	LT2a/1		LT2a/1/1B	14.06.97	05:53	09:46	233	15.5	285	517	102
LT2a	1500	LT2a/1		LT2a/1/2A	13.06.97	05:50	08:30	160	10.7	208	371	83
LT2a	1500	LT2a/1		LT2a/1/2B	13.06.97	08:35	11:58	203	13.5	211	461	77
LT2a	1500	LT2a/1		LT2a/1/3A	12.06.97	15:52	18:08	136	9.1	172	285	95
LT2a	1500	LT2a/1		LT2a/1/3B	12.06.97	18:13	19:01	48	3.2	11	13	7
LT2a	1500	LT2a/2	0					838	55.9	902	1662	138
LT2a	1500	LT2a/2		LT2a/2/1A	26.11.97	04:49	05:52	63	4.2	44	54	23
LT2a	1500	LT2a/2		LT2a/2/1B	26.11.97	05:53	09:23	210	14.0	370	484	109
LT2a	1500	LT2a/2		LT2a/2/2A	27.11.97	05:41	08:54	193	12.9	324	539	84
LT2a	1500	LT2a/2		LT2a/2/2B	27.11.97	08:57	11:57	180	12.0	271	515	89
LT2a	1500	LT2a/2		LT2a/2/3A	25.11.97	15:40	17:52	132	8.8	210	390	82
LT2a	1500	LT2a/2		LT2a/2/3B	25.11.97	17:53	18:40	47	3.1	37	64	19
LT2a	1500	LT2a/2	0					825	55.0	1256	2046	134
LT2a	1500	LT2a/1+2	0					1663	55.4	2158	3708	172
LT2b	1500	LT2b/1		LT2b/1/1A	25.06.97	04:51	05:51	60	4.0	3	3	3
LT2b	1500	LT2b/1		LT2b/1/1B	25.06.97	05:56	08:55	179	11.9	295	516	80
LT2b	1500	LT2b/1		LT2b/1/2A	26.06.97	05:55	09:05	190	12.7	360	575	91
LT2b	1500	LT2b/1		LT2b/1/2B	26.06.97	09:09	11:20	131	8.7	222	342	75
LT2b	1500	LT2b/1		LT2b/1/3A	25.06.97	15:35	17:37	122	8.1	175	332	68
LT2b	1500	LT2b/1		LT2b/1/3B	25.06.97	17:55	18:53	58	3.9	45	61	26
LT2b	1500	LT2b/1	0					740	49.3	1100	1829	128
LT2b	1500	LT2b/2		LT2b/2/1A	11.08.97	04:55	05:57	62	4.1	14	14	12
LT2b	1500	LT2b/2		LT2b/2/1B	11.08.97	05:59	10:18	259	17.3	398	646	110
LT2b	1500	LT2b/2		LT2b/2/2A	09.08.97	05:57	08:54	177	11.8	363	588	80
LT2b	1500	LT2b/2		LT2b/2/2B	09.08.97	09:05	11:39	154	10.3	215	375	75
LT2b	1500	LT2b/2		LT2b/2/3A	08.08.97	15:39	18:00	141	9.4	199	368	70
LT2b	1500	LT2b/2		LT2b/2/3B	08.08.97	18:02	18:57	55	3.7	28	47	14

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	Number of	
										records	birds recorded
LT2b	1500	LT2b/2	0					848	56.5	1217	2038
LT2b	1500	LT2b/1+2	0					1588	52.9	2317	3867
LT3	1225	LT3/1		LT3/1/1A	05.06.97	05:06	05:54	48	3.9	8	8
LT3	1225	LT3/1		LT3/1/1B	05.06.97	05:57	09:05	188	15.3	239	439
LT3	1225	LT3/1		LT3/1/2A	06.06.97	05:51	08:31	160	13.1	217	328
LT3	1225	LT3/1		LT3/1/2B	06.06.97	08:37	11:11	154	12.6	196	396
LT3	1225	LT3/1		LT3/1/3A	04.06.97	16:05	18:00	115	9.4	135	224
LT3	1225	LT3/1		LT3/1/3B	04.06.97	18:13	19:01	48	3.9	12	12
LT3	1225	LT3/1	0					713	58.2	807	1407
LT3	1225	LT3/2		LT3/2/1A	16.08.97	05:06	05:54	48	3.9	2	2
LT3	1225	LT3/2		LT3/2/1B	16.08.97	06:01	08:46	165	13.5	285	491
LT3	1225	LT3/2		LT3/2/2A	15.08.97	05:54	08:27	153	12.5	278	439
LT3	1225	LT3/2		LT3/2/2B	15.08.97	08:48	11:09	141	11.5	190	292
LT3	1225	LT3/2	1	LT3/2/3A	16.08.97	16:00	17:50	110	9.0	136	252
LT3	1225	LT3/2	1	LT3/2/3B	16.08.97	17:53	18:29	36	3.6	36	47
LT3	1225	LT3/2	1					653	53.3	927	1523
LT3	1225	LT3/1+2	1					1366	55.8	1734	2930
LT4a	1325	LT4a/1		LT4a/1/1A	09.06.97	05:01	06:01	60	4.5	9	28
LT4a	1325	LT4a/1		LT4a/1/1B	09.06.97	06:03	08:59	176	13.3	274	411
LT4a	1325	LT4a/1		LT4a/1/2A	08.06.97	05:49	08:57	188	14.2	290	421
LT4a	1325	LT4a/1		LT4a/1/2B	08.06.97	09:00	12:04	184	13.9	234	402
LT4a	1325	LT4a/1		LT4a/1/3A	05.06.97	15:58	18:01	123	9.3	148	290
LT4a	1325	LT4a/1		LT4a/1/3B	05.06.97	18:18	19:08	50	3.8	20	23
LT4a	1325	LT4a/1	0					781	58.9	975	1575
LT4a	1325	LT4a/2		LT4a/2/1A	01.12.97	04:58	05:48	50	3.8	20	25
LT4a	1325	LT4a/2		LT4a/2/1B	01.12.97	05:50	08:36	166	12.5	305	566
LT4a	1325	LT4a/2		LT4a/2/2A	04.12.97	05:46	08:07	141	10.6	239	376
LT4a	1325	LT4a/2		LT4a/2/2B	04.12.97	08:15	11:13	178	13.4	216	308
LT4a	1325	LT4a/2		LT4a/2/3A	28.11.97	15:51	17:52	121	9.1	157	234
LT4a	1325	LT4a/2		LT4a/2/3B	28.11.97	17:55	18:36	41	3.1	29	37
LT4a	1325	LT4a/2	0					697	52.6	966	1546
LT4a	1325	LT4a/1+2	0					1478	55.8	1941	3121
LT4b	1300	LT4b/1		LT4b/1/1A	12.06.97	05:03	05:54	51	3.9	12	12
LT4b	1300	LT4b/1		LT4b/1/1B	12.06.97	05:58	09:00	182	14.0	220	348
LT4b	1300	LT4b/1		LT4b/1/2A	10.06.97	05:47	08:56	189	14.5	271	467
LT4b	1300	LT4b/1		LT4b/1/2B	10.06.97	08:57	11:22	145	11.2	151	265
LT4b	1300	LT4b/1		LT4b/1/3A	08.06.97	16:03	17:59	116	8.9	121	194
LT4b	1300	LT4b/1	0	LT4b/1/3B	08.06.97	18:10	18:58	48	3.7	20	25
LT4b	1300	LT4b/1						731	56.2	795	1311

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	records	Number of birds recorded	species
LT4b	1300	LT4b/2		LT4b/2/1A	08.08.97	05:03	05:56	53	4.1	4	4	3
LT4b	1300	LT4b/2		LT4b/2/1B	08.08.97	06:00	08:43	163	12.5	227	372	71
LT4b	1300	LT4b/2		LT4b/2/2A	12.08.97	05:55	08:57	182	14.0	262	430	76
LT4b	1300	LT4b/2		LT4b/2/2B	12.08.97	09:15	11:50	155	11.9	214	422	72
LT4b	1300	LT4b/2		LT4b/2/3A	05.08.97	16:00	17:58	118	9.1	144	249	59
LT4b	1300	LT4b/2		LT4b/2/3B	05.08.97	18:00	18:57	57	4.4	45	54	26
LT4b	1300	LT4b/2	0					728	56.0	896	1531	114
LT4b	1300	LT4b/1+2	0					1459	56.1	1691	2842	141
LT5	1525	LT5/1		LT5/1/1A	04.06.97	04:53	05:52	59	3.9	7	7	5
LT5	1525	LT5/1		LT5/1/1B	04.06.97	05:55	09:25	210	13.8	357	450	86
LT5	1525	LT5/1		LT5/1/2A	03.06.97	05:48	08:32	164	10.8	272	356	86
LT5	1525	LT5/1		LT5/1/2B	03.06.97	08:35	11:37	182	11.9	263	466	97
LT5	1525	LT5/1		LT5/1/3A	02.06.97	15:51	18:08	137	9.0	201	284	89
LT5	1525	LT5/1		LT5/1/3B	02.06.97	18:12	19:08	56	3.7	22	29	14
LT5	1525	LT5/1	0					808	53.0	1122	1592	147
LT5	1525	LT5/2		LT5/2/1A	30.11.97	04:53	05:51	58	3.8	29	37	15
LT5	1525	LT5/2	1	LT5/2/1B	30.11.97	05:53	09:30	197 <sup>a</sup>	12.9	335	597	105
LT5	1525	LT5/2	1	LT5/2/2A	03.12.97	05:45	08:59	194	12.7	436	776	106
LT5	1525	LT5/2		LT5/2/2B	03.12.97	09:01	11:31	150	9.8	295	521	95
LT5	1525	LT5/2		LT5/2/3A	26.11.97	15:36	17:55	139	9.1	238	396	80
LT5	1525	LT5/2		LT5/2/3B	26.11.97	17:55	18:35	40	2.6	22	29	19
LT5	1525	LT5/2	2					778	51.0	1355	2356	161
LT5	1525	LT5/1+2	2					1586	52.0	2477	3948	187
LT6	1600	LT6/1		LT6/1/1A	09.03.97	04:35	05:54	79	4.9	9	11	6
LT6	1600	LT6/1		LT6/1/1B	09.03.97	06:05	09:13	188	11.8	337	488	86
LT6	1600	LT6/1		LT6/1/2A	08.03.97	06:05	08:27	142	8.9	255	369	80
LT6	1600	LT6/1		LT6/1/2B	08.03.97	08:35	10:48	133	8.3	176	282	73
LT6	1600	LT6/1	2	LT6/1/3A	16.03.97	16:01	18:15	134	8.4	184	272	75
LT6	1600	LT6/1		LT6/1/3B	16.03.97	18:20	19:25	65	4.1	13	13	10
LT6	1600	LT6/1	2					741	46.3	974	1435	136
LT6	1600	LT6/2		LT6/2/1A	15.04.97	04:51	05:55	64	4.0	8	9	7
LT6	1600	LT6/2		LT6/2/1B	15.04.97	06:00	08:44	164	10.3	239	324	83
LT6	1600	LT6/2		LT6/2/2A	16.04.97	05:55	08:33	158	9.9	298	438	91
LT6	1600	LT6/2		LT6/2/2B	16.04.97	08:40	11:09	149	9.3	175	284	79
LT6	1600	LT6/2		LT6/2/3A	17.04.97	16:01	18:18	137	8.6	215	308	80
LT6	1600	LT6/2		LT6/2/3B	17.04.97	18:30	19:28	58	3.6	7	11	5
LT6	1600	LT6/2	0					730	45.6	942	1374	129
LT6	1600	LT6/1+2	2					1471	46.0	1916	2809	164
LT7	1425	LT7/1		LT7/1/1A	26.04.97	04:55	05:51	56	3.9	7	8	5
LT7	1425	LT7/1		LT7/1/1B	26.04.97	05:55	08:46	171	12.0	216	302	63
LT7	1425	LT7/1		LT7/1/2A	24.04.97	05:55	08:03	128	9.0	150	206	47

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	records	Number of birds recorded	species
LT7	1425	LT7/1		LT7/1/2B	24.04.97	08:25	11:35	190	13.3	172	235	56
LT7	1425	LT7/1	1	LT7/1/3A	23.04.97	15:51	18:06	135	9.5	140	187	58
LT7	1425	LT7/1		LT7/1/3B	23.04.97	18:15	19:09	54	3.8	13	16	8
LT7	1425	LT7/1	1					734	51.5	698	954	97
LT7	1425	LT7/2		LT7/2/1A	01.08.97	04:57	05:54	57	4.0	8	8	5
LT7	1425	LT7/2		LT7/2/1B	01.08.97	06:01	08:50	169	11.9	230	373	68
LT7	1425	LT7/2		LT7/2/2A	06.08.97	05:53	08:54	181	12.7	302	477	76
LT7	1425	LT7/2		LT7/2/2B	06.08.97	08:59	11:25	146	10.2	180	275	55
LT7	1425	LT7/2		LT7/2/3A	01.08.97	15:56	17:50	114	8.0	102	166	50
LT7	1425	LT7/2		LT7/2/3B	01.08.97	17:58	18:57	59	4.1	44	58	25
LT7	1425	LT7/2	0					726	50.9	866	1357	100
LT7	1425	LT7/1+2	1					1460	51.2	1564	2311	125
LT8a	1625	LT8a/1		LT8a/1/1A	13.03.97	04:49	05:53	64	3.9	0	0	0
LT8a	1625	LT8a/1		LT8a/1/1B	13.03.97	06:10	09:00	170	10.5	187	281	67
LT8a	1625	LT8a/1		LT8a/1/2A	14.03.97	06:02	08:50	168	10.3	186	281	61
LT8a	1625	LT8a/1		LT8a/1/2B	14.03.97	09:03	11:22	139	8.6	50	197	50
LT8a	1625	LT8a/1		LT8a/1/3A	11.03.97	15:50	18:16	146	9.0	140	237	61
LT8a	1625	LT8a/1		LT8a/1/3B	11.03.97	18:30	19:40	70	4.3	10	14	6
LT8a	1625	LT8a/1	0					757	46.6	573	1010	103
LT8a	1625	LT8a/2		LT8a/2/1A	22.04.97	04:45	05:53	68	4.2	6	8	6
LT8a	1625	LT8a/2		LT8a/2/1B	22.04.97	06:00	09:50	230	14.2	226	321	72
LT8a	1625	LT8a/2		LT8a/2/2A	19.04.97	05:55	08:21	146	9.0	169	246	61
LT8a	1625	LT8a/2		LT8a/2/2B	19.04.97	08:25	11:06	161	9.9	109	139	64
LT8a	1625	LT8a/2		LT8a/2/3A	19.04.97	16:00	18:06	126	7.8	120	155	40
LT8a	1625	LT8a/2		LT8a/2/3B	19.04.97	18:15	19:20	65	4.0	12	10	7
LT8a	1625	LT8a/2	0					796	49.0	642	879	103
LT8a	1625	LT8a/1+2	0					1553	47.8	1215	1889	124
LT8b	1600	LT8b/1		LT8b/1/1A	25.04.97	04:45	05:49	64	4.0	6	8	5
LT8b	1600	LT8b/1		LT8b/1/1B	25.04.97	05:55	09:25	210	13.1	226	321	61
LT8b	1600	LT8b/1		LT8b/1/2A	23.04.97	06:06	08:35	149	9.3	169	246	57
LT8b	1600	LT8b/1		LT8b/1/2B	23.04.97	08:41	10:49	128	8.0	109	139	44
LT8b	1600	LT8b/1		LT8b/1/3A	20.04.97	15:46	18:12	146	9.1	120	155	46
LT8b	1600	LT8b/1		LT8b/1/3B	20.04.97	18:17	19:18	61	3.8	12	10	9
LT8b	1600	LT8b/1	0					758	47.4	642	879	89
LT8b	1600	LT8b/2		LT8b/2/1A	07.08.97	04:51	05:57	66	4.1	4	4	4
LT8b	1600	LT8b/2		LT8b/2/1B	07.08.97	06:00	09:07	187	11.7	249	338	63
LT8b	1600	LT8b/2		LT8b/2/2A	03.08.97	06:00	08:42	162	10.1	242	338	68
LT8b	1600	LT8b/2		LT8b/2/2B	03.08.97	08:58	11:38	160	10.0	152	243	66
LT8b	1600	LT8b/2		LT8b/2/3A	04.08.97	15:32	17:59	147	9.2	167	231	63
LT8b	1600	LT8b/2		LT8b/2/3B	04.08.97	18:05	18:36	31	1.9	7	10	7

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	Number of	
										records	birds recorded
LT8b	1600	LT8b/2	0					753	47.1	821	1164
LT8b	1600	LT8b/1+2	0					1511	47.2	1463	2043
LT9	1300	LT9/1		LT9/1/1A	25.02.97	04:35	05:55	80	6.2	3	3
LT9	1300	LT9/1		LT9/1/1B	25.02.97	06:12	08:28	136	10.5	144	197
LT9	1300	LT9/1		LT9/1/2A	23.02.97	06:06	08:03	117	9.0	122	145
LT9	1300	LT9/1		LT9/1/2B	23.02.97	08:47	11:04	137	10.5	103	147
LT9	1300	LT9/1		LT9/1/3A	22.02.97	16:25	18:21	116	8.9	39	110
LT9	1300	LT9/1		LT9/1/3B	22.02.97	18:40	19:47	67	5.2	4	4
LT9	1300	LT9/1	0					653	50.2	415	606
LT9	1300	LT9/2		LT9/2/1A	29.04.97	04:59	05:51	52	4.0	22	22
LT9	1300	LT9/2		LT9/2/1B	29.04.97	05:57	08:35	158	12.2	177	256
LT9	1300	LT9/2		LT9/2/2A	30.04.97	05:52	08:32	160	12.3	176	256
LT9	1300	LT9/2		LT9/2/2B	30.04.97	08:35	11:01	146	11.2	140	210
LT9	1300	LT9/2	1	LT9/2/3A	30.04.97	16:31	18:10	99 <sup>b</sup>	7.6	74	105
LT9	1300	LT9/2		LT9/2/3B	30.04.97	18:15	19:02	47	3.6	12	12
LT9	1300	LT9/2	1					662	50.9	601	861
LT9	1300	LT9/1+2	1					1315	50.6	1016	1467
LT9	1300	LT9/3		LT9/3/1A	26.07.97	05:03	05:56	53	4.1	17	16
LT9	1300	LT9/3		LT9/3/1B	26.07.97	06:00	09:36	216	16.6	236	446
LT9	1300	LT9/3		LT9/3/2A	24.07.97	06:00	08:48	143 <sup>c</sup>	11.0	188	283
LT9	1300	LT9/3		LT9/3/2B	24.07.97	08:55	11:55	180	13.8	197	298
LT9	1300	LT9/3		LT9/3/3A	25.07.97	15:49	18:13	144	11.1	131	204
LT9	1300	LT9/3		LT9/3/3B	25.07.97	18:15	19:00	45	3.5	36	42
LT9	1300	LT9/3	0					781	60.1	805	1289
LT9	1300	LT9/4		LT9/4/1A	13.01.98	05:03	05:57	54	4.2	2	2
LT9	1300	LT9/4		LT9/4/1B	13.01.98	06:03	08:36	153	11.8	198	355
LT9	1300	LT9/4		LT9/4/2A	12.01.98	06:03	08:18	135	10.4	185	272
LT9	1300	LT9/4		LT9/4/2B	12.01.98	08:23	11:09	166	12.8	176	251
LT9	1300	LT9/4		LT9/4/3A	13.01.98	15:56	17:48	112	8.6	113	189
LT9	1300	LT9/4		LT9/4/3B	13.01.98	17:49	18:50	61	4.7	45	58
LT9	1300	LT9/4	0					681	52.4	719	1127
LT9	1300	LT9/3+4	0					1462	56.2	1524	2416
LT9	1300	LT9/1-4	1					2777	53.4	2540	3883
LT10	1500	LT10/1		LT10/1/1A	27.02.97	04:54	05:59	65	4.3	3	4
LT10	1500	LT10/1		LT10/1/1B	27.02.97	06:04	09:09	185	12.3	177	242
LT10	1500	LT10/1		LT10/1/2A	28.02.97	06:07	08:33	146	9.7	146	196
LT10	1500	LT10/1		LT10/1/2B	28.02.97	08:40	11:02	142	9.5	121	158
LT10	1500	LT10/1		LT10/1/3A	26.02.97	16:10	18:20	130	8.7	99	117
LT10	1500	LT10/1		LT10/1/3B	26.02.97	18:40	19:44	64	4.3	4	4
LT10	1500	LT10/1	0					732	48.8	550	724
LT10	1500	LT10/1						?			102

## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	Number of	
										records	birds recorded
LT10	1500	LT10/2		LT10/2/1A	02.05.97	04:51	05:52	61	4.1	13	15
LT10	1500	LT10/2		LT10/2/1B	02.05.97	05:59	09:21	202	13.5	218	292
LT10	1500	LT10/2		LT10/2/2A	01.05.97	05:50	08:43	173	11.5	198	313
LT10	1500	LT10/2		LT10/2/2B	01.05.97	08:47	11:17	150	10.0	120	180
LT10	1500	LT10/2		LT10/2/3A	02.05.97	15:40	17:55	135	9.0	78	105
LT10	1500	LT10/2		LT10/2/3B	02.05.97	18:19	19:17	58	3.9	3	1
LT10	1500	LT10/2	0					779	51.9	630	906
LT10	1500	LT10/1+2	0					1511	50.4	1180	1630
LT10	1500	LT10/3		LT10/3/1A	28.07.97	04:55	05:59	64	4.3	11	12
LT10	1500	LT10/3		LT10/3/1B	28.07.97	06:03	10:29	266	17.7	311	484
LT10	1500	LT10/3		LT10/3/2A	27.07.97	06:00	08:53	173	11.5	208	243
LT10	1500	LT10/3		LT10/3/2B	27.07.97	08:58	12:25	207	13.8	185	276
LT10	1500	LT10/3		LT10/3/3A	28.07.97	15:33	18:23	170	11.3	170	271
LT10	1500	LT10/3		LT10/3/3B	28.07.97	18:26	19:16	50	3.3	19	21
LT10	1500	LT10/3	0					930	62.0	904	1307
LT10	1500	LT10/4		LT10/4/1A	14.01.98	04:55	06:05	70	4.7	16	18
LT10	1500	LT10/4		LT10/4/1B	14.01.98	06:07	09:56	229	15.3	277	370
LT10	1500	LT10/4	1	LT10/4/2A	15.01.98	06:01	08:58	177	11.8	252	368
LT10	1500	LT10/4		LT10/4/2B	15.01.98	09:01	12:16	195	13.0	205	320
LT10	1500	LT10/4		LT10/4/3A	14.01.98	15:21	17:46	145	9.7	150	231
LT10	1500	LT10/4		LT10/4/3B	14.01.98	17:51	18:21	30	2.0	19	21
LT10	1500	LT10/4	1					846	56.4	919	1328
LT10	1500	LT10/3+4	1					1776	59.2	1823	2635
LT10	1500	LT10/1-4	1					3287	54.8	3003	4265
LT11a	1650	LT11a/1		LT11a/1/1A	05.05.97	04:46	05:57	71	4.3	28	29
LT11a	1650	LT11a/1		LT11a/1/1B	05.05.97	06:01	09:16	195	11.8	227	364
LT11a	1650	LT11a/1		LT11a/1/2A	04.05.97	05:54	08:33	159	9.6	197	252
LT11a	1650	LT11a/1		LT11a/1/2B	04.05.97	08:38	12:01	203	12.3	168	232
LT11a	1650	LT11a/1		LT11a/1/3A	04.05.97	15:37	18:03	146	8.8	141	196
LT11a	1650	LT11a/1		LT11a/1/3B	04.05.97	18:07	19:19	72	4.4	26	24
LT11a	1650	LT11a/1	0					846	51.3	787	1097
LT11a	1650	LT11a/2		LT11a/2/1A	13.09.97	04:53	05:57	64	3.9	17	18
LT11a	1650	LT11a/2		LT11a/2/1B	13.09.97	05:59	09:08	189	11.5	260	380
LT11a	1650	LT11a/2	1	LT11a/2/2A	21.09.97	05:49	08:16	147	9.8	197	329
LT11a	1650	LT11a/2		LT11a/2/2B	21.09.97	08:23	11:05	162	9.8	144	236
LT11a	1650	LT11a/2		LT11a/2/3A	11.09.97	15:47	17:59	132	8.0	128	179
LT11a	1650	LT11a/2		LT11a/2/3B	11.09.97	18:01	19:07	66	4.0	29	33
LT11a	1650	LT11a/2	1					760	46.1	775	1175
LT11a	1650	LT11a/1+2	1					1606	48.7	1562	2272



## APPENDIX 3. Continued.

Transect	Lengths (m)	Survey	No. samples cancelled	Sample	Date	Start	End	Duration (min)	Sampling effort (min/100m)	Number of	
										records	birds recorded
LT11b	1650	LT11b/1		LT11b/1/1A	06.05.97	04:45	05:58	73	4.4	24	27
LT11b	1650	LT11b/1		LT11b/1/1B	06.05.97	06:00	10:33	273	16.5	262	433
LT11b	1650	LT11b/1		LT11b/1/2A	07.05.97	05:48	08:50	182	11.0	226	311
LT11b	1650	LT11b/1		LT11b/1/2B	07.05.97	09:01	12:08	187	11.3	205	265
LT11b	1650	LT11b/1	1	LT11b/1/3A	06.05.97	15:31	18:07	128 <sup>d</sup>	7.8	75	99
LT11b	1650	LT11b/1		LT11b/1/3B	06.05.97	18:11	19:23	72	4.4	15	12
LT11b	1650	LT11b/1	1					915	55.5	807	1147
LT11b	1650	LT11b/2		LT11b/2/1A	15.09.97	04:49	05:57	68	4.1	21	21
LT11b	1650	LT11b/2		LT11b/2/1B	15.09.97	05:58	09:59	241	14.6	246	359
LT11b	1650	LT11b/2		LT11b/2/2A	14.09.97	05:52	09:06	194	11.8	276	420
LT11b	1650	LT11b/2		LT11b/2/2B	14.09.97	09:20	12:38	198	12.0	186	280
LT11b	1650	LT11b/2	1	LT11b/2/3A	20.09.97	15:29	17:40	131	7.9	108	182
LT11b	1650	LT11b/2		LT11b/2/3B	20.09.97	17:42	18:35	53	3.2	57	68
LT11b	1650	LT11b/2	1					885	53.6	894	1330
LT11b	1650	LT11b/1+2	2					1800	54.5	1701	2477
LT11c	1700	LT11c/1		LT11c/1/1A	19.06.97	04:47	06:21	94	5.5	28	58
LT11c	1700	LT11c/1		LT11c/1/1B	19.06.97	06:31	11:02	271	15.9	215	311
LT11c	1700	LT11c/1	1	LT11c/1/2A	20.06.97	05:56	09:37	221	13.0	240	354
LT11c	1700	LT11c/1		LT11c/1/2B	20.06.97	09:57	13:07	190	11.2	179	234
LT11c	1700	LT11c/1		LT11c/1/3A	21.06.97	15:05	18:00	175	10.3	126	184
LT11c	1700	LT11c/1		LT11c/1/3B	21.06.97	18:03	19:09	66	3.9	31	33
LT11c	1700	LT11c/1	1					1017	59.8	819	1174
LT11c	1700	LT11c/2		LT11c/2/1A	17.09.97	04:47	06:03	76	4.5	54	54
LT11c	1700	LT11c/2		LT11c/2/1B	17.09.97	06:04	10:28	264	15.5	225	418
LT11c	1700	LT11c/2		LT11c/2/2A	16.09.97	05:50	09:10	200	11.8	234	331
LT11c	1700	LT11c/2		LT11c/2/2B	16.09.97	09:27	13:05	218	12.8	161	279
LT11c	1700	LT11c/2		LT11c/2/3A	-	-	-	0 <sup>e</sup>	0.0	0	0
LT11c	1700	LT11c/2		LT11c/2/3B	-	-	-	0 <sup>e</sup>	0.0	0	0
LT11c	1700	LT11c/2	0					758	44.6	674	1082
LT11c	1700	LT11c/1+2	1					1775	52.2	1493	2256
Summary	25 150	44	15					30 456	52.9	34 552	53 416
											?

## APPENDIX 4

System of 6-letter codes for scientific names of South American birds and alphabetical list of the codes for species recorded in Playa de Oro. The alphabetical list contains all bird species recorded between Jun. 1993 and Nov. 2000 in the community of Playa de Oro at elevations between about 50 and 450 m (own observations; P. Mena V., pers. comm.; Benítez & Matheus 1997; and other observers mentioned in Appendix 6). See Appendix 5 for the list in taxonomic order, English names, and references on the taxonomy.

In order to further the rapid and standardized collection of data in the field and to facilitate subsequent computer-based analysis, I have designed the present system for the generation of 6-letter codes for South American bird species.

The code system complies with the following prerequisites:

1. All species have their own unique codes.
2. The codes are self-explanatory, so that any person familiar with the taxonomy and scientific names of South American birds will easily recognize the species codified by them.

To achieve this, I chose a 2+2+2-letter code in which each pair of letters codifies the corresponding name of the family, genus, and species, respectively. Whenever possible, I used the first two letters for each of the three taxonomic levels (e.g., TICSRO for *Crypturellus soui*, family Tinamidae). However, sometimes it was necessary to permit exceptions in the coding to avoid repetitions for two or more species. In such cases, I combined a different letter than the second with the first letter of the corresponding taxonomic level (e.g., VIVLLE for *Vireolanius leucotis*, family Vireonidae, with 'VL' codifying the genus *Vireolanius* instead of 'VI', the latter already being used for the genus *Vireo*; thereby, I avoided that the code VIVILE, which was already occupied by *Vireo leucophrys*, occurred twice). In general, large families and genera were given precedence for regular coding over taxonomic groups with less species (e.g., in the family Accipitridae the genus *Leucopternis* comprises more species than *Leptodon*, and the former therefore obtained the regular code 'LE' and the latter the irregular 'LP'). At the species level, widespread species were given precedence for regular coding over species with a more limited distribution (e.g., in the family Troglodytidae, the species *Thryothorus leucotis* is widespread throughout the Amazon basin and beyond, also occurring in northern Venezuela, northern Colombia, and Panama, while *Thryothorus leucopogon* is restricted, in its South American range, to western Colombia and western Ecuador; therefore, the former was given the regular code TGTHLE and the latter the irregular TGTHLP). Naturally, exceptions in the coding at the level of genera occur more frequently in families with a high number of genera (e.g., Trochilidae, Tyrannidae, and Thraupidae), and at species level in genera with many species (e.g., *Myrmotherula* and *Tangara*). In the case of the Trochilidae, I decided to introduce different codes for the two distinct subfamilies, with "PH" for the Phaethornithinae and "TR" for the Trochilinae. A similar treatment was not possible for the other large families, the Tyrannidae and the Thraupidae, due to the fact that the family- and subfamily-level taxonomy of these groups is in a state of frequent revision, so that widely recognized subfamilies have not yet been established.

Irregular coding of family names is marked by an asterisk after the letter pair, as in 'CD\*' for the Cardinalidae. However, the asterisk for irregular coding at family level was not repeated in the 6-letter codes (see below). Exceptions in the coding at the level of genera are marked by asterisks at the beginning of the 6-letter codes, and in the case of irregular coding at species level, the asterisks are positioned at the end of the 6-letter codes. These marks were exclusively used to point the reader to the exceptions and, of course, are omitted in the day-by-day use of the codes. In field practice I only used the last four letters for most species. Only for rare species as well as for the few species that share the last four letters with another species in the study area, I used the complete 6-letter codes. The codes of the latter species are written in italics.

## APPENDIX 4. Continued.

Code	Scientific name family / species
AC	ACCIPITRIDAE
ACACBI	<i>Accipiter bicolor</i>
ACACSU	<i>Accipiter superciliosus</i>
ACBUBR	<i>Buteo brachyurus</i>
ACBUMA	<i>Buteo magnirostris</i>
*ACEAFO	<i>Elanoides forficatus</i>
ACHAHA	<i>Harpia harpyja</i>
*ACHGBI	<i>Harpagus bidentatus</i>
ACICPL	<i>Ictinia plumbea</i>
ACLEPL	<i>Leucopternis plumbeus</i>
ACLEPR	<i>Leucopternis princeps</i>
ACLESE	<i>Leucopternis semiplumbeus</i>
*ACLPCA	<i>Leptodon cayanensis</i>
ACPAHA	<i>Pandion haliaetus</i>
ACSPOR	<i>Spizaetus ornatus</i>
ACSPTY	<i>Spizaetus tyrannus</i>
*ACSRME	<i>Spizastur melanoleucus</i>
AL	ALCEDINIDAE
ALCHAE	<i>Chloroceryle aenea</i>
ALCHAM	<i>Chloroceryle americana</i>
ALCHIN	<i>Chloroceryle inda</i>
ALMETO	<i>Megaceryle torquata</i>
AN	ANATIDAE
ANANDI	<i>Anas discors</i>
AP	APODIDAE
APCHCI	<i>Chaetura cinereiventris</i>
APCHPE	<i>Chaetura pelagica</i>
APCHSP	<i>Chaetura spinicaudus</i>
APCYRU	<i>Cypseloides nutilus</i>
APPACA	<i>Panyptila cayennensis</i>
APSTZO	<i>Streptoprocne zonaris</i>
AR	ARDEIDAE
ARARAL	<i>Ardea alba</i>
*ARBTS*	<i>Butorides striata</i>
ARBUIB	<i>Bubulcus ibis</i>
AREGCA	<i>Egretta caerulea</i>
AREGTH	<i>Egretta thula</i>
ARTIFA	<i>Tigrisoma fasciatum</i>
BU	BUCCONIDAE
BUMAPA	<i>Malacoptila panamensis</i>
BUMILA	<i>Micromonacha lanceolata</i>
*BUNTMA	<i>Notharchus macrorhynchos</i>
*BUNTPE	<i>Notharchus pectoralis</i>
BUNYRA	<i>Nystalus radiatus</i>
CA	CAPRIMULGIDAE
*CANPRO	<i>Nyctiphrynus rosenbergi</i>
CANYAL	<i>Nyctidromus albicollis</i>
CB*	COLUMBIDAE
CBCLPR	<i>Claravis pretiosa</i>
CBGEMO	<i>Geotrygon montana</i>
CBGEPU	<i>Geotrygon purpurata</i>
CBGEVE	<i>Geotrygon veraguensis</i>
CBLEPA	<i>Leptotila pallida</i>
CBPAGO	<i>Patagioenas goodsoni</i>
CBPASP	<i>Patagioenas speciosa</i>
CBPASU	<i>Patagioenas subvinacea</i>

Code	Scientific name family / species
CD*	CARDINALIDAE
*CDCPCY	<i>Cyanocompsa cyanoides</i>
*CDPCLU	<i>Pheucticus ludovicianus</i>
CDSAAP*	<i>Saltator atripennis</i>
CDSAGR	<i>Saltator grossus</i>
CDSAMA	<i>Saltator maximus</i>
CN*	CAPITONIDAE
CNCAQU	<i>Capito quinticolor</i>
CNCASQ	<i>Capito squamatus</i>
CO	COTINGIDAE
*COCDDHO	<i>Carpodectes hopkei</i>
COCEPE	<i>Cephalopterus penduliger</i>
COCONA	<i>Cotinga nattererii</i>
COLARU	<i>Laniocera rufescens</i>
COLIUN	<i>Lipaugus unirufus</i>
COQUPU	<i>Querula purpurata</i>
CR	CRACIDAE
CRCRRU	<i>Crax rubra</i>
CRORER	<i>Ortalis erythroptera</i>
CRPEOR	<i>Penelope ortonii</i>
CRPEPU	<i>Penelope purpurascens</i>
CT*	CATHARTIDAE
CTCAAU	<i>Cathartes aura</i>
CTCOAT	<i>Coragyps atratus</i>
CTSAPA	<i>Sarcoramphus papa</i>
CU	CUCULIDAE
CUCOEU	<i>Coccyzus euleri</i>
CUCRAN	<i>Crotophaga ani</i>
CUCRSU	<i>Crotophaga sulcirostris</i>
CUNERA	<i>Neomorphus radiolus</i>
CUPICA	<i>Piaya cayana</i>
CUPIMI	<i>Piaya minuta</i>
CUTANA	<i>Tapera naevia</i>
DE	DENDROCOLAPTIDAE
DECAPI*	<i>Campylorhamphus pusillus</i>
DECATR	<i>Campylorhamphus trochilrostris</i>
DEDESA	<i>Dendrocolaptes sanctithomae</i>
*DEDIFU	<i>Dendrocincla fuliginosa</i>
DEGLSP	<i>Glyphorynchus spirurus</i>
DELESO	<i>Lepidocolaptes souleyetii</i>
DEXIER	<i>Xiphorhynchus erythropygius</i>
DEXILA	<i>Xiphorhynchus lachrymosus</i>
EM	EMBERIZIDAE
*EMAPCO	<i>Arremonops conirostris</i>
EMARAU	<i>Arremon aurantirostris</i>
EMORAN	<i>Oryzoborus angolensis</i>
*EMRSCR	<i>Rhodospingus cruentus</i>
EMSPCV*	<i>Sporophila corvina</i>
EMSPLU	<i>Sporophila luctuosa</i>
EMSPNI	<i>Sporophila nigricollis</i>
EMSPTE	<i>Sporophila telasco</i>
EMTIOB	<i>Tiaris obscurus</i>
EMVOJA	<i>Volatinia jacarina</i>
FA	FALCONIDAE
FAFAPE	<i>Falco peregrinus</i>
FAFARU	<i>Falco rufigularis</i>

## APPENDIX 4. Continued.

Code	Scientific name family / species
FAHECA	<i>Herpetotheres cachinnans</i>
FAMIMI	<i>Micrastur mirandollei</i>
FAMIPL	<i>Micrastur plumbeus</i>
FAMIRU	<i>Micrastur ruficollis</i>
FAMISE	<i>Micrastur semitorquatus</i>
FG*	FREGATIDAE
FGFRMA	<i>Fregata magnificens</i>
FO	FORMICARIIDAE
FOFONI	<i>Formicarius nigricapillus</i>
FOHYPE	<i>Hylopezus perspicillatus</i>
FOPIRU	<i>Pittasoma rufopileatum</i>
FU	FURNARIIDAE
FUAUOC	<i>Automolus ochrolaemus</i>
FUAURB*	<i>Automolus rubiginosus</i>
FUCRER	<i>Cranioleuca erythrops</i>
FUHYVI	<i>Hylostictes virgatus</i>
*FUSLME	<i>Sclerurus mexicanus</i>
FUSYBR	<i>Synallaxis brachyura</i>
FUXEMI	<i>Xenops minutus</i>
FUXTMI	<i>Xenerpestes minlosi</i>
GA	GALBULIDAE
GAGARU	<i>Galbula ruficauda</i>
GAJAAU	<i>Jacamerops aureus</i>
HI	HIRUNDINIDAE
HIHIRU	<i>Hirundo rustica</i>
HINETI	<i>Neochelidon tibialis</i>
HINOCY	<i>Notiochelidon cyanoleuca</i>
HIPEPY	<i>Petrochelidon pyrrhonota</i>
HIPRCH	<i>Progne chalybea</i>
HIPRSU	<i>Progne subis</i>
HIRIRI	<i>Riparia riparia</i>
HISTRU	<i>Stelgidopteryx ruficollis</i>
HITABI	<i>Tachycineta bicolor</i>
IC	ICTERIDAE
ICAMHO	<i>Amblycercus holosericeus</i>
ICCAMI	<i>Cacicus microrhynchus</i>
ICDOOR	<i>Dolichonyx oryzivorus</i>
ICICME	<i>Icterus mesomelas</i>
ICMOBO	<i>Molothrus bonariensis</i>
ICMOOR	<i>Molothrus oryzivorus</i>
ICZAWA	<i>Zarhynchus wagleri</i>
LA	LARIDAE
LALAPI	<i>Larus pipixcan</i>
MO	MOMOTIDAE
MOBAMA	<i>Baryphthengus martii</i>
MOELPL	<i>Electron platyrhynchum</i>
NY	NYCTIBIDAE
NYNYGR	<i>Nyctibius griseus</i>
OD	ODONTOPHORIDAE
ODODER	<i>Odontophorus erythrops</i>
ODRHCI	<i>Rhyncobortyx cinctus</i>
PA	PARULIDAE
PABACL*	<i>Basileuterus chlorophrys</i>
PABAFU	<i>Basileuterus fulvicauda</i>
PADEFU	<i>Dendroica fusca</i>
PADEPY*	<i>Dendroica pensylvanica</i>

Code	Scientific name family / species
PADEST	<i>Dendroica striata</i>
PAGEAU	<i>Geothlypis auricularis</i>
PAGESE	<i>Geothlypis semiflava</i>
PAOPAG	<i>Oporornis agilis</i>
PAOPPH	<i>Oporornis philladelphia</i>
PASENO	<i>Seiurus noveboracensis</i>
PH	PHAETHORNITHINAE (TROCHILIDAE)
PHEUAQ	<i>Eutoxeres aquila</i>
PHGLAE	<i>Glaucis aeneus</i>
PHPHST	<i>Phaethornis striigularis</i>
PHPHYA	<i>Phaethornis yaruqui</i>
PHTHRU	<i>Threnetes ruckeri</i>
PI	PICIDAE
PICAGA	<i>Campephilus गयाquilensis</i>
PICAHA	<i>Campephilus haematogaster</i>
PICELO	<i>Ceelus loricated</i>
PIDRLI	<i>Dryocopus lineatus</i>
PIMEPU	<i>Melanerpes pucherani</i>
PIPIOL	<i>Picumnus olivaceus</i>
*PIPLLI	<i>Piculus litae</i>
PIVECA	<i>Veniliornis callonotus</i>
PIVECH	<i>Veniliornis chocoensis</i>
PIVEKI	<i>Veniliornis kirkii</i>
PR*	PIPRIDAE
PRCHHO	<i>Chloropipo holochlora</i>
PRLECO	<i>Lepidothrix coronata</i>
PRMAMA	<i>Manacus manacus</i>
*PRMICH	<i>Masius chrysopterus</i>
*PRMPDE	<i>Machaeopterus deliciosus</i>
PRPIME	<i>Pipra mentalis</i>
PRSAAE	<i>Sapayoa aenigma</i>
PRSCUTU	<i>Schiffornis turdina</i>
PS	PSITTACIDAE
PSAMAU	<i>Amazona autumnalis</i>
PSAMFA	<i>Amazona farinosa</i>
PSARAM	<i>Ara ambiguus</i>
PSPICH	<i>Pionus chalcopterus</i>
PSPIME	<i>Pionus menstruus</i>
*PSPPPU	<i>Pionopsitta pulchra</i>
PSPYME	<i>Pyrrhura melanura</i>
PSTODI	<i>Touit dilectissimus</i>
PT*	POLIOPTILIDAE
PTMICI	<i>Microbatas cinereiventris</i>
PTPOPL	<i>Polioptila plumbea</i>
PTPOSC	<i>Polioptila schistaceigula</i>
PX*	PHALACROCORACIDAE
PXPHBR	<i>Phalacrocorax brasilianus</i>
RA	RALLIDAE
RAAMCO	<i>Ammaurolimnas concolor</i>
RALAAL	<i>Laterallus albigularis</i>
RANECO	<i>Neocrex colombiana</i>
RH	RHINOCRYPTIDAE
RHSCCH	<i>Scytalopus chocoensis</i>
RM*	RAMPHASTIDAE
RMAUHA	<i>Aulacorhynchus haematopygus</i>
RMPTSA	<i>Preroglossus sanguineus</i>

## APPENDIX 4. Continued.

Code	Scientific name family / species
RMRABR	<i>Ramphastos brevis</i>
RMRASW	<i>Ramphastos swainsonii</i>
RMSESP	<i>Selenidera spectabilis</i>
SC	SCOLOPACIDAE
SCACMA	<i>Actitis macularius</i>
SO*	STEATORNITHIDAE
SOSTCA	<i>Steatornis caripensis</i>
ST	STRIGIDAE
STGLGR	<i>Glauclidium griseiceps</i>
STLOCR	<i>Lophotrix cristata</i>
STMECE	<i>Megascops centralis</i>
STPUPE	<i>Pulsatrix perspicillata</i>
STSTNI	<i>Strix nigrolineata</i>
STSTVI	<i>Strix virgata</i>
TG*	TROGLODYTIDAE
TGCAZO	<i>Campylorhynchus zonatus</i>
TGCPYP	<i>Cyphorhinus phaeocephalus</i>
TGHELE	<i>Henicorhina leucosticta</i>
TGMIMA	<i>Microcerculus marginatus</i>
TGODBR	<i>Odontorchilus branickii</i>
TGTHLP*	<i>Thryothorus leucopogon</i>
TGTHNI	<i>Thryothorus nigricapillus</i>
TGTRAE	<i>Troglodytes aedon</i>
TH	THAMNOPHILIDAE
THCETY	<i>Cercomacra tyrannina</i>
THCYLI	<i>Cymbilaimus lineatus</i>
THDYPU	<i>Dysithamnus puncticeps</i>
THGYLE	<i>Gymnophithys leucaspis</i>
*THHXND*	<i>Hylophylax naevioides</i>
THMIQU	<i>Microrhopias quixensis</i>
THMYAX	<i>Myrmotherula axillaris</i>
THMYFU	<i>Myrmotherula fulviventris</i>
THMYIG	<i>Myrmotherula ignota</i>
THMYPA	<i>Myrmotherula pacifica</i>
THMYSL*	<i>Myrmotherula schisticolor</i>
*THMZBE	<i>Myrmeciza berlepschi</i>
*THMZEX	<i>Myrmeciza exsul</i>
*THMZIM	<i>Myrmeciza immaculata</i>
*THMZNI	<i>Myrmeciza nigricauda</i>
*THPTMC	<i>Phaenostictus mcleannani</i>
THTAMA	<i>Taraba major</i>
THTHAT	<i>Thamnophilus atrinucha</i>
*THTTAN	<i>Thamnistes anabatinus</i>
TI	TINAMIDAE
TICRBE	<i>Crypturellus berlepschi</i>
TICRSO	<i>Crypturellus soui</i>
TIITIMA	<i>Tinamus major</i>
TN*	TROGONIDAE
TNTRCH	<i>Trogon chionurus</i>
TNTRCM*	<i>Trogon comptus</i>
TNTRCO	<i>Trogon collaris</i>
TNTRRU	<i>Trogon rufus</i>
TP*	THRAUPIDAE
TPBAED	<i>Bangsia edwardsi</i>
TPBARO	<i>Bangsia rothschildi</i>
*TPCBFL	<i>Coereba flaveola</i>

Code	Scientific name family / species
*TPCLFL	<i>Chlorophonia flavirostris</i>
*TPCRSP	<i>Chlorophanes spiza</i>
*TPCTOL	<i>Chlorothraupis olivacea</i>
*TPCTST	<i>Chlorothraupis stolzmanni</i>
TPCYCA	<i>Cyanerpes caeruleus</i>
TPCYCY	<i>Cyanerpes cyaneus</i>
TPDABE	<i>Dacnis berlepschi</i>
TPDACA	<i>Dacnis cayana</i>
TPDAEG	<i>Dacnis egregia</i>
TPDAVE	<i>Dacnis venusta</i>
TPERSA	<i>Erythrolhyppis salmoni</i>
TPEUFU	<i>Euphonia fulvicrissa</i>
TPEULA	<i>Euphonia laniirostris</i>
TPEUMI	<i>Euphonia minuta</i>
TPEUXA	<i>Euphonia xanthogaster</i>
*TPHOXA	<i>Heterospingus xanthopygius</i>
TPMICA	<i>Mitrospingus casinii</i>
TPPIRU	<i>Piranga rubra</i>
TPRAIC	<i>Ramphocelus icteronotus</i>
TPTACY	<i>Tangara cyanicollis</i>
TPTAFL	<i>Tangara florida</i>
TPTAGY	<i>Tangara gyrola</i>
TPTAJO	<i>Tangara johannae</i>
TPTALT*	<i>Tangara larvata</i>
TPTALV*	<i>Tangara lavinia</i>
TPTAPL*	<i>Tangara palmeri</i>
TPTARU	<i>Tangara rufigula</i>
TPTTEVI	<i>Tersina viridis</i>
TPTHEP	<i>Thraupis episcopus</i>
TPTHPA	<i>Thraupis palmarum</i>
*TPTYDE	<i>Tachyphonus delatrii</i>
*TPTYLU	<i>Tachyphonus luctuosus</i>
*TPTYRU	<i>Tachyphonus rufus</i>
TR	TROCHILINAE (TROCHILIDAE)
TRAMAB*	<i>Amazilia amabilis</i>
TRAMRO	<i>Amazilia rosenbergi</i>
TRAMTZ	<i>Amazilia tzacatl</i>
*TRARAE	<i>Androdon aequatorialis</i>
*TRCBUR	<i>Chalybura urochrysis</i>
TRDAJU	<i>Damophila julie</i>
TRFLME	<i>Florisuga mellivora</i>
*TRHXBA	<i>Heliothryx barroti</i>
*TRPPCO	<i>Popelairia conversii</i>
TRTHFA	<i>Thalurania fannyi</i>
TU	TURDIDAE
TUCAUS	<i>Catharus ustulatus</i>
TUCILE	<i>Cichlopsis leucogenys</i>
TUMYRA	<i>Myadestes nalloides</i>
TUTUDA	<i>Turdus daguae</i>
TUTUOB	<i>Turdus obsoletus</i>
TY	TYRANNIDAE
TYATSP	<i>Attila spadiceus</i>
*TYCLCO	<i>Colonia colonus</i>
TYCOCO	<i>Contopus cooperi</i>
*TYCPAL	<i>Conopias albobittatus</i>
*TYCTOB	<i>Campostoma obsoletum</i>

## APPENDIX 4. Continued.

Code	Scientific name family / species
TYELFL	<i>Elaenia flavogaster</i>
TYEMVI	<i>Empidonax virescens</i>
TYLESU	<i>Leptopogon superciliosus</i>
*TYLGLE	<i>Legatus leucophaeus</i>
TYLOPI	<i>Lophotriccus pileatus</i>
*TYMBFA	<i>Myiophobus fasciatus</i>
*TYMCOR	<i>Myiotriccus ornatus</i>
*TYMDMA	<i>Myiodynastes maculatus</i>
*TYMGCA	<i>Myiopagis caniceps</i>
*TYMGVI	<i>Myiopagis viridicata</i>
*TYMHPI	<i>Megarynchus pitangua</i>
TYMIOL	<i>Mionectes oleagineus</i>
TYMIOV*	<i>Mionectes olivaceus</i>
*TYMOAT	<i>Myiornis atricapillus</i>
*TYMRPH	<i>Mitrephanes phaeocercus</i>
*TYMSAT	<i>Myiobius atricaudus</i>
*TYMSSU	<i>Myiobius sulphureipygus</i>
*TYMSVI	<i>Myiobius villosus</i>
TYMYTU	<i>Myiarchus tuberculifer</i>
*TYMZCA	<i>Myiozetetes cayanensis</i>
*TYMZGR	<i>Myiozetetes granadensis</i>
*TYMZSI	<i>Myiozetetes similis</i>
TYORBR	<i>Ornithion brunneicapillus</i>
TYPAAL	<i>Pachyramphus albogriseus</i>
TYPACI	<i>Pachyramphus cinnamomeus</i>

Code	Scientific name family / species
TYPLCO	<i>Platyrrinchus coronatus</i>
*TYPMGR	<i>Phyllomyias griseiceps</i>
TYPTHO	<i>Platypsaris homochrous</i>
TYRHPA	<i>Rhynchocyclus pacificus</i>
*TYRTHO	<i>Rhytipterna holerythra</i>
TYSANI	<i>Sayornis nigricans</i>
TYSECI	<i>Serpophaga cinerea</i>
TYSIAL	<i>Sirystes albogriseus</i>
TYTEER	<i>Terenotriccus erythrurus</i>
TYTIIN	<i>Tityra inquisitor</i>
TYTISE	<i>Tityra semifasciata</i>
*TYTLEL	<i>Tyrannulus elatus</i>
*TYTMFT*	<i>Tolmomyias flavotectus</i>
TYTOCI	<i>Todirostrum cinereum</i>
TYTONI	<i>Todirostrum nigriceps</i>
TYTYME	<i>Tyrannus melancholicus</i>
TYTYNI	<i>Tyrannus niveigularis</i>
TYTYTY	<i>Tyrannus tyrannus</i>
TYZICH	<i>Zimmerius chrysops</i>
VI	VIREONIDAE
VIHYDE	<i>Hylophilus decurtatus</i>
VIHYOC	<i>Hylophilus ochraceiceps</i>
VIVIOL	<i>Vireo olivaceus</i>
*VIVLLE	<i>Vireolanius leucotis</i>



## APPENDIX 5

Birds of Playa de Oro: 6-letter codes, subspecies, English names, and taxonomy. List of bird species recorded between Jun. 1993 and Nov. 2000 in the community of Playa de Oro at elevations between about 50 and 450 m (own observations; P. Mena V., pers. comm.; Benítez & Matheus 1997; and other observers mentioned in Appendix 6); see page 117 for additional species that could not be included in the analysis. The asterisks before and after some of the family and species codes indicate exceptions to the rules for their derivation; cf. Appendix 4. See Appendix 6 for information on the status of confirmation, type of record, abundance score, and other details; see Appendix 7 for published erroneous records. For taxonomy, linear sequence, and English names I follow Ridgely & Greenfield (2001b). However, I implemented recent gender agreements (David & Gosselin 2002a, 2002b) and changes at the level of genera (e.g., Banks *et al.* 2003). In the case of inconsistencies between the taxonomy proposed by Ridgely & Greenfield (2001b) and Remsen *et al.* (2004, 2011), I also cite key references that discuss the corresponding taxonomic questions. For all species I quote the page numbers of the main reference as 'R&G (2001b: page/s)', in order to make it easier to find general information on their status and distribution in Ecuador as well as on their taxonomy (i.e., the numerous references not mentioned here). See Remsen *et al.* (2011; and subsequent versions) for more recent changes in bird taxonomy.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TI	TINAMIDAE (3)		TINAMOUS (3)		
TTTMA	<i>Tinamus major</i>	<i>latifrons</i>	Great Tinamou		R&G (2001b: 92)
TICRBE	<i>Crypturellus berlepschi</i>	[monotypic]	Berlepsch's Tinamou		R&G (2001b: 93-94)
TICRSO	<i>Crypturellus soui</i>	<i>harrieri</i>	Little Tinamou		R&G (2001b: 94)
FG*	FREGATIDAE (1)		FRIGATEBIRDS (1)		
FGFRMA	<i>Fregata magnificens</i>	[monotypic]	Magnificent Frigatebird		R&G (2001b: 111-112)
PX*	PHALACROCORACIDAE (1)		CORMORANTS AND SHAGS (1)		
PXPHBR	<i>Phalacrocorax brasilianus</i>	<i>brasiliannus</i>	Neotropic Cormorant		R&G (2001b: 115-116)
AN	ANATIDAE (1)		DUCKS, GESE, AND SWANS (1)		Anseriformes and Galliformes are sister taxa and currently placed in linear sequence to follow the Tinamiformes, as they are basal within the neognath birds (e.g., Mayr & Clarke 2003)
ANANDI	<i>Anas discors</i>	<i>discors</i> (+ <i>orphnae</i> ?)	Blue-winged Teal		R&G (2001b: 125-126)
AR	ARDEIDAE (6)		HERONS, EGRETS, AND BITTERNS (6)		
ARTIFA	<i>Tigrisoma fasciatum</i>	<i>salmoni</i>	Fasciated Tiger-Heron		R&G (2001b: 134)
ARARAL	<i>Ardea alba</i>	<i>egretta</i>	Great Egret		R&G (2001b: 135-136)
AREGTH	<i>Egretta thula</i>	<i>thula</i>	Snowy Egret		R&G (2001b: 136)
AREGCA	<i>Egretta caerulea</i>	[monotypic]	Little Blue Heron		R&G (2001b: 136)
ARBUJB	<i>Bubulcus ibis</i>	<i>ibis</i>	Cattle Egret		R&G (2001b: 137-138)
*ARB/TST	<i>Butorides striata</i>	<i>striata</i>	Striated Heron		R&G (2001b: 138), David & Gosselin (2002b)

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
CT*	CATHARTIDAE (3)		AMERICAN VULTURES (3)	some authors place this family in its own order Cathartiformes (e.g., Remsen <i>et al.</i> 2011)	
CTSAPA	<i>Sarcoramphus papa</i>	[monotypic]	King Vulture	R&G (2001b: 147-148)	
CTCOAT	<i>Coragyps atratus</i>	[monotypic]	Black Vulture	R&G (2001b: 148)	
CTCAAU	<i>Cathartes aura</i>	<i>jota</i>	Turkey Vulture	R&G (2001b: 148-149); subspecies group ( <i>jota</i> and <i>falklandica</i> ) may deserve recognition as a separate species (cf. Remsen <i>et al.</i> 2011)	
AC	ACCIPITRIDAE (16)		OSPREY, KITES, HAWKS, AND EAGLES (16)	R&G (2001b: 150-151); often placed in separate family Pandionidae	
ACPAHA	<i>Pandion haliaetus</i>	<i>carolinensis</i>	Osprey		
*ACLPCA	<i>Leptodon cayanensis</i>	<i>cayanensis</i>	Gray-headed Kite	R&G (2001b: 151)	
*ACEAFO	<i>Elanoides forficatus</i>	<i>forficatus</i> (+ <i>yetapa</i> )	Swallow-tailed Kite	R&G (2001b: 152-153)	
*ACHGBI	<i>Harpagus bidentatus</i>	<i>faciatus</i>	Double-toothed Kite	R&G (2001b: 155-156)	
ACICPL	<i>Ictinia plumbea</i>	[monotypic]	Plumbeous Kite	R&G (2001b: 156-157)	
ACACSU	<i>Accipiter superciliosus</i>	<i>fontanieri</i>	Tiny Hawk	R&G (2001b: 159)	
ACACBI	<i>Accipiter bicolor</i>	<i>bicolor</i>	Bicolored Hawk	R&G (2001b: 159)	
ACLEPL	<i>Leucopternis plumbeus</i>	[monotypic]	Plumbeous Hawk	R&G (2001b: 161), David & Gosselin (2002b)	
ACLESE	<i>Leucopternis semiplumbeus</i>	[monotypic]	Semiplumbeous Hawk	R&G (2001b: 161-162), David & Gosselin (2002b)	
ACLEPR	<i>Leucopternis princeps</i>	[monotypic]	Barred Hawk	R&G (2001b: 163)	
ACBUMA	<i>Buteo magnirostris</i>	<i>magnirostris</i>	Roadside Hawk	R&G (2001b: 168); sometimes placed in monotypic genus <i>Rupornis</i> (Riesing <i>et al.</i> 2003)	
ACBUBR	<i>Buteo brachyurus</i>	<i>brachyurus</i>	Short-tailed Hawk	R&G (2001b: 169-170)	
ACHAHA	<i>Harpia harpyja</i>	[monotypic]	Harpy Eagle	R&G (2001b: 173)	
*ACSRME	<i>Spizastur melanoleucus</i>	[monotypic]	Black-and-white Hawk-Eagle	R&G (2001b: 173-174); genera <i>Spizastur</i> and <i>Oroaetus</i> were recently merged into <i>Spizaetus</i> (Remsen <i>et al.</i> 2011)	
ACSPTY	<i>Spizaetus tyrannus</i>	<i>serus</i>	Black Hawk-Eagle	R&G (2001b: 174-175)	
ACSPOR	<i>Spizaetus ornatus</i>	<i>vicarius</i>	Ornate Hawk-Eagle	R&G (2001b: 175)	
FA	FALCONIDAE (7)		FALCONS AND CARACARAS (7)	Remsen <i>et al.</i> (2011)	
FAMIRU	<i>Micrastur ruficollis</i>	<i>interstes</i>	Barred Forest-Falcon	R&G (2001b: 179)	
FAMIPL	<i>Micrastur plumbeus</i>	[monotypic]	Plumbeous Forest-Falcon	R&G (2001b: 180)	
FAMIMI	<i>Micrastur mirandollei</i>	[monotypic]	Slaty-backed Forest-Falcon	R&G (2001b: 180-181)	
FAMISE	<i>Micrastur semitorquatus</i>	<i>naso</i>	Collared Forest-Falcon	R&G (2001b: 181)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
FAHECA	<i>Herpetotheres cachimans</i>	<i>fulvescens</i>	Laughing Falcon	R&G (2001b: 182)	R&G (2001b: 182) R&G (2001b: 184) R&G (2001b: 185-186)
FAFARU	<i>Falco rufigularis</i>	<i>petoensis</i>	Bat Falcon		
FAFAPE	<i>Falco peregrinus</i>	<i>anatium, tundrius</i> or <i>cassini</i>	Peregrine Falcon		
CR	CRACIDAE (4)		CHACHALACAS, GUANS, AND CURASSOWS (4)	Anseriformes and Galliformes are sister taxa and currently placed in linear sequence to follow the Tinamiformes, as they are basal within the neognath birds (e.g., Mayr & Clarke 2003)	
CRODER	<i>Ortalis erythroptera</i>	[monotypic]	Rufous-headed Chachalaca	R&G (2001b: 186-187)	
CRPEOR	<i>Penelope ortoni</i>	[monotypic]	Baudó Guan	R&G (2001b: 189)	
CRPEPU	<i>Penelope purpurascens</i>	<i>aequatorialis</i>	Crested Guan	R&G (2001b: 190-191)	
CRCRRU	<i>Crax rubra</i>	<i>rubra</i>	Great Curassow	R&G (2001b: 193-194)	
OD	ODONTOPHORIDAE (2)		NEW WORLD QUAILS (2)	Sibley & Ahlquist (1990: 289-300); see also note under 'Cracidae'	
ODODER	<i>Odontophorus erythrops</i>	<i>parambae</i>	Rufous-fronted Wood-Quail	R&G (2001b: 196)	
ODRHCI	<i>Rhychorhtyx cinctus</i>	<i>australis</i>	Tawny-faced Quail	R&G (2001b: 198)	
RA	RALLIDAE (3)		RAILS, GALLINULES, AND COOTS (3)		
RALAAL	<i>Laterallus albigularis</i>	<i>albigularis</i>	White-throated Crane	R&G (2001b: 199)	
RAAMCO	<i>Anaurotelimnas concolor</i>	<i>guatemalensis</i>	Uniform Crane	R&G (2001b: 201)	
RANECO	<i>Neorex colombiana</i>	<i>colombiana</i>	Colombian Crane	R&G (2001b: 203), David & Gosselin (2002b)	
SC	SCOLOPACIDAE (1)		SANDPIPERS, SNIPES, AND PHALAROPES (1)		
SCACMA	<i>Actitis macularius</i>	[monotypic]	Spotted Sandpiper	R&G (2001b: 215-216), David & Gosselin (2002b)	
LA	LARIDAE (1)		GULLS AND TERNS (1)		
LALAPI	<i>Larus pipixcan</i>	[monotypic]	Franklin's Gull	R&G (2001b: 245-246); recently transferred to genus <i>Leucophaeus</i> (Rensen <i>et al.</i> 2011)	
CB*	COLUMBIDAE (8)		PIGEONS AND DOVES (8)		
CBPASP	<i>Patagioenas speciosa</i>	[monotypic]	Scaled Pigeon	R&G (2001b: 255-256), Johnson <i>et al.</i> (2001), Banks <i>et al.</i> (2003)	
CBPASU	<i>Patagioenas subvinacea</i>	<i>berlepschi</i>	Ruddy Pigeon	R&G (2001b: 257), Johnson <i>et al.</i> (2001), Banks <i>et al.</i> (2003); subspecies <i>berlepschi</i> may deserve recognition as a separate species (cf. Rensen <i>et al.</i> 2011)	
CBPAGO	<i>Patagioenas goodsoni</i>	[monotypic]	Dusky Pigeon	R&G (2001b: 258), Johnson <i>et al.</i> (2001), Banks <i>et al.</i> (2003)	
CBCLPR	<i>Claravis pretiosa</i>	[monotypic]	Blue Ground-Dove	R&G (2001b: 261-262)	
CBLEPA	<i>Leptotila pallida</i>	[monotypic]	Pallid Dove	R&G (2001b: 263-264)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
CBGEPU	<i>Geotrygon purpurata</i>	[monotypic]	Indigo-crowned Quail-Dove	R&G (2001b: 265-266); often regarded as subspecies of <i>G. saphirina</i>	
CBGEVE	<i>Geotrygon veraguensis</i>	[monotypic]	Olive-backed Quail-Dove	R&G (2001b: 266)	
CBGEMO	<i>Geotrygon montana</i>	<i>montana</i>	Ruddy Quail-Dove	R&G (2001b: 267)	
PS	PSITTACIDAE (8)		MACAWS AND PARROTS (8)	Remsen <i>et al.</i> (2011)	
PSARAM	<i>Ana ambigua</i>	[monotypic]	Great Green Macaw	R&G (2001b: 269-270), David & Gosselin (2002b)	
PSPYME	<i>Pyrrhura melanura</i>	<i>pacifica</i>	Maroon-tailed Parakeet	R&G (2001b: 276)	
PSTODI	<i>Touit dilectissimus</i>	[monotypic]	Blue-fronted Parrotlet	R&G (2001b: 283-284), David & Gosselin (2002b)	
*PSPPPU	<i>Pionopsitta pulchra</i>	[monotypic]	Rose-faced Parrot	R&G (2001b: 285); recently transferred to genus <i>Pyrilia</i> (Remsen <i>et al.</i> 2011)	
PSPIME	<i>Pionus menstruus</i>	<i>rubrigularis</i>	Blue-headed Parrot	R&G (2001b: 287-288)	
PSPICH	<i>Pionus chalcopterus</i>	[monotypic]	Bronze-winged Parrot	R&G (2001b: 289)	
PSAMAU	<i>Amazona autumnalis</i>	<i>lilacina</i>	Red-lored Amazon	R&G (2001b: 289-290)	
PSAMFA	<i>Amazona farinosa</i>	<i>inornata</i>	Mealy Amazon	R&G (2001b: 292)	
CU	CUCULIDAE (7)		CUCKOOS AND ANIS (7)	Remsen <i>et al.</i> (2011)	
CUCOEU	<i>Coccyzus euleri</i>	[monotypic]	Pearly-breasted Cuckoo	R&G (2001b: 294-295)	
CUPICA	<i>Piaya cayana</i>	<i>nigricirisa</i>	Squirrel Cuckoo	R&G (2001b: 296)	
CUPIMI	<i>Piaya minuta</i>	<i>gracilis</i>	Little Cuckoo	R&G (2001b: 296-297); recently transferred to genus <i>Coccyzus</i> (Remsen <i>et al.</i> 2011)	
CUCRAN	<i>Crotophaga ani</i>	[monotypic]	Smooth-billed Ani	R&G (2001b: 297-298)	
CUCRSU	<i>Crotophaga sulcirostris</i>	<i>sulcirostris</i>	Groove-billed Ani	R&G (2001b: 298)	
CUTANA	<i>Tapera naevia</i>	<i>naevia</i>	Striped Cuckoo	R&G (2001b: 298-299)	
CUNERA	<i>Neomorphus radiolobus</i>	[monotypic]	Banded Ground-Cuckoo	R&G (2001b: 301)	
ST	STRIGIDAE (6)		TYPICAL OWLS (6)	Sibley & Ahlquist (1990: 410-411)	
STMECE	<i>Megascops centralis</i>	[monotypic]	Chocó Screech-Owl	R&G (2001b: 303), Banks <i>et al.</i> (2003); often regarded as subspecies of <i>M. guatemalae</i>	
STGLGR	<i>Glauclidium griseiceps</i>	[unknown ssp.]	Central American Pygmy-Owl	R&G (2001b: 307-308)	
STLOCR	<i>Lophotrix cristata</i>	<i>wedelli</i>	Crested Owl	R&G (2001b: 310)	
STPUPE	<i>Pulsatrix perspicillata</i>	<i>chapmani</i>	Spectacled Owl	R&G (2001b: 310-311)	
STSTNI	<i>Strix nigrolineata</i>	[monotypic]	Black-and-white Owl	R&G (2001b: 311-312); sometimes placed in the genus <i>Ciccaba</i>	
STSTVI	<i>Strix virgata</i>	<i>virgata</i>	Mottled Owl	R&G (2001b: 312-313); sometimes placed in the genus <i>Ciccaba</i>	
SO*	SEALORNITHIDAE (1)		OWL (1)	Remsen <i>et al.</i> (2011)	
SOSTCA	<i>Steatornis caripensis</i>	[monotypic]	Oilbird	R&G (2001b: 315-316)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
NY	NYCTIBIDAE (1)		POTOOS (1)		
NYNYGR	<i>Nyctibius griseus</i>	<i>panamensis?</i>	Gray Potoo		R&G (2001b: 317)
CA	CAPRIMULGIDAE (2)		NIGHTJARS AND NIGHTHAWKS (2)		
CANYAL	<i>Nyctidromus albigollis</i>	<i>albigollis</i>	Pauraque		R&G (2001b: 321-322)
*CANPRO	<i>Nyctiphrynus rosenbergi</i>	[monotypic]	Chocó Poorwill		R&G (2001b: 322-323)
AP	APOIDAE (6)		SWIFTS (6)		
APSTZO	<i>Streptoprocne zonaris</i>	<i>subtropicalis</i>	White-collared Swift		R&G (2001b: 326-327)
APCYRU	<i>Cypseloides nutilus</i>	<i>brunneitorques</i>	Chestnut-collared Swift		R&G (2001b: 327); since Martín & Stiles (1992) often placed in the genus <i>Streptoprocne</i>
APCHPE	<i>Chaetuna pelagica</i>	[monotypic]	Chimney Swift		R&G (2001b: 329-330)
APCHSP	<i>Chaetuna spinicaudus</i>	<i>aetherodroma</i>	Band-rumped Swift		R&G (2001b: 331), David & Gosse (2002a)
APCHCI	<i>Chaetuna cinereiventris</i>	<i>occidentalis</i>	Gray-rumped Swift		R&G (2001b: 331-332)
APPACA	<i>Panyptila cayennensis</i>	<i>cayennensis</i>	Lesser Swallow-tailed Swift		R&G (2001b: 333)
PH/TR	TROCHILIDAE (15)		HUMMINGBIRDS (15)		Remsen <i>et al.</i> (2011)
PHGLAE	<i>Glaucois aeneus</i>	<i>columbianus</i>	Bronzy Hermit		R&G (2001b: 334), David & Gosse (2002b)
PHTHRU	<i>Threnetes ruckeri</i>	<i>ruckeri</i>	Band-tailed Barbthroat		R&G (2001b: 335)
PHPHYA	<i>Phaethornis yaruqui</i>	[monotypic]	White-whiskered Hermit		R&G (2001b: 335)
PHPHST	<i>Phaethornis striigularis</i>	<i>subrufescens</i>	Stripe-throated Hermit		R&G (2001b: 338)
PHEUAQ	<i>Eutoxeres aquila</i>	<i>heterura</i>	White-tipped Sicklebill		R&G (2001b: 339)
*TRARAE	<i>Androdon aequatorialis</i>	[monotypic]	Tooth-billed Hummingbird		R&G (2001b: 340)
TRFLME	<i>Florisuga mellivora</i>	<i>mellivora</i>	White-necked Jacobin		R&G (2001b: 342)
*TRPPCO	<i>Popelairia conversii</i>	[monotypic]	Green Thornail		R&G (2001b: 347-348); genus <i>Popelairia</i> is now often merged into <i>Discosura</i>
TRTHEA	<i>Thalurania fannyi</i>	<i>verticeps</i>	Green-crowned Woodnymph		R&G (2001b: 350-351)
TRDAJU	<i>Damophila julie</i>	<i>felicianae</i>	Violet-bellied Hummingbird		R&G (2001b: 351)
TRAMTZ	<i>Amazilia tzacatl</i>	<i>jucunda</i>	Rufous-tailed Hummingbird		R&G (2001b: 355)
TRMAB*	<i>Amazilia amabilis</i>	<i>amabilis</i>	Blue-chested Hummingbird		R&G (2001b: 357-358); sometimes placed in the genus <i>Polyerata</i>
TRAMRO	<i>Amazilia rosenbergi</i>	[monotypic]	Purple-chested Hummingbird		R&G (2001b: 358); sometimes placed in the genus <i>Polyerata</i>
*TRCBUR	<i>Chalybura urochrysa</i>	<i>urochrysa</i>	Bronze-tailed Plumeteer		R&G (2001b: 359)
*TRHXBA	<i>Heliothryx barroii</i>	[monotypic]	Purple-crowned Fairy		R&G (2001b: 384-385)
TN*	TROGONIDAE (4)		TROGONS AND QUETZALS (4)		
TNTRCM*	<i>Trogon comops</i>	[monotypic]	Chocó Trogon		R&G (2001b: 392)
TNTRCH	<i>Trogon chionurus</i>	[monotypic]	Western White-tailed Trogon		R&G (2001b: 393); formerly regarded as subspecies of <i>T. viridis</i>

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TNTRCO	<i>Trogon collaris</i>	<i>virginalis</i>	Collared Trogon	R&G (2001b: 393-394)	
TNTRRU	<i>Trogon rufus</i>	<i>cupreicauda</i>	Black-throated Trogon	R&G (2001b: 395)	
AL	ALCEDINIDAE (4)		KINGFISHERS (4)		
ALMETO	<i>Megasceryle torquata</i>	<i>torquata</i>	Ringed Kingfisher	R&G (2001b: 396), David & Gosse (2002b); sometimes placed in genus <i>Ceryle</i>	
ALCHAM	<i>Chloroceryle americana</i>	<i>cabanisi</i>	Green Kingfisher	R&G (2001b: 397)	
ALCHIN	<i>Chloroceryle inda</i>	<i>choacensis</i>	Green-and-rufous Kingfisher	R&G (2001b: 397-398)	
ALCHAE	<i>Chloroceryle aenea</i>	<i>aenea</i>	American Pygmy Kingfisher	R&G (2001b: 398)	
MO	MOMOTIDAE (2)		MOTMOTS (2)		
MOELPL	<i>Electron platyrhynchos</i>	<i>platyrhynchos</i>	Broad-billed Motmot	R&G (2001b: 398-399)	
MOBAMA	<i>Baryphthengus martii</i>	<i>seminufus</i>	Rufous Motmot	R&G (2001b: 399)	
GA	GALBULIDAE (2)		JACAMARS (2)		
GAGARU	<i>Galbula ruficauda</i>	<i>melanogenia</i>	Rufous-tailed Jacamar	R&G (2001b: 403)	
GAJAAU	<i>Jacamerops aureus</i>	<i>penardi</i>	Great Jacamar	R&G (2001b: 404); David & Gosse (2002b)	
BU	BUCCONIDAE (5)		PUFFBIRDS (5)		
*BUNTMA	<i>Notharchus macrorhynchos</i>	<i>hyperrhynchus</i>	White-necked Puffbird	R&G (2001b: 404-405); taxon <i>hyperrhynchus</i> recently elevated to species rank (Remsen <i>et al.</i> 2011)	
*BUNTPE	<i>Notharchus pectoralis</i>	[monotypic]	Black-breasted Puffbird	R&G (2001b: 405)	
BUNYRA	<i>Nyctalus radiatus</i>	[monotypic]	Barred Puffbird	R&G (2001b: 406-407)	
BUMAPA	<i>Malacoptila panamensis</i>	<i>poliopsis</i>	White-whiskered Puffbird	R&G (2001b: 408)	
BUMILA	<i>Micromonacha lanceolata</i>	[monotypic]	Lanceolated Monklet	R&G (2001b: 409)	
CN*	CAPTIONIDAE (2)		NEW WORLD BARBETS (2)	Prum (1988), Sibley & Ahlquist (1990: 318-332), Barker & Lanyon (2000)	
CNCASQ	<i>Capito squamatus</i>	[monotypic]	Orange-fronted Barbet	R&G (2001b: 412)	
CNCAQU	<i>Capito quinticolor</i>	[monotypic]	Five-colored Barbet	R&G (2001b: 412-413)	
RM*	RAMPHASTIDAE (5)		TOUCANS (5)	Barker & Lanyon (2000)	
RMAUHA	<i>Aulacorhynchus haematopygus</i>	<i>sexnotatus</i>	Crimson-rumped Toucanet	R&G (2001b: 415-416)	
RMSESP	<i>Selenidera spectabilis</i>	[monotypic]	Yellow-eared Toucanet	R&G (2001b: 416)	
RMPTSA	<i>Peroplossus sanguineus</i>	[monotypic]	Stripe-billed Araçari	R&G (2001b: 417); often regarded as subspecies of <i>P. torquatus</i>	
RMRABR	<i>Ramphastos brevis</i>	[monotypic]	Chocó Toucan	R&G (2001b: 421)	
RMRASW	<i>Ramphastos swainsonii</i>	[monotypic]	Chestnut-mandibled Toucan	R&G (2001b: 421); often regarded as subspecies of <i>R. ambigua</i>	
PI	PICIDAE (10)		WOODPECKERS AND PICULETS (10)	Remsen <i>et al.</i> (2011)	
PIPIOL	<i>Picumnus olivaceus</i>	<i>harteri</i>	Olivaceous Piculet	R&G (2001b: 424)	



## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
*PIPLI	<i>Picus litae</i>	[monotypic]	Lita Woodpecker	R&G (2001b: 427-428); sometimes regarded as subspecies of <i>P. leucolaemus</i>	
PICELO	<i>Celexus loricanus</i>	<i>loricanus</i>	Cinnamon Woodpecker	R&G (2001b: 429)	
PIDRLI	<i>Dryocopus lineatus</i>	<i>fuscipennis</i>	Lineated Woodpecker	R&G (2001b: 430-431)	
PIMEPU	<i>Melanerpes pucherani</i>	[monotypic]	Black-cheeked Woodpecker	R&G (2001b: 431)	
PIVECH	<i>Veniliornis choensis</i>	[monotypic]	Chocó Woodpecker	R&G (2001b: 432-433); sometimes regarded as subspecies of either <i>V. cassini</i> or <i>V. affinis</i>	
PIVEKI	<i>Veniliornis kirkii</i>	<i>cecilii</i>	Red-rumped Woodpecker	R&G (2001b: 433)	
PIVECA	<i>Veniliornis callonotus</i>	<i>callonotus</i>	Scarlet-backed Woodpecker	R&G (2001b: 434)	
PICAGA	<i>Campephilus guyaquilensis</i>	[monotypic]	Guayaquil Woodpecker	R&G (2001b: 435)	
PICAHA	<i>Campephilus haematogaster</i>	<i>splendens</i>	Crimson-bellied Woodpecker	R&G (2001b: 435-436)	
FU	FURNARIIDAE (8)		OVENBIRDS (8)	Sibley & Ahlquist (1990: 597-601), Irestedt <i>et al.</i> (2002), Remsen <i>et al.</i> (2011)	
FUSYBR	<i>Synallaxis brachyura</i>	<i>chapmani</i>	Slaty Spinetail	R&G (2001b: 440)	
FUCRER	<i>Cranioleuca erythrops</i>	<i>erythrops</i>	Red-faced Spinetail	R&G (2001b: 446)	
*FUXTMI	<i>Xenopetes minlosi</i>	<i>umbraticus?</i>	Double-banded Graytail	R&G (2001b: 450-451)	
FUHYVI	<i>Hylocisthes virgatus</i>	<i>assimilis</i>	Western Woodhaunter	R&G (2001b: 457-458); often regarded as subspecies of <i>H. subulatus</i>	
FUAUOC	<i>Automolus ochrolaemus</i>	<i>pallidigularis</i>	Buff-throated Foliage-gleaner	R&G (2001b: 461-462)	
FUAURB*	<i>Automolus rubiginosus</i>	<i>nigricauda</i>	Ruddy Foliage-gleaner	R&G (2001b: 463)	
FUXEMI	<i>Xenops minutus</i>	<i>littoralis</i>	Plain Xenops	R&G (2001b: 467)	
*FUSLME	<i>Sclerurus mexicanus</i>	<i>obscurior</i>	Tawny-throated Leafosser	R&G (2001b: 468)	
DE	DENDROCOLAPTIDAE (8)		WOODCREEPERS (8)	recently merged into Furnariidae as subfamily Dendrocolapinae (Remsen <i>et al.</i> 2011)	
*DEDIFU	<i>Dendrocincla fuliginosa</i>	<i>ridgwayi</i>	Plain-brown Woodcreeper	R&G (2001b: 470-471)	
DEGLSP	<i>Glyphorhynchus spirurus</i>	<i>sublestus</i>	Wedge-billed Woodcreeper	R&G (2001b: 472-473)	
DEDESA	<i>Dendrocolaptes sanctithomae</i>	<i>colombianus</i>	Northern Barred-Woodcreeper	R&G (2001b: 475)	
DEXILA	<i>Xiphorhynchus lachrymosus</i>	<i>lachrymosus</i>	Black-striped Woodcreeper	R&G (2001b: 478)	
DEXIER	<i>Xiphorhynchus erythropygius</i>	<i>aequatorialis</i>	Spotted Woodcreeper	R&G (2001b: 478)	
DELESO	<i>Lepidocolaptes souleyetii</i>	<i>esmeraldae</i>	Streak-headed Woodcreeper	R&G (2001b: 478-479)	
DECATR	<i>Campylorhamphus trochilirostris</i>	<i>thoracicus</i>	Red-billed Scythebill	R&G (2001b: 480-481)	
DECAPL*	<i>Campylorhamphus pusillus</i>	<i>pusillus</i>	Brown-billed Scythebill	R&G (2001b: 481-482)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TH	THAMNOPHILIDAE (19)		TYPICAL ANTBIRDS (19)		Sibley & Ahlquist (1990: 597-601), Irestedt <i>et al.</i> (2002), Rensen <i>et al.</i> (2011)
THCYLI	<i>Cymbilaimus lineatus</i>	<i>fasciatus</i>	Fasciated Antshrike		R&G (2001b: 482)
THTAMA	<i>Taraba major</i>	<i>transandeanus</i>	Great Antshrike		R&G (2001b: 482-483)
THTHAT	<i>Thamophilus atrinucha</i>	<i>atrinucha</i>	Western Slaty-Antshrike		R&G (2001b: 487)
*THTTAN	<i>Thamnistes anabatinus</i>	<i>intermedius</i>	Russet Antshrike		R&G (2001b: 489)
THDYPU	<i>Dysithamnus puncticeps</i>	<i>flemmingi</i>	Spot-crowned Antwren		R&G (2001b: 490)
THMYIG	<i>Myrmotherula ignota</i>	<i>ignota</i>	(Griscom's Antwren)		R&G (2001b: 493); Isler & Isler (2003) merged <i>M. obscura</i> into <i>M. ignota</i> and proposed the name 'Moustached Antwren' for the combined species; thus, the trans-Andean taxon is now nominate <i>M. i. ignota</i>
THMYPA	<i>Myrmotherula pacifica</i>	[monotypic]	Pacific Antwren		R&G (2001b: 494)
THMYFU	<i>Myrmotherula fulviventris</i>	<i>fulviventris</i>	Checker-throated Antwren		R&G (2001b: 495); recently transferred to genus <i>Epinecrophylla</i> (Rensen <i>et al.</i> 2011)
THMYAX	<i>Myrmotherula axillaris</i>	<i>albigula</i>	White-flanked Antwren		R&G (2001b: 498)
THMYSL*	<i>Myrmotherula schisticolor</i>	<i>schisticolor</i>	Slaty Antwren		R&G (2001b: 498-499)
THMIQU	<i>Microhospitis quixensis</i>	<i>consobrina</i>	Dot-winged Antwren		R&G (2001b: 500-501)
THCETY	<i>Cercomacra tyrannina</i>	<i>tyrannina</i>	Dusky Antbird		R&G (2001b: 505)
*THHXND*	<i>Hylophylax naevioides</i>	<i>naevioides</i>	Spotted Antbird		R&G (2001b: 509)
*THMZIM	<i>Myrmeciza immaculata</i>	<i>macrorhyncha</i>	Immaculate Antbird		R&G (2001b: 515-516)
*THMZEX	<i>Myrmeciza exsul</i>	<i>maculifer</i>	Chestnut-backed Antbird		R&G (2001b: 516)
*THMZNII	<i>Myrmeciza nigricauda</i>	[monotypic]	Esmeraldas Antbird		R&G (2001b: 516)
*THMZBE	<i>Myrmeciza berlepschi</i>	[monotypic]	Stub-tailed Antbird		R&G (2001b: 516-517)
THGYLE	<i>Gymnophylus leucaspis</i>	<i>aequatorialis</i>	Bicolored Antbird		R&G (2001b: 517-518)
*THPTMC	<i>Phaenostictus mcleammani</i>	<i>pacificus</i>	Ocellated Antbird		R&G (2001b: 519-520)
FO	FORMICARIIDAE (3)		ANTTHUSHES AND ANTPITTAS (3)		Sibley & Ahlquist (1990: 597-601), Irestedt <i>et al.</i> (2002), Rensen <i>et al.</i> (2011)
FOFONI	<i>Formicarius nigricapillus</i>	<i>destrucrus</i>	Black-headed Anthrush		R&G (2001b: 521)
FOPIRU	<i>Pittasoma rufopileatum</i>	<i>rufopileatum</i>	Rufous-crowned Antpitta		R&G (2001b: 523); genus <i>Pittasoma</i> recently transferred to family Conopophagidae (Rensen <i>et al.</i> 2011)
FOHYPE	<i>Hylopezus perspicillatus</i>	<i>perioththalmicus</i>	Streak-chested Antpitta		R&G (2001b: 531); now placed in the newly created family Grallaridae (Rensen <i>et al.</i> 2011)
RH	RHINOCRYPTIDAE (1)		TAPACULOS (1)		Irestedt <i>et al.</i> (2002), Rensen <i>et al.</i> (2011)
RHSCCH	<i>Scytalopus chocensis</i>	[monotypic]	Chocó Tapaculo		R&G (2001b: 538-539)

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TY	TYRANNIDAE (49)		TYRANT FLYCATCHERS (49)	Remsen <i>et al.</i> (2011)	
*TYPMGR	<i>Phyllomyias griseiceps</i>	<i>griseiceps</i>	Sooty-headed Tyrannulet	R&G (2001b: 542)	
TYZICH	<i>Zimmerius chrysops</i>	<i>albicularis</i>	Golden-faced Tyrannulet	R&G (2001b: 543-544); taxon <i>albicularis</i> recently elevated to species rank, the 'Chocó Tyrannulet' (Remsen <i>et al.</i> 2011)	
TYORBR	<i>Ornithion brunneicapillus</i>	<i>brunneicapillus</i>	Brown-capped Tyrannulet	R&G (2001b: 546), David & Gosselin (2002a)	
*TYCTOB	<i>Camptostoma obsoletum</i>	<i>sceleri</i>	Southern Beardless Tyrannulet	R&G (2001b: 546-547)	
*TYTLEL	<i>Tyrannulus elatus</i>	[monotypic]	Yellow-crowned Tyrannulet	R&G (2001b: 548-549)	
*TYMGCA	<i>Myiopygus caniceps</i>	<i>parambae</i>	Gray Elaenia	R&G (2001b: 549)	
*TYMGVI	<i>Myiopygus viridicatus</i>	<i>implacens</i>	Greenish Elaenia	R&G (2001b: 550-551)	
TYELFL	<i>Elaenia flavogaster</i>	<i>semipagana</i>	Yellow-bellied Elaenia	R&G (2001b: 551)	
TYSECI	<i>Serpophaga cinerea</i>	<i>cinerea</i>	Torrent Tyrannulet	R&G (2001b: 557)	
TYMIOV*	<i>Mionectes olivaceus</i>	<i>hederaceus</i>	Olive-striped Flycatcher	R&G (2001b: 560-561)	
TYMIOL	<i>Mionectes oleagineus</i>	<i>pacificus</i>	Ochre-bellied Flycatcher	R&G (2001b: 561)	
TYLESU	<i>Lepidopogon superciliosus</i>	<i>transandinus</i>	Slaty-capped Flycatcher	R&G (2001b: 561-562)	
*TYMOAT	<i>Myiornis atricapillus</i>	[monotypic]	Black-capped Pygmy-Tyrant	R&G (2001b: 566-567)	
TYLOPI	<i>Lophortyx pileatus</i>	<i>squamaecrista</i>	Scale-crested Pygmy-Tyrant	R&G (2001b: 567)	
TYTONI	<i>Todirostrum nigricaps</i>	[monotypic]	Black-headed Tody-Flycatcher	R&G (2001b: 572)	
TYTOCI	<i>Todirostrum cinereum</i>	<i>sceleri</i>	Common Tody-Flycatcher	R&G (2001b: 572-573)	
TYRHPA	<i>Rhynchocyclus pacificus</i>	[monotypic]	Pacific Flatbill	R&G (2001b: 575)	
*TYTMT*	<i>Tolmomyias flavotectus</i>	[monotypic]	Yellow-margined Flatbill	R&G (2001b: 577-578); sometimes regarded as subspecies of <i>T. assimilis</i>	
TYPLCO	<i>Platyrinchus coronatus</i>	<i>superciliaris</i>	Golden-crowned Spadebill	R&G (2001b: 579)	
*TYMCOR	<i>Myiornis ornatus</i>	<i>stellatus</i>	Ornate Flycatcher	R&G (2001b: 581-582); genus <i>Myiornis</i> might belong in the family Oxyruncidae (Remsen <i>et al.</i> 2011)	
TYTEER	<i>Terenotriccus erythrinus</i>	<i>fulvicularis</i>	Ruddy-tailed Flycatcher	R&G (2001b: 583); since Lanyon (1988) sometimes merged into genus <i>Myiobius</i> ; genus <i>Terenotriccus</i> might belong in the family Oxyruncidae (Remsen <i>et al.</i> 2011)	
*TYMSAT	<i>Myiobius atricaudus</i>	<i>portovellae</i>	Black-tailed Flycatcher	R&G (2001b: 583); genus <i>Myiobius</i> might belong in the family Oxyruncidae (Remsen <i>et al.</i> 2011)	
*TYMSSU	<i>Myiobius sulphureipygus</i>	<i>aureatus</i>	Sulphur-rumped Flycatcher	R&G (2001b: 584); often regarded as subspecies of <i>M. barbatus</i> ; see previous note on genus <i>Myiobius</i>	
*TYMSVI	<i>Myiobius villosus</i>	<i>villosus</i>	Tawny-breasted Flycatcher	R&G (2001b: 584); see previous note	
*TYMBFA	<i>Myiophobus fasciatus</i>	<i>crypterythrus</i>	Bran-colored Flycatcher	R&G (2001b: 586)	
*TYMRPH	<i>Mitrephanes phaeocercus</i>	<i>berlepschi</i>	Northern Tufted-Flycatcher	R&G (2001b: 588)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TYCOCO	<i>Contopus cooperi</i>	[monotypic]	Olive-sided Flycatcher	R&G (2001b: 591)	
TYEMVI	<i>Empidonax virescens</i>	[monotypic]	Acadian Flycatcher	R&G (2001b: 591)	
TYSANI	<i>Sayornis nigricans</i>	<i>angustirostris</i>	Black Phoebe	R&G (2001b: 594)	
*TYCLCO	<i>Colonia colonus</i>	<i>leuconota</i>	Long-tailed Tyrant	R&G (2001b: 604-605), David & Gosselin (2002a)	
TYATSP	<i>Atrila spadiceus</i>	<i>parambae</i>	Bright-rumped Atrila	R&G (2001b: 606); Leger & Mountjoy (2003) proposed separating Central American populations as <i>A. flammulatus</i> from South American taxa; however, Remsen <i>et al.</i> (2004) assumed that trans-Andean <i>parambae</i> might be closer to the Central American <i>flammulatus</i> group than to cis-Andean populations	
*TYRTHO	<i>Rhytipterna holerythra</i>	<i>rosenbergi</i>	Rufous Mourner	R&G (2001b: 608)	
TYSIAL	<i>Sirystes albogriseus</i>	[monotypic]	Western Sirystes	R&G (2001b: 608-609); often regarded as subspecies of <i>S. sibilator</i>	
TYMYTU	<i>Myiarchus tuberculifer</i>	<i>nigripes</i>	Dusky-capped Flycatcher	R&G (2001b: 609)	
*TYMHPI	<i>Megarychus pitangua</i>	<i>chrysogaster</i>	Boat-billed Flycatcher	R&G (2001b: 611-612)	
*TYMZSI	<i>Myiozetetes similis</i>	<i>grandis</i>	Social Flycatcher	R&G (2001b: 612)	
*TYMZCA	<i>Myiozetetes cayanensis</i>	<i>hellmayri</i>	Rusty-margined Flycatcher	R&G (2001b: 612-613)	
*TYMZGR	<i>Myiozetetes granadensis</i>	<i>occidentalis</i>	Gray-capped Flycatcher	R&G (2001b: 613)	
*TYCPAL	<i>Conopias albobittatus</i>	<i>albobittatus</i>	White-ringed Flycatcher	R&G (2001b: 614), David & Gosselin (2002b)	
*TYMDMA	<i>Myiodynastes maculatus</i>	<i>chapmani</i>	Streaked Flycatcher	R&G (2001b: 615-616)	
*TYLGLE	<i>Legatus leucophaeus</i>	<i>leucophaeus</i> (+ <i>variegatus</i> ?)	Piratic Flycatcher	R&G (2001b: 617)	
TYTYME	<i>Tyrannus melancholicus</i>	<i>melancholicus</i>	Tropical Kingbird	R&G (2001b: 618)	
TYTYNI	<i>Tyrannus niveigularis</i>	[monotypic]	Snowy-throated Kingbird	R&G (2001b: 619)	
TYTYTY	<i>Tyrannus tyrannus</i>	[monotypic]	Eastern Kingbird	R&G (2001b: 619-620)	
TYPACI	<i>Pachyrhamphus cinnamomeus</i>	<i>cinnamomeus</i>	Cinnamon Becard	R&G (2001b: 623); genus <i>Pachyrhamphus</i> sometimes tentatively placed in the Cotingidae; currently placed in family Tityridae (Remsen <i>et al.</i> 2011)	
TYPAAL	<i>Pachyrhamphus albogriseus</i>	<i>guayaquilensis</i> ? (+ <i>salvini</i> ?)	Black-and-white Becard	R&G (2001b: 624); see previous note	
*TYPTHO	<i>Platypsaris homochrous</i>	<i>homochrous</i>	One-colored Becard	R&G (2001b: 625); genus <i>Platypsaris</i> often merged into <i>Pachyrhamphus</i> ; currently placed in family Tityridae (Remsen <i>et al.</i> 2011)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TYTISE	<i>Tityra semifasciata</i>	<i>nigriceps</i>	Masked Tityra	R&G (2001b: 626); genus <i>Tityra</i> sometimes tentatively placed in the Cotingidae; currently placed in its own family Tityridae (Remsen <i>et al.</i> 2011)	
TYTIIN	<i>Tityra inquisitor</i>	<i>albinotus</i>	Black-crowned Tityra	R&G (2001b: 626); see previous note	
CO	COTINGIDAE (6)		COTINGAS (6)	Remsen <i>et al.</i> (2011)	
COLARU	<i>Laniocera rufescens</i>	<i>tertia</i>	Speckled Mourner	R&G (2001b: 633); currently placed in family Tityridae (Remsen <i>et al.</i> 2011)	
COLIUN	<i>Lipaugus unirufus</i>	<i>castaneocinctus</i>	Rufous Piha	R&G (2001b: 634-635)	
COCONA	<i>Cotinga nattererii</i>	[monotypic]	Blue Cotinga	R&G (2001b: 635)	
*COCDHO	<i>Carpodectes hopkei</i>	[monotypic]	Black-tipped Cotinga	R&G (2001b: 636)	
COQUPU	<i>Querula purpurata</i>	[monotypic]	Purple-throated Fruitcrow	R&G (2001b: 637)	
COCEPE	<i>Cephalopterus penduliger</i>	[monotypic]	Long-wartled Umbrellabird	R&G (2001b: 638-639)	
PR*	PTIRIDAE (8)		MANAKINS (8)	Remsen <i>et al.</i> (2011)	
PRPIME	<i>Pipra mentalis</i>	<i>minor</i>	Red-capped Manakin	R&G (2001b: 640-641)	
PRLECO	<i>Lepidothrix coronata</i>	<i>minuscule</i>	Blue-crowned Manakin	R&G (2001b: 641-642)	
*PRMICH	<i>Masius chrysoternus</i>	<i>coronulatus</i>	Golden-winged Manakin	R&G (2001b: 642-643)	
PRMAMA	<i>Manacus manacus</i>	<i>bangsi</i>	White-bearded Manakin	R&G (2001b: 643)	
*PRMPDE	<i>Machaeropterus deliciosus</i>	[monotypic]	Club-winged Manakin	R&G (2001b: 644)	
PRCHHO	<i>Chloropipo holochlora</i>	<i>litae</i>	Green Manakin	R&G (2001b: 644-645); since Prum (1992) genus <i>Chloropipo</i> often merged into <i>Xenopipo</i>	
PRSCTU	<i>Schiffornis tudina</i>	<i>rosenbergi</i>	Thrush-like Schiffornis	R&G (2001b: 647-648), David & Gosselin (2002b); genus <i>Schiffornis</i> sometimes tentatively placed in the Cotingidae; currently placed in family Tityridae (Remsen <i>et al.</i> 2011)	
PRSAAE	<i>Sapayoa aenigma</i>	[monotypic]	Broad-billed Sapayoa	R&G (2001b: 648-649); closely related to the Old World suboscine families Eurylaimidae and Pittidae (Fjeldså <i>et al.</i> 2003); currently placed in its own monotypic family 'Sapayoidae' (Remsen <i>et al.</i> 2011)	
VI	VIREONIDAE (4)		VIREOS, PEPPERSHRIKES, AND SHRIKE-VIREOS (4)	Johnson <i>et al.</i> (1988), Sibley & Ahlquist (1990: 617-618), Cicero & Johnson (2001), Barker <i>et al.</i> (2002), Remsen <i>et al.</i> (2011)	
*VIVLLE	<i>Vireolanius leucotis</i>	<i>miketiae</i>	Slaty-capped Shrike-Vireo	R&G (2001b: 653)	
VIVVOL	<i>Vireo olivaceus</i>	<i>olivaceus</i>	Red-eyed Vireo	R&G (2001b: 653-655)	
VIHYDE	<i>Hylophilus decurtatus</i>	<i>minor</i>	Lesser Greenlet	R&G (2001b: 656-657)	
VIHYOC	<i>Hylophilus ochraceiceps</i>	<i>bulmenis</i>	Tawny-crowned Greenlet	R&G (2001b: 657-658)	

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
TU	TURDIDAE (5)		THRUSHES (5)	Remsen <i>et al.</i> (2011)	
TUMYRA	<i>Myadestes ralloides</i>	<i>plumbiceps</i>	Andean Solitaire	R&G (2001b: 658)	
TUCILE	<i>Cichlopsis leucogenys</i>	<i>chubbi</i>	Rufous-brown Solitaire	R&G (2001b: 658-659)	
TUCAUS	<i>Catharus ustulatus</i>	<i>swainsoni</i>	Swainson's Thrush	R&G (2001b: 661-662)	
TUTUOB	<i>Turdus obsoletus</i>	<i>parambanus</i>	Pale-vented Thrush	R&G (2001b: 665)	
TUTUDA	<i>Turdus daguae</i>	[monotypic]	Dagua Thrush	R&G (2001b: 666-667); traditionally regarded as subspecies of <i>T. assimilis</i> , but voice resembles that of <i>T. albicollis</i>	
HI	HIRUNDINIDAE (9)		SWALLOWS AND MARTINS (9)		
HIPRCH	<i>Progne chalybea</i>	<i>chalybea</i>	Gray-breasted Martin	R&G (2001b: 669-670)	
HIPRSU	<i>Progne subis</i>	[unknown ssp.]	Purple Martin	R&G (2001b: 670)	
HITABI	<i>Tachycineta bicolor</i>	[monotypic]	Tree Swallow	R&G (2001b: 671-672)	
HINOCY	<i>Notiochelidon cyanoleuca</i>	<i>cyanoleuca?</i>	Blue-and-white Swallow	R&G (2001b: 672); sometimes placed in the genus <i>Pygochelidon</i>	
HINETI	<i>Neochelidon tibialis</i>	<i>minima</i>	White-thighed Swallow	R&G (2001b: 673-674); recently transferred to genus <i>Atticon</i> (Remsen <i>et al.</i> 2011)	
HISTRU	<i>Stelgidopteryx ruficollis</i>	<i>uropygialis</i>	Southern Rough-winged Swallow	R&G (2001b: 674)	
HIRIRI	<i>Riparia riparia</i>	<i>riparia</i>	Sand Martin	R&G (2001b: 674)	
HIHIRU	<i>Hirundo rustica</i>	<i>erythrogaster</i>	Barn Swallow	R&G (2001b: 674-675)	
HIPEPY	<i>Petrochelidon pyrrhonota</i>	[unknown ssp.]	Cliff Swallow	R&G (2001b: 675)	
TG*	TROGLODYTIDAE (8)		WRENS (8)		
TGCAZO	<i>Campylorhynchus zonatus</i>	<i>brevirostris</i>	Band-backed Wren	R&G (2001b: 677)	
TGODBR	<i>Odontorchilus branickii</i>	<i>minor</i>	Gray-mantled Wren	R&G (2001b: 677-678)	
TGTHNI	<i>Thryothorus nigricapillus</i>	<i>connectens</i>	Bay Wren	R&G (2001b: 679); recently transferred to genus <i>Cantorchilus</i> (Remsen <i>et al.</i> 2011)	
TGTHLP*	<i>Thryothorus leucopogon</i>	<i>leucopogon</i>	Stripe-throated Wren	R&G (2001b: 682); see previous note	
TGTRAE	<i>Troglodytes aedon</i>	<i>albicans</i>	House Wren	R&G (2001b: 682-683); Neotropical mainland populations often regarded as a separate species <i>T. musculus</i>	
TGHELE	<i>Henicorhina leucosticta</i>	<i>inornata</i>	White-breasted Wood-Wren	R&G (2001b: 683-684); <i>inornata</i> group may deserve recognition as a separate species (Dingle <i>et al.</i> 2006)	
TGCVPH	<i>Cyphorhinus phaeocephalus</i>	<i>phaeocephalus</i>	Song Wren	R&G (2001b: 685-686)	
TGMIMA	<i>Microcerulus marginatus</i>	<i>occidentalis</i>	Southern Nightingale-Wren	R&G (2001b: 686-687)	
PT*	POLIOPTILIDAE (3)		GNATCATCHERS AND GNATWRENS (3)		
PTMICI	<i>Microbates cinereiventris</i>	<i>cinereiventris</i>	Tawny-faced Gnatwren	Sibley & Ahlquist (1990: 644-645), Sheldon & Gill (1996), Remsen <i>et al.</i> (2011)	
PTPOPL	<i>Polioptila plumbea</i>	<i>bilineata</i>	Tropical Gnatcatcher	R&G (2001b: 687-688)	
				R&G (2001b: 689)	



## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
PTPOSC	<i>Poliophtila schistaceigula</i>	[monotypic]	Slate-throated Gnatcatcher	R&G (2001b: 689-690)	Often called 'Wood-Warblers'; now regarded as a sister group of the Icteridae; Sibley & Ahlquist (1990: 683-698); Barker <i>et al.</i> (2002); Lovette & Bermingham (2002); Yuri & Mindell (2002)
PA	PARULIDAE (10)		NEW WORLD WARBLERS (10)		R&G (2001b: 693-694)
PADEST	<i>Dendroica striata</i>	[monotypic]	Blackpoll Warbler		R&G (2001b: 694)
PADEFU	<i>Dendroica fusca</i>	[monotypic]	Blackburnian Warbler		R&G (2001b: 695)
PADEPY*	<i>Dendroica pensylvanica</i>	[monotypic]	Chestnut-sided Warbler		R&G (2001b: 696); recently transferred to newly created genus <i>Parkesia</i> (Remsen <i>et al.</i> 2011)
PASENO	<i>Seiurus noveboracensis</i>	[monotypic]	Northern Waterthrush		R&G (2001b: 697)
PAGESE	<i>Geothlypis semiflava</i>	<i>semiflava</i>	Olive-crowned Yellowthroat		R&G (2001b: 697-698); often regarded as subspecies of <i>G. aequinoctialis</i>
PAGEAU	<i>Geothlypis auricularis</i>	<i>auricularis</i>	Black-lored Yellowthroat		R&G (2001b: 698)
PAOPPH	<i>Oporornis philadelphia</i>	[monotypic]	Mourning Warbler		R&G (2001b: 698)
PAOPAG	<i>Oporornis agilis</i>	[monotypic]	Connecticut Warbler		R&G (2001b: 701); often regarded as subspecies of <i>B. chrysogaster</i>
PABACL*	<i>Basileuterus chlorophrys</i>	[monotypic]	Chocó Warbler		R&G (2001b: 703); often placed in genus <i>Phaethothlypis</i>
PABAFU	<i>Basileuterus fulvicauda</i>	<i>semicervinus</i>	Buff-rumped Warbler		Sibley & Ahlquist (1990: 683-698), Klicka <i>et al.</i> (2000), García-Moreno <i>et al.</i> (2001), Sato <i>et al.</i> (2001), Barker <i>et al.</i> (2002), Burns <i>et al.</i> (2002), Lovette & Bermingham (2002), Yuri & Mindell (2002)
TP*	THRAUPIDAE (36)		BANANAQUIT, HONEYCREEPERS, TANAGERS, AND PLUSHCAP (36)		R&G (2001b: 704); historically often separated in family Coerebidae; currently treated as Incertae Sedis by Remsen <i>et al.</i> (2011)
*TPCBFL	<i>Coereba flaveola</i>	<i>intermedia</i>	Bananaquit		R&G (2001b: 705)
TPCYCA	<i>Cyanerpes caeruleus</i>	<i>chocoanus</i>	Purple Honeycreeper		R&G (2001b: 705-706)
TPCYCY	<i>Cyanerpes cyaneus</i>	<i>pacificus</i>	Red-legged Honeycreeper		R&G (2001b: 706)
*TPCRSP	<i>Chlorophanes spiza</i>	<i>exsul</i>	Green Honeycreeper		R&G (2001b: 706-707)
TPDACA	<i>Dacnis cayana</i>	<i>baudoana</i>	Blue Dacnis		R&G (2001b: 707); often regarded as subspecies of <i>D. lineata</i>
TPDAEG	<i>Dacnis egregia</i>	<i>aequatorialis</i>	Yellow-tufted Dacnis		R&G (2001b: 708)
TPDAVE	<i>Dacnis venusta</i>	<i>fuliginata</i>	Scarlet-thighed Dacnis		R&G (2001b: 708-709)
TPDABE	<i>Dacnis berlepschi</i>	[monotypic]	Scarlet-breasted Dacnis		R&G (2001b: 716-717); genus <i>Erythrothlypis</i> often merged into <i>Chrysotrochilys</i>
TPERSA	<i>Erythrothlypis salmoni</i>	[monotypic]	Scarlet-and-white Tanager		

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name	References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies		
*TPCLFL	<i>Chlorophonia flavirostris</i>	[monotypic]	Yellow-collared Chlorophonia	R&G (2001b: 719); genus <i>Chlorophonia</i> recently placed in subfamily Euphoniinae within family Fringillidae (Banks <i>et al.</i> 2003)
TPEULA	<i>Euphonia lanirostris</i>	<i>hypoxantha</i>	Thick-billed Euphonia	R&G (2001b: 719-720); genus <i>Euphonia</i> recently placed in subfamily Euphoniinae within family Fringillidae (Banks <i>et al.</i> 2003)
TPEUXA	<i>Euphonia xanthogaster</i>	<i>choensis</i>	Orange-bellied Euphonia	R&G (2001b: 720-721); see previous note
TPEUMI	<i>Euphonia minuta</i>	<i>humilis</i>	White-vented Euphonia	R&G (2001b: 721); see previous note
TPEUFU	<i>Euphonia fulvica</i>	<i>purpurascens</i>	Fulvous-vented Euphonia	R&G (2001b: 722); see previous note
TPTARU	<i>Tangara rufigula</i>	[monotypic]	Rufous-throated Tanager	R&G (2001b: 723-724)
TPTAPL*	<i>Tangara palmeri</i>	[monotypic]	Gray-and-gold Tanager	R&G (2001b: 724)
TPTAFL	<i>Tangara florida</i>	[monotypic]	Emerald Tanager	R&G (2001b: 724-725)
TPTACY	<i>Tangara cyanicollis</i>	<i>cyanopygia</i>	Blue-necked Tanager	R&G (2001b: 730)
TPTALT*	<i>Tangara larvata</i>	<i>fanny</i>	Golden-hooded Tanager	R&G (2001b: 730-731)
TPTAJO	<i>Tangara johannae</i>	[monotypic]	Blue-whiskered Tanager	R&G (2001b: 732-733)
TPTAGY	<i>Tangara geyla</i>	<i>nupera</i>	Bay-headed Tanager	R&G (2001b: 733-734)
TPTALV*	<i>Tangara lavinia</i>	<i>lavinia</i>	Rufous-winged Tanager	R&G (2001b: 734)
TPBARO	<i>Bangsia rothschildi</i>	[monotypic]	Golden-chested Tanager	R&G (2001b: 739)
TPBAED	<i>Bangsia edwardsi</i>	[monotypic]	Moss-backed Tanager	R&G (2001b: 739)
TPTEVI	<i>Tersina viridis</i>	<i>occidentalis</i>	Swallow Tanager	R&G (2001b: 741); formerly placed in its own monotypic family Tersinidae
TPTHEP	<i>Thraupis episcopus</i>	<i>quaesita</i>	Blue-gray Tanager	R&G (2001b: 741-742)
TPTHPA	<i>Thraupis palmarum</i>	<i>violilavata</i>	Palm Tanager	R&G (2001b: 742)
TPRAIC	<i>Ramphocelus icteronotus</i>	[monotypic]	Lemon-rumped Tanager	R&G (2001b: 744); often regarded as subspecies of <i>R. flammigerus</i>
TPPIRU	<i>Pinanga rubra</i>	<i>rubra</i>	Summer Tanager	R&G (2001b: 745); genus <i>Pinanga</i> recently transferred to family Cardinalidae (Rensen <i>et al.</i> 2011)
*TPCTOL	<i>Chlorothraupis olivacea</i>	[monotypic]	Lemon-spectacled Tanager	R&G (2001b: 746-747); genus <i>Chlorothraupis</i> recently transferred to family Cardinalidae (Rensen <i>et al.</i> 2011)
*TPCTST	<i>Chlorothraupis stolzmanni</i>	<i>dugandi?</i>	Ochre-breasted Tanager	R&G (2001b: 747-748); see previous note
TPMICA	<i>Mitrospingus cassinii</i>	<i>cassinii</i>	Dusky-faced Tanager	R&G (2001b: 748); genus <i>Mitrospingus</i> almost certainly does not belong in the Thraupidae; currently treated as Incertae Sedis by Rensen <i>et al.</i> (2011)
*TPTYRU	<i>Tachyphonus rufus</i>	[monotypic]	White-lined Tanager	R&G (2001b: 748-749)

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
*TPTYLU	<i>Tachyphonus luctuosus</i>	<i>panamensis</i>	White-shouldered Tanager	R&G (2001b: 749-750)	
*TPTYDE	<i>Tachyphonus delatii</i>	[monotypic]	Tawny-crested Tanager	R&G (2001b: 750)	
*TPTHOXA	<i>Heterospingus xanthopygius</i>	<i>berthozii</i>	Scarlet-browed Tanager	R&G (2001b: 750-751)	
CD*	CARDINALIDAE (5)		SALTATORS, GROSBEAKS, AND CARDINALS (5)		Sibley & Ahlquist (1990: 683-698), Klicka <i>et al.</i> (2000), Yuri & Mindell (2002), Remsen <i>et al.</i> (2011)
CDSAMA	<i>Salinator maximus</i>	<i>maximus</i>	Buff-throated Saltator		R&G (2001b: 760); genus <i>Salinator</i> almost certainly does not belong in the Cardinalidae; currently treated as Incertae Sedis by Remsen <i>et al.</i> (2011)
CDSAAP*	<i>Salinator atripennis</i>	[monotypic]	Black-winged Saltator		R&G (2001b: 760); see previous note
CDSAGR	<i>Salinator grossus</i>	<i>saturatus</i>	Slate-colored Grosbeak		R&G (2001b: 762-763); see previous note
*CDPCLU	<i>Phenicticus ludovicianus</i>	[monotypic]	Rose-breasted Grosbeak		R&G (2001b: 764-765)
*CDCPCY	<i>Cyanocompsa cyanoides</i>	<i>cyanoides</i>	Blue-black Grosbeak		R&G (2001b: 765)
EM	EMBERIZIDAE (10)		EMBERIZINE FINCHES (10)		Sibley & Ahlquist (1990: 683-698), Loughheed <i>et al.</i> (2000), Burns <i>et al.</i> (2002), Yuri & Mindell (2002), Remsen <i>et al.</i> (2011)
*EMRSCR	<i>Rhodospingus cruentus</i>	[monotypic]	Crimson-breasted Finch		R&G (2001b: 766-767); genus <i>Rhodospingus</i> might belong in the Thraupidae (Remsen <i>et al.</i> 2011)
EMVOJA	<i>Volatinia jacarina</i>	<i>peruvienis</i>	Blue-black Grassquit		R&G (2001b: 767-768); genus <i>Volatinia</i> might belong in the Thraupidae (Remsen <i>et al.</i> 2011)
EMTIOB	<i>Tiaria obscurus</i>	<i>pauper</i>	Dull-colored Grassquit		R&G (2001b: 768-769), David & Gosselin (2002b); genus <i>Tiaria</i> almost certainly does not belong in the Emberizidae; currently treated as Incertae Sedis by Remsen <i>et al.</i> (2011)
EMORAN	<i>Oryzoborus angolensis</i>	<i>funereus</i>	Lesser Seed-Finch		R&G (2001b: 769); subspecies <i>funereus</i> sometimes regarded as separate species "Thick-billed Seed-Finch"; genus <i>Oryzoborus</i> might belong in the Thraupidae (Remsen <i>et al.</i> 2011)
EMSPCV*	<i>Sporophila corvina</i>	<i>ophthalmica</i>	Variable Seedeater		R&G (2001b: 772); since Stiles (1996) regarded as separate species from <i>S. americana</i> ; genus <i>Sporophila</i> might belong in the Thraupidae (Remsen <i>et al.</i> 2011)
EMSPLU	<i>Sporophila luctuosa</i>	[monotypic]	Black-and-white Seedeater		R&G (2001b: 773-774); see previous note on genus <i>Sporophila</i>
EMSPNI	<i>Sporophila nigricollis</i>	<i>vivida</i>	Yellow-bellied Seedeater		R&G (2001b: 774); see previous note
EMSPTI	<i>Sporophila telasco</i>	[monotypic]	Chestnut-throated Seedeater		R&G (2001b: 775-776); see previous note
EMARAU	<i>Arremon aurantiivestris</i>	<i>occidentalis</i>	Orange-billed Sparrow		R&G (2001b: 788-789)
*EMAPCO	<i>Arremonops conirostris</i>	<i>striaticeps</i>	Black-striped Sparrow		R&G (2001b: 789-790)

## APPENDIX 5. Continued.

6-letter code	Scientific name		English name		References and notes on taxonomy
	Family (no. of spp.) / species	Subspecies	Family (no. of spp.) / species		
IC	ICTERIDAE (7)		AMERICAN ORIOLES AND BLACKBIRDS (7)		Now regarded as a sister group of the Parulidae; Sibley & Ahlquist (1990: 683-698), Lanyon & Omland (1999), Barker <i>et al.</i> (2002), Lovette & Bermingham (2002)
ICAMI	<i>Caticus microhynchus</i>	<i>pacificus</i>	Scarlet-rumped Cacique		R&G (2001b: 794); often regarded as subspecies of <i>C. uropygialis</i>
ICAMHO	<i>Amblycercus holosericeus</i>	<i>flavirostris</i>	Yellow-billed Cacique		R&G (2001b: 795)
ICZAWA	<i>Zarhynchus wagleri</i>	<i>ridgwayi</i>	Chestnut-headed Oropendola		R&G (2001b: 796); genus <i>Zarhynchus</i> should be merged into <i>Paracolibus</i> (Price & Lanyon 2002)
ICMOBO	<i>Molothrus bonariensis</i>	<i>aequatorialis</i>	Shiny Cowbird		R&G (2001b: 799)
ICMOOR	<i>Molothrus oryzivorus</i>	<i>oryzivorus</i>	Giant Cowbird		R&G (2001b: 799)
ICICME	<i>Icterus mesomelas</i>	<i>taczanowskii</i>	Yellow-tailed Oriole		R&G (2001b: 803)
ICDOOR	<i>Dolichonyx oryzivorus</i>	[monotypic]	Bobolink		R&G (2001b: 805)

## APPENDIX 6

Bird species of Playa de Oro: status of confirmation, type of record, abundance rank, breeding/non-breeding status, and core/non-core species: List of bird species recorded between Jun. 1993 and Nov. 2000 in the community of Playa de Oro at elevations between about 50 and 450 m (own observations; P. Mena V., pers. comm.; Benítez & Mathews 1997; and other observers mentioned below); see page 117 for additional species that could not be included in the analysis. In the case of uncertain records the species have only been taken into account if their occurrence in the study area is likely. See Appendix 7 for published erroneous records. The abundance rank refers to the average frequency with which the species can be detected by audiovisual methods in appropriate habitat, elevation, and season. The abundance rank of species that are underrecorded by such methods may underestimate their real abundance (but see below). Likewise, the abundance rank is not necessarily correlated with absolute population size, as the extension of some habitat types was very restricted in comparison with others (e.g., open and semi-open habitats vs. forest). For species that mainly inhabit elevations above 400 m, the abundance rank had to be extrapolated due to the limited observation effort in this zone. When species were detected with varying frequencies in different habitats, localities, elevations, or seasons, the abundance ranks were given in rather wide ranges (e.g., uncommon to common). Abbreviations used: (a) status of confirmation (Status conf.); 1 = confirmed record (photos and sound recordings); 2 = confirmable record, e.g., identification of sound recordings need further confirmation; 3 = unconfirmable record, e.g., sight and/or acoustical records without any confirmable documentation such as sound recordings or photos; 4 = uncertain record, e.g., unconfirmable sight records of species that may be difficult to identify in the field, species not seen well enough to ensure the correctness of identification with certainty, etc.; (b) type of record: vi = visual observation; au = acoustical record; tr = tape recording; mn = mist-netted by the author; ph = photo; hu = reported by experienced local hunters; B&M (97) = reported by Benítez & Mathews (1997), but species could not be confirmed with certainty by other researchers; (c) abundance rank: ac = accidental; exclusively used for migrants and stragglers: vagrants that presumably do not occur every year; oc = occasional; exclusively used for migrants and stragglers: a few to several individuals presumably occur every year; vr = very rare; less than one record per year from 1995–2000; ta = rare; only a few to several individuals encountered per year; uc = uncommon; not encountered every day; fc = fairly common; encountered every day as a few to several individuals; co = common; many individuals encountered every day; vc = very common; many individuals can be encountered locally even in small areas, e.g., at large leks or communal roosts; (...) = abundance rank extrapolated due to a lack of data; used here for species with uncertain status of confirmation as well as for species mainly found above 400 m; [...] = if the abundance rank is usually underestimated by audiovisual methods, the higher rank stated in the brackets may come closer to the real situation, which would be revealed if more appropriate survey methods were used; (d) breeding/non-breeding status: br = breeding resident; breeding either confirmed or suspected; nbv = non-breeding visitor or straggler of unknown origin; nbv-lo = non-breeding visitor or short-distance migrant from the coastal lowlands; nbv-fl = non-breeding visitor or altitudinal migrant from the foothills above Playa de Oro; NN-mi = Nearctic-Neotropical migrant; iN-mi = intra-Neotropical migrant presumably from Central America; au-mi = austral migrant; (e) core/non-core sensu Remsen (1994): C = core species; taxa that regularly occur either as breeding species or non-breeding visitor in any of the life zones or elevational ranges of Playa de Oro; underrecorded low-density species (e.g., *Harporhynchus harporhynchus*, *Crax rubra*, and *Neomorphus radiolobus*) were counted as core species; N = non-core species; taxa that are either true vagrants, i.e., species that might visit the area only a few times per decade or century (e.g., *Fregata magnificens*, *Oporornis agilis*) or transients, i.e., birds that pass in high flight over the area or make stopovers of merely a few hours or days on migration (e.g., *Falco peregrinus*, *Progne subis*). I also counted some other irregularly recorded taxa as non-core, especially when it seems that they do not occur or breed every year in Playa de Oro because the area lies outside their normal distribution range and does not cover their preferred habitats or life zones (e.g., *Clarus pretiosa*, *Cyanocampa cyanoidea*, *Icterus mesomelas*); probably some species of the latter group were merely underrecorded and might, in fact, turn out to be in fact core species (e.g., *Buteo brachyurus*, *Pyrrhura melanura*, *Touit dilectissimus*, *Xenopetes minlosi*); (f) B&M (97): + = species reported by Benítez & Mathews (1997); (g) notes and published records: PdO = community area of Playa de Oro; MNT = mist-netting transect; LT = line transect; see plates (p. 280–291) for photos of selected species; published audio recordings from Playa de Oro: CD1 = Jahn *et al.* (2002); CD2 = Coopmans *et al.* (2004); DVD = Krabbe & Nilsson (2003).

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<b>TINAMIDAE (3)</b>							
<i>Tinamus major</i>	1	vi/au/tr	uc-fc	br	C		DVD
<i>Crypturellus berlepschi</i>	1	vi/au/tr/ph	uc	br	C	+	Plate 1a; DVD
<i>Crypturellus soui</i>	1	vi/au/tr	uc-co	br	C	+	CD1
<b>FREGATIDAE (1)</b>							
<i>Fregata aequinoctialis</i>	3	vi	ac	nbv-lo	N		One immature or female-plumaged bird flying upriver on 28 Nov. 1995.
<b>PHALACROCORACIDAE (1)</b>							
<i>Phalacrocorax brasilianus</i>	3	vi	uc	nbv-lo	C	+	
<b>ANATIDAE (1)</b>							
<i>Anas discors</i>	3	vi	ac	NN-mi	N		Small flocks of this species were flushed on at least two occasions from calmer sections of the Río Santiago in 1996 and 1997 (exact dates not available).
<b>ARDEIDAE (6)</b>							
<i>Tigrisoma fasciatum</i>	3	vi	ra	br	C		At least two individuals were regularly observed from 1997 to 2009 along fast-flowing sections of the Río Santiago (mostly upstream of the Estero Pote area) at an elevation of about 80–100 m.
<i>Ardea alba</i>	3	vi	oc	nbv-lo	N	+	
<i>Egretta thula</i>	3	vi	uc	nbv-lo	C	+	
<i>Egretta caerulea</i>	3	vi	uc-fc	nbv-lo	C	+	
<i>Bubulcus ibis</i>	1	vi/ph	uc	nbv-lo (+ NN-mi)	C	+	
<i>Butorides striata</i>	3	vi/au	ra-uc	br	C	+	
<b>CATHARTIDAE (3)</b>							
<i>Sarcoramphus papa</i>	3	vi	ra	br? + nbv-lo	C	+	Most observations were made in the dry season and probably refer to dispersing non-breeding visitors. However, a very few pairs may also breed in PdO, as one soaring adult was observed during the rainy season on 27 Feb. 1997 at the base of the Andes at about 150 m.
<i>Conopsis atratus</i>	3	vi	oc	nbv-lo	N	+	Curiously, according to Benítez & Matheus (1997), this species was 'common' at their study sites, E. Angostura and E. Pote, in 1993/94. However, I regard this statement as doubtful, because my only record of this species was of a dispersing individual seen on 3 Dec. 1995 patrolling the riverbank of the Río Santiago near Playa Rica.
<i>Cathartes aura</i>	3	vi	uc-fc	br	C	+	



## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>ACCIPITRIDAE</i> (16)							
<i>Pandion haliaetus</i>	3	vi	oc	NN-mi	C		Most frequently observed during migration periods and northern winter months, but in some years a few individuals also occur during boreal summer months; e.g., one was observed on various occasions around 27 Jul. 1999.
<i>Leptodon cayanensis</i>	1	vi/au/tr	uc	br	C		
<i>Elanoides forficatus</i>	3	vi	uc	br? + NN-mi? + iN-mi	C	+	It is unclear whether the species breeds in PdO. Presumably at least 95 % of the birds observed were migrants.
<i>Harpagus bidens</i>	1	vi/au/tr	ra-uc	br	C		
<i>Ictinia plumbea</i>	3	vi	ra-uc	br? + iN-mi	C	+	
<i>Acipiter superciliosus</i>	3	vi	ra	br	C		
<i>Acipiter bicolor</i>	1	vi/au/tr	vr	br	C		CD1
<i>Leucopternis plumbeus</i>	1	vi/au/tr	uc-fc	br	C		CD1, DVD
<i>Leucopternis semiplumbens</i>	1	vi/au/tr	ra-uc	br	C		
<i>Leucopternis princeps</i>	3	vi/au	ra-uc	br	C		
<i>Buteo magnirostris</i>	1	vi/au/tr/mn/ph	fc	br	C	+	CD1
<i>Buteo brachyurus</i>	3	vi	vr	br? + nbv	N		Dispersing (?) individuals of this species were seen on a very few occasions in 1995/96 (exact dates not available).
<i>Harpia harpyja</i>	1	hu	vr	br	C		Until recently, there were no reports from PdO since J. Arroyo, Senior (pers. comm.) shot the 'last' individual in the 1960s or 1970s. However, in the mid-1990s one Harry Eagle was shot in Wimbi, just a few km N of PdO. M. Morales (pers. comm.) inspected the bird's leg, which was preserved as a trophy by the local hunter. Finally, in 2004, local people located a fledged but still dependent juvenile in PdO. P. Tufiño <i>et al.</i> (pers. comm.) positively identified the bird in May of the same year.
<i>Spizaster melanoleucus</i>	2	au/tr	vr	br	C		Tape recording 'OJ032B296_318' fits the description of the species's song in Howell & Webb (1995), but identification needs further confirmation. (Note: in 2009 the author reidentified the corresponding recording as the song of an immature <i>Spizaeus tyrannus</i> ; thus, the status of confirmation of the present species should be changed to '4'.)
<i>Spizaeus tyrannus</i>	1	vi/au/tr	ra-uc	br	C	+	DVD
<i>Spizaeus ornatus</i>	1	vi/au/tr	uc	br	C		
<i>FALCONIDAE</i> (7)							
<i>Microastur ruficollis</i>	1	vi/au/mn/ph	ra-uc	br	C		

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Microtus plumbeus</i>	2	au/tr	ra?	br?	C		Tape recording 'OJ024A012_024' was identified as "surely uttered by this species" by P. Coopmans (pers. comm.), but it sounds unlike other published and confirmed vocalizations of this species (e.g., N. Krabbe in Jahn <i>et al.</i> (2002), disc #1, cuts 11a.1 and 11a.2). Some of the tape recordings previously believed to contain vocalizations of this species may in fact represent records for <i>M. mindolllei</i> (see following species).
<i>Microtus mindolllei</i>	2	au/tr	ra?	br?	C		Tape recordings 'OJ024B558_575' and 'OJ032A548_553' contain calls of either this or the previous species (P. Salaman, pers. comm.); other recordings seem to present some kind of subsong of this species but this needs further confirmation. Most probably both species, <i>M. plumbeus</i> and <i>M. mindolllei</i> , were present at PdO.
<i>Microtus semitorquatus</i>	1	vi/au/tr	uc	br	C		
<i>Heterothobes cahirinans</i>	1	vi/au/tr	uc	br	C	+	
<i>Falco rufigularis</i>	3	vi	ra	br	C		
<i>Falco peregrinus</i>	3	vi	oc	NN-mi (+ nbv-lo?)	N		One hunting immature was observed on 25 Nov. 1996 near Playa Rica.
CRACIDAE (4)							
<i>Oriolus erythroptera</i>	3	vi/au	ra	br?	C		A group heard calling on 31 Aug. 1995 west of the village. A few individuals were shot by local hunters in most years.
<i>Penelope orioni</i>	1	vi/au/tr	ra-uc	br	C		CD1
<i>Penelope purpurascens</i>	1	vi/au/tr	uc	br	C	+	CD1
<i>Caxx rubra</i>	3	hu	vr	br?	C		According to D. Medina (pers. comm.) a single male was observed in Nov. 1999 on the bank of Estero Mamariana N of the Rio Santiago. More recently, J. Arroyo, Junior (pers. comm.) saw another male in Mar. 2004 on the trail between Padre Santos and Las Juntas. At least one bird was shot (sex unknown) in the same year.
ODONTOPHORIDAE (2)							
<i>Odontophorus erythrops</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Rhyrchorys cinctus</i>	1	vi/au/tr	fc	br	C	+	DVD
RALLIDAE (3)							
<i>Lateralus albigularis</i>	1	vi/au/tr/mn/ph	fc-co	br	C		CD1
<i>Anaerolimnas concolor</i>	1	vi/au/tr/ph	uc[-fc]	br	C		Plate 1b; CD1, DVD
<i>Neorex colombiana</i>	1	vi/au/tr/mn/ph	ra[-uc]	br	C		Plate 1c

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<b>SCOLOPACIDAE (1)</b>							
<i>Actitis macularia</i>	3	vi/au	uc-fc	NN-mi	C	+	
<b>LARIDAE (1)</b>							
<i>Larus pipixcan</i>	3	vi	ac	NN-mi	N		One individual in non-breeding plumage flying upriver on 2 Dec. 1997 near the village.
<b>COLUMBIDAE (8)</b>							
<i>Patagona speciosa</i>	1	vi/au/tr	uc	br	C		CD1
<i>Patagona subinacca</i>	1	vi/au/tr	uc-fc	br	C	+	CD1
<i>Patagona godsoni</i>	1	vi/au/tr/mn/ph	fc-co	br	C		CD1
<i>Clarus pretiosa</i>	1	au/tr	vr	br? + nbv-lo	N		At least one individual sang for several weeks in the very dry second half of 1996 in the plantations at the outskirts of the village; the bird was tape-recorded on 17 Nov. 1996 by P. Mena V. (PMV018B377_380).
<i>Leptotila pallida</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	CD1
<i>Georgina purpurata</i>	1	vi/au/tr	ra[-uc]	br	C		
<i>Georgina veraguensis</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C		Plate 1d
<i>Georgina montana</i>	1	vi/au/tr/mn/ph	ra[-uc]	br	C		CD1
<b>PSITTACIDAE (8)</b>							
<i>Ana ambigua</i>	1	vi/au/tr	ra-uc	br + nbv-flh	C	+	CD1, DVD
<i>Pyrrhura melanura</i>	4	au/B&M (97)	(oc?)	nbv-flh	N	+	According to Benítez & Matheus (1997), the species was 'abundant' at their study sites. E. Angostura and E. Pote (both between about 80-150 m), in 1993/94. I consider this statement as doubtful due to the fact that I never observed or tape-recorded this species there or at any other site in PdO up to 450 m (neither did P. Mena V., pers. comm.). Furthermore, none of the local hunters knew the species. However, on 25 Feb. 1997, I heard two small fast-flying flocks that, I now believe, were of this species on LT11b above 250 m. Indeed, it is rather probable that this erratic parakeet visits PdO at least occasionally or seasonally, as it regularly occurs down to about 200 m some 35 km SW of PdO in the Río Guadalupe drainage in Corriente Grande (pers. obs.) and Cooperativa Nueva Aurora (P. Mena V. in Jahn <i>et al.</i> (2002), disc #1, cut 25.2).

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Touit dilectissimus</i>	1	au/tr	oc?	(br? +) nbv-flh	N		The flight calls of one or two individuals were tape-recorded at Chapulá, 80 m, on 26 Jul. 1997 (recording: OJ026B314_322), and also close to the village, 60 m, on 21 Nov. 1997 (OJ035A527_532). This species may occasionally breed in a few pairs in PdO (according to Ridgely & Greenfield (2001b: 283) a nesting pair was found by P. Coopmans near the San Lorenzo-Mataje road at only 50 m).
<i>Pionopitita pulchra</i>	1	vi/au/tr	fc-co	br	C	+	CD1, DVD
<i>Pionus menstruus</i>	1	vi/au/tr	uc-fc	br	C	+	CD1
<i>Pionus chalcopterus</i>	1	vi/au/tr	fc	br	C		CD1
<i>Amazona autumnalis</i>	4	hu/B&M (97)	(oc?)	nbv-lo	N	+	I never observed, heard, or tape-recorded this species in PdO (neither did P. Mena V., pers. comm.). However, one local hunter claimed that flocks of this species have visited PdO in the past (i.e., in drier years?), and, according to Benítez & Mathews (1997), it was 'fairly common' in the E. Angostura and E. Pote area in 1993/94. However, the latter report seems rather doubtful because other researchers did not find the species there. More recently, the species was heard in Jan. 2000 in Tseipi, Río Zapallo, some 10 km SW of PdO (P. Mena V., pers. comm.), as well as in May and Nov. 2000 in Palma Real, Río Santiago, some 10 km NW of Playa de Oro (pers. obs.).
<i>Amazona farrinosa</i>	1	vi/au/tr	fc	br	C	+	DVD
CUCULIDAE (7)							
<i>Coccyzus euleri</i>	4	vi	(ac)	au-mi	N		A <i>Coccyzus</i> cuckoo, accompanying a mixed-species understory flock in young secondary forest, was briefly seen in the afternoon of 4 Jul. 1997 on LT3 at about 70 m. The bird appeared uniformly grayish white below, but details like the bill and eye-ring colors or tail pattern could not be seen well enough to allow an identification to species level. However, the bird showed no rufous in the primaries when it took wing. Due to the observation date, at the height of the austral winter, it was most likely <i>C. euleri</i> , but I could not exclude the minor possibility that <i>C. erythrophthalmus</i> was the species involved. The latter species reportedly accompanies mixed-species flocks at the wintering grounds (Payne 1997: 595). There is also an MECN specimen collected on 8 Jul. 1966, which makes it possible that a few individuals might spend the boreal summer months in South America, though the specimen's collecting date was questioned by Ridgely & Greenfield (2001b: 293-294).
<i>Piaya cayana</i>	1	vi/au/tr	uc	br	C	+	
<i>Piaya minuta</i>	1	vi/au/tr/mn/ph	uc	br?	C	+	
<i>Crotophaga ani</i>	1	vi/au/tr	uc-fc	br	C		CD1, CD2

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species							
<i>Crotophaga sulcirostris</i>	3	vi	ac	nbv-lo	N		A single dispersing individual was seen well on 24 Aug. 1995 at Playa Rica.
<i>Tapera naevia</i>	1	vi/au/tr	uc	br	C		CD1, CD2
<i>Neomorphus radiolobus</i>	1	au/tr	vr	br?	C		Until now, no sight records of this species were reported from PdO. However, the bill snaps of probably two individuals were tape-recorded on 27 May 1996 at the end of MNT2 at 70 m (recording: OJ003B634_639). Until recently, I had doubts about the identification, because the record was obtained at such a low elevation and none of the local hunters knew the species; but, after comparing the bill snaps of this recording directly with those tape-recorded by N. Krabbe at Alto Tambo (Jahn <i>et al.</i> (2002), disc #1, cut 34.2), virtually no doubts about the identification remain. Furthermore, M. Lysinger (ML79D5455Au00) tape-recorded the song of this species in Aug. 2000 on LT4b at roughly 130 m, only about 1 to 2 km to the west of the first locality. The latter vocalization is almost identical to the song K.S. Berg obtained in Bilka after playback (Jahn <i>et al.</i> (2002), disc #1, cut 34.1).
STRIGIDAE (6)							
<i>Megascops centralis</i>	1	vi/au/tr	uc-fc	br	C		CD1, DVD
<i>Glauclidium griseiceps</i>	1	au/tr	ra-uc	br	C		DVD
<i>Lophotrix cristata</i>	1	au/tr	ra[-uc]	br	C	+	CD1, DVD
<i>Pulsatrix perspicillata</i>	1	vi/au/tr	uc	br	C	+	CD1
<i>Strix nigrolineata</i>	2	au/tr	vi[-uc?]	br	C		A series of recordings (OJ043A682_710, OJ043A711_731, and others), obtained on 20 Oct. 1999 on LT11b at about 260 m, most probably contain calls of this species. However, due to the similarity of some vocalization types of <i>S. nigrolineata</i> with those of <i>S. virgata</i> , it is necessary to get further confirmation for the identification.
<i>Strix virgata</i>	1	vi/au/tr/mm/ph	uc[-fc]	br	C		CD1, DVD
STEATORNITHIDAE (1)							
<i>Steatornis caripensis</i>	1	vi/au/tr	uc[-fc]	nbv-fh	C		CD1, DVD
NYCTIBIDAE (1)							
<i>Nyctibius griseus</i>	1	vi/au/tr	ra-uc	br	C	+	DVD
CAPRIMULGIDAE (2)							
<i>Nyctidromus albigollis</i>	1	vi/au/tr/ph	uc	br	C	+	CD1
<i>Nyctipyrnus rosenbergi</i>	1	vi/au/tr	uc-fc	br	C		CD1, DVD. (Note: as confirmed through playback experiments in Jul. 2009, some flight calls originally identified as vocalizations of <i>N. rosenbergi</i> were, in fact, emitted by <i>Loriculus semitorquatus</i> . In other words, the latter species was systematically overlooked and misidentified during the present study. Without a doubt, <i>L. semitorquatus</i> and <i>N. rosenbergi</i> were virtually present at all transects in PdO, including at MNT1 and MNT2.)

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<b>APODIDAE (6)</b>							
<i>Streptoprocne zonaris</i>	1	vi/au/tr	uc-co	nbv-fh	C	+	Low-flying flocks were observed well at various occasions, often close to the front of approaching thunderstorms. However, the identification of one high-flying flock, tape-recorded (OJ007A394_417) on 25 Aug. 1996 at the outskirts of the village at 60 m, needs further confirmation; these calls were possibly not emitted by this species but by <i>C. cherriei</i> . (Note: indeed the aforementioned recording represents a confirmable record of the latter species.)
<i>Cypseloides nuytius</i>	2	vi/au/tr	uc	nbv-fh	C		
<i>Chaetura pelagica</i>	2	vi/au/tr	uc-fc	NN-mi	C		Small and mid-sized flocks, most probably of this species, were regularly observed during the migration periods (roughly Feb.-Apr. and Sep.-Nov. (Chandler & Driessens 1995: 166-167; Chantler 1999: 443-444; pers. obs.). (Note: the status of confirmation of the present species should be changed to '4'; see next species.)
<i>Chaetura spinicaudus</i>	1	vi/au/tr	fc	br	C		This species was observed on a very few occasions; e.g., on 9 Apr. 1996 at Playa Rica, together with <i>C. spinicaudus</i> and <i>C. pelagica</i> , close to the front of a thunderstorm. (Note: a flock, tape-recorded (OJ035A199_210) on 20 Nov. 1997 on the outskirts of the village at 70 m, was originally identified as <i>C. pelagica</i> but, in fact, represents a confirmed record of the present species; thus, the status of confirmation of <i>C. cinereiventris</i> should be changed to '1'.)
<i>Chaetura cinereiventris</i>	4	vi	(oc?)	nbv-lo?	N		
<i>Panyptila cayennensis</i>	3	vi	ra-uc	br	C		
<b>TROCHILIDAE (15)</b>							
<i>Glaucois aeneus</i>	1	vi/au/tr/tr/mn/ph	ra-fc	br	C	CD1	
<i>Threnetes ruckeri</i>	1	vi/au/tr/tr/mn/ph	uc-vc	br	C	+	Plate 1c; CD1
<i>Phaethornis yaruqui</i>	1	vi/au/tr/tr/mn/ph	fc-vc	br	C	+	CD1
<i>Phaethornis striigularis</i>	1	vi/au/tr/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Eutoxeres aquila</i>	1	vi/au/tr/tr/mn/ph	uc-co	br	C	+	Plate 1f
<i>Anadrodon aquatorididis</i>	1	vi/au/tr/tr/mn/ph	uc-co	br + nbv-fh	C	+	Plate 2a; CD1
<i>Florisuga mellivora</i>	1	vi/au/tr/tr/mn/ph	uc-fc	br + nbv-fh	C	+	
<i>Popelatria conversii</i>	3	vi/mn	ra[-uc]	br + nbv-fh	C		
<i>Thalurania fannyi</i>	1	vi/au/tr/tr/mn/ph	uc[-fc]	br	C		CD1
<i>Dumophila julie</i>	1	vi/au/tr/tr/mn/ph	ra[-uc]	br	C		CD1
<i>Amazilia tzacatl</i>	1	vi/au/tr/tr/mn/ph	uc-fc	br	C		CD1



## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Amazonia ambilis</i>	1	vi/mn/ph	ra	(br? +) nbv-lo	C	+	I have not found any lek of this species in PdO (neither has P. Mena V., pers. comm.), and it may not breed there, or at least not regularly. The individuals observed, mist-netted, and photographed in the dry seasons of 1995 and 1996 probably represented non-breeding, short-distance migrants. Erratic seasonal movements of this species have also been reported from other areas of its distribution (Weller 1999: 601-602).
<i>Amazonia rosenbergi</i>	1	vi/au/tr/mn/ph	co	br	C	+	Plate 3a; CD1
<i>Chalybura urucaryia</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C	+	CD1
<i>Helminthophila barrovi</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C	+	CD1
TROGONIDAE (4)							
<i>Trogon comptus</i>	1	vi/au/tr	fc	br	C	+	CD1, DVD
<i>Trogon chionurus</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1, DVD
<i>Trogon collaris</i>	1	au/tr	uc	br	C		
<i>Trogon rufus</i>	1	vi/au/tr/mn/ph	uc-fc	br	C		CD1
ALCEDINIDAE (4)							
<i>Megasceryle torquata</i>	1	vi/au/tr	uc-fc	br	C	+	CD1
<i>Chloroceryle americana</i>	1	vi/au/mn/ph	uc-fc	br	C	+	
<i>Chloroceryle inda</i>	1	vi/au/mn/ph	uc	br	C		
<i>Chloroceryle aenea</i>	1	vi/mn/ph	vr[-ra?]	br	C		A female was mist-netted on 30 May 1996 in Playa Rica at 70 m.
MONOTIDAE (2)							
<i>Electron platyrhynchos</i>	1	vi/au/tr/mn/ph	fc	br	C	+	
<i>Berythengus martii</i>	1	vi/au/tr/mn/ph	fc	br	C	+	CD1
GALBULIDAE (2)							
<i>Galbula ruficauda</i>	1	vi/au/tr/mn/ph	uc	br	C		CD1
<i>Jacamerops aureus</i>	1	vi/au/tr	uc	br	C		DVD
BUCCONIDAE (5)							
<i>Notharchus macrorhynchos</i>	1	vi/au/tr	vr[-ra]	br	C		One individual was heard and tape-recorded (OJ048B239-287) on 2 Apr. 2000 at the 'La Tabla' camp north of the Río Santiago at about 250 m.

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Notarchus pectoralis</i>	3	vi	vr	br	C		One pair was seen well on two occasions between 5 and 17 Apr. 1996 in the Estero Playa Rica area at 60 m, the first time by U. Wittmann (pers. comm.) and the second time by J. Beintmann, F. Herder, and D. Renvert (pers. comm.).
<i>Nystalus radiatus</i>	1	au/tr	uc	br	C		
<i>Melacoptila panamensis</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	CD1
<i>Micromonacha lanceolata</i>	1	vi/ph	ra	br	C		Plate 2b
CAPITONIDAE (2)							
<i>Capito squamatus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	
<i>Capito quinticolor</i>	1	vi/au/tr	uc	br	C		CD1, DVD
RAMPHASTIDAE (5)							
<i>Aulacorhynchus baematopygus</i>	4	B&M (97)	(ra?)	br?	C	+	Curiously, according to Benítez & Matheus (1997) this species was 'common' at their study sites, E. Angostura and E. Pote (both between about 80-150 m), in 1993/94. I consider this statement as doubtful due to the fact that I never observed, heard, or tape-recorded this species there or at any other site in PdO up to 450 m (neither did P. Mena V., pers. comm.). Furthermore, none of the local hunters in PdO knew the bird. However, according to local hunters this toucanet occasionally occurs down to about 400 m in the Río Bravo drainage in Corriente Grande and in the Coracachi-Cayapas Ecological Reserve, some 25 km SW of Playa de Oro. It regularly occurs down to about 250 m at Río Palenque in SW Pichincha (Ridgely & Greenfield 2001b: 415-416). Therefore, it is likely that the species is also present, at least occasionally or seasonally, on the highest hills and slopes of PdO.
<i>Selenidera spectabilis</i>	3	vi	ac	nbw-fh?	N		A pair was seen well by E. Vargas G. (pers. comm.) in late Nov. 1997 in young secondary forest on LT5 at about 70 m.
<i>Pteroglossus sanguineus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	Plate 2c, d; CD1, DVD. Seemingly, most araçaris observed and mist-netted in Playa de Oro belonged to a hybrid population of <i>P. sanguineus</i> x <i>P. erythroggius</i> , with bill patterns of some birds showing characteristics of either <i>P. sanguineus</i> or <i>P. erythroggius</i> , and of others a mixture between both taxa.
<i>Ramphastos brevis</i>	1	vi/au/tr	uc-fc	br	C	+	DVD
<i>Ramphastos swainsonii</i>	1	vi/au/tr/mm	fc	br	C	+	CD1, DVD
PICIDAE (10)							
<i>Picumnus olivaceus</i>	1	vi/au/tr/mm/ph	uc	br	C		CD1
<i>Picus lineae</i>	1	vi/au/tr	uc	br	C		CD1, DVD

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species							
<i>Celeus loritatus</i>	1	vi/au/tr	uc-fc	br	C	+	CD1, DVD
<i>Dryocopus lineatus</i>	1	vi/au/tr	uc	br	C		CD1
<i>Melanerpes pucherani</i>	1	vi/au/tr	uc-fc	br	C	+	CD1
<i>Veniliornis chocoensis</i>	2	vi/tr	ra-uc	br	C		This species was regularly observed in the foothill zone down to about 130 m. However, all tape recordings believed to contain vocalizations of this species need further confirmation (e.g., PMV040B01_20, OJ024A616_632, and OJ034A618_624).
<i>Veniliornis kirkii</i>	1	vi/au/tr	uc-fc	br	C		CD1
<i>Veniliornis callonotus</i>	1	vi/au/tr/mm/ph	uc	br	C		Plate 2e; CD1
<i>Campephilus garyquellensis</i>	1	vi/au/tr	uc-fc	br	C	+	
<i>Campephilus haematogaster</i>	1	vi/au/tr	uc	br	C		DVD
FURNARIIDAE (8)							
<i>Synallaxis brachyura</i>	1	vi/au/tr/mm/ph	fc-co	br	C	+	CD1
<i>Craniotoca erythrops</i>	3	vi	oc?	(br? +) nbv-fh	N		Two juvenile/immature-plumaged birds (i.e., lacking the rufous crown and face coloration of adults) were observed in a mixed canopy flock about 30 m above the ground on 22 Feb. 1997 on LT9 at about 130 m. The species is known to occur regularly down to about 150 m in the coastal hills S of Río Ayampe, NW Guayas (Ridgely & Greenfield 2001b: 446).
<i>Xenorpes minlosi</i>	4	vi	(ra?)	br?	N		One or two individuals likely of this species, due to the almost <i>Xenops</i> -like proportions, were observed in the subcanopy, accompanying a mixed-species flock, on 25 Feb. 1997 on LT11c at about 300 m. I regard this sight record as uncertain because I failed to see some distinctive details well enough to ensure the species's identity (i.e., the white supercilii and wing bars). Furthermore, I never heard or tape-recorded the vocalizations of this species while surveying the same transect in the following months. However, it is rather likely that the graytail occurs in PdO, as it was recorded at about 400–500 m in NW Pichincha and SW Imbabura (Ridgely & Greenfield 2001b: 450–451) and at 80–150 m in the Awacachi Biological Corridor c. 25 km NE of the community (pers. obs.).
<i>Hylocistes virgatus</i>	1	vi/au/tr/mm/ph	fc	br	C	+	Plate 3b; CD1, DVD
<i>Automolus ochrolaemus</i>	1	vi/au/tr	ra	br	C	+	
<i>Automolus rubiginosus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	CD1
<i>Xenops minutus</i>	1	vi/au/tr/mm/ph	uc[-fc]	br	C	+	CD1

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Scelerus mexicanus</i>	1	vi/au/tr	uc	br	C	+	CD1, DVD
DENDROCOLAPTIDAE (8)							
<i>Dendrocincla fuliginosa</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C	+	CD1
<i>Glyphorynchus spirurus</i>	1	vi/au/tr/mn/ph	fc[-co]	br	C	+	CD1, DVD
<i>Dendrocolaptes sanctithomae</i>	1	vi/au/tr/mn/ph	uc	br	C		CD1
<i>Xiphorhynchus lachrymosus</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	Plate 3c; CD1, DVD
<i>Xiphorhynchus erythropygus</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C	+	
<i>Lepidocolaptes souleyetii</i>	1	vi/au/tr/mn/ph	uc	br	C		CD1
<i>Campylorhynchus trochilirostris</i>	1	vi/au/tr/mn/ph	ra-uc	br	C		CD1
<i>Campylorhynchus pusillus</i>	1	vi/au/tr	ra	br	C		
THAMNOPHILIDAE (19)							
<i>Gymbilatinus lineatus</i>	1	vi/au/tr	uc-fc	br	C		CD1
<i>Taraba major</i>	1	vi/au/tr/mn/ph	fc	br	C		CD1
<i>Thamnophilus atrinucha</i>	1	vi/au/tr/mn/ph	fc	br	C	+	CD1
<i>Thamnistes anabatinus</i>	1	vi/au/tr	uc-fc	br	C	+	
<i>Dysithamnus puncticeps</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	Plate 2f; CD1, DVD
<i>Myrmotherula ignota</i>	1	vi/au/tr	uc-fc	br	C		CD1, DVD
<i>Myrmotherula pacifica</i>	1	vi/au/tr/mn/ph	fc	br	C		Plate 4a; CD1
<i>Myrmotherula fulviventris</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	CD1, DVD
<i>Myrmotherula axillaris</i>	1	vi/au/tr/mn/ph	co	br	C	+	CD1
<i>Myrmotherula schisticolor</i>	1	vi/mn/ph	ra[-uc]	br + nbv-fh	C		
<i>Micronotopis quixensis</i>	1	vi/au/tr/mn/ph	uc-co	br	C		CD1, DVD
<i>Cercomacra tyrannina</i>	1	vi/au/tr/mn/ph	fc-co	br	C		CD1
<i>Hylophylax nucioides</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1
<i>Myrmeciza immaculata</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	
<i>Myrmeciza exul</i>	1	vi/au/tr/mn/ph	co	br	C	+	CD1
<i>Myrmeciza nigricauda</i>	1	vi/au/tr	vr-uc	br	C		
<i>Myrmeciza belzepsi</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	Plate 3d; CD1, DVD

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species							
<i>Gymnophis leucapiss</i>	1	vi/au/tr/mm/ph	uc-co	br	C	+	CD1, DVD
<i>Phaenostictus mclernani</i>	1	vi/au/tr	uc	br	C	+	CD1, DVD
FORMICARIIDAE (3)							
<i>Formicarius nigricapillus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C		CD1, DVD
<i>Pitasona rufipileatum</i>	1	vi/au/tr	ra-uc	br	C	+	CD1, DVD
<i>Hylaptes perspicillatus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	Plate 4b; CD1, DVD
RHINOCRYPTIDAE (1)							
<i>Syrrhaptes chocensis</i>	1	au/tr	ra(-fc?)	br	C		
TYRANNIDAE (49)							
<i>Phyllomyias griseiceps</i>	1	au/tr	ra	br	C		
<i>Zimmerius chrysops</i>	1	vi/au/tr/mm/ph	fc-co	br	C		DVD
<i>Oreithyon brunneicapillus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C		CD1
<i>Camptostoma obsolenum</i>	1	vi/au/tr	uc	br	C		CD2
<i>Tyrannulus elatus</i>	1	vi/au/tr	uc	br	C		CD1
<i>Myiophobus caniceps</i>	1	vi/au/tr	uc-fc	br	C		
<i>Myiophobus viridicatus</i>	1	vi/mm/ph	oc	nbv-lo	C		
<i>Elanoides flavogaster</i>	3	vi	ac	nbv-fh	N		One presumably dispersing individual was observed in a plantation near the village on 6 Mar. 1997 at about 60 m.
<i>Serpophaga cinerea</i>	3	vi	ac?	nbv-fh	N		One dispersing individual was seen on 2 Nov. 1995 at Playa Rica at about 60 m.
<i>Mionectes olivaceus</i>	1	vi/au/tr/mm/ph	fc[-co]	br + nbv-fh	C	+	
<i>Mionectes oleagineus</i>	1	vi/au/tr/mm/ph	ra[-fc]	br + nbv-lo	C		
<i>Lepidopygia superciliosa</i>	1	vi/au/tr/mm/ph	uc-fc	br	C		
<i>Myiornis atricapillus</i>	1	vi/au/tr	fc-co	br	C		
<i>Lophortyx pileatus</i>	1	vi/au/tr/mm/ph	uc-co	br	C		
<i>Todirostrum nigriceps</i>	1	vi/au/tr	uc-fc	br	C		
<i>Todirostrum cinereum</i>	1	vi/au/tr/mm/ph	uc-co	br	C		CD1
<i>Rhyncocyclus pacificus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	CD1
<i>Trogonops flavotinctus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C		CD1, DVD

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Platyrinchus coronatus</i>	1	vi/au/tr/mm/ph	fc	br	C	+	CD1, DVD
<i>Myiarchus ornatus</i>	1	vi/au/tr	ra-uc	br	C		
<i>Terenotriccus erythrurus</i>	1	vi/au/tr/mm/ph	uc[-fc]	br	C	+	Plate 4c; CD1
<i>Myiobius atricaudus</i>	1	vi/mm/ph	uc[-fc]	br	C		
<i>Myiobius sulphureipygius</i>	1	vi/au/tr/mm/ph	uc[-co]	br	C	+	Plate 4d
<i>Myiobius villosus</i>	4	B&M (97)	(ra-uc?)	br?	C	+	According to Benítez & Matheus (1997) the species was 'common' in mist-netting samples in 1993/94 at their study sites, E. Angostura and E. Pote (both between about 80-150 m), while <i>M. barbatius</i> , now often regarded as a distinct species <i>M. sulphureipygius</i> (Ridgely & Greenfield 2001b: 584), was listed as 'uncommon' for only one of the two sites. Likely erroneous identification is behind this statement. In fact, <i>M. sulphureipygius</i> is the most common forest-inhabiting <i>Myiobius</i> flycatcher in the lowlands and lower foothills of PdO (pers. obs.). Unfortunately, the individual of <i>M. barbatius</i> shown in Hilty & Brown (1986; plate 37, no. 9) has a distinct eye ring, not present in <i>M. sulphureipygius</i> (Ridgely & Greenfield 2001a: plate 70, no. 4) and, indeed, the latter species can easily be confused with <i>M. villosus</i> (Ridgely & Tudor 1994: 558-560; Ridgely & Greenfield 2001a: 497). However, at least in El Placer, Esmeraldas, <i>M. villosus</i> is known to be fairly common at only 600 m (Ridgely & Greenfield 2001b: 584), and thus the species is probably also present in the upper hills and slopes of PdO.
<i>Myiophobus fasciatus</i>	1	vi/au/tr/mm/ph	ra-uc	br	C		CD1, DVD
<i>Mitrephanes phaeocercus</i>	1	vi/au/tr	uc-fc	br	C		
<i>Contopus cooperi</i>	3	vi	oc	NN-mi	N		This species was observed well on various occasions during migration periods and boreal winters.
<i>Empidonax virescens</i>	1	vi/au/tr/mm/ph	uc-fc	NN-mi	C		
<i>Sayornis nigricans</i>	3	vi	uc-fc	br	C		Several pairs were present along fast-flowing sections of the Río Santiago (upstream of the Estero Pote area) at an elevation of about 80-100 m.
<i>Colonia colonus</i>	1	vi/au/tr/mm/ph	uc-fc	br	C		
<i>Attila spadiceus</i>	1	vi/au/tr	uc	br	C		CD1, DVD
<i>Rhytiperna holerythra</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	
<i>Sirystes albogriseus</i>	1	vi/au/tr	uc	br	C		
<i>Myiarchus tuberculifer</i>	1	vi/au/tr	uc	br	C		
<i>Megaryrchus pitangua</i>	1	vi/au/tr	uc	br	C		CD1



## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Myiozetetes similis</i>	1	au/tr	ra-uc	br	C		CD1. This species was largely outnumbered by <i>M. cayanaensis</i> . Only a few pairs occurred in the largest plantations of PdO, and I noted their presence only while reidentifying the comprehensive tape collections of P. Mena V. and myself (see following species for more details).
<i>Myiozetetes cayanaensis</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	In subspecies <i>helmgryi</i> , the narrow rufous margins of the flight feathers are often hardly visible in the field, and in my experience never as distinct as in the bird shown in Ridgely & Greenfield (2001a: plate 74, no. 25). In fact, one mist-netted and photographed adult, with somewhat worn plumage and with wings half-opened, only showed any rufous edges on primaries p4 to p6, while the rest of the primaries and secondaries had very narrow buff-brown margins. Furthermore, the coronal patch of the same bird was intense orange in the frontal part, with more yellowish coloration restricted to the tips of the crown feathers. For the same reasons, I misidentified all individuals of <i>M. cayanaensis</i> as <i>M. similis</i> during the first months of my field work, until I learned the distinctive vocalizations of the former species. Likewise, I overlooked the few 'real' pairs of <i>M. similis</i> present at PdO for several years (see above).
<i>Myiozetetes grandis</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	CD1
<i>Conopias albonotatus</i>	1	vi/au/tr	uc-fc	br	C		CD1, DVD
<i>Myiodiastres maculatus</i>	3	vi	oc	nbw-lo	N		One individual was seen well on 13 Jul. 1995 and two, presumably a pair, on 23 Nov. 1995. Both observations took place at Playa Rica at about 60 m.
<i>Legatus leucophaeus</i>	1	vi/au/tr/mn/ph	uc-co	br (+ iN-mi?)	C		CD1
<i>Tyrannus melancholicus</i>	1	vi/au/tr	uc-fc	br	C	+	CD1
<i>Tyrannus niveigularis</i>	1	vi/au/tr	uc-fc	iN-mi	C		CD2. Non-breeding individuals establish and defend feeding territories in semi-open conditions during the dry season. Sometimes, a few presumably dispersing individuals were also heard calling in the canopy of continuous forest.
<i>Tyrannus tyrannus</i>	3	vi	oc	NN-mi	N		One individual was seen well on 17 Oct. 1999 at the Estero Porte camp at about 80 m.
<i>Pachyrhamphus cinnamomeus</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1
<i>Pachyrhamphus albogriseus</i>	1	vi/mn/ph	oc	nbw-lo (+ nbv-ftr?)	N		One female-plumaged bird was seen on 26 Sep. 1996 near LT2b at 60 m and an immature was mist-netted on 4 Oct. 1996 on MNT2 at Playa Rica.
<i>Platyparis homachrous</i>	1	vi/mn/ph	ra-uc	nbw-lo	C		This species was regularly observed and mist-netted in semi-open habitat and less frequently also inside secondary forest, principally during the dry season.
<i>Tietya semifuscata</i>	1	vi/au/tr	ra-fc	br	C	+	CD1

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species	3	vi	vr	br	C		One male was observed on 29 Apr. 1995 south of the village and another on 12 Mar. 1998 east of the village on LTI; both at about 60 m.
<b>COTINGIDAE (6)</b>							
<i>Laniocera rufescens</i>	1	vi/au/tr	ra	br	C	+	CD1
<i>Lipaugus uirinfus</i>	1	vi/au/tr	uc-co	br	C	+	CD1, DVD
<i>Cotinga nattererii</i>	1	vi/au/tr	ra	br	C		
<i>Carpodectes hopkei</i>	3	vi	ra	br + nbv-lo?	C		
<i>Querula purpurata</i>	1	vi/au/tr	ra-fc	br	C	+	
<i>Cephalopterus penduliger</i>	1	vi/au/tr	ra	br	C		CD1
<b>PIFRIIDAE (8)</b>							
<i>Pipra mentalis</i>	1	vi/au/tr/mn/ph	uc-vc	br	C	+	Plate 4c, f; CD1
<i>Lepidothrix coronata</i>	1	vi/au/tr/mn/ph	fc-vc	br	C	+	Plate 5a; CD1, DVD
<i>Masius chrysopterus</i>	3	B&M (97)	(ra?)	(br?) + nbv-fh	C	+	According to Benítez & Matheus (1997) one individual of undisclosed sex was mist-netted in Oct. 1993 in the E. Angostura area (80–150 m). This species was previously known to range locally down to about 400 m on the west slope of the Andes and is also present in the coastal Cordillera of Machadillo (Ridgely & Greenfield 2001b: 642–643). At least some individuals may regularly disperse into the lowermost foothills during the dry season (the presumed non-breeding period), like <i>Macharopterus deliciosus</i> and other foothill species. A small breeding population may exist on the upper hills and slopes of PdO.
<i>Manacus manacus</i>	1	vi/au/tr/mn/ph	uc-vc	br	C	+	CD1
<i>Macharopterus deliciosus</i>	1	vi/au/mn/ph	ra[-uc]	(br?) + nbv-fh	C	+	Plate 5b
<i>Chloropipo holochlora</i>	1	vi/au/tr/mn/ph	uc[-co]	br	C	+	Plate 3c; CD1
<i>Schiffornis viridina</i>	1	vi/au/tr/mn/ph	ra-fc	br	C	+	CD1, DVD
<i>Sapayoa aenigma</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	Plate 3f; CD1, DVD
<b>VIREONIDAE (4)</b>							
<i>Vireodanius leucotis</i>	1	vi/au/tr	uc-fc	br	C	+	DVD
<i>Vireo olivaceus</i>	1	vi/mn/ph	oc	NN-mi	C		
<i>Hylophilus decurtatus</i>	1	vi/au/tr	co	br	C		CD1
<i>Hylophilus ochraceiceps</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	Plate 5c; CD1

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<b>Turdidae (5)</b>							
<i>Myadestes ralloides</i>	3	B&M (97)	(ra?)	(br? +) nbv-fh	N	+	According to Benítez & Mathews (1997) two individuals were mist-netted in Nov. 1994, the first in the E. Angostura area and the second above E. Pote (both localities between about 80-150 m). This species was previously known to range locally down to about 600 m on the west slope of the Andes (Ridgely & Greenfield 2001b; 658). Recently it was also found in the coastal Cordillera of Macho-Chindul (K.S. Berg recordings: KSB020A354_382 and KSB020B270_284; Mar. 1999). At least some individuals may regularly disperse into the lowermost foothills during the dry season (the presumed non-breeding period), like <i>Cichloptis leucogenys</i> and other foothill species. A few pairs may breed on the upper hills and slopes of PdO.
<i>Cichloptis leucogenys</i>	3	vi	vr[-ra]	(br? +) nbv-fh	N		One dispersing individual was seen well on 25 Feb. 1997 above Estero Pote on LT11a at about 100 m. A few pairs may breed on the upper hills and slopes of PdO.
<i>Catharus ustulatus</i>	1	vi/mn/ph	oc	NN-mi	N		
<i>Turdus obsoletus</i>	1	vi/au/tr	ra-uc	br + nbv-fh	C		CD1
<i>Turdus daguae</i>	1	vi/au/tr/mn/ph	fc-co	br + nbv-fh	C	+	Plate 5d; CD1, DVD
<b>HIRUNDINIDAE (9)</b>							
<i>Progne chalybea</i>	3	vi	ra-uc	br (+ nbv-to)	C		A few pairs breed in the larger plantations. High-flying swallows of the genus <i>Progne</i> were sometimes observed during the migration periods, but due to the difficulties in field identification it remains unclear how many individuals belonged to this or the following species.
<i>Progne subis</i>	4	vi	(oc?)	NN-mi	N		Several high-flying <i>Progne</i> swallows, migrating southward, were observed on 2 Oct. 1996, and at least one of these was believed to be a male of <i>P. subis</i> .
<i>Tachycineta bicolor</i>	3	vi	ac?	NN-mi	N		A loose group of 6 individuals was seen well on 2 Oct. 1996 at Playa Rica.
<i>Notiochelidon cyanoleuca</i>	3	B&M (97)	oc	nbv-fh	N	+	According to Benítez & Mathews (1997) the species was 'abundant' in the E. Pote area in Jun. 1993; curiously, before 2005 I never recorded this swallow in PdO (neither did P. Mena V., pers. comm.). However, a few pairs bred regularly in San Miguel, Río Cayapas, at only about 60 m (pers. obs.). Due to the fact that the Jun. 1993 date virtually excludes all Nearctic-Neotropical migrant species, it seems likely that a dispersing flock of <i>N. c. cyanoleuca</i> was indeed involved. Alternatively, the long-distance austral migrant subspecies, <i>N. c. patagonica</i> , could accidentally occur during austral winter months. The latter taxon is known to be an uncommon transient and austral winter resident in eastern Ecuador (Ridgely & Greenfield 2001b: 672). (Note: since about 2005 <i>N. cyanoleuca</i> occurs regularly in PdO (pers. obs.).)

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species							
<i>Nochelidon tibialis</i>	1	vi/au/tr/mm/ph	uc-fc	br	C	+	CD1
<i>Stelgidopteryx ruficollis</i>	1	vi/au/tr/mm/ph	uc-co	br	C	+	CD1
<i>Riparia riparia</i>	3	vi	oc	NN-mi	N		This species was seen well on a few occasions during migration. It may occur more regularly than the few observations imply.
<i>Hirundo rustica</i>	3	vi	uc-fc	NN-mi	C	+	Migrating and dispersing individuals were observed in most months.
<i>Petrochelidon pyrrhonota</i>	3	vi	oc	NN-mi	N		This species was seen well on a few occasions during migration. It may occur more regularly than the few observations imply.
TROGLODYTIDAE (8)							
<i>Campylorhynchus zonatus</i>	1	vi/au/tr	ra-fc	br	C		CD1
<i>Odontorchilus branickii</i>	1	vi/au/tr	uc-fc	br	C		CD1
<i>Thryothorus nigricapillus</i>	1	vi/au/tr/mm/ph	uc-co	br	C	+	CD1
<i>Thryothorus leucopogon</i>	1	vi/au/tr/mm/ph	uc-co	br	C	+	Plate 5e; CD1, DVD
<i>Troglodytes aedon</i>	1	vi/au/tr	fc	br	C	+	CD1, CD2
<i>Henicorhina leucosticta</i>	1	vi/au/tr/mm/ph	fc-co	br	C		Plate 5f; CD1, DVD
<i>Gypohirinus phaeocephalus</i>	1	vi/au/tr/mm/ph	uc	br	C	+	CD1
<i>Microcerulus marginatus</i>	1	vi/au/tr/mm/ph	co	br	C	+	CD1
POLIOPTILIDAE (3)							
<i>Microbatas cinereiventris</i>	1	vi/au/tr/mm/ph	fc-co	br	C	+	Plate 6a; CD1
<i>Polioptila plumbea</i>	1	vi/au/tr	uc-fc	br	C		CD1, CD2
<i>Polioptila schistaceigula</i>	1	vi/au/tr	uc[-fc]	br	C		CD1
PARULIDAE (10)							
<i>Dendroica striata</i>	3	vi	ac?	NN-mi	N		A female was seen well on 14 Apr. 1997, in young regenerating vegetation at the outskirts of the village at 60 m.
<i>Dendroica fusca</i>	3	vi	oc	NN-mi	N		One individual, presumably a female in breeding plumage, was observed on 15 Apr. 1997 in the canopy of a secondary forest patch on the outskirts of the village at about 60 m.
<i>Dendroica pensylvanica</i>	3	vi	ac	NN-mi	N		Presumably a male in breeding plumage, accompanying a mixed-species flock in a clearing within secondary forest, was seen on 24 Apr. 1997 on L17 at about 70 m.
<i>Seiurus noveboracensis</i>	1	mn/ph	oc	NN-mi	N		One individual was mist-netted and photographed on 11 Mar. 1996 on transect MNT1 at 60 m.

## APPENDIX 6. Continued.

Scientific name	Status	Type of record <sup>b</sup>	Abundance	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
Family (no. spp.) / species	conf. <sup>a</sup>		rank <sup>c</sup>				
<i>Geothlypis semiflava</i>	1	vi/au/tr/mn/ph	uc	br	C		Plate 6c. All records were obtained in the dry season: a total of six individuals were mist-netted between Jun. and Nov. 1996 on MNT1, and a pair was observed on 1 Sep. 1996 on the outskirts of the village. I never heard this species sing in PdO (neither did P. Mena Y. pers. comm.), and it remains unclear whether breeding takes place there or not. However, as <i>G. auricularis</i> generally prefers less humid areas than <i>G. semiflava</i> (Ridgely & Greenfield 2001b: 697), it actually seems probable that the former would rather breed in PdO in the dry season, and not in the rainy season like most other species.
<i>Geothlypis auricularis</i>	1	vi/mn/ph	ra	br? (+ nbv-lo?)	C		One adult male was mist-netted and photographed on 11 Mar. 1996 on MNT1 at about 60 m.
<i>Oporornis philadelphia</i>	1	mn/ph	ac?	NN-mi	N		Plate 6b. One immature was mist-netted and photographed on 21 Nov. 1996 on MNT1 at about 60 m (Jahn <i>et al.</i> 1999a).
<i>Oporornis agilis</i>	1	mn/ph	ac?	NN-mi	N		
<i>Basileuterus chlorophrys</i>	1	vi/au/tr	ra-uc	br	C		
<i>Basileuterus fulvicauda</i>	1	vi/au/tr/mn/ph	ra-fc	br	C	+	CD1
THRAUPIDAE (36)							
<i>Coereba flaveola</i>	1	vi/au/tr/mn/ph	uc-co	br	C		CD1
<i>Cyanerpes caeruleus</i>	1	vi/au/tr	uc[-fc]	br	C		CD1
<i>Cyanerpes cyaneus</i>	1	vi/au/tr	uc-fc	br	C		CD1
<i>Chlorophanes spiza</i>	1	vi/au/tr/mn	uc[-fc]	br	C	+	
<i>Dacnis cayana</i>	1	vi/mn/ph	uc[-fc]	br	C		
<i>Dacnis egregia</i>	1	vi/au/tr/mn/ph	uc	br	C		
<i>Dacnis venusta</i>	1	vi/mn/ph	ra[-uc]	br? + nbv-fh	C		Plate 6d; CD1
<i>Dacnis berlepschi</i>	1	vi/au/tr/mn/ph	uc-fc	br	C		CD1, DVD
<i>Erythrathyris salmoni</i>	1	vi/au/tr	uc-fc	br	C	+	
<i>Chlorophonia flavivrostris</i>	3	vi	ra?	br? + nbv-fh	C		A male was observed on 22 Jun. 1997 in the foothills above LTI11c at about 450 m.
<i>Euphonia lanirostris</i>	1	vi/au/tr/mn/ph	uc-fc	br	C		CD1
<i>Euphonia xanthogaster</i>	1	vi/au/tr/mn/ph	fc-co	br	C	+	DVD
<i>Euphonia minima</i>	1	vi/au/tr	ra[-uc]	br	C		CD1
<i>Euphonia fulvicauda</i>	1	vi/au/tr	uc-fc	br	C		

## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Tangara nifigala</i>	1	vi/au/tr	ra[-uc]	br	C		
<i>Tangara palmeri</i>	1	vi/au/tr	uc-fc	br	C	+	DVD
<i>Tangara florida</i>	1	vi/au/tr	ra[-uc]	br	C		
<i>Tangara cyanicollis</i>	1	vi/au/tr	uc	br	C		CD1
<i>Tangara larvata</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	
<i>Tangara johannae</i>	1	vi/au/tr	uc[-fc]	br	C	+	CD1
<i>Tangara gypola</i>	3	vi	vr	br?	N	+	One individual was seen by P. Mena V. (pers. comm.) on 11 May 1996, in a mixed-species flock in a plantation about 2 km east of the village at about 60 m.
<i>Tangara lavinia</i>	1	vi/au/tr/mn/ph	uc[-fc]	br	C	+	CD1, DVD
<i>Bangia rothschildi</i>	1	vi/au/tr	ra[-uc]	br	C	+	
<i>Bangia edwardsi</i>	1	vi/au/tr	ra(-uc?)	br	C		A pair, feeding a juvenile, was observed on 22 Jun. 1997 in the foothills above LT11c at about 450 m.
<i>Tersina viridis</i>	3	vi	ra?	br? + nbv-fh	C		One male was observed on 22 Jun. 1997 in the foothills above LT11c at about 450 m.
<i>Thraupis episcopus</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1
<i>Thraupis palmarum</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Ramphocelus icteronotus</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1
<i>Pranga rubra</i>	1	vi/au/tr/mn/ph	uc	NN-mi	C		
<i>Chlorothraupis olivacea</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	Plate 6c; CD1, DVD
<i>Chlorothraupis stolzmanni</i>	1	vi/au/tr	uc-co	br	C		
<i>Mitrospingus cassinii</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Tachyphonus rufus</i>	3	vi	vr	br	C		A pair was observed on 12 Mar. 1998 in an abandoned plantation west of the village.
<i>Tachyphonus luctuosus</i>	1	vi/mn/ph	ra-uc	br? (+ nbv-lo?)	C	+	
<i>Tachyphonus delatrii</i>	1	vi/au/tr/mn/ph	uc-vc	br	C	+	Plate 6f; CD1
<i>Heterospingus xanthopygius</i>	1	vi/au/tr	fc	br	C		CD1
CARDINALIDAE (5)							
<i>Salpator maximus</i>	1	vi/au/tr/mn/ph	uc-co	br (+ nbv-lo?)	C		CD1
<i>Salpator atripennis</i>	1	vi/au/tr	uc-fc	br	C		

## APPENDIX 6. Continued.

Scientific name	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non-breeding status <sup>d</sup>	Core/non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Saltator grossus</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Phenicticus ludovicianus</i>	1	mn/ph	oc?	NN-mi	N		One individual, presumably an immature male, was mist-netted and photographed on 27 Nov. 1996 on MNT2 at 60 m.
<i>Gynaecomys cynoides</i>	1	au/tr	vr	br?	N		One individual was heard and tape-recorded (OJ041B662_671), but not seen, on 27 Jul. 1999 on LT8a at about 80 m.
EMBERIZIDAE (10)							
<i>Rhodopis cruentus</i>	1	mn/ph	oc?	nbw-lo + iN-mi	N		One immature male was mist-netted and photographed on 27 Nov. 1996 on MNT2 at 60 m.
<i>Volatinia jacarina</i>	1	vi/au/mn/ph	ra	br (+ nbv-lo?)	C		
<i>Tiaris obscurus</i>	1	vi/au/tr/mn/ph	ra-uc	br	C		
<i>Oryzoborus angolensis</i>	1	vi/au/tr/mn/ph	fc	br	C		CD1
<i>Sporophila corvina</i>	1	vi/au/tr/mn/ph	fc-co	br	C		CD1
<i>Sporophila luctuosa</i>	3	vi	oc?	nbw-fh	N		One male observed well on 25 Nov. 1996 at Playa Rica.
<i>Sporophila nigricollis</i>	1	vi/au/tr/mn/ph	uc	br	C		CD1
<i>Sporophila telasco</i>	3	vi	oc	nbw-lo	N		Three males and one female were seen on 15 Nov. 1996 on the soccer pitch east of the village. A single male was seen between 18 and 21 Apr. 1997 at Playa Rica.
<i>Arremon aurantirostris</i>	1	vi/au/tr/mn/ph	uc-fc	br	C	+	CD1
<i>Arremonops conirostris</i>	1	vi/au/tr	ra	br	C		CD1
ICTERIDAE (7)							
<i>Catigua microhynchus</i>	1	vi/au/tr/mn/ph	uc-co	br	C	+	CD1
<i>Amphycercus holosericeus</i>	1	vi/au/tr	ra	br	C		The alarm calls of one individual were tape-recorded on 22 Jul. 1996 by P. Mena V. (PMV005B482_485). All the subsequent records were obtained in the same area on transect MNT1 at about 60 m, and one was seen well by E. Vargas G. (pers. comm.) in late Nov. 1997. Tape recording 'OJ035B254_287', obtained on 22 Nov. 1997, also contains the alarm calls of this species in the background; and recordings 'OJ010B648_655' and 'OJ015B105_112', taped in early 1997, may contain the duet of this species. Due to its rail-like character, I previously believed that the rail <i>Neorex colombiana</i> was the author of the song. However, a very similar rail-like duet was tape-recorded and visually confirmed in Aug. 1988 by R.S. Ridgely in SW Ecuador (RSR8B296_306).
<i>Zarhynchus uagleri</i>	1	vi/au/tr	ra-uc	br	C		CD1



## APPENDIX 6. Continued.

Scientific name Family (no. spp.) / species	Status conf. <sup>a</sup>	Type of record <sup>b</sup>	Abundance rank <sup>c</sup>	Breeding/non- breeding status <sup>d</sup>	Core/ non-core <sup>e</sup>	B&M (97) <sup>f</sup>	Notes on the status of confirmation, notable observations, and published records (recordings, photos, etc.) <sup>g</sup>
<i>Molothrus bonariensis</i>	1	vi/au/tr/nm/ph	uc-fc	br	C		
<i>Molothrus oryzivorus</i>	1	vi/au/tr	uc	br	C	CD1	
<i>Icterus mesomelas</i>	3	vi	vr	(br? +) nbv-lo	N		One individual was seen by P. Mena V. (pers. comm.) on 12 Nov. 1995 about 2 km east of the village at about 60 m.
<i>Dolichonyx oryzivorus</i>	3	vi	oc?	NN-mi	N		One individual in non-breeding plumage was seen well on 14 Oct. 1996 at the outskirts of the village.

## APPENDIX 7

Birds of Playa de Oro: published erroneous records. Probably misidentified species reported by Benítez & Matheus (1997) for their study sites Estero Angostura and Estero Pote, both located in the foothill zone between about 80 and 150 m a.s.l. They collected data on four field trips from Jun. 1993 to Nov. 1994, using mist nets and audiovisual methods. See Appendix 6 for the status of other species recorded in the same study. Abbreviations used: B&M (97) = Benítez & Matheus (1997); PdO = community area of Playa de Oro.

Scientific name	English name	
Family (no. spp.) / species	Family (no. spp.) / species	Reason why the record is believed to be in error
ACCIPITRIDAE (1)	OSPREY, KITES, HAWKS, AND EAGLES (1)	
<i>Gampsonyx swainsonii</i>	Pearl Kite	B&M (97) regarded this species as 'common' in Oct. 1993 in the Estero Angostura area. This statement seems to be in error, because, in western Ecuador, <i>G. swainsonii</i> is a species of arid open and semi-open habitats and light deciduous woodland and is not known to occur north of Manabí (Ridgely & Greenfield 2001b: 153). Although the species has a tendency to spread into recently cleared areas in more humid regions, as documented for northeastern Ecuador, this behavior has not been reported from the northwest so far. Furthermore, PdO belongs to one of the few intact forest areas in the lowlands of the Ecuadorian Chocó and is, therefore, an unlikely place for this kite to occur, even as a vagrant.
PSITTACIDAE (2)	MACAWS AND PARROTS (2)	
<i>Brotogeris pyrrhoptera</i>	Grey-cheeked Parakeet	B&M (97) stated that possibly this species was 'common' in Jun. 1993 in the Estero Pote area. Without a doubt the parrots involved were misidentified. <i>B. pyrrhoptera</i> is a Tumbesian endemic not reported to occur north of central Manabí (Ridgely & Greenfield 2001b: 153). Most likely either <i>Pionus chalcopterus</i> or <i>Pionopsitta pulchra</i> were the species involved. Both are fairly common in the E. Pote area but, curiously, were not recorded there by B&M (97). The spelling of ' <i>pyrrhoptera</i> ' follows David & Gosselin (2002b).
<i>Pionopsitta pyrrilia</i>	Saffron-headed Parrot	According to Ridgely & Greenfield (2001b: 285-286), <i>Pionopsitta pyrrilia</i> was reported on two occasions from northwestern Ecuador. In addition, this parrot was allegedly also seen in Oct. 1992 in Charco Vicente, Río San Miguel (Benítez <i>et al.</i> 1997) and in Jun. 1993 in the Estero Pote area in PdO (B&M 97). For the following reasons, I (together with P. Mena V., pers. comm.) assume that all Ecuadorian reports are in error: (a) freshly fledged juveniles of <i>P. pulchra</i> have basically yellowish brown heads, i.e., lack the rosy face mask of adults, and look much like adults of <i>P. pyrrilia</i> ; (b) under certain light conditions, e.g., when the sunlight reflects on the crown and hind neck, distant or fast-flying adults of <i>P. pulchra</i> may look almost golden-headed and can be easily confused with <i>P. pyrrilia</i> ; (c) local people regard <i>P. pulchra</i> as bird pest, because they regularly feed on and damage banana crops; therefore, hundreds or perhaps even a few thousand individuals of <i>P. pulchra</i> are shot every year; nevertheless, none of the local hunters interviewed in PdO and in other areas of Esmeraldas had ever shot an individual of <i>P. pyrrilia</i> .
TROGONIDAE (1)	TROGONS AND QUETZALS (1)	
<i>Trogon violaceus</i>	Violaceous Trogon	B&M (97) have listed <i>T. violaceus</i> , now regarded as a separate species <i>T. caligatus</i> by Ridgely & Greenfield (2001b: 396), as 'common' in the Estero Angostura area in Oct. 1993. Most likely, <i>T. rufus</i> was the species involved, as the latter can be easily confused with <i>T. caligatus</i> under the often poor light conditions in the forest midstory; e.g., all alleged observations of <i>T. violaceus</i> in my own study turned out to be misidentified individuals of <i>T. rufus</i> when I reidentified their vocalizations. Until now, <i>T. caligatus</i> has not been recorded from the Río Santiago drainage, but it is present west of the Río Cayapas and in the Río Ónzole drainage (pers. obs.).
TYRANNIDAE (1)	TYRANT FLYCATCHERS (1)	
<i>Pogonotriccus ophthalmicus</i>	Marble-faced Bristle-Tyrant	One individual, allegedly of this species, was mist-netted in Nov. 1994 in the E. Angostura area (B&M 97). This record is obviously in error, as <i>P. ophthalmicus</i> inhabits subtropical montane forest and is not known to occur below about 1200 m in Ecuador (Ridgely & Greenfield 2001b: 564). Most likely a misidentified individual of <i>Leptopogon superciliosus</i> was involved.
TROGLODYTIDAE (1)	WRENS (1)	
<i>Henicorhina leucophrys</i>	Gray-breasted Wood-Wren	According to B&M (1997) this wren was 'common' in 1993/94 at their study sites, while <i>H. leucosticta</i> was not recorded. Obviously, individuals of the subspecies <i>inornata</i> of <i>H. leucosticta</i> were misidentified as <i>H. leucophrys</i> . Indeed, <i>inornata</i> can be easily confused with <i>H. leucophrys</i> (Ridgely & Tudor 1989: 93; Ridgely & Greenfield 2001a, plate 80, no. 17NW). Especially juveniles are almost as gray below as some individuals of <i>H. leucophrys</i> (pers. obs.). In northwestern Ecuador <i>H. leucophrys</i> is not known to occur below c. 750 m (Ridgely & Greenfield 2001b: 684).

## APPENDIX 8

Birds of Playa de Oro: altitudinal range, abundance rank per life zone, and habitat selection. List of bird species recorded between Jun. 1993 and Nov. 2000 in the community of Playa de Oro at elevations between about 50 and 450 m a.s.l. (own observations; P. Mena V., pers. comm.; Benítez & Matheus 1997; and other observers mentioned in Appendix 6); see page 117 for additional species that could not be included in the data analysis. The altitudinal range in western Ecuador is stated according to Ridgely & Greenfield (2001b), under consideration of the situation in southwestern Colombia according to Hilty & Brown (1986), and my own observations from Esmeraldas Province. Minimum and maximum elevations are given in brackets whenever records at these extreme elevations were exclusively obtained from northwestern Ecuador or southwestern Colombia, as well as in the case of disjunct populations (e.g., in the highlands) or dispersing and migrating individuals. However, the extremes are given within the main range when the available data imply that in northwestern Ecuador a breeding population exists more or less continuously over the entire altitudinal range stated. An asterisk after the minimum value indicates that the species is known from such low elevations only from Esmeraldas (i.e., from the study site). A question mark indicates that the extreme value has yet to be established or confirmed for western Ecuador, but that the species was recorded at such elevations in southwestern Colombia according to Hilty & Brown (1986). The abundance rank per life zone intends to reflect the average frequency with which the species can be detected by audiovisual methods in appropriate habitat, elevation, and season within the Río Santiago drainage, stretching from the Borbón area to the foothills up to about 900 m above Playa de Oro. See p. 26, Life zone, for a brief description of the life zones found in the study area and Dodson & Gentry (1991) for their distribution in western Ecuador. Note that the life zone 'tropical humid forest' is restricted to the lower Río Santiago drainage and thus is not found within the area of Playa de Oro. It is included here mainly to demonstrate the life zone preferences of the bird species recorded in the study area. In the case of species inhabiting open or semi-open country, the abundance rank for the premontane life zones may reflect the limited availability of the habitat rather than the bird's preference for the lower elevation life zones. This is due to the fact that deforestation in the foothill zone of the Río Santiago drainage has just begun in recent years. If the available data imply a strong preference for one to three life zones within western Ecuador, the corresponding abundance rank is written in bold letters. The species involved may be regarded as an indicator species for these life zones (p. 193, Life zone assemblages). Abbreviations used: (a) altitudinal range in western Ecuador: L = lowlands (from near sea level up to the elevation stated); (b) abundance rank per life zone: life zones: TrHF = tropical humid forest; cf. p. 26, Life zones: TrHF = tropical humid forest; coastal lowlands and hill country in the lower drainages of the Santiago, Cayapas, and Onzole rivers, <300 m; TrWF = tropical wet forest; rolling hill country and valleys close to the base of the Andes between c. 30 and 350 m; PmWF = premontane wet forest; lowermost base of the Andean foothills between c. 150 and 350 m; note that it is uncertain whether the lowermost foothills of Playa de Oro belong to the tropical wet forest or premontane wet forest life zone; PmPF = premontane pluvial forest; foothill zone and Andean slopes between >400 and c. 1,800 m; ranks stated here refer to elevations below c. 900 m; abundance ranks, see Appendix 6 for details: ac = accidental; oc = occasional; vr = very rare; ra = rare; uc = uncommon; fc = fairly common; co = common; vc = very common; (...) = abundance rank extrapolated due to a lack of data: [...] = if the abundance rank is usually underestimated by audiovisual methods, the higher rank stated between the brackets may come closer to the real situation, which would be revealed if more appropriate survey methods were used; (c) general habitat class: F = forest; F/E = forest edge (usually to open and semi-open country); OC = open country and semi-open country (mixed-culture plantations, abandoned plantations, young successional scrub, etc.); R = river (used here exclusively for migrants, stragglers, and vagrants, which use the Santiago river as a roost habitat or migration route on passage); R/E = river edge (either to forest or to open and semi-open country); S = settlements; NP = no preference (used here exclusively for migrants, stragglers, and vagrants, which either overfly the study area high on passage, or which can be regularly observed in the airspace above any kind of habitat); (d) main habitat types: matF = mature forest (high-canopy forest, either primary or secondary, with numerous old and large-diameter trees per area: i.e., with a DBH >60 cm); magF = medium-age forest (high-canopy forest in submature stages; trunks of bigger trees have medium-sized diameters; i.e., a DBH of 30-60 cm, rarely more); ysF = young successional forest (low-canopy, low-diameter forest in early stages of regeneration; only a few tree stems have a DBH >30 cm); F/OC = forest-to-open-country edge or forest-to-semi-open-country edge; F/R = forest-to-river edge; mcPL = mixed-culture plantation (traditional, semi-open

plantation with a variety of cultivated plants, like cocoa and plantain, and single, often high, shading trees); psOC = poorly structured open country (pastures with single shading trees, degenerated grassy or shrubby country, large sugar-cane plantations, dry rice fields, etc.); OC/R = open country-to-river edge or semi-open-country-to-river edge; SE = settlements; NP = no preferences (see comments above); (e) important microhabitats: inF = forest interior (used exclusively for species that are only rarely encountered at forest edges); tgF = tree-fall gap within forest (usually small light gap caused by standing dead, broken, fallen, or selectively logged trees); dF = clearing within forest (mid-size to large forest opening, usually, but not always, created by humans); riF = ridge-top forest; baF = earth and sand banks within forest (usually encountered along ridges or on slopes of steep gullies and ravines; at least for some smaller species this also includes the earth pulled up by uprooted trees); ysSC = young successional scrub (mosaic of grassy and scrubby areas with small pioneer trees, like *Cecropia* and *Ochroma*, in overgrown plantations, pastures, and on river islands); HEL = *Heliconia* thickets; guaB = *Guadua* bamboo stands; sLR = slow-flowing river sections; faR = fast-flowing river sections; saR/E = river-edge sandbar (usually encountered in slow-flowing river sections; regularly inundated during flash floods); gvR/E = river-edge gravel bar and rocks (usually encountered in fast-flowing river sections; regularly inundated); baR = river or stream bank; tsR/V = river-edge trees and scrubs (regularly inundated); gsR/V = grassy river-edge vegetation (young successional weeds, grasses, shrubs, and treelets that replace the vegetation cover on sandbars and low banks washed away during flash floods or that colonize newly deposited sediments; including *Gynerium* cane stands); strF = stream within forest (used for aquatic as well as non-aquatic species that tend to be more frequently encountered in stream-rich forest sections than in stands without streams; most of them regularly search for food along forest streams or construct their nests above the watercourse); strOC = stream within open country or semi-open country (same as previous, but for open-country-inhabiting species); (f) less important habitats and microhabitats: same codes as for (d) and (e).

Scientific name	Altitudinal range in western Ecuador (m)	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF				
<b>TINAMIDAE (3)</b>									
<i>Tinamus major</i>	L-1200 (1350)	uc-fc	uc-fc	uc-fc	uc-fc	F	matF; magF	inF	ysF
<i>Crypturellus berlepschi</i>	L-450 (900?)	uc	uc	ra-uc	ra	F	matF; magF	strF	ysF; F/OC; F/R;
<i>Crypturellus soui</i>	L-1200	uc-co	uc-co	uc-fc	(uc-fc?)	OC	mcPL; F/OC; OC/R;	ysSC	psOC; F/R; magF; dF
<b>FREGATIDAE (1)</b>									
<i>Fregata magnificens</i>	0 (1900)	ac	ac	(ac?)	(ac?)	(R)			sLR; faR
<b>PHALACROCORACIDAE (1)</b>									
<i>Phalacrocorax brasilianus</i>	0-800	uc	uc	(oc)	(oc)	R/E	OC/R; F/R	sLR; tsR/V	saR/E; gvR/E
<b>ANATIDAE (1)</b>									
<i>Anas discors</i>	0-3200	oc	ac	(ac?)	(ac?)	R	OC/R	sLR	
<b>ARDEIDAE (6)</b>									
<i>Tigrisoma fasciatum</i>	80*-2200	-	-	ra	(ra)	R/E	F/R	faR; gvR/E; tsR/V	
<i>Ardea alba</i>	0-300 (3500)	uc	oc	(oc)	(oc)	R/E	OC/R	sLR; saR/E	F/R; strOC
<i>Egretta ibula</i>	0-500 (2600)	uc	uc	ra	(oc)	R/E	OC/R	sLR; saR/E	F/R; faR; tsR/V; gvR/E
<i>Egretta caerulea</i>	0-600 (2800)	uc	uc	ra	(oc)	R/E	OC/R	sLR; saR/E; gvR/E	F/R; faR; tsR/V
<i>Bubulcus ibis</i>	0-2800 (3300)	fc-co	uc	uc	(uc)	OC	psOC; OC/R	gsR/V; tsR/V	saR/E; mcPL
<i>Butorides striata</i>	0-500 (2800)	uc-fc	ra-uc	ra-uc	(ra)	R/E	OC/R; F/R	tsR/V; sLR; faR	saR/E; gvR/E; strOC

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>			General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF			
<b>CATHARTIDAE (3)</b>								
<i>Sarcorhamphus papa</i>	L-500 (2000)	<b>uc</b>	<b>ra-uc</b>	ra	(oc?)	F	matF; magF; F/OC; F/R	saR/E; gvR/E
<i>Coragyps atratus</i>	0-2000 (3000)	<b>fc-vc</b>	ra-fc	(oc)	(oc)	OC	psOC; OC/R; F/OC	SE; mcPL
<i>Cathartes aura</i>	0-2000 (3000)	fc-vc	uc-fc	uc	(uc?)	F/E	OC/R; F/R; F/OC; psOC	mcPL; matF; magF; SE
<b>ACCIPITRIDAE (16)</b>								
<i>Pandion haliaetus</i>	0-3000	oc	oc	oc	(oc)	R/E	F/R; OC/R	faR
<i>Lepidodon cayanensis</i>	L-1400	uc	uc	ra	(ra?)	F	matF; magF; F/OC; mcPL	F/R
<i>Elanoides forficatus</i>	L-2000 (3500)	uc-co	uc	ra-uc	(ra-uc?)	F/E	F/OC; F/R; matF; magF	mcPL; OC/R
<i>Harpagus bidens</i>	L-1800 (2200)	ra-uc	ra-uc	(ra?)	(ra?)	F	matF; magF; F/OC	
<i>Ictinia plumbea</i>	L-1000 (2600)	uc	ra-uc	ra-uc	(ra-uc?)	F/E	F/OC; F/R; matF; magF	OC/R; mcPL
<i>Accipiter superciliosus</i>	L-900 (1300?)	ra	ra	(ra)	(ra)	F	matF; magF; F/OC; F/R	mcPL
<i>Accipiter bicolor</i>	L-1800 (2700)	uc	ra	vr	(vr?)	F	matF; magF; F/OC; F/R	
<i>Leucopternis plumbeus</i>	L-1700	uc	uc-fc	uc-fc	uc-fc	F	matF; magF	inF
<i>Leucopternis semiplumbeus</i>	L-600 (1000?)	<b>uc-fc</b>	<b>ra-uc</b>	( <b>ra-uc</b> )	(vr?)	F/E	F/OC; F/R; matF; magF	mcPL
<i>Leucopternis princeps</i>	(50*) 300-2200	ra	ra-uc	ra-uc	(uc?)	F/E	F/OC; matF; magF	F/R
<i>Buteo magister</i>	L-2500 (3000)	fc	fc	uc	(uc?)	OC	mcPL; F/OC; OC/R	
<i>Buteo brachyurus</i>	L-1600 (2200)	ra-uc	vr	(vr?)	(ra?)	F/E	F/OC; F/R	F/OC
<i>Harpia harpyja</i>	L-400 (700)	<b>vr</b>	<b>vr</b>	(vr)	(vr?)	F	matF; magF; F/R	
<i>Spizaetus melanoleucus</i>	L-1400	(vr?)	(vr?)	vr	(vr?)	F	matF; magF; F/OC; F/R	ritF; clF
<i>Spizaetus tyrannus</i>	L-1700	uc?	ra-uc	ra-uc	(ra-uc?)	F/E	F/OC; F/R; matF; magF	
<i>Spizaetus ornatus</i>	L-1000 (1800?)	ra?	uc	uc	ra-uc?	F	matF; magF	F/OC; F/R
<b>FALCONIDAE (7)</b>								
<i>Micrastur ruficollis</i>	L-2900	uc?	ra-uc	ra-uc	(ra-uc)	F	matF; magF	ysF; F/R; F/OC; mcPL; clF
<i>Micrastur plumbeus</i>	L-800 (1400?)	ra?	ra?	ra-uc?	ra-uc?	F	matF; magF	ysF
<i>Micrastur mirandollei</i>	L-400?	<b>uc</b>	ra?	(ra?)	(vr?)	F	matF; magF	ysF; F/R; F/OC; mcPL; clF
<i>Micrastur semitorquatus</i>	L-1800 (2450)	uc	uc	uc	uc	F	matF; magF	ysF; F/R; F/OC; mcPL; clF
<i>Herpetotheres cachimans</i>	L-800 (1000?)	uc	uc	uc	uc	R/E	F/R; F/OC	clF
<i>Falco rufigularis</i>	L-1500	ra	ra	(ra)	(ra)	F/E	F/OC; F/R; matF; magF	matF; magF; ysF; mcPL
<i>Falco peregrinus</i>	0-2800	oc	oc	oc	oc	NP	NP	ysF
<b>CRACIDAE (4)</b>								
<i>Ortalis erythropera</i>	L-1000 (1850)	<b>ra-uc</b>	ra	?	-	R/E	F/R	ysF; magF; matF; F/OC
<i>Penelope ortoni</i>	70*-1000 (1500?)	(ra?)	<b>ra-uc</b>	<b>uc</b>	<b>uc</b>	F	matF; magF	inF; ritF

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF	habitat			
<i>Penelope purpurascens</i>	L-1500	uc	uc	ra-uc	(ra-uc)	F	matF; magF		F/OC; F/R
<i>Cyx rubra</i>	L-400 (700)	<b>ra</b>	<b>vr</b>	?	?	F	matF; magF	inF	F/R
ODONTOPHORIDAE (2)									
<i>Odontophorus erythrops</i>	L-900 (1600)	uc?	uc-fc	uc-fc	uc-fc?	F	matF; magF		ysF; F/OC
<i>Rhysochoris cinctus</i>	L-600	<b>fc</b>	<b>fc</b>	<b>uc-fc</b>	(ra-uc?)	F	matF; magF	inF	ysF
RALLIDAE (3)									
<i>Lateralus albigularis</i>	L-1700	fc-co	fc-co	(uc-fc?)	(uc-fc?)	OC	psOC; OC/R; mcPL	gsR/V	ysSC
<i>Amazilia amabilis</i>	L-300	uc[-fc]	uc[-fc]	ra[-uc]	-	R/E	OC/R; F/OC	tsR/V; ysSC; HEL	ysF; F/R
<i>Neotrex colombiana</i>	L-500 (2100?)	ra[-uc]	ra[-uc]	(ra?)	(ra?)	OC	psOC; mcPL	ysSC; gsR/V	OC/R
SCOLOPACIDAE (1)									
<i>Actitis macularia</i>	0-4000	uc-fc	uc-fc	uc-fc	(uc-fc?)	R/E	OC/R	saR/E; gyR/E	F/R; strOC
LARIDAE (1)									
<i>Larus pipixcan</i>	0 (2800)	(ac)	ac	(ac)	(ac)	(R)	(sR; faR)		
COLUMBIDAE (8)									
<i>Patagioenas spectiosa</i>	L-1200 (1700)	uc	uc	(ra?)	(ra?)	F/E	F/OC; mcPL		F/R; ysF
<i>Patagioenas subvinacea</i>	L-2000	uc-fc	uc-fc	fc	fc	F	matF; magF; F/OC; F/R	ritF; clF	mcPL; ysF
<i>Patagioenas goodsoni</i>	L-800	fc-co	co	fc	fc	F	matF; magF		F/OC; F/R; ysF; mcPL; clF
<i>Claravis pretiosa</i>	L-1000 (1300)	<b>uc</b>	<b>vr</b>	(vr?)	(vr?)	F/E	F/OC; OC/R; mcPL	ysSC	
<i>Leptotilla pallida</i>	L-800	fc-co	fc-co	(fc?)	(uc-fc?)	F/E	F/OC; OC/R; mcPL; F/R	tsR/V; ysSC	psOC
<i>Geotrygon purpurata</i>	100*-700	-	(vr?)	ra[-uc]	ra[-uc]	F	matF; magF	inF	ysF
<i>Geotrygon venguerensis</i>	L-300	ra[-uc]	uc[-fc]	(vr?)	-	F	matF; magF; ysF; F/OC	clF; tgF	F/R; mcPL
<i>Geotrygon montana</i>	L-1300 (1600)	uc[-fc]	ra[-uc]	ra[-uc]	(ra-uc?)	F	matF; magF; ysF	tgF	F/OC; mcPL
PITTACIDAE (8)									
<i>Ara ambiguus</i>	L-800	oc	<b>ra-uc</b>	<b>ra-uc</b>	(ra?)	F	matF; magF		F/OC
<i>Pyrrhura melanura</i>	(230) 500-1400 (1900)	(oc?)	oc?	oc?	( <b>uc-fc?</b> )	F	matF; magF; F/OC		
<i>Touit dilectissimus</i>	(L) 500-1400 (2500)	<b>ra-uc?</b>	oc?	oc?	( <b>uc-fc?</b> )	F	matF; magF		F/OC; F/R
<i>Pionopsitta pulchra</i>	L-1300	<b>ra-uc</b>	fc-co	fc	fc	F	matF; magF; ysF; F/OC; mcPL		F/R
<i>Pionus menstruus</i>	L-1100 (1400)	uc-fc	uc-fc	uc-fc	(uc-fc?)	F/E	F/OC; F/R; mcPL		matF; magF; ysF
<i>Pionus chalcopterus</i>	L-1400 (1650)	uc	fc	fc	fc	F	matF; magF; F/R	clF	F/OC; mcPL; ysF
<i>Amazona autumnalis</i>	0-700 (1300)	<b>uc-fc</b>	oc?	(oc?)	(oc?)	F	matF; magF; F/OC; F/R	clF	
<i>Amazona farrinosa</i>	L-700	fc	fc	fc	(uc?)	F	matF; magF		F/OC; F/R; mcPL
CUCULIDAE (7)									
<i>Coccyzus euleri</i>	L-1300	ac?	ac?	(ac?)	(ac?)	F	matF; magF; ysF; F/OC		

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>			General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF			
<i>Piaya cayana</i>	L-2200 (2700)	uc	uc	uc	uc	F/E	F/OC; F/R; ysf; mcPL	OC/R; magf; matf
<i>Piaya minuta</i>	L-900 (1500)	uc	uc	(uc)	(ra-uc)	F/E	F/OC; F/R; mcPL	
<i>Crotophaga ani</i>	0-1400 (2200)	fc-co	uc-co	(uc)	(uc)	OC	psOC; OC/R	mcPL
<i>Crotophaga sulcirostris</i>	L-1200 (2750)	ra?	ac	(ac)	(ac)	OC	psOC; OC/R	
<i>Tapera naevia</i>	L-800 (2300)	fc	uc	(uc)	(uc)	OC	psOC; OC/R; mcPL	
<i>Neomorphus radiolobus</i>	(70*) 450-1200 (1500)	(oc)	vr	(vr)	(ra)	F	matf; magf	
STRIGIDAE (6)								
<i>Megascops centralis</i>	L-1000	ra-uc?	uc-fc	uc-fc	(uc-fc)	F	matf; magf; ysf	
<i>Glauclaudium griseiceps</i>	(70*) 150-400 (600?)	-	vr	uc	(ra-uc)	F	matf; magf	
<i>Lophotrix cristata</i>	L-800	ra[-uc]	ra[-uc]	ra[-uc]	(ra-uc)	F	matf; magf	F/OC
<i>Pulsatrix perspicillata</i>	L-1700	uc	uc	uc	(uc)	F	matf; magf; F/OC	
<i>Strix nigrolineata</i>	L-1400	ra-uc?	vr[-uc]	vr[-uc]	(ra-uc)	F	magf; matf; F/OC; F/R	
<i>Strix virgata</i>	L-2000	uc[-fc]	uc[-fc]	uc[-fc]	(uc)	F	magf; matf; F/R; OC/R; mcPL	ysf
STEATORNITHIDAE (1)								
<i>Steatornis caripensis</i>	(40*) 700-2400 (2600)	(ra)	uc[-fc]	uc[-fc]	(uc-fc)	R/E	F/R; matf; magf	tsR/V
NYCTIBIDAE (1)								
<i>Nyctibius griseus</i>	L-2300	ra[-uc]	ra[-uc]	ra[-uc]	(ra-uc)	F	magf; matf; F/R; F/OC; mcPL	ritf; tgF; dF
CAPRIMULGIDAE (2)								
<i>Nyctidromus albigollis</i>	L-1200 (1850)	uc-fc	uc	uc	(uc)	OC	psOC; OC/R; mcPL; F/OC	gsR/V; ysf
<i>Nyctiphrynus rosenbergi</i>	L-600	uc-fc	uc-fc	uc-fc	(uc)	F	matf; magf; F/R; F/OC	tgF; ritf; dF; tsR/V
APOIDAE (6)								
<i>Streptoprocne zonaris</i>	L-4000	uc-co	uc-co	uc-co	uc-co	NP	NP	
<i>Cypseloides nuytius</i>	(50*) 1000-2700	uc	uc	uc	(uc)	NP	NP	
<i>Chaetura pelagica</i>	L-3200	fc-co?	uc-fc	(uc)	(uc)	NP	NP	
<i>Chaetura spinicaudus</i>	50*-1500	uc?	fc	fc	fc	F/E	F/OC; F/R; mcPL; OC/R; dF	psOC
<i>Chaetura cinereiventris</i>	L-1000 (1600)	(uc-fc)	(oc)	(oc)	(oc)	F/E	matf; magf; F/OC; F/R; OC/R; mcPL; matf; magf	psOC
<i>Panyptila cayennensis</i>	L-900 (1300)	ra-uc	ra-uc	ra-uc	ra-uc	F/E	F/OC; OC/R; psOC; mcPL; matf; magf	
TROCHILIDAE (15)								
<i>Glaucois aeneus</i>	L-600	uc-fc	ra-fc	(ra-uc)	(ra-uc)	R/E	OC/R; mcPL; psOC	F/OC; F/R



## APPENDIX 8. Continued.

Scientific name Family (no. spp.) / species	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
		TrHF	TrWF	PmWF	PmPF				
<i>Threnetes ruckertii</i>	L-900	uc-co	uc-co	uc-fc	uc-fc	F/E	F/OC; F/R; OC/R; mcPL; ysF	HEL, ysSC; tgF; dF; strF	matF; magF; psOC
<i>Phaethornis yaruqui</i>	L-1500 (1750)	fc-co	fc-co	fc-co	fc-co	F	OC; mcPL	HEL, ysSC; tgF; dF; strF	OC/R; psOC
<i>Phaethornis striatularis</i>	L-1350	uc-fc	uc-fc	uc-fc	(uc-fc)	F/E	F/OC; F/R; mcPL; ysF	HEL, ysSC; tgF; dF; strF	matF; magF; psOC
<i>Eutoerates aquila</i>	50*-1600	uc?	uc-co	uc-co	uc-co	F/E	F/OC; F/R; mcPL; ysF	HEL, ysSC; tgF; dF; strF	matF; magF
<i>Androdon aequatorialis</i>	50*-800	ra-uc?	<b>uc-fc</b>	<b>fc-co</b>	<b>uc-co?</b>	F	matF; magF	tgF; dF	ysF; F/R; F/OC; mcPL
<i>Florisuga mellivora</i>	L-1300 (1550)	fc	uc-fc	uc-fc	uc-fc?	F	matF; magF; F/OC; F/R	clF	mcPL; ysF
<i>Popelairia conversii</i>	(L) 300-1000	(ra?)	ra[- <b>uc</b> ]	( <b>uc</b> )	( <b>uc?</b> )	F/E	F/OC; OC/R; mcPL	tgF; dF	matF; magF; ysF
<i>Thalurania fannyi</i>	L-1500	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	magF; matF; ysF; F/OC; F/R	ysSC	mcPL
<i>Dumophila julie</i>	L-1100	uc?	ra[-uc]	(ra?)	(ra?)	OC	mcPL; F/OC; OC/R	ysSC	F/R; psOC
<i>Amazilia tzacatl</i>	L-1500 (2500)	fc-co	uc-fc	(uc-fc?)	(uc-fc?)	OC	mcPL; OC/R	ysSC	F/OC; psOC; SE
<i>Amazilia amabilis</i>	L-300 (1200)	<b>uc-co</b>	oc?	(oc?)	(oc?)	F/E	F/OC; F/R; OC/R; mcPL	ysSC; tsR/V	ysF; psOC
<i>Amazilia rosenbergi</i>	L-600 (900)	<b>uc-fc?</b>	<b>co</b>	<b>co</b>	(uc?)	F	matF; magF; ysF; F/OC; F/R; mcPL	ysSC; tgF; clF	
<i>Chalybura urochrysa</i>	50-800	ra[-uc]	uc[-fc]	uc[-fc]	( <b>uc-fc</b> )	F	matF; magF	inF	F/R; HEL; ysF
<i>Heliothryx barroti</i>	L-800	uc[-fc]	uc[-fc]	uc[-fc]	(uc-fc?)	F/E	F/OC; F/R; matF; magF; ysF; mcPL; OC/R	tsR/V; tgF; clF	
<b>TROGONIDAE (4)</b>									
<i>Trogon comptus</i>	50-800	(ra-uc?)	<b>fc</b>	<b>fc</b>	<b>uc-fc</b>	F	matF; magF	ysF; F/R; F/OC	
<i>Trogon chionurus</i>	L-800	<b>uc-co</b>	<b>uc-co</b>	<b>uc-fc</b>	(uc?)	F	ysF; magF; F/OC; F/R	tgF; clF	mcPL; matF
<i>Trogon collaris</i>	(250) 400-1300 (1500)	-	-	ra	( <b>uc-fc</b> )	F	matF; magF; ysF; F/OC	clF	mcPL?
<i>Trogon rufus</i>	L-750	uc-fc	uc-fc	fc	uc-fc	F	ysF; magF; matF	tgF; clF	F/R; F/OC
<b>ALCEDINIDAE (4)</b>									
<i>Megasceryle torquata</i>	L-1300 (3000)	uc-fc	uc-fc	uc	(uc?)	R/E	OC/R; F/R	slR; tsR/V; baR	gvR/E; faR
<i>Chloroceryle americana</i>	L-1300	uc-fc	uc-fc	uc	(uc?)	R/E	OC/R; F/R	slR; tsR/V; strF; strOC; baR	gvR/E; faR
<i>Chloroceryle inda</i>	L-400 (1300?)	uc[-fc]	ra[- <b>uc</b> ]	<b>ra</b>	(vr?)	F	strF	slR; baR	F/R; tsR/V
<i>Chloroceryle aenea</i>	L-400 (700)	<b>ra-uc?</b>	[ra?]	(ra?)	(vr?)	F	strF	slR; baR; baF	F/R; tsR/V
<b>MONOTIDAE (2)</b>									
<i>Electron platythymum</i>	L-1600	fc	fc	fc	fc	F	matF; magF; ysF	baF	F/R; F/OC
<i>Baryphengus martii</i>	L-1600	fc	fc	fc	fc	F	matF; magF; ysF	baF	F/R; F/OC
<b>GALBULIDAE (2)</b>									
<i>Galbula ruficauda</i>	L-800	uc-fc	uc	uc	uc	F/E	F/OC; OC/R; mcPL	ysSC; clF; ritF; baF	matF; magF; ysF; psOC
<i>Jacamerops aureus</i>	L-450 (900?)	ra-uc	<b>uc</b>	<b>uc-fc</b>	(ra-uc?)	F	matF; magF	baF	ysF; F/OC; F/R; mcPL

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>			General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF			
<b>BUCCONIDAE (5)</b>								
<i>Notharchus macrorhynchos</i>	L-400	ra[-uc]	vr[-ra]	(vr?)	-	F	matF; magF; F/OC	tgF; clF
<i>Notharchus pectoralis</i>	L-200	uc-fc	vr-ra	?	-	F/E	F/OC; F/R; matF; magF; ysF	
<i>Nystalus radiatus</i>	L-1500	uc	uc	uc	uc	F/E	F/OC; mcPL; F/R	clF; ritF
<i>Melospiza panamensis</i>	L-900	uc-fc	uc-fc	uc-fc	(uc-fc?)	F	magF; matF; ysF; F/OC; F/R; mcPL	ritF; clF; tsR/V; ysSC; baF
<i>Micromonacha lanceolata</i>	L-1300	ra	ra	(ra)	(ra)	F	matF; magF; F/OC; F/R; ysF	clF; baF
<b>CAPTIONIDAE (2)</b>								
<i>Capito squamatus</i>	L-800 (1300)	uc-fc	uc-fc	uc	(uc?)	F/E	F/OC; matF; magF; ysF; mcPL; F/R	clF
<i>Capito quinticolor</i>	60°-400 (550?)	(ra?)	uc	uc-fc	(ra-uc?)	F	matF; magF	clF
<b>RAMPHASTIDAE (5)</b>								
<i>Aulacorhynchus haematopygus</i>	(250) 500-2000 (2750)	-	-	(oc?)	(uc-fc?)	F	matF; magF; F/OC	ysF
<i>Selenidera spectabilis</i>	L (300-1200?)	ac	ac	(ac)	(ac?)	F	matF; magF; ysF; F/OC; mcPL	
<i>Pteroglossus sanguineus</i>	L-800	uc-fc	uc-fc	uc-fc	uc-fc	F/E	F/OC; F/R; ysF; mcPL	clF
<i>Ramphastos brevis</i>	L-900 (1550)	uc-fc	uc-fc	uc-fc	uc-fc	F	matF; magF	clF
<i>Ramphastos swainsonii</i>	L-1000 (1500?)	fc	fc	fc	fc	F	matF; magF	clF
<b>PICIDAE (10)</b>								
<i>Picumnus olivaceus</i>	L-900	uc	uc	(uc?)	(uc?)	OC	mcPL; ysSC; F/OC; OC/R	
<i>Picus lineatus</i>	L-800	ra	uc	uc	uc	F	matF; magF	clF
<i>Celeus loriscus</i>	L-800	uc-fc	uc-fc	uc-fc	uc-fc	F	magF; matF; ysF; F/OC	clF
<i>Dryocopus lineatus</i>	L-1200	uc-fc	uc	(uc)	(uc)	F/E	F/OC; OC/R; mcPL	
<i>Melanerpes pucherani</i>	L-800 (1500)	uc-fc	uc-fc	(uc-fc)	(uc-fc)	F/E	F/OC; F/R; OC/R; mcPL; psOC	ysSC; clF; strF; ritF; tgF
<i>Veniliornis chacoensis</i>	150-700	?	ra	uc	uc	F	matF; magF	F/OC; ysF
<i>Veniliornis kirkii</i>	L-1200	uc-fc	uc-fc	uc-fc	(uc?)	F	matF; magF; F/OC; mcPL	clF
<i>Veniliornis adlonotus</i>	L-1000 (1800)	uc-fc	uc	(ra?)	-	OC	mcPL; psOC	ysSC
<i>Campephilus garyquensis</i>	L-1400	uc-fc	uc-fc	uc	(uc?)	F	matF; magF; F/OC	clF
<i>Campephilus haematogaster</i>	L-800	uc	uc	uc	(ra-uc?)	F	matF; magF	inF
<b>FURNARIIDAE (8)</b>								
<i>Synallaxis brachyura</i>	L-1750	fc-co	fc-co	(fc?)	(fc?)	OC	mcPL; OC/R; F/OC; psOC	gsR/V; ysSC
<i>Cranioleuca erythrops</i>	(130°) 700-1850	-	oc?	(oc?)	(ra-uc?)	F	matF; magF; ysF; F/OC	

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m)	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF				
<i>Xenopetes minlosi</i>	(300?) 400-500 (900?)	-	-	(ra?)	(ra-uc?)	F	matF; magF; F/OC		
<i>Hylocistetes virgatus</i>	L-1100	fc	fc	fc	uc-fc	F	matF; magF	tgF	ysF; F/OC; F/R; mcPL
<i>Automolus ochrolaemus</i>	L-800 (1300)	<b>uc</b>	<b>ra</b>	(vr?)	(vr)	F/E	F/OC; F/R; magF; ysF	baF; baR	mcPL
<i>Automolus rubiginosus</i>	L-1300	uc-fc	uc-fc	(ra-uc?)	(ra-uc?)	F/E	F/OC; F/R; mcPL; ysF	ysSC; baF	magF
<i>Xenops minutus</i>	L-1300	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	matF; magF; ysF; F/OC; F/R; mcPL	tgF; clF; ysSC	
<i>Scelerurus mexicanus</i>	L-1500 (1650)	ra	uc	uc	uc	F	matF; magF	inF; baF; baR	ysF
<b>DENDROCOLAPTIDAE (8)</b>									
<i>Dendrocincla fuliginosa</i>	L-1400	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	matF; magF; ysF; F/OC; F/R; mcPL	clF; ysSC	
<i>Glyphorynchus spirurus</i>	L-1700	fc-[co]	fc-[co]	fc-[co]	fc-[co]	F	matF; magF; ysF; F/OC	clF	F/R; mcPL; ysSC
<i>Dendrocolaptes sanctithomae</i>	L-800	uc	uc	uc	(ra-uc?)	F	inF; matF; magF		ysF; F/OC
<i>Xiphorhynchus lachrymosus</i>	L-450	<b>co</b>	<b>co</b>	<b>fc-co</b>	ra-uc	F	matF; magF; ysF; F/OC	clF	F/R; mcPL
<i>Xiphorhynchus erythroggius</i>	L-1700 (2000)	uc[-fc]	uc[-fc]	uc[-fc]	fc[-co]	F	matF; magF; ysF; F/OC	clF	F/R; mcPL
<i>Lepidocolaptes souleyetii</i>	L-1300 (1800)	<b>fc</b>	<b>uc</b>	?	?	OC	mcPL; OC/R; psOC	tsR/V; ysSC	F/OC
<i>Campylorhynchus trochilostrius</i>	L-800 (1900)	<b>uc-fc</b>	<b>ra-uc</b>	(ra?)	(ra?)	F/E	mcPL; F/OC; OC/R	tsR/V; ysSC	
<i>Campylorhynchus pusillus</i>	60*-2100	-	vr	<b>ra</b>	<b>uc?</b>	F	matF; magF; ysF	inF	F/OC
<b>THAMNOPHILIDAE (19)</b>									
<i>Cymbilaimus lineatus</i>	L-1000	uc-fc	uc-fc	uc	(uc?)	F/E	F/OC; mcPL	clF; ysSC; guaB	OC/R; F/R
<i>Taraba major</i>	L-1000 (1600)	fc	fc	(uc-fc?)	(uc-fc?)	OC	mcPL; OC/R; F/OC; psOC	ysSC	
<i>Thamnophilus atrinucha</i>	L-1350	fc	fc	uc	(uc?)	F/E	F/OC; F/R; OC/R; mcPL; ysF	ysSC; clF; tgF; tsR/V	magF; strF
<i>Thamnistes analabatus</i>	60*-1300	ra-uc?	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	F	matF; magF; ysF	tgF	F/OC
<i>Dysithamnus puncticeps</i>	L-800	uc	fc	co	fc?	F	matF; magF; ysF		F/OC
<i>Myrmotherula ignea</i>	L-500	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	F	magF; ysF; matF; F/OC; F/R; mcPL	clF; tgF	
<i>Myrmotherula pacifica</i>	L-1300	fc	fc	uc-fc	(uc-fc?)	OC	mcPL; psOC; F/OC; OC/R; F/R	tsR/V; ysSC	
<i>Myrmotherula fulviventris</i>	L-900	uc-fc	fc-co	fc-co	fc-co	F	matF; magF; ysF		F/OC
<i>Myrmotherula acillaris</i>	L-900	fc-co	co	co	fc-co	F	matF; magF; ysF		F/OC
<i>Myrmotherula schisticolor</i>	(70*) 400-1450	?	oc?	oc?	<b>uc</b>	F	matF; magF; ysF		F/OC
<i>Microtopias quixensis</i>	L-800	uc-co	uc-co	uc-fc	uc?	F	magF; ysF; matF; F/OC; mcPL; F/R	tgF; guaB; clF	
<i>Cercomacra tyrannina</i>	L-1400	fc-co	fc-co	(fc?)	(fc?)	OC	mcPL; OC/R; F/OC; psOC	ysSC; gsR/V	ysF; clF; strF
<i>Hylophylax naeviusoides</i>	L-500	<b>fc-co</b>	<b>fc-co</b>	<b>uc-fc</b>	(ra?)	F	matF; magF; ysF; F/OC	tgF	ysSC

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m)	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF	habitat <sup>c</sup>			
<i>Myrmeciza immaculata</i>	L-2000	uc-fc	uc-fc	uc-fc	uc-fc	F	matF; magF; ysF	strF; tgF	F/OC; F/R; clF; ysSC
<i>Myrmeciza exul</i>	L-1500	co	co	co	fc-co	F	F/R	tgF; clF	mcPL; ysSC
<i>Myrmeciza nigricauda</i>	250*-1300	-	-	vr	<b>uc-fc</b>	F	matF; magF; ysF	inF	
<i>Myrmeciza borleschi</i>	L-650	ra	<b>uc-fc</b>	<b>uc-fc</b>	ra	F	magF; ysF; matF; F/OC; F/R; mcPL	tgF; clF; ysSC	OC/R
<i>Gymnophis leucapis</i>	L-900	uc-co	uc-co	uc-co	uc-fc	F	matF; magF; ysF; F/OC	tgF	ysSC
<i>Phaeoictictus inclanmani</i>	L-700	<b>uc</b>	<b>uc</b>	<b>uc</b>	(ra?)	F	matF; magF	inF; tgF	ysF; F/OC
FORMICARIIDAE (3)									
<i>Formicarius nigricapillus</i>	L-1300	uc-fc	uc-fc	uc-fc	uc-fc	F	magF; ysF; matF; F/OC; F/R	strF; HEL	
<i>Pittaoma rufipilatum</i>	70*-700 (1000)	vr	<b>ra-uc</b>	<b>uc</b>	<b>ra-uc</b>	F	matF; magF; ysF	inF; tgF	
<i>Hylopezus perspicillatus</i>	L-800	<b>uc</b>	<b>uc-fc</b>	<b>uc-fc</b>	(ra?)	F	matF; magF	inF	ysF; F/OC
RHINOCRYPTIDAE (1)									
<i>Scytalopus chocoensis</i>	350-950	-	-	vr	<b>uc-fc</b>	F	matF; magF; ysF		(F/OC?)
TYRANNIDAE (49)									
<i>Phylomyias griseiceps</i>	L-1350	<b>uc</b>	ra	(ra?)	(ra?)	OC	mcPL; OC/R; F/OC	ysSC	
<i>Zimmerius thrysops</i>	L-1600	fc-co	fc-co	fc-co	fc-co	F	matF; magF; ysF; F/OC; F/R; mcPL	clF	
<i>Ornithion brunneiicapillus</i>	L-800	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	ra-uc?	F	matF; magF; ysF; F/OC; F/R; mcPL	clF	
<i>Camptostoma obscurum</i>	L-2800	uc-fc	uc	(ra?)	(ra?)	OC	mcPL; OC/R; psOC	ysSC	F/OC
<i>Tyrannulus alatus</i>	L-600 (950)	uc-fc	uc	(ra-uc?)	(ra?)	OC	mcPL; OC/R; F/OC	ysSC	F/R; psOC
<i>Myiophaps caniceps</i>	L-500	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	F	matF; magF; F/OC		ysF; mcPL; F/R
<i>Myiophaps viridicata</i>	L-500 (1000)	<b>ra-uc</b>	oc	oc	(oc?)	F/E	F/OC; OC/R; mcPL; F/R	ysSC	ysF; magF; matF
<i>Elanina flavogaster</i>	L-1300 (1800)	<b>ra-uc</b>	ac	(ac?)	(ac?)	OC	mcPL; psOC	ysSC	
<i>Serpophaga cinerea</i>	(60*) 300-3100	-	ac?	ac?	<b>(uc-fc?)</b>	R/E	F/R; OC/R	faR; gvR/E	
<i>Monectes olivaceus</i>	50*-2000	uc[-fc]	fc[-co]	fc[-co]	fc[-co]	F	matF; magF; ysF; F/OC; F/R	ysSC; clF	mcPL
<i>Monectes olivaceus</i>	L-1000 (1600)	ra[-fc]	ra[-fc]	(ra-uc?)	(ra-uc?)	F/E	F/OC; F/R; mcPL; ysF	ysSC; tsR/V	magF; matF
<i>Lepidopogon superciliosus</i>	50*-1500	uc	uc-fc	uc-fc	fc?	F	matF; magF; ysF; F/OC	strF	
<i>Myiornis atricapillus</i>	L-800	fc-co	fc-co	fc-co	(uc-fc?)	F	matF; magF; ysF; F/OC; F/R; mcPL	tgF; ritF; dF; ysSC	
<i>Lophortyx ptilatus</i>	L-1700	uc-co	uc-co	(uc-fc?)	(uc-fc?)	F/E	F/OC; F/R; mcPL; ysF	ysSC; guab; dF; strF	
<i>Todirostrum nigricaps</i>	L-900	uc-fc	uc-fc	uc-fc	uc-fc	F	matF; magF; ysF; F/OC; F/R; mcPL	tgF; clF; ritF	

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWFF	PmWF	PmPF				
<i>Todirostrum cinereum</i>	L-1500	fc-co	uc-co	(uc-fc?)	(uc-fc?)	OC	mcPL; OC/R; F/OC; F/R; psOC	tsR/V; ysSC	
<i>Rhynchocyclus pacificus</i>	L-800	uc-fc	uc-fc	uc-fc	(uc?)	F	matF; magF	inF	ysF; F/OC; F/R
<i>Tolmomyias flavotectus</i>	L-500	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	F	matF; magF; ysF; F/OC; F/R; mcPL	tgF; dLF	
<i>Platyrinchus coronatus</i>	L-700 (900?)	fc	fc	fc	uc-fc?	F	matF; magF	inF	ysF; F/OC
<i>Myiornis ornatus</i>	350*-2000 (2300?)	-	-	ra	<b>uc-fc</b>	F	matF; magF; ysF; F/OC	tgF; dLF	
<i>Terenotriccus erythrurus</i>	L-1000	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	matF; magF; ysF	inF	F/OC; F/R
<i>Myiobius atricaudus</i>	L-1000 (1300)	uc[-fc]	uc[-fc]	(uc-fc?)	(uc-fc?)	F/E	F/OC; F/R; mcPL	tsR/V; ysSC; guaB	
<i>Myiobius sulphureipigius</i>	L-1000 (1300)	uc[-co]	uc[-co]	uc[-co]	(uc-fc?)	F	matF; magF; ysF	inF; strF	F/OC
<i>Myiobius villosus</i>	600-1700	-	-	-	( <b>uc-fc?</b> )	F	matF; magF; ysF	inF; strF	
<i>Myiophobus fasciatus</i>	L-1500 (2000)	uc	ra-uc	(ra-uc?)	(ra-uc?)	OC	mcPL; psOC; OC/R	ysSC	
<i>Mitrephanes phaeocercus</i>	100-600	-	<b>uc</b>	<b>uc-fc</b>	ra-uc?	F	matF; magF	tgF; ritF; dLF	F/OC; ysF
<i>Conopus cooperi</i>	L-1500	oc	oc	(oc?)	(oc?)	F/E	F/OC; mcPL; OC/R	magF; ysF; matF; F/OC; dLF; ysSC	psOC
<i>Empidonax virens</i>	L-1500 (3400)	uc-fc	uc-fc	uc	(uc?)	F	F/R; mcPL		
<i>Sayornis nigricans</i>	80*-2800	-	-	uc-fc	(fc?)	R/E	F/R; OC/R	gyR/E; faR	matF; magF; ysF
<i>Colonia colinus</i>	L-1100	uc-fc	uc-fc	uc-fc	(uc-fc?)	F/E	F/OC; OC/R; mcPL; F/R	dLF; ysSC; tgF	matF; magF; ysF; OC/R
<i>Atila spadiceus</i>	L-1300 (2000)	uc-fc?	uc	(ra-uc?)	(ra-uc?)	F/E	F/OC; F/R; mcPL	clF	ysF; F/OC; F/R
<i>Rhytiperna holerythra</i>	L-700	uc	uc-fc	uc-fc	uc?	F	matF; magF	tgF	ysF; F/OC; F/R; mcPL
<i>Sirystes albobrisens</i>	L-500	<b>uc</b>	<b>uc</b>	<b>ra-uc</b>	(ra?)	F	matF; magF; F/OC		
<i>Myiarchus tuberculifer</i>	L-1500 (2700)	uc-fc	uc	(uc?)	(uc?)	F/E	F/OC; mcPL; OC/R; F/R	clF; ysSC	
<i>Megarynchus pitangua</i>	L-1300 (1900)	uc-fc	uc	(uc?)	(uc?)	F/E	F/OC; OC/R; mcPL; F/R; psOC		
<i>Myiozetetes similis</i>	L-1300 (2400)	uc	ra-uc	(ra?)	(ra?)	OC	mcPL; psOC; OC/R	ysSC	
<i>Myiozetetes cayanensis</i>	L-1400	fc-co	fc-co	(fc?)	(fc?)	OC	mcPL; psOC; OC/R; F/R; F/OC	tsR/V; ysSC	
<i>Myiozetetes gundensis</i>	L-1300	fc-co	fc-co	(fc?)	(fc?)	OC	mcPL; psOC; OC/R; F/R; F/OC	tsR/V; ysSC	
<i>Conopias albonotatus</i>	L-500 (900?)	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	ra-uc?	F	matF; magF; F/OC; F/R	tgF; ritF; dLF	mcPL; ysF
<i>Myiodynastes macularis</i>	L-1000	<b>ra</b>	oc	(oc?)	(oc?)	OC	mcPL; OC/R; F/OC; psOC	ysSC	
<i>Legatus leucophaeus</i>	L-1300 (1600)	uc-co	uc-co	uc-fc	(uc-fc?)	F/E	F/OC; F/R; mcPL; OC/R; psOC	dLF; ysSC	strF
<i>Tyrannus melancholicus</i>	L-1500 (2800)	uc-fc	uc-fc	uc-fc	(uc-fc?)	OC	psOC; OC/R; mcPL	tsR/V; ysSC	
<i>Tyrannus niveigularis</i>	L-700 (1350)	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	(ra-uc?)	OC	mcPL; OC/R; F/OC; psOC		matF; magF; ysF; F/R

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF				
<i>Tyrannus tyrannus</i>	L-1300 (3700)	oc	oc	oc	(oc?)	F/E	F/OC; F/R; OC/R; mcPL; psOC		
<i>Pachyramphus cinnamomeus</i>	L-1500	uc-co	uc-co	uc-co	uc-co	F/E	F/OC; F/R; mcPL; OC/R	tsR/V	matF; magF; cLF
<i>Pachyramphus albobasis</i>	L-2000 (2500)	ra?	oc	oc	(ra-uc?)	F	matF; magF; ysF; F/OC		
<i>Platypsaris homochrous</i>	L-1000 (1500)	uc-fc?	ra-uc	(ra-uc)	(ra-uc?)	F/E	F/OC; OC/R; F/R; mcPL; matF; magF; ysF;	cLF; tgF; ysSC	
<i>Tijuya semifasciata</i>	L-1500	ra-fc	ra-fc	ra-fc	(ra-fc)	F/E	F/OC; F/R; mcPL; OC/R	cLF	matF; magF; ysF
<i>Tijuya inquisitor</i>	L-700	(ra-uc?)	vr	(vr)	(vr?)	F/E	F/OC; F/R; mcPL; OC/R	cLF	matF; magF; ysF
COTINGIDAE (6)									
<i>Laniocera rufescens</i>	L-500	ra-uc	ra-uc	ra	(vr?)	F	matF; magF	inF	ysF; F/R
<i>Lipaugus unirufus</i>	L-700	uc-fc	uc-fc	fc-co	uc-fc	F	matF; magF	inF; ritF	ysF; F/OC; F/R
<i>Cotinga nattererii</i>	L-300 (900)	ra-uc	ra	(ra?)	(vr?)	F	matF; magF; ysF; F/OC; F/R; mcPL	cLF; tsR/V	
<i>Carpodectes hopkei</i>	L-700 (1450?)	ra-uc	ra	ra-uc	(vr)	F	matF; magF	ritF; tgF; cLF	ysF; F/OC; F/R; mcPL
<i>Querula purpurata</i>	L-700	uc-fc	ra-fc	ra-fc	(ra-uc?)	F/E	F/OC; F/R	ritF; cLF; strF	matF; magF; ysF; mcPL
<i>Cephalopterus penduliger</i>	80-1500 (1800?)	ra	ra	ra	uc	F	matF; magF	cLF	ysF; F/OC; F/R
PIPIRIDAE (8)									
<i>Pipra mentalis</i>	L-500	uc-vc	uc-vc	uc-co	(ra-fc?)	F	magF; ysF; F/OC	tgF; cLF; ysSC	matF; mcPL; F/R
<i>Lepidothrix coronata</i>	L-900	fc-vc	fc-vc	fc-vc	fc-co	F	matF; magF; ysF; F/OC	tgF; cLF	mcPL; F/R; ysSC
<i>Masius chrysopterus</i>	(100?) 400-2000	-	(oc?)	(oc?)	(ra-uc?)	F	matF; magF; ysF; F/OC	tgF; cLF	
<i>Manacus manacus</i>	L-800 (1300)	uc-vc	uc-vc	uc-co	(uc-fc?)	F/E	F/OC; F/R; OC/R; mcPL; ysF	cLF; ysSC	matF; magF; tgF
<i>Machaeropterus deliciosus</i>	(50*) 600-1500	oc?	ra[-uc]	ra[-uc]	(uc?)	F	matF; magF; ysF; F/OC	tgF; cLF	mcPL; ysSC; F/R
<i>Chloropipo holochlora</i>	60*-1100	(ra-uc?)	uc[-fc]	uc[-co]	(uc-co)	F	matF; magF; ysF;	inF; tgF	
<i>Schiffornis turdina</i>	L-1300	ra-uc	ra-fc	uc-fc	uc-fc?	F	matF; magF	inF	ysF; F/OC
<i>Sapsayoa aenigma</i>	L-500 (900?)	ra-uc	fc	uc-fc	(ra-uc?)	F	matF; magF; ysF	inF; strF	
VIREONIDAE (4)									
<i>Vireolanus leucotis</i>	70*-1100	ra?	ra-fc	fc	uc-fc	F	matF; magF; F/R		F/OC
<i>Vireo olivaceus</i>	L-3250	oc	oc	oc	oc	F/E	F/OC; F/R; OC/R; mcPL; matF; magF; ysF	ysSC	
<i>Hylophilus decuratus</i>	L-1100 (1400)	fc-co	fc-co	uc-fc	(uc-fc?)	F	matF; magF; ysF; F/R; F/OC; mcPL	cLF; ysSC	
<i>Hylophilus ochraceiceps</i>	L-750	ra-uc	uc-fc	ra-uc	(ra-uc?)	F	matF; magF	inF	ysF
TURDIDAE (5)									
<i>Myadestes ralloides</i>	(100?) 800-2500	-	(oc?)	(oc?)	(ra?)	F	matF; magF; ysF; F/OC		
<i>Cichlopsis leucogenys</i>	(100*) 500-1200	-	oc?	oc?	(ra-uc?)	F	matF; magF; ysF; F/OC		

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m)	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF				
<i>Catharus ustulatus</i>	L-3000 (3800)	oc	oc	oc	(uc-fc?)	F	magf; ysf; matf; F/OC; mcPL	clF; ysSC	
<i>Turdus obsoletus</i>	(200) 450-1100	-	-	oc?	<b>ra-uc</b>	F	matf; magf; F/OC	ysF; dF	
<i>Turdus daguae</i>	L-600 (900?)	<b>fc-co</b>	<b>fc-co</b>	<b>fc-co</b>	(ra-uc?)	F	matf; magf; ysf; F/OC; F/R; mcPL	clF	
<b>HIRUNINIDAE (9)</b>									
<i>Progne chalybea</i>	L-2000 (2600)	<b>fc-vc</b>	ra-uc	(ra-uc?)	(ra-uc?)	OC	psOC; OC/R; mcPL		
<i>Progne subis</i>	L-3000	(oc?)	(oc?)	(oc?)	(oc?)	NP	NP		
<i>Tachycineta bicolor</i>	L-2800	(ac?)	ac?	(ac?)	(ac?)	R/E	OC/R		
<i>Notiochelidon cyanoleuca</i>	(0) 500-3000	ra-uc	oc	(oc)	<b>(uc-fc?)</b>	OC	F/R; psOC; OC/R; mcPL	(SE)	
<i>Neochelidon tibialis</i>	L-800 (1000?)	uc-fc	uc-fc	uc-fc	uc-fc	F/E	F/OC; F/R; mcPL; OC/R; matf; magf; ysf	clF	
<i>Selgadopteryx ruficollis</i>	L-1500	uc-co	uc-co	uc-fc	(uc-fc?)	R/E	F/R; OC/R	strOC; baR	mcPL; psOC
<i>Riparia riparia</i>	L-2500	oc	oc	(oc)	(oc)	OC	psOC; OC/R; mcPL		
<i>Hirundo rustica</i>	L-4000	uc-fc	uc-fc	uc-fc	(uc-fc?)	R/E	F/OC; F/R; psOC		mcPL
<i>Petrochelidon pyrrhonota</i>	L-4000	oc	oc	(oc)	(oc)	OC	psOC; OC/R; mcPL		
<b>TROGLODYTIDAE (8)</b>									
<i>Campylorhynchus zonatus</i>	L-800	ra-fc	ra-fc	ra-fc	ra-fc	F/E	F/OC; SE; mcPL	ritF; clF	matf; magf; ysf
<i>Odontorhynchus brunickii</i>	50*-500 (1100?)	ra?	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	F	matf; magf	tgF	F/OC
<i>Thryothorus nigricapillus</i>	L-1400	uc-co	uc-co	uc-co	uc-co	R/E	F/R; OC/R	tsR/V; strf; clF; ysSC	strOC; F/OC; mcPL
<i>Thryothorus leucopogon</i>	L-750	ra-fc	<b>co</b>	<b>fc-co</b>	ra-uc	F	matf; magf; ysf		F/OC; F/R
<i>Troglodytes aedon</i>	L-3300	fc-co	fc	(fc?)	(fc?)	S	SE		
<i>Henicorhina leucosticta</i>	L-900	fc-co	fc-co	co	co	F	matf; magf	inf; tgF	ysF; F/OC
<i>Cyphorhinus phaeocephalus</i>	L-900	uc	uc	uc	uc	F	matf; magf	inf	ysSC
<i>Microcerulus marginatus</i>	L-1300	co	co	co	uc-co?	F	matf; magf; ysf; F/OC; F/R		
<b>POLOPTILIDAE (3)</b>									
<i>Microbates cinereiventris</i>	L-1000	fc-co	fc-co	fc-co	fc-co	F	matf; magf; ysf	inf; tgF	
<i>Polioptila plumbea</i>	L-1500 (1900)	uc-fc	uc-fc	(uc?)	(ra-uc?)	OC	mcPL; psOC; OC/R	tsR/V; ysSC	F/OC; F/R
<i>Polioptila schistaceigula</i>	L-750	uc[-fc]	uc[-fc]	uc[-fc]	(ra-fc?)	F	matf; magf; ysf; F/OC	tgF	mcPL
<b>PARULIDAE (10)</b>									
<i>Dendroica striata</i>	L-800 (2800)	(ac?)	ac?	(ac?)	(ac?)	F/E	mcPL; F/OC; matf; magf; ysf	ysSC; clF	
<i>Dendroica fusca</i>	(60*) 900-2800	(oc?)	oc	(oc)	(oc)	F	magf; ysf	ysSC	
<i>Dendroica pensylvanica</i>	L-800	(ac?)	ac	(ac?)	(ac?)	F/E	mcPL F/OC; magf	ysF; tgF	



## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m)	Abundance rank per life zone <sup>b</sup>					General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF					
<i>Sciturus noveboracensis</i>	L-400 (2000?)	oc	oc	(oc)	(oc)	R/E	F/R; OC/R	tsR/V; strf; strOC; ysSC		
<i>Geothlypis semiflava</i>	L-1500 (2300)	uc	uc	(ra-uc?)	(ra-uc?)	OC	psOC; OC/R	gsR/V; strOC; ysSC		mcPL
<i>Geothlypis auricularis</i>	L-1100 (1500)	(uc?)	ra	?	?	OC	psOC; OC/R; mcPL	gsR/V; ysSC		
<i>Oporornis philladelphica</i>	L (2500?)	(ac?)	ac?	(ac?)	(ac?)	OC	psOC; OC/R; mcPL	gsR/V; strOC; ysSC		
<i>Oporornis agilis</i>	L (?)	(ac?)	ac?	(ac?)	(ac?)	OC	psOC; OC/R; mcPL; F/OC	gsR/V; strOC; ysSC		matf; magf; ysF
<i>Basiluterus chlorophrys</i>	400-1200	-	-	-	<b>ra-co</b>	F	matf; magf; ysF; F/OC			
<i>Basiluterus fuscicauda</i>	L-1000	uc-fc	uc-fc	uc-fc	uc-fc	R/E	F/R; OC/R	tsR/V; strf; strOC		
THRAUPIDAE (36)										
<i>Coereba flavola</i>	L-1300 (1800)	uc-co	uc-co	uc-co	uc-co	F/E	F/OC; F/R; OC/R; mcPL; psOC; SE	ysSC; tsR/V		matf; magf; ysF
<i>Cyanerpes caeruleus</i>	L-1200	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	matf; magf; ysF; F/OC			
<i>Cyanerpes cyaneus</i>	L-300 (1200?)	uc-fc	uc-fc	(uc-fc?)	(ra?)	R/E	F/R; OC/R; mcPL; psOC	tsR/V		F/OC
<i>Chlorophanes spiza</i>	L-1100	uc[-fc]	uc[-fc]	uc[-fc]	(uc?)	F	matf; magf; ysF; F/R; F/OC; mcPL	clf; ysSC		
<i>Dacnis cayana</i>	L-1000	uc[-fc]	uc[-fc]	uc[-fc]	uc[-fc]	F	matf; magf; ysF; F/R; F/OC; mcPL	clf; ysSC		
<i>Dacnis egregia</i>	L-900	uc[-fc]	uc	(uc?)	(uc?)	F/E	F/OC; mcPL; OC/R; F/R	ysSC; clf		matf; magf; ysF
<i>Dacnis venusta</i>	L-800	ra[-uc]	ra[-uc]	ra[-uc]	ra[-uc]	F	matf; magf; ysF; F/R; F/OC; mcPL	clf; ysSC		
<i>Dacnis berlepschi</i>	L-600	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc</b>	(ra-uc?)	F	matf; magf; ysF; F/R; F/OC; mcPL	clf; tgF; tsR/V; ysSC		
<i>Erythroblyps salmوني</i>	50-700	ra?	<b>uc-fc</b>	<b>fc-co</b>	<b>uc-fc</b>	F	matf; magf; ysF; F/OC	ritf		
<i>Chlorophonia flavirostris</i>	450*-1500	-	(oc?)	(oc?)	<b>ra-uc?</b>	F	matf; magf; ysF; F/OC	clf		
<i>Euphonia lanirostris</i>	L-1500 (1800)	uc-fc	uc-fc	(uc?)	(uc?)	OC	mcPL; psOC; OC/R; F/OC	ysSC		
<i>Euphonia xanthogaster</i>	L-2000 (2750)	fc-co	co	fc-co	fc-co	F	matf; magf; ysF; F/R; F/OC; mcPL	clf; tsR/V; ysSC		
<i>Euphonia minuta</i>	L-700	uc[-fc]	ra[-uc]	ra[-uc]	(ra-uc?)	F	matf; magf; F/OC	clf		ysF; mcPL; ysSC
<i>Euphonia fulvicaesa</i>	L-500	<b>uc-fc</b>	<b>uc-fc</b>	<b>uc-fc</b>	(ra-uc?)	F	matf; magf; F/OC	clf		ysF; mcPL; ysSC
<i>Tangara rufigula</i>	450*-1400	-	-	(ra?)	ra[- <b>fc</b> ]	F	matf; magf; F/OC	clf		ysF
<i>Tangara palmeri</i>	50*-1000	ra?	<b>uc-fc</b>	<b>fc</b>	( <b>fc?</b> )	F	matf; magf; F/OC	clf		mcPL
<i>Tangara florida</i>	150*-1200	-	vr[-ra]	ra[- <b>uc</b> ]	uc[- <b>fc</b> ]	F	matf; magf; F/OC	clf; tgF		ysF
<i>Tangara cyanicollis</i>	L-1400	uc-fc?	uc	(ra-uc?)	(ra-uc?)	OC	psOC; mcPL; F/OC; F/R; OC/R	ysSC		
<i>Tangara larvata</i>	L-800	uc-fc	uc-fc	(uc?)	(uc?)	F/E	F/OC; OC/R; mcPL; psOC	ysSC; clf		

## APPENDIX 8. Continued.

Scientific name	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
Family (no. spp.) / species		TrHF	TrWF	PmWF	PmPF				
<i>Tangara johannae</i>	L-700 (900)	uc[-fc]	uc[-fc]	uc[-fc]	(ra-uc?)	F	matf; magf; F/OC		
<i>Tangara gnyola</i>	L-1500	<b>uc</b>	vr	?	?	OC	psOC; mcPL		ysf; mcPL
<i>Tangara lavinia</i>	L-750	ra?	uc[-co]	uc[-fc]	uc[-fc]	F	matf; magf; ysf; F/OC; mcPL	clF; ysSC	
<i>Bangsia rothschildi</i>	100-600	-	(ra?)	ra[-uc]	(ra?)	F	matf; magf	inF	ysF
<i>Bangsia eduardi</i>	450*-1700	-	-	-	<b>ra-fc</b>	F	matf; magf; F/OC	clF	ysF
<i>Tersina viridis</i>	50-1400	ra	(ra?)	(ra?)	ra(-fc?)	F/E	F/OC; mcPL	clF	
<i>Thraupis episcopus</i>	L-1500 (2500)	uc-co	uc-co	uc-fc	(uc-fc?)	OC	psOC; mcPL; OC/R; F/OC	ysSC; tsR/V	F/R; SE
<i>Thraupis palmarum</i>	L-1300 (1900)	uc-fc	uc-fc	(uc?)	(uc?)	OC	psOC; mcPL; F/OC; OC/R	ysSC; clF	F/R; SE; ysf; magF
<i>Ramphoctes icteronotus</i>	L-1600	fc-co	uc-co	uc-co	(uc-fc?)	OC	psOC; mcPL; OC/R; F/OC	ysSC; tsR/V; clF	F/R
<i>Pinanga rubra</i>	L-1500 (2800)	uc	uc	uc	uc	OC	mcPL; F/OC; OC/R	ysSC	
<i>Chlorothraupis olivacea</i>	L-450	ra-fc	<b>fc-co</b>	<b>uc-co</b>	(ra?)	F	matf; magf		ysF; F/OC
<i>Chlorothraupis stolemanni</i>	(350*) 400-1500	-	-	ra	<b>fc-co</b>	F	matf; magf		ysF; F/OC
<i>Mitrospingus cassinii</i>	L-800	uc-fc	uc-fc	uc-fc	(uc?)	R/E	F/R; F/OC; mcPL	tsR/V; ysSC; clF; strf	
<i>Tachyphonus rufus</i>	L-1700	<b>ra-fc</b>	vr	(vr?)	(vr?)	OC	psOC; mcPL	ysSC	
<i>Tachyphonus luctuosus</i>	L-1300	ra-fc?	ra-uc	ra-uc	(ra-uc?)	F	matf; magf; ysf; F/OC; mcPL	clF; ysSC	
<i>Tachyphonus delatarii</i>	L-800	ra-fc	fc-vc	uc-fc	ra-fc	F	matf; magf; ysf; F/R; F/OC	clF; tsR/V; ysSC	mcPL
<i>Heterospingus xanthopygius</i>	50-800	ra-uc	fc	fc	uc-fc	F	matf; magf; F/OC	clF	ysF
<b>CARDINALIDAE (5)</b>									
<i>Salator maximus</i>	L-1300 (1500)	uc-co	uc-co	uc-fc	(uc-fc)	OC	mcPL; psOC; OC/R; F/OC	ysSC; clF	F/R
<i>Salator atripennis</i>	50*-1500	?	uc-fc	uc-fc	uc-fc	F/E	F/OC; mcPL; OC/R	ysSC; clF	F/R
<i>Salator grossus</i>	L-1200	uc-fc	uc-fc	uc-fc	uc-fc	F/E	F/OC; F/R; magf; ysf; mcPL	clF; ritf	matF
<i>Pheucticus ludovicianus</i>	L-3300	(oc?)	oc?	(oc?)	(oc?)	F/E	F/OC; mcPL	ysSC	
<i>Cyanocitta cyanoides</i>	L-1300 (1700)	<b>uc</b>	vr	(vr?)	(vr?)	F	magf; ysf; F/OC; F/R; mcPL	clF	
<b>EMBERIZIDAE (10)</b>									
<i>Rhodospingus cruentus</i>	L-500 (900)	(ra-uc?)	oc?	-	-	OC	OC/R; mcPL; F/OC	ysSC	
<i>Volatinia jacarina</i>	L-1400 (2500)	uc-fc	ra	(ra?)	(ra?)	OC	psOC; mcPL; OC/R	gsR/V; ysSC	
<i>Tiuris obscurus</i>	L-1400 (1750)	ra-fc	ra-uc	(ra?)	(ra?)	OC	mcPL; F/OC; OC/R	ysSC	psOC
<i>Oryzoborus angolensis</i>	L-1200	fc	fc	(uc-fc?)	(uc-fc?)	OC	psOC; mcPL; OC/R	gsR/V; ysSC	F/OC

## APPENDIX 8. Continued.

Scientific name Family (no. spp.) / species	Altitudinal range in western Ecuador (m) <sup>a</sup>	Abundance rank per life zone <sup>b</sup>				General habitat <sup>c</sup>	Main habitat types <sup>d</sup>	Important microhabitats <sup>e</sup>	Less important habitats and microhabitats <sup>f</sup>
		TrHF	TrWF	PmWF	PmPF				
		fc-co	fc-co	(fc?)	(fc?)	OC	mcPL; OC/R; F/OC; psOC	gsR/V; cLF; ysSC	
<i>Sporophila corvina</i>	L-1500					OC			
<i>Sporophila luctuosa</i>	L-2400	(oc?)	oc?	(oc?)	(oc?)	OC	psOC; OC/R		
<i>Sporophila nigricollis</i>	L-2400	uc	uc	(uc?)	(uc?)	OC	psOC; OC/R; mcPL	gsR/V; ysSC	
<i>Sporophila telasco</i>	L-500 (1400)	ra-fc	oc	(oc?)	(oc?)	OC	psOC; OC/R		
<i>Arremon aurantirostris</i>	L-1350	uc-fc	uc-fc	(uc-fc?)	(uc-fc?)	F/E	F/OC; F/R; mcPL; ysF	cLF; ysSC; strf	
<i>Arremonops conirostris</i>	L-1400	uc	ra	(ra?)	(ra?)	OC	psOC; mcPL; OC/R	ysSC	
ICTERIDAE (7)									
<i>Cactus microhynchus</i>	L-1300	uc-co	uc-co	uc-co	(uc-fc?)	F	matF; magF; ysF; F/OC; F/R; mcPL	cLF	
<i>Amblycercus holosericeus</i>	L-1700	<b>uc</b>	ra	(ra?)	(ra?)	F/E	F/OC; mcPL; ysF	ysSC; strOC	
<i>Zarhynchus uugleri</i>	L-700	ra-uc	ra-uc	(ra-uc?)	(ra-uc?)	F/E	F/OC; F/R; OC/R; mcPL; ysF; magF	cLF	matF
<i>Molothrus bonariensis</i>	L-1600 (2700)	uc-fc	uc-fc	(uc?)	(uc?)	OC	psOC; OC/R; mcPL	ysSC	
<i>Molothrus oryzivorus</i>	L-2000	uc	uc	(ra?)	(ra?)	F/E	F/R; mcPL	ysSC; cLF; saR/E	psOC; OC/R
<i>Icterus mesomelas</i>	L-900 (1750)	<b>uc-fc</b>	vr	(oc?)	(oc?)	OC	F/OC; mcPL; OC/R	ysSC	F/R
<i>Dolichonyx oryzivorus</i>	L-300 (1300)	(oc?)	oc?	(oc?)	(oc?)	OC	psOC; OC/R; mcPL		

## APPENDIX 9

Birds of Playa de Oro: territoriality, foraging flocks and aggregations, use of strata, main foraging and survey strata, foraging guilds, and body masses. List of bird species recorded between Jun. 1993 and Nov. 2000 in the community of Playa de Oro, at elevations between about 50 and 450 m (own observations; P. Mena V., pers. comm.; Benítez & Matheus 1997; and other observers mentioned in Appendix 6); see page 117 for additional species that could not be included in the data analysis. Each species was assigned to a 'category of territoriality', that is influenced by their natural history and greatly affects their detectability in bird surveys (cf. Chapter 4). For resident pair- or family-clan-forming species, which advertise (e.g., by producing sounds) and actively defend (e.g., by challenging or attacking intruders) breeding and/or foraging territories, I estimated the size class of the territories. However, for species breeding in colonies or gathering in single-species foraging flocks, and which usually do not defend territories against members of the same species, I opted to estimate the size of their home ranges. For a given species, the size of the home range may be considerably larger than the territory. In the case of species that do not form pairs, but the males of which establish either display territories or leks to attract females, I indicated this behavior without estimating the size of display or foraging territories, which are usually small (<10 ha) if established at all. Likewise, I have not estimated the size of temporary feeding territories established by some of the non-breeding visitors. The territory size and home range classes were estimated on the basis of the observed densities of the species (Appendices 18b & 19b), as well as with the help of the information presented for the same species or sister taxa by other authors (e.g., Willis 1974, Thiollay 1989b, Terborgh *et al.* 1990), and should be regarded as preliminary. For all species, I state whether the participation in foraging flocks or foraging associations was observed in the study area or elsewhere, as well as the relative frequency with which this behavior was noted or reported in the literature (see below). Furthermore, I define the types of the flocks that the species normally attend. The 'strata used' embraces all strata the species use regularly (e.g., for foraging and roosting) or during certain phases of the life cycle (e.g., for the collection of nest material or for nesting) within the Ecuadorian Chocó. However, water is mentioned only for species that are either aquatic (e.g., kingfishers) or regularly catch their prey directly above water bodies (e.g., some swallows). Likewise, the airspace is listed exclusively for species regularly observed 'on the wing' above the canopy, open landscapes, or water bodies. This includes some vagrant seabirds (e.g., *Fregata magnificens* and *Larus pipixcan*), soaring non-passerines (e.g., American vultures, some diurnal raptors), and small to medium-sized aerial insectivores (e.g., swifts and swallows), but excludes all kinds of sallying insectivores and sallying omnivores (e.g., *Nyctidromus albigollis*, trogons, motmots, flycatchers, and others), as well as all hummingbirds. The list of strata used is probably still incomplete in many cases. For some species the 'main survey stratum', which is defined here as the stratum where most records for a species were, or might be, obtained in audiovisual surveys, does not coincide with one of the preferred 'foraging strata' of the species. This is especially the case for birds frequently vocalizing in strata that are different from their main foraging strata. Therefore both categories are listed separately here. The 'main foraging strata' refer to the strata most frequently used by the species to obtain their food. This here includes the entire process of searching for food, collecting or catching as well as consuming it (e.g., *Pandion haliaetus* hunts on the wing, flying slowly and hovering briefly c. 5–40 m above shallow water, then performs a steep dive to catch a surface fish and, if successful, flies off to a feeding perch, usually a bare branch or treetop, where the fish is eaten; thus, the main foraging strata of the Osprey are airspace, water, and treetops). For each species I chose only a single 'main survey stratum' where the species was most frequently noted in the study area. For species not recorded in audiovisual surveys, I selected the stratum where they would most likely be detected in such surveys according to the literature and own observations from other sites. Note that the 'airspace' was selected as the 'main survey stratum' whenever a species was most frequently recorded in flight (e.g., species that are often silent when perched but loudly call in flight, like parrots). In other words, the airspace was listed here also for species for which it was not mentioned in the previous two categories ('strata used' and 'main foraging strata'). In this study, the 'main survey stratum' was used to compare the efficiency of bird detection between different survey methods (cf. Chapter 4; Appendices 17a–17c). Of course, the selection of a single 'main survey stratum' might be somewhat arbitrary in some cases. Especially for rarely recorded species, the assignment of the stratum might be biased due to small sample size or misleading information in the literature. In general, for species regularly producing sounds, I selected the stratum where they were most frequently heard, and for species that are basically silent I chose the stratum where

they were seen most often. The assignment of species to broad diet categories and foraging guilds was based on the information presented in del Hoyo *et al.* (1992, 1994, 1996, 1997, 1999, 2001, 2002, 2003) and in Stiles & Skutch (1989), as well as on my own observations. All species not predominantly using a certain food resource during most seasons of the year are listed as omnivorous. For species in which the body mass differs considerably between sexes, the mean or the range was given for males and females separately. If this information was not available, or the difference between sexes was minimal, I stated the body mass in the known range for unsexed individuals. Abbreviations used: (a) category of territoriality; SMT = small territory ( $\leq 10$  ha); MST = medium-sized territory (11–30 ha); LAT = large territory (31–90 ha); VLT = very large territory ( $\geq 91$  ha); SHR = small home range ( $\leq 10$  ha); MHR = medium-sized home range (11–30 ha); LHR = large home range (31–90 ha); VHR = very large home range ( $\geq 91$  ha); DIT = display territory; usually small territories established by males of some species to attract females; the females usually perform all nesting activities; LEK = lek; aggregation of several-to-many males at a communal courtship display site where they attract females; the females usually perform all nesting activities; PSL = 'pseudo-lek'; singing aggregation of trogons with unknown biological function (cf. Collar 2001: 93–94); COL = breeding-colony-forming species; species for which the existence of breeding colonies has been confirmed or suspected within the study area; COB = cooperative breeding species; species regularly living in 'extended' family groups of 5 to 12 birds, which cooperatively care for the nestling/s and fledgling/s of one shared clutch; CMR = species gathering in communal roosts; species for which the existence of roosting sites has been confirmed or suspected in the study area; NOT = non-territorial, non-breeding visitor, recorded predominantly on passage; includes long-distance and short-distance migrants, as well as stragglers; NBV-T = non-breeding visitor of which at least some individuals temporarily establish feeding territories; (b) foraging flocks and foraging aggregations: ant-f,FL = ant-following flock (a special case, as the ants are the attracting force, not the birds themselves; cf. Willis & Oniki 1978); mx-sp,ug-us,FL = undergrowth-to-understory-dwelling mixed-species flock; mx-sp,sw,FL = species attending mixed-species flocks in the 'understory' as well as 'canopy' and regularly 'switch' between them (cf. Munn & Terborgh 1979); mx-sp,ca,FL = canopy-dwelling mixed-species flock; mx-sp,f/e,FL = mixed-species flock inhabiting forest edge and plantations; suffix for species' attendance in the previous flock types: 1 = core species; present in almost all flocks of this type; 1L = core species that regularly act as flock leader; 2 = regular attendant, present in many flocks; species that have smaller territories and/or lower densities than the core species; 3 = rare-to-occasional attendants; aer,FL = aerial flock; single-species and mixed-species flocks of swifts or swallows (includes migratory taxa); mig,FL = migration flocks (without swifts and swallows); mx-sp,gs,FL = grassland-dwelling mixed-species flock; si-sp,gr,FL = ground-dwelling single-species flock; si-sp,ug-us,FL = undergrowth-to-understory-dwelling single-species flock; si-sp,ca,FL = canopy-dwelling single-species flock; si-sp,f/e,FL = single-species flock inhabiting forest edge and plantations; si-sp,gs,FL = grassland-dwelling single-species flock; np,non-f,FA = foraging aggregations of larger non-passerine species that form principally in non-forest habitats; i.e., single-species or mixed-species aggregations of vultures and aquatic birds; suffix for species' attendance in the previous nine flock types: I = permanently or regularly flocking species; II = occasionally or seasonally flocking species; III = occasionally or rarely flockings; (...) = the participation in this flock type was observed outside the study area or reported by other researchers (e.g., Hilty & Brown 1986, Stiles & Skutch 1989, Levey & Stiles 1994, Ridgely & Greenfield 2001a, and others); applies to all types of foraging flocks; (c) use of strata: wa = water; used for predominantly or partially aquatic species; gr = ground level; cl = cliff; i.e., rocky cliffs, waterfalls, and caves; ug = undergrowth; combined stratum of herbs, shrubs, and treelets (0 to  $4 \pm 1$  m); us = understory; stratum between the shrub layer and the base of the lowest branches of bigger trees ( $4 \pm 1$  m to c. 15 m); sc = subcanopy; embraces the layer of lower and inner branches of canopy trees as well as medium-sized trees and palms reaching up to this level (c. 15–25 m); ca = canopy; used for species feeding at or near the foliage-air interface in the upper or outer branches of canopy trees and emergent trees ( $>20 \pm 5$  m); some canopy-dwelling species regularly descend down to shrub level at forest borders and within tree-fall gaps; of = outer foliage; used for species frequently appearing at the outer foliage of shrubs, small trees, and/or canopy trees; tt = tree-tops and bare or dead snags; used for species frequently perching on exposed and elevated sites like tree-tops, wires, fence posts, and bare or dead snags of large trees; ai = airspace; see comments above; (d) main foraging strata: same abbreviations as in (c); (e) main survey stratum: same abbreviations as in (c); (...) = the assignment of the main survey stratum was likely biased by small sample size; (f) diet: broad diet categories: aqPL & aqIV = aquatic plant matter and some invertebrates; aqVE/aqIV = aquatic vertebrates and/or invertebrates; CAR = carrion; FT/SD = fruits and/or seeds; FT/smVE = fruits and/or seeds & invertebrates and/or small

vertebrates; NE & AR = nectar and some arthropods; lgIS = large insects; lgIS & FT = large insects and fruits; smIS & FT = small insects and fruits; VE = vertebrates; VE & lgIS = vertebrates and large insects; (g) main foraging guild: AQ = aquatic (without differentiation); SC = scavenger; ter,O = terrestrial omnivore (note: a species was regarded as omnivorous if plant matter as well as animal prey each provide at least one-third of the food resources on average); arb,gle,O = arboreal gleaner omnivore; arb,sal,O = arboreal sallying omnivore (here 'sallying' is used broadly to include species that hawk, hover, snatch, or strike [sensu Fitzpatrick 1981]; also includes the 'hover-gleaning' technique used by some flycatchers to collect fruits, seeds, and insects); ter,G = terrestrial granivore; st-fe,G = stem-feeding granivore; arb,G = arboreal granivore; ter,F = terrestrial frugivore; arb,F = arboreal frugivore; N = nectarivore (note that, apart from nectar, all hummingbirds also feed on pollen and regularly 'hover-glean' or 'hawk' for small arthropods, like insects and spiders); ter,gle,I = terrestrial gleaner insectivore; ter,sal,I = terrestrial sallying insectivore; ba-cl,sur,I = bark-climbing insectivore, feeding on surface; ba-cl,ter-in,I = bark-climbing insectivore, feeding in trunk interiors; arb,dl-se,I = arboreal dead-leaf-searching insectivore; arb,gle,I = arboreal gleaner insectivore; arb,sal,I = arboreal sallying insectivore; aer,I = aerial insectivore; aer,R = arboreal diurnal or nocturnal raptor; used for raptors hunting their prey almost exclusively in trees and shrubs; ter,arb,R = terrestrial and arboreal, diurnal or nocturnal raptor; used for raptors obtaining their prey from the ground as well as in the vegetation; (h) body mass: m = male; f = female; (...) = estimated; (i) Ref: references for body mass: 0 = estimated, 1 = this study, 2 = Dunning (1993), 3 = Cabot (1992), 4 = Martínez-Vilalta & Motis (1992), 5 = Houston (1994), 6 = Thiollay (1994a), 7 = White *et al.* (1994), 8 = Salaman (1994), 9 = del Hoyo (1994), 10 = Carroll (1994), 11 = Collar (1997), 12 = Marks *et al.* (1999), 13 = Thomas (1999), 14 = Cleere (1999), 15 = Schuchmann (1999), 16 = Collar (2001), 17 = Woodall (2001), 18 = Jahn *et al.* (2000), 19 = Short & Horne (2002), 20 = Krabbe & Schulenberg (1997), 21 = Stiles & Skutch (1989), 22 = Leutfield (1992).

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<b>TINAMIDAE (3)</b>									
<i>Tinamus major</i>	MST	(ant-f,FL:3)	gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	824-1337	2
<i>Crypturellus beltopschii</i>	MST?	ant-f,FL:3	gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	m= 430-527, f= 512-615	3
<i>Crypturellus soui</i>	SMT		gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	m= 165-204, f= 213-268	2
<b>FREGATIDAE (1)</b>									
<i>Fregata magnificens</i>	NOT	(np,non-f,FA:I)	wa; of; ai	wa; ai	ai	aqVE/aqIV	AQ	m= 1281, f= 1667	2
<b>PHALACROCORACIDAE (1)</b>									
<i>Phalacrocorax brasilianus</i>	NOT (CMR)	np,non-f,FA:I	wa; of; tt	wa	wa	aqVE/aqIV	AQ	m= 1260, f= 1070	2
<b>ANATIDAE (1)</b>									
<i>Anas discors</i>	NOT	mig,FL:I	wa; gr	wa	wa	aqPL & aqIV	AQ	m= 409, f= 363	2
<b>ARDEIDAE (6)</b>									
<i>Tigrisoma fasciatum</i>	MST?		wa; gr; ug; us; of	wa	wa	aqVE/aqIV	AQ	850	2
<i>Ardea alba</i>	NOT	(np,non-f,FA:II)	wa; gr; of	wa	wa	aqVE/aqIV	AQ	m= 935, f= 812	2
<i>Egretta thula</i>	NOT	(np,non-f,FA:II)	wa; gr; of	wa	wa	aqVE/aqIV	AQ	371	2
<i>Egretta caerulea</i>	NOT	(np,non-f,FA:II)	wa; gr; of	wa	wa	aqVE/aqIV	AQ	m= 364, f= 315	2

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
Family (no. spp.) / species	NOT (CMR) MST?	mig, FL:I	gr; of wa; gr; ug; of	gr wa	gr wa	lgIS aqVE/aqIV	ter, gl, I AQ	340-390 212	4 2
<b>Bucconidae (3)</b>									
<i>Bubulcus ibis</i>									
<i>Sarcophaga papua</i>	VHR	(np, non-f, FA:III)	gr; us; sc; ca; tt; ai	gr; ai	ai	CAR	SC	3000-3750	5
<i>Conopsis atratus</i>	NOT	(np, non-f, FA:II)	gr; tt; ai	gr; ai	ai	CAR	SC	m=2172, f=1989	2
<i>Cathartes aura</i>	VHR	np, non-f, FA:II	gr; us; sc; ca; tt; ai	gr; ai	ai	CAR	SC	1467	2
<b>ACCIPITRIDAE (16)</b>									
<i>Pandion haliaetus</i>	NOT		wa; ca; tt; ai	wa; ai; tt	ai	aqVE/aqIV	AQ	m=1403, f=1568	2
<i>Lepododon cayanensis</i>	LAT		sc; ca; tt; ai	sc; ca	ai	VE & lgIS	arb, R	416-605	6
<i>Elanoides forficatus</i>	LAT	mig, FL:I	sc; ca; tt; ai	ca; ai	ai	VE & lgIS	aer, R	372-510	2
<i>Harpagus bidentatus</i>	LAT		sc; ca; tt; ai	sc; ca	ai	VE & lgIS	arb, R	m=182, f=239	2
<i>Ictinia plumbea</i>	LAT?	mig, FL:I	sc; ca; tt; ai	ca; ai	ai	VE & lgIS	aer, R	190-280	2, 6
<i>Accipiter supercilliosus</i>	MST?		us; sc; ca; tt; ai	us; sc; ca	(tt)	VE	arb, R	m=80, f=116	2
<i>Accipiter bicolor</i>	LAT		us; sc; ca; tt; ai	us; sc; ca	sc	VE	arb, R	m=245, f=436	2
<i>Leucopternis plumbeus</i>	LAT		gr; ug; us; sc; ca	gr; ug; us	sc	VE & lgIS	terarb, R	482	2
<i>Leucopternis semiplumbeus</i>	LAT		gr; ug; us; sc; ca	gr; ug; us	sc	VE & lgIS	terarb, R	m=250, f=325	2
<i>Leucopternis princeps</i>	VLT		gr; ug; us; sc; ca; ai	gr; ug; us	ai	VE & lgIS	terarb, R	1000	2
<i>Buteo magnirostris</i>	LAT?		gr; ug; us; sc; ca; tt; ai	gr; sc; tt	sc	VE & lgIS	terarb, R	m=251, f=303	6
<i>Buteo badius</i>	LAT?		gr; ug; us; sc; ca; tt; ai	ca; ai	ai	VE	arb, R	m=460, f=530	2
<i>Harpia harpyja</i>	VLT		gr; ug; us; sc; ca; tt	sc; ca; tt	(tt)	VE	terarb, R	m=4000-4800, f=7600-9000	6
<i>Spizastur melanoleucus</i>	VLT		gr; ug; us; sc; ca; tt; ai	sc; ca; ai	ai	VE	terarb, R	850	2
<i>Spizaetus tyrannus</i>	VLT		gr; ug; us; sc; ca; tt; ai	sc; ca	ai	VE	terarb, R	m=950, f=1120	6
<i>Spizaetus ornatus</i>	VLT		gr; ug; us; sc; ca; tt; ai	sc; ca; ai	ai	VE	terarb, R	m=1069, f=1421	2
<b>FALCONIDAE (7)</b>									
<i>Micrastur ruficollis</i>	LAT	(ant-f, FL:3)	gr; ug; us; sc	gr; ug; us	us	VE & lgIS	terarb, R	m=161, f=196	2
<i>Micrastur plumbeus</i>	LAT	(ant-f, FL:3?)	gr; ug; us; sc	gr; ug; us	us	VE & lgIS	terarb, R	(160-200?)	0
<i>Micrastur mirandolai</i>	LAT		gr; ug; us; sc; ca	us; sc	sc	VE	arb, R	556	2
<i>Micrastur semitorquatus</i>	LAT	(ant-f, FL:3)	gr; ug; us; sc; ca	ug; us	sc	VE & lgIS	terarb, R	m=584, f=820	7
<i>Herpaelohers cacinmans</i>	LAT?		gr; ug; us; sc; ca; tt	gr; sc; tt	sc	VE	terarb, R	m=620, f=715	2
<i>Falco rufigularis</i>	LAT		gr; ca; tt; ai	ai; tt	ai	VE & lgIS	aer, R	m=129, f=202	2
<i>Falco peregrinus</i>	NOT		gr; ch; sc; ca; tt; ai	ai; tt	ai	VE	aer, R	m=611, f=952	2



## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<b>CRACIDAE (4)</b>									
<i>Ortalis erythroptera</i>	MST?	si-sp,ug-us,FL:I	gr; ug; us; sc; of	ug; us	us	FT/SD	arb,F	620-645	2
<i>Penelope ortoni</i>	MST?		gr; ug; us; sc; ca; of; tt	gr; us	us	FT/SD	arb,F	850	8
<i>Penelope purpurascens</i>	MST?		gr; ug; us; sc; ca; of; tt	us; sc	sc	FT/SD	arb,F	1620-2430	9
<i>Crax rubra</i>	LAT?	(si-sp,gr,FL:II)	gr; ug; us; sc	gr	gr	FT/SD	ter,F	m= 3600-4800, f= 3100-4270	9
<b>ODONTOPHORIDAE (2)</b>									
<i>Odontophorus erythrops</i>	MST?	(si-sp,gr,FL:I)	gr; ug; us	gr	gr	FT/SD & IV/smVE	ter,O	280	2
<i>Rhyncoryttus cinctus</i>	SMT	(si-sp,gr,FL:II)	gr; ug; us	gr	gr	FT/SD & IV/smVE	ter,O	150-165	2, 10
<b>RALLIDAE (3)</b>									
<i>Lateralus albigularis</i>	SMT		gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	m=50, f= 45	2
<i>Amatulinna concolor</i>	SMT		wa; gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	133	2
<i>Neotrex colombiana</i>	SMT		wa; gr; ug	gr	gr	FT/SD & IV/smVE	ter,O	71-75	1
<b>SCOLOPACIDAE (1)</b>									
<i>Actitis macularia</i>	NOT		wa; gr; ug	wa; gr	wa	aqVE/aqIV	AQ	29-60	2
<b>LARIDAE (1)</b>									
<i>Larus pipiscan</i>	NOT	(mig,FL:II)	wa; gr; ai	wa	ai	aqVE/aqIV	AQ	220-335	2
<b>COLUMBIDAE (8)</b>									
<i>Patagioenas speciosa</i>	SMT?		us; sc; ca; of	ca	ca	FT/SD	arb,F	m= 262; f= 225	2
<i>Patagioenas subvinacea</i>	MST?		ug; us; sc; ca; of	ca	ca	FT/SD	arb,F	m=180, f= 164	2
<i>Patagioenas goodsoni</i>	SMT?		ug; us; sc; ca; of	ca	ca	FT/SD	arb,F	134	1
<i>Claravis pretiosa</i>	SMT?		gr; ug; us; of	gr	(us)	FT/SD	ter,G	52-77	2
<i>Lepotila pallida</i>	SMT		gr; ug; us; of	gr	ug	FT/SD	ter,G	135-175	1
<i>Georgyina purpurata</i>	MST?		gr; ug	gr	gr	FT/SD	ter,F	(150?)	0
<i>Georgyina veraguensis</i>	MST?		gr; ug	gr	gr	FT/SD	ter,F	129-180	1
<i>Georgyina montana</i>	MST?		gr; ug	gr	gr	FT/SD	ter,F	108-130	1
<b>PSITTACIDAE (8)</b>									
<i>Ara ambiguus</i>	VHR	si-sp,ca,FL:II	us; sc; ca; of	ca	ai	FT/SD	arb,G	1265-1430	11
<i>Pyrrhura melanura</i>	MHR?	(si-sp,ca,FL:I)	us; sc; ca; of	ca	ai	FT/SD	arb,G	83	11
<i>Touit dilectissimus</i>	NOT?	(si-sp,ca,FL:II)	us; sc; ca; of	ca	ai	FT/SD	arb,G	59-71	2
<i>Pionopsitta pulchra</i>	MHR?	si-sp,ca,FL:I	us; sc; ca; of	ca	ai	FT/SD	arb,G	(150?)	0
<i>Pionus mensstruus</i>	MHR?	si-sp,ca,FL:I	us; sc; ca; of	ca	ai	FT/SD	arb,G	209-295	11
<i>Pionus chalcopernus</i>	MHR?	si-sp,ca,FL:I	us; sc; ca; of	ca	ai	FT/SD	arb,G	210	2
<i>Amazona autumnalis</i>	NOT	(si-sp,ca,FL:I)	us; sc; ca; of	ca	ai	FT/SD	arb,G	314-485	11
<i>Amazona farina</i>	LAT	si-sp,ca,FL:II	us; sc; ca; of	ca	ai	FT/SD	arb,G	535-644	2

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<b>CUCULIDAE (7)</b>									
<i>Coccyzus erythrophthalmus</i>	NOT	mx-sp,ug-us,FL:3?	ug; us; sc; ca	us; sc	(us)	lgIS	arb-gle,I	61	2
<i>Plegadis falcinellus</i>	MST?	mx-sp,sw,FL:3; (ant-f,FL:3)	gr; ug; us; sc; ca	us; sc	us	lgIS	arb-gle,I	108	2
<i>Plegadis falcinellus</i>	MST?		gr; ug; us; sc	ug; us	ug	lgIS	arb-gle,I	31-39	1
<i>Crotophaga ani</i>	SMT? (COB)	si-sp,gs,FL:I	gr; ug; us; of	gr; ug	of	lgIS	arb-gle,I	m=119, f=91	2
<i>Crotophaga sulcirostris</i>	NOT	(si-sp,gs,FL:I)	gr; ug; us; of	gr	of	lgIS	tergle,I	m=87, f=77	2
<i>Tapera naevia</i>	MST?		gr; ug; us; of	gr; ug	ug	lgIS	tergle,I	52	2
<i>Neomorphus nudiolus</i>	VLT?	(ant-f,FL:2?)	gr; ug	gr	gr	lgIS	tergle,I	(340?)	0
<b>STRIGIDAE (6)</b>									
<i>Megascops centralis</i>	MST		gr; ug; us; sc	ug; us	ug	VE & lgIS	terarb,R	(100-110?)	0
<i>Glaucidium griseiceps</i>	MST		ug; us; sc; ca	sc	sc	VE & lgIS	arb,R	40-59	2
<i>Lophotrix cristata</i>	LAT		gr; ug; us; sc; ca	gr; ug; us	(sc)	VE & lgIS	terarb,R	m=468, f=620	2
<i>Pulsatrix perspicillata</i>	VLT?		gr; ug; us; sc; ca	gr; ug; us	sc	VE & lgIS	terarb,R	591-1250	2
<i>Sorex nigrolineata</i>	LAT?		gr; ug; us; sc; ca	gr; ug; us	sc	VE & lgIS	terarb,R	m=435, f=535	12
<i>Sorex virgatus</i>	LAT?		gr; ug; us; sc; ca	gr; ug; us	sc	VE & lgIS	terarb,R	187-333	2
<b>SEATONITHIDAE (1)</b>									
<i>Seatonis caripensis</i>	NOT	si-sp,ca,FL:II	cl; us; sc; ca; of	ca; of	ai	FT/SD	arb,F	350-485	13
<b>NYCTIBIDAE (1)</b>									
<i>Nyctibius griseus</i>	LAT?		ug; us; sc; ca; tt	ca; tt	ca	lgIS	arb,ssal,I	145-202	2
<b>CAPRIMULGIDAE (2)</b>									
<i>Nyctidromus albigollis</i>	MST		gr; ug; of	gr; ug	gr	smlS	tersal,I	53	2
<i>Nyctiphypus rosenbergi</i>	MST		gr; ug; us; sc; ca; ai	sc; ca; ai	ug	smlS	tersal,I	52	14
<b>AFODIDAE (6)</b>									
<i>Streptoprocne zonaris</i>	NOT	aer,FL:I	cl; ai	ai	ai	smlS	aer,I	86-107	2
<i>Cypseloides nylus</i>	NOT	aer,FL:I	cl; ai	ai	ai	smlS	aer,I	18-24	2
<i>Chaetura pelagica</i>	NOT	aer,FL:I	us; sc; ca; ai	ai	ai	smlS	aer,I	17-30	2
<i>Chaetura spinicaudus</i>	VHR	aer,FL:I	us; sc; ca; ai	ai	ai	smlS	aer,I	13-20	2
<i>Chaetura cinereiventris</i>	NOT?	aer,FL:I	us; sc; ca; ai	ai	ai	smlS	aer,I	12-18	2
<i>Pomptila cyanoptera</i>	VHR	aer,FL:II	us; sc; ca; ai	ai	ai	smlS	aer,I	15.5-28	2
<b>TROCHILIDAE (15)</b>									
<i>Glaucopteryx aeneus</i>	DIT		ug	ug	ug	NE & AR	N	4.5-6	1
<i>Threnetes ruckeri</i>	LEK		ug	ug	ug	NE & AR	N	5.5-8.0	1
<i>Phaethornis yaruqui</i>	LEK		ug; us	ug	ug	NE & AR	N	4.5-7.5	1
<i>Phaethornis strigularis</i>	LEK		ug	ug	ug	NE & AR	N	2-3	1
<i>Eutoxeres aquila</i>	LEK		ug	ug	ug	NE & AR	N	9-13	1
<i>Androdon aequatorialis</i>	LEK		ug; us; sc; ca; of	us; sc	us	NE & AR	N	6.5-8.5	1

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main strata <sup>d</sup>	Main stratum <sup>e</sup>	Main foraging guild <sup>f</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Florisuga mellivora</i>	LEK		ug; us; sc; ca; of	ca; of	ca	NE & AR	6.5-8	15, 1
<i>Popelairia conversii</i>	DIT?		us; sc; ca; of	ca; of	of	NE & AR	3	2
<i>Thalurania faniyai</i>	LEK		ug; us; sc; ca; of	us; sc; of	(sc)	NE & AR	4-5	1
<i>Damophila julie</i>	DIT		ug; us; sc; of	ug; of	ug	NE & AR	2.5-3.5	1
<i>Amazilia tzacatl</i>	DIT		ug; us; sc; ca; of	ug; us; of	ug	NE & AR	4-5.5	1
<i>Amazilia amabilis</i>	NOT		ug; us; sc; ca; of	ug	(ug)	NE & AR	4-5	1
<i>Amazilia rosenbergi</i>	LEK		ug; us; sc; ca; of	ug	us	NE & AR	3.5-5	1
<i>Chalybura urochrysis</i>	DIT?		ug; us	ug	ug	NE & AR	5.5-8	1
<i>Heliothryx barroti</i>	DIT		ug; us; sc; ca; of	us; sc; ca; of	of	NE & AR	4.5-5.5	1, 2
<b>TROGONIDAE (4)</b>								
<i>Trogon campus</i>	SMT (PSL)	mx-sp,sw,FL:3	ug; us; sc; ca	sc	sc	FT/SD & IV/smVE	100-108	2
<i>Trogon chinomuris</i>	SMT (PSL)		ug; us; sc; ca	us; sc	us	FT/SD & IV/smVE	69-99	2, 16
<i>Trogon collaris</i>	SMT (PSL)		ug; us; sc; ca	us	us	lgS & FT	m=63, f=65	2
<i>Trogon rufus</i>	SMT (PSL)	mx-sp,ug-us,FL:3	ug; us; sc	ug; us	us	FT/SD & IV/smVE	53-65	1
<b>ALCEDINIDAE (4)</b>								
<i>Megasceryle torquata</i>	MST?		gr; wa; ug; us	wa; us	us	aqVE/aqIV	254-330	17
<i>Chloroceryle americana</i>	MST		gr; wa; ug	wa; ug	ug	aqVE/aqIV	37.5	2
<i>Chloroceryle inda</i>	MST		gr; wa; ug	wa; ug	ug	aqVE/aqIV	53-58	1
<i>Chloroceryle acnea</i>	MST?		gr; wa; ug	wa; ug	ug	aqVE/aqIV	m= 14, f= 16	2
<b>MOMOTIDAE (2)</b>								
<i>Electron platyrhynchos</i>	SMT?	mx-sp,sw,FL:3; ant-f,FL:3	gr; ug; us; sc	ug; us	us	lgS & FT	76	1
<i>Baryphthengus martii</i>	SMT?	mx-sp,sw,FL:3; ant-f,FL:3	gr; ug; us; sc; ca	ug; us	us	FT/SD & IV/smVE	12.1-164	1
<b>GALBULIDAE (2)</b>								
<i>Galbula ruficauda</i>	SMT	mx-sp,sw,FL:3	gr; ug; us; sc; ca; of	ug; us	us	lgS	22-27.5	1
<i>Jacamerops aureus</i>	MST	mx-sp,sw,FL:3	gr; ug; us; sc; ca	us; sc	sc	lgS	58-76	2
<b>BUCCONIDAE (5)</b>								
<i>Notharchus macrorhynchos</i>	MST	(ant-f,FL:3)	gr; ug; us; sc; ca; tt	sc; tt	sc	lgS	96	2
<i>Notharchus pectoralis</i>	MST	(ant-f,FL:3)	gr; ug; us; sc; ca	sc	sc	lgS	69	2
<i>Nyctalus radiatus</i>	MST	mx-sp,sw,FL:3	gr; ug; us; sc; ca; tt	sc	sc	lgS	59-63	2
<i>Malacoptila panamensis</i>	SMT	mx-sp,ug-us,FL:3; ant-f,FL:3	gr; ug; us	ug	ug	lgS	35-49.5	1
<i>Micromonacha lanceolata</i>	SMT	mx-sp,ug-us,FL:3; ant-f,FL:3	gr; ug; us; sc	us	(ug)	lgS	19	2
<b>CARTONIDAE (2)</b>								
<i>Capito squamatus</i>	SMT?	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	sc	FT/SD	57.5-59	1
<i>Capito quinticolor</i>	SMT?	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	sc	FT/SD	55-64	18

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<b>RAMPHASTIDAE (5)</b>									
<i>Aulacorhynchus haematopygus</i>	MST (COB)	(si-sp,ca,FL:1)	ug; us; sc; ca; of	sc; ca	ca	FT/SD & IV/smVE	arb,gle,O	200-232	2
<i>Selenidera spectabilis</i>	NOT	(si-sp,ca,FL:II)	ug; us; sc; ca; of	sc	sc	FT/SD & IV/smVE	arb,gle,O	175-252	2
<i>Peraglossus sanguineus</i>	MST (COB)	si-sp,ca,FL:1	ug; us; sc; ca; of	us; sc	1	FT/SD & IV/smVE	arb,gle,O	242-270	1
<i>Ramphastos brevis</i>	LAT (COB)	si-sp,ca,FL:1	ug; us; sc; ca; of	sc; ca	ca	FT/SD & IV/smVE	arb,gle,O	365-482	19
<i>Ramphastos swinsonii</i>	LAT (COB)	si-sp,ca,FL:1	ug; us; sc; ca; of	sc; ca	ca	FT/SD & IV/smVE	arb,gle,O	m= 660, f= 584	2
<b>PICIDAE (10)</b>									
<i>Picramnus olivaceus</i>	SMT?	mx-sp,f/e,FL:2	ug; us; sc	ug	ug	smlS	ba-cl,sur,I	10.5-13.5	1
<i>Piculus litae</i>	MST	mx-sp,sw,FL:2	us; sc; ca	us; sc; ca	sc	smlS	ba-cl,tr-in,I (53?)		0
<i>Celexus loritatus</i>	LAT	mx-sp,sw,FL:3	ug; us; sc; ca	us; sc; ca	sc	smlS	ba-cl,tr-in,I	74-80	2
<i>Dryocopus lineatus</i>	LAT		ug; us; sc; ca; tt	us; sc; ca	sc	lgIS	ba-cl,tr-in,I	m= 194, f= 173	2
<i>Melanerpes pucherani</i>	MST		ug; us; sc; ca; tt	us; sc; ca	sc	smlS & FT	arb,gle,O	m= 66, f= 59	2
<i>Veniliornis chocoensis</i>	MST	mx-sp,sw,FL:2	us; sc; ca	us; sc; ca	sc	smlS	ba-cl,tr-in,I (30-42?)		0
<i>Veniliornis kirikii</i>	MST	mx-sp,sw,FL:3	us; sc; ca	us; sc; ca	sc	smlS	ba-cl,tr-in,I	32-42	2
<i>Veniliornis callonotus</i>	MST	mx-sp,f/e,FL:3	ug; us; sc; ca	us	us	smlS	ba-cl,tr-in,I	26-27.5	1
<i>Campephilus gyaquilensis</i>	LAT		us; sc; ca; tt	sc; ca	sc	lgIS	ba-cl,tr-in,I	230-253	2
<i>Campephilus haematogaster</i>	LAT		ug; us	ug; us	us	lgIS	ba-cl,tr-in,I	225-250	2
<b>FURNARIIDAE (8)</b>									
<i>Synallaxis bacchyna</i>	SMT		gr; ug; us	ug	ug	smlS	arb,gle,I	16-22	1
<i>Cranioleuca erythrops</i>	NOT	mx-sp,sw,FL:2	ug; us; sc; ca	us; sc	sc	smlS	arb,dl-se,I	17	2
<i>Xenopetes minioi</i>	SMT?	(mx-sp,sw,FL:2)	us; sc; ca	sc; ca	sc	smlS	arb,gle,I	11	2
<i>Hylocichla ustulata</i>	MST	mx-sp,ug-us,FL:1	gr; ug; us; sc	ug; us	ug	lgIS	arb,dl-se,I	30.5-39	1
<i>Automolus ochrolaemus</i>	MST	mx-sp,ug-us,FL:3	gr; ug; us	ug	ug	lgIS	arb,dl-se,I	40	2
<i>Automolus rubiginosus</i>	MST	mx-sp,f/e,FL:3	gr; ug; us	ug	ug	lgIS	arb,dl-se,I	38-54.5	1
<i>Xenops minutus</i>	SMT	mx-sp,sw,FL:1;	ug; us; sc; ca	ug; us; sc	us	smlS	arb,gle,I	10-13.5	1
		mx-sp,f/e,FL:2	gr; ug	gr	gr	smlS	tergle,I	21-27.5	2
<i>Sclerurus mexicanus</i>	MST								
<b>DENDROCOLAPTIDAE (8)</b>									
<i>Dendrocincla fuliginosa</i>	MST	ant-f,FL:2;	gr; ug; us; sc	ug; us	us	lgIS	ba-cl,sur,I	32.5-44.5	1
		mx-sp,ug-us,FL:2							
<i>Glyphornychus spirarius</i>	SMT	mx-sp,sw,FL:2	ug; us; sc; ca	ug; us; sc	ug	smlS	ba-cl,sur,I	12-16	1
<i>Dendrocolaptes sanctithomae</i>	MST	ant-f,FL:2;	gr; ug; us; sc	ug; us	us	lgIS	ba-cl,sur,I	68	1
		mx-sp,ug-us,FL:2							
<i>Xiphorhynchus lachrymosus</i>	MST	mx-sp,sw,FL:1	ug; us; sc; ca	sc	sc	lgIS	ba-cl,sur,I	51-66	2
<i>Xiphorhynchus erythropygius</i>	MST	mx-sp,sw,FL:1	ug; us; sc; ca	us	us	smlS	ba-cl,sur,I	45-50.5	1

## APPENDIX 9. Continued.

Scientific name	Category of	Foraging flocks and	Main	Main	Main	Ref. <sup>i</sup>
Family (no. spp.) / species	Territoriality <sup>a</sup>	foraging aggregations <sup>b</sup>	foraging strata <sup>d</sup>	survey stratum <sup>e</sup>	foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]
<i>Lepidocolaptes souleyetii</i>	MST		us	us	ba-cl, sur, I	27.5
<i>Campylorhynchus trochilirostris</i>	MST	mx-sp, f/e, FL:2	ug; us	us	ba-cl, sur, I	39-47
<i>Campylorhynchus pusillus</i>	MST	mx-sp, ug-us, FL:2	ug; us	us	ba-cl, sur, I	33-48
THAMNOPHILIDAE (10)						
<i>Gymbilaimus lineatus</i>	SMT?	mx-sp, f/e, FL:2; (ant-f, FL:3)	us	us	arb, gle, I	35
<i>Taraba major</i>	MST?	(mx-sp, f/e, FL:3)	ug	ug	arb, gle, I	55.5-65.5
<i>Thamnophilus atrinucha</i>	SMT	mx-sp, f/e, FL:2; ant-f, FL:3	ug	ug	arb, gle, I	21.5-25
<i>Thamnistes anabatinus</i>	SMT?	mx-sp, sw, FL:1	sc; ca	sc	arb, gle, I	19-24
<i>Dysithamnus puncticeps</i>	SMT	mx-sp, ug-us, FL:1	ug; us	ug	arb, gle, I	16.5-17.5
<i>Myiotherula ignota</i>	SMT	mx-sp, sw, FL:2	ug; us; sc; ca; of	sc	arb, gle, I	(7)
<i>Myiotherula pacifica</i>	SMT	mx-sp, f/e, FL:3	ug; us; of	ug	arb, gle, I	8.5-11
<i>Myiotherula fulviventris</i>	SMT	mx-sp, ug-us, FL:1	ug; us	ug	arb, dl-se, I	9-12
<i>Myiotherula axillaris</i>	SMT	mx-sp, ug-us, FL:1	ug; us	ug	arb, gle, I	7-10
<i>Myiotherula schiscolior</i>	SMT	mx-sp, ug-us, FL:2	ug; us	ug	arb, gle, I	8.5
<i>Microhopus quisenis</i>	SMT	mx-sp, sw, FL:2	ug; us; sc	sc	arb, gle, I	9
<i>Cercomacra tyrannina</i>	SMT	mx-sp, f/e, FL:3	ug	ug	arb, gle, I	15-20
<i>Hylophylax naevoides</i>	SMT	ant-f, FL:1	gr; ug	ug	arb, gle, I	14.5-18.5
<i>Myrmeciza immaculata</i>	MST	ant-f, FL:2	gr; ug	ug	arb, gle, I	39-55
<i>Myrmeciza exsul</i>	SMT	mx-sp, ug-us, FL:3; ant-f, FL:3	gr; ug	ug	arb, gle, I	20.5-28.5
<i>Myrmeciza nigricauda</i>	MST?	(ant-f, FL:3)	gr; ug	ug	arb, gle, I	24
<i>Myrmeciza berlepschi</i>	SMT		gr; ug	ug	arb, gle, I	26-32
<i>Gymnophis leucaspis</i>	SMT?	ant-f, FL:1	gr; ug	ug	arb, gle, I	28.5-40
<i>Phaenostictus mcleannani</i>	LAT	ant-f, FL:1	gr; ug	ug	arb, gle, I	51
FORMICARIIDAE (3)						
<i>Formicarius nigricapillus</i>	SMT	(ant-f, FL:3)	gr; ug	gr	ter, gle, I	49-64
<i>Pitasoma rufofasciatum</i>	LAT?	ant-f, FL:3	gr; ug	gr	ter, gle, I	(95?)
<i>Hylopezus perspicillatus</i>	SMT	ant-f, FL:3	gr; ug	gr	ter, gle, I	41-42.5
RHINOCRYPTIDAE (1)						
<i>Scytalopus chocoensis</i>	SMT?		gr; ug	ug	ter, gle, I	19-22.5
TYRANNIDAE (49)						
<i>Phyllomyias griseiceps</i>	SMT		ug; us; sc; ca; of	(of)	arb, sal, I	7
<i>Zimmerius chrysops</i>	SMT	mx-sp, ca, FL:2	ug; us; sc; ca; of	sc; ca	arb, sal, O	7.5-9.5
<i>Ornithion brunneicapillus</i>	SMT?	mx-sp, ca, FL:2	ug; us; sc; ca; of	ca	arb, gle, I	7
<i>Camptostoma obsolatum</i>	SMT		ug; us; sc; ca; of	of	arb, gle, O	6-10
<i>Tyrannulus elanus</i>	SMT		ug; us; sc; ca; of	(of)	arb, sal, O	7-8.5

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Myiopagis caniceps</i>	SMT?	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	ca	smlS	arb,sa,I	9.5-11	2
<i>Myiopagis viriditata</i>	NOT	mx-sp,f/e,FL:3	ug; us; sc; ca; of	ug; us; sc	us	smlS	arb,sa,I	12.5-14.5	1
<i>Elania flavogaster</i>	NOT		ug; us; sc; ca; of	us; of	of	smlS & FT	arb,sa,O	21-27.5	2
<i>Serpophaga cinerea</i>	NOT		gr; ug	gr; ug	gr	smlS	ter,sa,I	8	2
<i>Mionectes olivaceus</i>	DIT (LEK?)	mx-sp,ug-us,FL:3	ug; us; sc	ug; us	ug	smlS & FT	arb,sa,O	11-17.5	1
<i>Mionectes olivaceus</i>	DIT (LEK?)	mx-sp,f/e,FL:3	ug; us	ug; us	ug	smlS & FT	arb,sa,O	9-13	1
<i>Lepidopogon superciliosus</i>	SMT	mx-sp,ug-us,FL:2	ug; us; sc	us	us	smlS & FT	arb,sa,O	10-14	1
<i>Myiornis atricapillus</i>	SMT	mx-sp,sw,FL:2	ug; us; sc; ca	us; sc	sc	smlS	arb,sa,I	5-6	21, 2
<i>Lophortyx pikeatus</i>	DIT (LEK?)		ug; us; sc	ug; us	us	smlS	arb,sa,I	7-8.5	1
<i>Todrostrum nigriceps</i>	SMT	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	ca	smlS	arb,sa,I	6.5	2
<i>Todrostrum cinereum</i>	SMT		ug; us; sc; ca; of	us; of	us	smlS	arb,sa,I	6.5-7.0	1
<i>Rhynchocyclus pacificus</i>	SMT (DIT?)	mx-sp,ug-us,FL:2; (ant-f,FL:3)	ug; us; sc	ug; us	us	smlS	arb,sa,I	24-29.5	1
<i>Tolmomyia flavovinctus</i>	SMT	mx-sp,sw,FL:1	ug; us; sc; ca	us; sc	sc	smlS	arb,sa,I	13.5-15.5	1
<i>Platyrinchus coronatus</i>	SMT	mx-sp,ug-us,FL:3; (ant-f,FL:3)	ug; us	ug	ug	smlS	arb,sa,I	9-10.5	1
<i>Myiornis ornatus</i>	SMT	(mx-sp,ug-us,FL:2)	ug; us; sc	ug; us	us	smlS	arb,sa,I	13.5	2
<i>Terenotriccus erythronus</i>	SMT (DIT?)	mx-sp,ug-us,FL:3	ug; us	ug; us	ug	smlS	arb,sa,I	6-8.5	1
<i>Myiobius atricaudus</i>	SMT (DIT?)	mx-sp,f/e,FL:2	ug; us	ug; us	ug	smlS	arb,sa,I	8-11.5	1
<i>Myiobius sulphureipygus</i>	SMT (DIT?)	mx-sp,ug-us,FL:2	ug; us	ug; us	ug	smlS	arb,sa,I	9-14	1
<i>Myiobius villosus</i>	SMT (DIT?)	(mx-sp,ug-us,FL:2)	ug; us	ug; us	ug	smlS	arb,sa,I	12-15	2
<i>Myiophobus fasciatus</i>	SMT		ug; us; of	ug	ug	smlS	arb,sa,I	9.5-10.5	1
<i>Mitrephanes phaeoerues</i>	SMT	mx-sp,ca,FL:2	us; sc; ca; of; tt	sc; ca; tt	sc	smlS	arb,sa,I	8-9	2
<i>Contopus cooperi</i>	NOT		us; sc; ca; of; tt	ca; tt	tt	smlS	arb,sa,I	27-42	2
<i>Empidonax virescens</i>	NBV-T	mx-sp,ug-us,FL:3; (ant-f,FL:3)	ug; us	ug; us	ug	smlS	arb,sa,I	10-16	2
<i>Sayornis nigricans</i>	SMT		gr; ug; of	gr; of	(gr)	smlS	arb,sa,I	17-22	2
<i>Colonia colonus</i>	SMT?		ug; us; sc; ca; of; tt	of; tt	tt	smlS	arb,sa,I	15-17	2
<i>Attila spadiceus</i>	MST	mx-sp,sw,FL:3; (ant-f,FL:3)	gr; ug; us; sc; ca	us; sc	sc	lgS & FT	arb,sa,O	35-44	2
<i>Rhytipterna holerythra</i>	MST	mx-sp,sw,FL:2	ug; us; sc; ca	us; sc	sc	lgS & FT	arb,sa,O	38.5	1
<i>Syrstes albobrunneus</i>	MST	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	ca	smlS	arb,sa,I	(33?)	0
<i>Myiarchus tuberculifer</i>	MST?	mx-sp,f/e,FL:3	gr; ug; us; sc; ca; of; tt	of	of	lgS & FT	arb,sa,O	20	2
<i>Megarynchus pitangua</i>	MST	mx-sp,f/e,FL:3	us; sc; ca; of; tt	ca	ca	lgS & FT	arb,sa,O	m=77; f=70	2
<i>Myiozetetes similis</i>	SMT	(mx-sp,f/e,FL:3)	gr; ug; us; sc; ca; of; tt	of; tt	of	smlS & FT	arb,sa,O	28	2
<i>Myiozetetes cayanensis</i>	SMT	mx-sp,f/e,FL:3	gr; ug; us; sc; ca; of; tt	of; tt	of	smlS & FT	arb,sa,O	24-27.5	1

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Myiozetetes grandis</i>	SMT	mx-sp,f/e,FL:3; (si-sp,f/e,FL:III)	gr; ug; us; sc; ca; of; tt	of; tt	of	smIS & FT	arb,sal,O	26-26.5	1
<i>Conopias albobittatus</i>	MST?	mx-sp,ca,FL:1	us; sc; ca; of; tt	ca; tt	ca	smIS & FT	arb,sal,O	23.5-26	2
<i>Myiodinastes maculatus</i>	NOT		us; sc; ca; of; tt	sc; ca; tt	(of)	lgIS & FT	arb,sal,O	39-52.5	2
<i>Legatus leucophaeus</i>	SMT		ug; us; sc; ca; of; tt	sc; ca; tt	ca	smIS & FT	arb,sal,O	19-31	2
<i>Tyrannus melancholicus</i>	SMT?		gr; ug; us; sc; ca; of; tt	of; tt	of	lgIS & FT	arb,sal,O	32-42.5	2
<i>Tyrannus niveigularis</i>	NBV-T		gr; ug; us; sc; ca; of; tt	ca; tt	ca	lgIS & FT	arb,sal,O	(37?)	0
<i>Tyrannus tyrannus</i>	NOT	(mig,FL:III)	us; sc; ca; of; tt	of; tt	of	lgIS & FT	arb,sal,O	43.5	2
<i>Pachyanphus cinnamomeus</i>	SMT	mx-sp,f/e,FL:3; mx-sp,ca,FL:3	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,sal,O	19-23	1
<i>Pachyanphus albogriseus</i>	NOT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	(of)	smIS & FT	arb,sal,O	17.5	1
<i>Platyparis homochrous</i>	NOT	mx-sp,f/e,FL:3; mx-sp,sw,FL:3	ug; us; sc; ca; of	us; sc; ca	(sc)	lgIS & FT	arb,sal,O	30-38	1
<i>Tityra semifaciata</i>	MST	mx-sp,f/e,FL:3	sc; ca; of	sc; ca	ca	lgIS & FT	arb,sal,O	79	2
<i>Tityra inquisitor</i>	MST		us; sc; ca; of	sc; ca	ca	lgIS & FT	arb,sal,O	36-47	2
COTINGIDAE (6)									
<i>Laniocera rufescens</i>	DIT (LEK?)	mx-sp,ug-us,FL:3	ug; us; sc	us	us	lgIS & FT	arb,sal,O	39-56	2
<i>Lipaugus unirufus</i>	DIT (LEK?)	mx-sp,sw,FL:3; (si-sp,ca,FL:III)	gr; ug; us; sc; ca	us; sc	sc	lgIS & FT	arb,sal,O	69-87	2
<i>Cotinga nattererii</i>	DIT?		us; sc; ca; of	sc; ca	ca	FT/SD	arb,F	(55-65?)	0
<i>Carpodectes hopkei</i>	DIT (LEK?)	si-sp,ca,FL:II	us; sc; ca; tt	sc; ca	tt	FT/SD	arb,F	(90-130?)	0
<i>Querula purpurata</i>	MST? (COB)	si-sp,ca,FL:1; mx-sp,ca,FL:2	ug; us; sc; ca	sc; ca	sc	FT/SD	arb,F	91-133	2
<i>Cephalopterus penduliger</i>	LEK		gr; ug; us; sc; ca	us; sc	sc	FT/SD	arb,F	338	2
PIPRIDAE (8)									
<i>Pipra mentalis</i>	LEK	mx-sp,ug-us,FL:3	ug; us; sc	ug; us	us	FT/SD	arb,F	10.5-18	1
<i>Lepidothrix coronata</i>	LEK	mx-sp,ug-us,FL:3	ug; us; sc	ug	ug	FT/SD	arb,F	7.5-11	1
<i>Mniotiltus chrysipernus</i>	LEK	(mx-sp,ug-us,FL:3)	ug; us; sc	ug	ug	FT/SD	arb,F	9-13.5	2
<i>Manacus manacus</i>	LEK		ug; us; sc	ug	ug	FT/SD	arb,F	14.5-21	1
<i>Macheropterus deliciosus</i>	LEK	mx-sp,ug-us,FL:3	ug; us; sc	ug; us	us	FT/SD	arb,F	12-17.5	1
<i>Chloropipo holochlora</i>	DIT (LEK?)	mx-sp,ug-us,FL:3	ug; us	ug	ug	FT/SD	arb,F	14-18	1
<i>Schiffornis turdina</i>	DIT	mx-sp,ug-us,FL:3	ug	ug	ug	smIS & FT	arb,sal,O	29.5-32.5	1
<i>Sapayoa aenigma</i>	SMT	mx-sp,ug-us,FL:1	ug; us; sc	ug; us	ug	smIS & FT	arb,sal,O?	18.5-25	1
VIREONIDAE (4)									
<i>Vireolanius leucotis</i>	SMT?	mx-sp,ca,FL:1	us; sc; ca; of	ca	ca	lgIS & FT	arb,gle,O	26	2
<i>Vireo olivaceus</i>	NOT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	sc; ca	sc	smIS & FT	arb,gle,O	12-25	2



## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Hylophilus decurtatus</i>	SMT	mx-sp,sw,FL:1; mx-sp,fl/e,FL:1	us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	8-10	2
<i>Hylophilus ochraceiceps</i>	SMT	mx-sp,ug-us,FL:1	ug; us	ug	ug	smIS	arb,gle,I	10.5-13.5	1
<b>TURDIDAE (5)</b>									
<i>Myadestes ridgwayi</i>	NOT?	mx-sp,ug-us,FL:3	ug; us; sc	ug; us	us	FT/SD	arb,F	28	2
<i>Cichlopsis leucogenys</i>	NOT?	(mig,FL:III)	ug; us; sc	ug; us	us	FT/SD	arb,F	61	2
<i>Catharus ustulatus</i>	NOT	(mx-sp,sw,FL:3)	gr; ug; us	ug	ug	FT/SD	arb,F	26.5-31.5	1
<i>Turdus obsoletus</i>	MST?	mx-sp,sw,FL:3	gr; ug; us; sc	ug; us	us	FT/SD	arb,F	66-98	2
<i>Turdus douglasii</i>	SMT?	mx-sp,ug-us,FL:3; ant-f,FL:3	gr; ug; us; sc	ug; us	ug	FT/SD & IV/smVE	arb,gle,O	46-59	1
<b>HIRUNDINIDAE (9)</b>									
<i>Progne chalybea</i>	LHR (CMR)	aer,FL:II	wa; tr; ai	ai	ai	smIS	aer,I	36-48	2
<i>Progne subis</i>	NOT	(aer,FL:II)	ai	ai	ai	smIS	aer,I	49.5	2
<i>Tachycineta bicolor</i>	NOT	aer,FL:I	ai	ai	ai	smIS	aer,I	15.5-25.5	2
<i>Notiochelidon cyanoleuca</i>	NOT	aer,FL:II	ai	ai	ai	smIS	aer,I	8.5-11	2
<i>Neochelidon tibialis</i>	MHR? (CMR)	aer,FL:I	wa; tr; ai	ai	ai	smIS	aer,I	10.5	1
<i>Scolecophagus ruficollis</i>	MHR? (CMR)	aer,FL:I	wa; gr; tr; ai	ai	ai	smIS	aer,I	12.5-14	1
<i>Riparia riparia</i>	NOT	aer,FL:II	ai	ai	ai	smIS	aer,I	12-18.5	2
<i>Hirundo rustica</i>	NOT	aer,FL:II	wa; ai	ai	ai	smIS	aer,I	11-28	2
<i>Petrochelidon pyrrhonota</i>	NOT	aer,FL:II	ai	ai	ai	smIS	aer,I	17.5-26.5	2
<b>TROGLODYTIDAE (8)</b>									
<i>Campylorhynchus zonatus</i>	MST? (COB)	si-sp,fl/e,FL:1; mx-sp,ca,FL:3	gr; ug; us; sc; ca; of	sc; ca	sc	smIS	arb,gle,I	28-39.5	2
<i>Odonorhynchus brunickii</i>	SMT?	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	sc	smIS	arb,gle,I	9-10	2
<i>Thryothorus nigricapillus</i>	SMT	mx-sp,ug-us,FL:1	ug; us; sc	ug	ug	smIS	arb,gle,I	18.5-24.5	1
<i>Thryothorus leucopogon</i>	SMT	mx-sp,ug-us,FL:1	ug; us; sc	ug; us	us	smIS	arb,gle,I	14.5-18	1
<i>Troglodytes aedon</i>	SMT	mx-sp,ug-us,FL:3; (ant-f,FL:3)	gr; ug; us; sc; of	ug; us	ug	smIS	arb,gle,I	10-12	2
<i>Henicorhina leucosticta</i>	SMT	mx-sp,ug-us,FL:3; (ant-f,FL:3)	gr; ug; us	ug	ug	smIS	arb,gle,I	14.5-18	1
<i>Cyporhynchus phaeocephalus</i>	MST? (COB?)	ant-f,FL:3; mx-sp,ug-us,FL:3	gr; ug	gr; ug	ug	smIS	tergle,I	24.5	2
<i>Microcerclus marginatus</i>	SMT	ant-f,FL:3	gr; ug	gr	gr	smIS	tergle,I	17.5-21.5	1
<b>POLIOPTILIDAE (3)</b>									
<i>Microbatas cinereiventris</i>	SMT	mx-sp,ug-us,FL:2	gr; ug; us	gr; ug	ug	smIS	arb,gle,I	10.5-14	1
<i>Polioptila plumbea</i>	SMT	mx-sp,fl/e,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS	arb,gle,I	5-7	2
<i>Polioptila schistacegula</i>	SMT	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	ca	smIS	arb,gle,I	(5-7?)	0

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<b>PARULIDAE (10)</b>									
<i>Dendroica striata</i>	NOT	(mig,FL:III; mx-sp,FL:3)	ug; us; sc; ca; of	sc; ca	(of)	smIS	arb,gle,I	10-21	2
<i>Dendroica fusca</i>	NOT	mx-sp,ca,FL:2; (mig,FL:III)	ug; us; sc; ca; of	sc; ca	ca	smIS	arb,gle,I	9.5-10	2
<i>Dendroica pensilvanica</i>	NOT	mx-sp,sw,FL:2	ug; us; sc; ca	us; sc	(sc)	smIS	arb,gle,I	7.5-13	2
<i>Seiurus noveboracensis</i>	NOT		gr; ug	gr	gr	smIS	ter,gle,I	14-24	2
<i>Geothlypis semiflava</i>	SMT		gr; ug	ug	ug	smIS	arb,gle,I	14.5-17	1
<i>Geothlypis auricularis</i>	SMT		gr; ug	ug	ug	smIS	arb,gle,I	9.5-11	1
<i>Oporornis philadelphia</i>	NOT		gr; ug	gr; ug	(ug)	smIS	arb,gle,I	9.5-18	2
<i>Oporornis agilis</i>	NOT		gr; ug	gr	(gr)	smIS	ter,gle,I	11-27	2
<i>Basileuterus chlorophrys</i>	SMT	mx-sp,ug-us,FL:2	ug; us; sc	ug; us	(ug)	smIS	arb,gle,I	(11?)	0
<i>Basileuterus fulvicauda</i>	MST?	ant-f,FL:3	gr; ug	gr	gr	smIS	ter,gle,I	12-15.5	1
<b>THRAUPIDAE (36)</b>									
<i>Coereba flaveola</i>	SMT	mx-sp,FL:2; mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	8-12	1
<i>Cyanerpes caeruleus</i>	SMT	mx-sp,ca,FL:1; (si-sp,ca,FL:II)	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	8-14	2
<i>Cyanerpes cyaneus</i>	SMT	mx-sp,FL:3; (si-sp,FL:III)	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	11-18	2
<i>Chlorophanes spiza</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	14-23	2
<i>Dacnis cayana</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	10-15.5	2
<i>Dacnis egregia</i>	SMT	mx-sp,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	13.5	1
<i>Dacnis venusta</i>	SMT	mx-sp,ca,FL:2; (si-sp,ca,FL:II)	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	16	2
<i>Dacnis berlepschi</i>	SMT	mx-sp,ca,FL:2; si-sp,ca,FL:II	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	11.5-16	1
<i>Erythrolipys sathnoui</i>	SMT	mx-sp,ca,FL:2; si-sp,ca,FL:II	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	12	2
<i>Chlorophonia flavirostris</i>	SMT	(si-sp,ca,FL:II; mx-sp,ca,FL:3)	ug; us; sc; ca; of	sc; ca	ca	FT/SD	arb,F	11	2
<i>Euphonia lanirostris</i>	SMT	mx-sp,FL:2; (si-sp,FL:FL:2)	ug; us; sc; ca; of	sc; ca	of	FT/SD	arb,F	13.5-15.5	1
<i>Euphonia xanthogaster</i>	SMT	mx-sp,sw,FL:1; mx-sp,FL:2	ug; us; sc; ca; of	us; sc	us	FT/SD	arb,F	9.5-17	1
<i>Euphonia minuta</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	FT/SD	arb,F	8-11.5	2
<i>Euphonia fulvicauda</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	FT/SD	arb,F	10-13	2
<i>Tangara rufigula</i>	SMT	mx-sp,ca,FL:2	us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	19	2
<i>Tangara palmeri</i>	SMT?	mx-sp,ca,FL:1	us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	32.5	2

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Tangara florida</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	18.5-20.5	2
<i>Tangara cyanicollis</i>	SMT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	14-19	2
<i>Tangara laruta</i>	SMT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	15.5-16.5	1
<i>Tangara johannae</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	20-21.5	22
<i>Tangara gyrola</i>	SMT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	17.5-26.5	2
<i>Tangara laetitia</i>	SMT	mx-sp,ca,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	17.5-24	1, 2
<i>Bangia rothschildi</i>	SMT?	mx-sp,sw,FL:2	ug; us; sc	us; sc	us	smIS & FT	arb,gle,O	(35-40)	0
<i>Bangia edwardsi</i>	SMT?	mx-sp,sw,FL:2	ug; us; sc	us; sc	us	smIS & FT	arb,gle,O	(35-40)	0
<i>Tersina viridis</i>	SMT	(si-sp,f/e,FL:1)	ug; us; sc; ca; of; π	of; π	of	smIS & FT	arb,sa,O	26-35	2
<i>Thraupis episcopus</i>	SMT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	31.5-35	1
<i>Thraupis palmarum</i>	SMT	(si-sp,f/e,FL:II)	ug; us; sc; ca; of	sc; ca	ca	smIS & FT	arb,gle,O	30.5-34.5	1
<i>Ramphocelus icteronotus</i>	SMT	mx-sp,ca,FL:3	ug; us; sc; ca; of	ug; us; of	of	smIS & FT	arb,gle,O	28.5-38.5	1
<i>Piranga rubra</i>	NBV-T	si-sp,f/e,FL:3	ug; us; sc; ca	us; sc	(sc)	smIS & FT	arb,gle,O	29.5-30.5	1
<i>Chlorothraupis olivacea</i>	SMT?	mx-sp,f/e,FL:2	ug; us; sc	ug; us	us	smIS & FT	arb,gle,O	35-45	1
<i>Chlorothraupis stolzmanni</i>	SMT	mx-sp,ug-us,FL:1	ug; us; sc	ug; us	us	smIS & FT	arb,gle,O	40.5	2
<i>Mitrospingus cassinii</i>	MST?	mx-sp,ug-us,FL:2	ug	ug	ug	smIS & FT	arb,gle,O	37.5-44	1
<i>Tachyphonus rufus</i>	SMT	si-sp,f/e,FL:1	ug	ug	ug	smIS & FT	arb,gle,O	26-42.5	2
<i>Tachyphonus luctuosus</i>	SMT	mx-sp,sw,FL:2	gr; ug	ug	ug	smIS & FT	arb,gle,O	11.5-15.0	2
<i>Tachyphonus delattrei</i>	SHR	si-sp,ug-us,FL:1	ug; us; sc; ca	ug; us; sc; ca	sc	smIS & FT	arb,gle,O	15.5-23.5	1
<i>Heterospingus xanthopygius</i>	SMT?	mx-sp,ug-us,FL:2	ug; us; sc; ca	ug; us	ug	smIS & FT	arb,gle,O	(38?)	0
CARDINALIDAE (5)									
<i>Salator maximus</i>	SMT	mx-sp,f/e,FL:2	ug; us; sc; ca; of	us; sc	us	smIS & FT	arb,gle,O	41-57	1
<i>Salator atipennis</i>	SMT?	mx-sp,f/e,FL:2	ug; us; sc; ca; of	us; sc	us	smIS & FT	arb,gle,O	55-58	2
<i>Salator grossus</i>	MST?	mx-sp,sw,FL:3	ug; us; sc; ca	us; sc	sc	smIS & FT	arb,gle,O	45.5-54.5	1
<i>Phenacurus ludovicianus</i>	NOT	(mig,FL:III; si-sp,f/e,FL:III)	ug; us; sc; ca	us; sc	(us)	smIS & FT	arb,gle,O	44.5	1
<i>Cyanocampsa cyanooides</i>	MST?	(mx-sp,ug-us,FL:3)	ug; us	ug	ug	smIS & FT	arb,gle,O	32.5	2
EMBERIZIDAE (10)									
<i>Rhodospingus cruentus</i>	NOT	(si-sp,gs,FL:II)	gr; ug; us; sc	ug	ug	smIS & FT	arb,gle,O	9.5-11	1, 2
<i>Volatinia jacarina</i>	SMT	mx-sp,gs,FL:II	gr; ug; of	gr; ug	(ug)	FT/SD	ter,G?	8-12	2

## APPENDIX 9. Continued.

Scientific name	Category of Territoriality <sup>a</sup>	Foraging flocks and foraging aggregations <sup>b</sup>	Strata used <sup>c</sup>	Main foraging strata <sup>d</sup>	Main survey stratum <sup>e</sup>	Diet <sup>f</sup>	Main foraging guild <sup>g</sup>	Body mass <sup>h</sup> [g]	Ref. <sup>i</sup>
<i>Tiatis olivaceus</i>	SMT	si-sp, f/e, FL:II; mx-sp, gs, FL:III	gr; ug; us; of	gr; ug	(ug)	FT/SD	st-fe, G	10-11.5	1
<i>Oryzoborus angolensis</i>	SMT	mx-sp, gs, FL:II	gr; ug; us; of	ug	us	FT/SD	st-fe, G	10.5-13.5	1
<i>Sporophila corvina</i>	SMT	mx-sp, gs, FL:II; si-sp, gs, FL:II	gr; ug; us; of	ug	us	FT/SD	st-fe, G	8.5-12	1
<i>Sporophila luctuosa</i>	NOT	mx-sp, gs, FL:II; (si-sp, gs, FL:II)	gr; ug; us; of	ug	(ug)	FT/SD	st-fe, G	12.5	2
<i>Sporophila nigricollis</i>	SMT	mx-sp, gs, FL:II; si-sp, gs, FL:II	gr; ug; us; of	ug	us	FT/SD	st-fe, G	7.5-8.5	1
<i>Sporophila telasco</i>	NOT	mx-sp, gs, FL:II; si-sp, gs, FL:II	gr; ug; of	ug	(ug)	FT/SD	st-fe, G	8.5	2
<i>Arremon aurantitrostris</i>	SMT	(ant-f, FL:3)	gr; ug	ug	ug	smS & FT	arb, gle, O	23.5-29.5	1
<i>Arremonops caninirostris</i>	SMT		gr; ug; us	gr; ug	ug	smS & FT	arb, gle, O	37-42	2
<b>ICTERIDAE (7)</b>									
<i>Cacicus microbrychus</i>	LHR (COL; CMR)	si-sp, ca, FL:I; mx-sp, ca, FL:3	gr; ug; us; sc; ca	us; sc	sc	lgS	arb, gle, I	m= 75	1
<i>Amblycercus holosericeus</i>	MST?	(mx-sp, f/e, FL:3; ant-f, FL:3)	gr; ug; us	ug	ug	lgS	arb, dl-se, I	m= 71, f= 56.5	2
<i>Zarhynchus wagleri</i>	LHR? (COL; CMR)	si-sp, ca, FL:I; mx-sp, ca, FL:3	us; sc; ca; of	sc; ca	ca	FT/SD & IV/smVE	arb, gle, O	m= 214, f= 113	2
<i>Molothrus bonariensis</i>	MHR? (CMR)	si-sp, gs, FL:I	gr; ug; us; sc; ca; of	gr	us	lgS & FT	ter, O	m= 52.5, f= 46.5	1
<i>Molothrus oryzivorus</i>	LHR? (CMR)	si-sp, f/e, FL:II; si-sp, gs, FL:II	gr; ug; us; sc; ca	gr; us	us	lgS & FT	arb, gle, O	m= 219, f= 162	2
<i>Icterus megalonyx</i>	NOT	(mx-sp, f/e, FL:3)	ug; us; sc; ca	ug; us	us	lgS	arb, gle, I	34-48	2
<i>Dolichonyx oryzivorus</i>	NOT	(mig, FL:II; si-sp, gs, FL:II; mx-sp, gs, FL:II)	gr; ug	gr; ug	(gr)	FT/SD	ter, G?	m= 47, f= 37	2

## APPENDIX 10

Mist-netting study: number of birds captured per species in the complete (not standardized) surveys. Number of first captures and recaptures per species and locality; mist-netted in Playa de Oro from Aug. 1995 to Nov. 1996. See Appendix 1 for sampling dates and effort per locality; and p. 65f, Mist-netting study; for details on the methodology. Abbreviations used: (a) locality and transect: PdO: village of Playa de Oro; PR: Playa Rica, c. 3 km SE of village; MNT1/c: complete set of data for mist-netting transect 1; MNT2/c: complete set of data for mist-netting transect 2; TT1: test transect 1, c. 650 m S of village; TT2: test transect 2, c. 900 m SW of Playa Rica; (b) number of captures; FC: first captures; birds netted for the first time in this study; R1: recaptures type 1; individuals already trapped in the running mist-netting sample and section; R2: recaptures type 2; birds already netted in another section or in earlier samples of the same section. Note: the total number of individuals recorded might be slightly smaller than indicated by the sum of first captures, because not all species and individuals could be permanently marked.

Scientific name	PdO: MNT1/c <sup>a</sup>			PR: MNT2/c <sup>a</sup>			MNT1/c+MNT2/c <sup>a</sup>			PdO: TT1 <sup>a</sup>			PR: TT2 <sup>a</sup>			Complete study				
	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum
ACCIPITRIDAE (1)																				
<i>Buteo magnirostris</i>	1			1				1									1			1
FALCONIDAE (1)																				
<i>Micrastur ruficollis</i>					1			1	1	1							1			1
ODONTOPHORIDAE (1)																				
<i>Odonophorus erythrops</i>					1			1	1	1							1			1
RALLIDAE (2)																				
<i>Lanius albigularis</i>	1		1	2					1								1			1
<i>Neotrex colombiana</i>	2			2					2								2			2
COLUMBIDAE (4)																				
<i>Patagioenas goodsoni</i>					1			1	1	1							1			1
<i>Lepotila pallida</i>	5	1	6	12	4	9	1	14	10								9	1		10
<i>Geotrygon venusta</i>	4		4	8	3	7		10	7								7			7
<i>Geotrygon montana</i>	1		1	2	3	4		7	4								4			4
CUCULIDAE (1)																				
<i>Piaya minuta</i>	3		3	6	5			11	9								8			9
STRIGIDAE (1)																				
<i>Strix virgata</i>	1			1					1								1			1
TROCHILIDAE (15)																				
<i>Glauis aeneus</i>	10		10	2				2	12								12			12
<i>Threnetes ruckeri</i>	73	2	2	77	58	13	3	74	131	15	5	151	5	2	2	138	15	5	158	
<i>Phaethornis yaruqui</i>	65	5	4	74	77	4	2	83	142	9	6	157	4	4	5	151	9	6	166	
<i>Phaethornis strigularis</i>	9			9	5			14	14								14			14
<i>Eutoxeres aquila</i>	7		1	8	43	15	3	61	50	15	4	69	2	2	2	52	15	4	71	
<i>Andradon aequatorialis</i>	7			7					7							2	9			9
<i>Florisuga mellivora</i>	2			2	2				2							2	2			2
<i>Popelairia universii</i>	1			1					1							1	1			1

## APPENDIX 10. Continued.

Scientific name	PaO: MNT1/c <sup>a</sup>			PR: MNT2/c <sup>a</sup>			MNT1/c+MNT2/c <sup>a</sup>			PdO: TT1 <sup>a</sup>			PR: TT2 <sup>a</sup>			Complete study			
	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	Sum	
Family (no. of spp.) / species																			
<i>Thalassidroma fannyi</i>	4		4	1		1	5		5							5		5	
<i>Damophila julie</i>	3		3				3		3							3		3	
<i>Amazilia tzacatl</i>	7		7				7		7							7		7	
<i>Amazilia amabilis</i>	7		7				7		7							7		7	
<i>Amazilia rosebergi</i>	42		42	37	1	38	79	1	80	1	1	2	5		5	85	2	87	
<i>Chalybura urochrysa</i>	4	4	8	8	5	13	12	9	21	1	1	1			13	9	22		
<i>Heliothryx barroti</i>	3		3				3		3						3			3	
TROGONIDAE (2)																			
<i>Trogon chionurus</i>				1		1	1	1	1							1		1	
<i>Trogon rufus</i>				3		3	3	3	3							3		3	
ALCEDINIDAE (3)																			
<i>Chloroceryle americana</i>	1		1					1	1							1		1	
<i>Chloroceryle inda</i>	2	1	4	1		1	3	1	5						3	1	1	5	
<i>Chloroceryle aenea</i>				1		1	1	1	1						1			1	
MOMOTIDAE (2)																			
<i>Electron platyrhynchos</i>				1		1	1	1	1							1		1	
<i>Baryphthengus nairii</i>				2		2	2	2	2						2			2	
GALULIDAE (1)																			
<i>Gallbula ruficauda</i>	8		8	1		1	9		9						9			9	
BUCCONIDAE (1)																			
<i>Malacopsila panamensis</i>	5	1	6	13	3	4	20	18	4	26	1	1			19	4	4	27	
CAPTIONIDAE (1)																			
<i>Capito squamatus</i>	2		2	2		2	4		4						4			4	
RAMPHASTIDAE (2)																			
<i>Pteroglossus sanguineus</i>	1		1	2		2	3		3	1		1			4			4	
<i>Ramphastos swainsonii</i>	1		1				1		1						1			1	
PICIDAE (2)																			
<i>Picumnus olivaceus</i>	5	1	3	9		9	5	1	3	9					5	1	3	9	
<i>Veniliornis callonotus</i>	2		2				2		2						2			2	
FURNARIIDAE (4)																			
<i>Synallaxis brachyura</i>	27	3	12	42	4		31	3	12	46					31	3	12	46	
<i>Hylocistes virgatus</i>	7	1	4	12	16	2	7	25	23	3	11	37		1	24	3	11	38	
<i>Autolimus rubiginosus</i>	2	1	3	5	2	3	10	7	3	13					7	3	13	13	
<i>Xenops minutus</i>	12	3	11	26	13	7	20	25	3	18	46	2		2	27	3	18	48	
DENDROCOLAPTIDAE (7)																			
<i>Dendrocincla fuliginosa</i>	7		4	11	7	7	14	14		11	25	1		1	2	17		11	28
<i>Glyphorhynchus spirurus</i>	23	5	16	44	16	10	40	39	15	30	84	5		5	5	49	15	30	94
<i>Dendrocolaptes sanctithomae</i>					1		1	1		1					1			1	1
<i>Xiphorhynchus lachrymosus</i>	1		1					1		1					1			1	1
<i>Xiphorhynchus erythrogaster</i>	3	3	2	8	4		4	7	3	2	12			7	3	2		12	12
<i>Lepidocolaptes souleyetii</i>	1		1					1		1				1		1		1	1
<i>Campylorhynchus trachilitrostris</i>	2		2	4	1		1	3		2	5			3		2		5	5

## APPENDIX 10. Continued.

Scientific name	PdO: MNT1/c <sup>a</sup>			PR: MNT2/c <sup>a</sup>			MNT1/c+MNT2/c <sup>a</sup>			PdO: TT1 <sup>a</sup>			PR: TT2 <sup>a</sup>			Complete study		
	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	Sum
THAMNOPHILIDAE (14)																		
<i>Taraba major</i>	3			3	1			1	4							4		4
<i>Thamnophtila arinuacha</i>	2			2	8	1		10	10	1						12		12
<i>Dysithamnus puncticeps</i>	1			1	2	1		2	2							4		4
<i>Myrmotherula pacifica</i>	13	4	17	34	8			20	21	6						27		27
<i>Myrmotherula fulviventris</i>	15	1	5	21	18	11	7	36	33	12	12	57	4	1	5	2	39	13
<i>Myrmotherula axillaris</i>	9		2	11	20	1	8	29	29	1	10	40	2	2	2	31	1	42
<i>Myrmotherula schisticolor</i>	1			1					1							1		1
<i>Microtopia quixensis</i>	1			1					1							1		1
<i>Cercocarpia tyramina</i>	32	14	12	58	17	11	12	40	49	25	24	98				2	51	25
<i>Hylophylax naevoides</i>	7	4	2	13	26	3	20	49	33	7	22	62	7	5	12	1	41	12
<i>Myrmeciza immaculata</i>	7	1	3	11	11	1	5	17	18	2	8	28	1	1		19	2	8
<i>Myrmeciza exul</i>	13	3	7	23	23	4	7	34	36	7	14	57	3	1	4	3	42	8
<i>Myrmeciza berlepschi</i>	6		2	8	8		4	12	14	6	20	4				14		6
<i>Gymnotophis leucaspis</i>	11	2	13	26	22	20	16	58	33	20	18	71	4			37	20	18
FORMICARIIDAE (3)																		
<i>Formicarius nigricapillus</i>	3	1	1	5	9	1	6	16	12	2	7	21				12	2	7
<i>Hylopezus perspicillatus</i>					3	1		4	3	1		4				3	1	4
TYRANNIDAE (24)																		
<i>Zimmerius chrysops</i>	3			3					3			3				3		3
<i>Ornithion brunneicapillus</i>	1			1					1			1				1		1
<i>Myiophis viridicatus</i>	5			5	1			1	6			6				6		6
<i>Myiophis olivaceus</i>	25	5	11	41	84	25	42	151	109	30	53	192	4	4	3	116	30	53
<i>Myiophis elegans</i>	6	1	3	10	7	2		9	13	3	3	19	2	2	8	8	23	3
<i>Lophophanes superciliosus</i>	8	1	9	18	4	1		5	12	1	1	14	1	1		13	1	15
<i>Lophophanes pileatus</i>	3	1	1	5	2		2	4	5	1	3	9				5	1	3
<i>Todirostrum cinereum</i>	4	1	5	10	5			4	4		1	5				4		5
<i>Rhyncocyclus pacificus</i>	4	1	5	10	2		3	5	6		4	10				6		10
<i>Tolmomyias flaviventris</i>	1			1	1			1	2			2				2		2
<i>Platyrinchus coronatus</i>	5	1	1	7	5	1	5	11	10	2	6	18	4	4		14	2	6
<i>Terenotriccus erythrurus</i>	7	2	7	16	11		4	15	18	2	11	31	1	1		20	2	11
<i>Myiophis atricaudatus</i>	15	5	12	32	3	6	5	14	18	11	17	46				18	11	17
<i>Myiophis sulphureipennis</i>	11	9	20	40	20	9	20	49	31	18	40	89	3	3		34	18	40
<i>Myiophobus fasciatus</i>	3			3					3			3				3		3
<i>Empidonax virens</i>					1			1	1			1				1		1
<i>Colonia colona</i>	1			1					1			1				1		1
<i>Rhytipterna holerythra</i>					1			1	1			1				1		1
<i>Myiozetetes cayanensis</i>	1			1	2			2	3			3				3		3
<i>Myiozetetes granadensis</i>	2			2					2			2				2		2
<i>Legatus leucophthalmus</i>	2			2					2			2				2		2
<i>Pachyanphus cinnamomeus</i>	4	1		5					4	1		5				4	1	5
<i>Pachyanphus albogriseus</i>					1			1	1			1				1		1
<i>Platysaris homochrous</i>	6		1	7					6			1				6		7



## APPENDIX 10. Continued.

Scientific name	PdO: MNT1/c <sup>a</sup>			PR: MNT2/c <sup>a</sup>			MNT1/c+MNT2/c <sup>a</sup>			PdO: TTT1 <sup>a</sup>			PR: TT2 <sup>a</sup>			Complete study				
	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum
PIPRIDAE (7)																				
<i>Pipra mentalis</i>	14	1	4	19	91	8	16	115	105	9	20	134	5			5	110	9	20	139
<i>Lepidobtrix coronata</i>	13	2	6	21	33	4	14	51	46	6	20	72	4	3	7	7	57	9	20	86
<i>Manacus manacus</i>	57	12	32	101	84	25	27	136	141	37	59	237	1	12	1	13	154	38	59	251
<i>Machaeroperus deliciosus</i>	6		6	2	2			2	8			8	1		1		9			9
<i>Chloropipo holochlora</i>	3	9	10	22	14	6	6	26	17	15	16	48				17	15	16	48	
<i>Schiffornis turdina</i>				2	2		1	3	2		1	3				2	2	1	3	
<i>Sapayoa aenigma</i>	6	3	9	9	5	2	6	13	11	2	9	22				11	2	9	22	
VIREONIDAE (2)																				
<i>Vireo olivaceus</i>	2			2					2			2					2			2
<i>Hylophilus ochraceiceps</i>	4	1	4	9	6	3	2	11	10	4	6	20				10	4	6	20	
TURDIDAE (2)																				
<i>Catharus ustulatus</i>	2			2	4			4	6			6				6				6
<i>Turdus daguae</i>	12	4	3	19	42	3	10	55	54	7	13	74	1	6	1	6	61	7	13	81
HIRUNINIDAE (2)																				
<i>Neochelidon tibialis</i>	1			1					1			1				1				1
<i>Stelgidopteryx ruficollis</i>	3	1		4					3	1		4				3	1			4
TROGLODYTIDAE (5)																				
<i>Thryothorus nigricapillus</i>	14	3	7	24	6	1	2	9	20	4	9	33				20	4	9	33	
<i>Thryothorus leucopogon</i>	2			2	4	1	2	7	6	1	2	9				6	1	2	9	
<i>Henicorhina leucosticta</i>	3			3	7	3		10	10	3	13					10	3		13	
<i>Cypothrinus phaeocephalus</i>	1			1					1	0	0	1				1			1	
<i>Microcerulus marginatus</i>	8	2	6	16	16	12	13	41	24	14	19	57				24	14	19	57	
POLIOPTILIDAE (1)																				
<i>Microbatas cinereiventris</i>	8	1	9	9	18	4	9	31	26	4	10	40	6	4		36	4	10	50	
PARULIDAE (6)																				
<i>Seiurus noveboracensis</i>	1			1					1			1				1				1
<i>Geothlypis semiflava</i>	2			2	1	1		2	3	1		4				3	1		4	
<i>Geothlypis auricularis</i>	6			2	8				6		2	8				6		2	8	
<i>Oporornis philadelphica</i>	1			1	1				1			1				1			1	
<i>Oporornis agilis</i>	1			1					1			1				1			1	
<i>Basiluterus fulicauda</i>	8	3	11	22	4		1	5	12	3	12	27				12	3	12	27	
THRAUPIDAE (18)																				
<i>Coereba flaveola</i>	19	2	4	25	4	2		6	23	4	4	31				23	4	4	31	
<i>Chlorophanes spiza</i>													1			1				1
<i>Dacnis cayana</i>					1			1	1			1				1				1
<i>Dacnis egregia</i>	1			1	1			1	2			2				2				2
<i>Dacnis venusta</i>													1			1				1
<i>Dacnis berlepschi</i>					4			4	4			4				4				4
<i>Euphonia lanirostris</i>	2			2					2			2				2				2
<i>Euphonia xanthogaster</i>	16	4	7	27	15	2	5	22	31	6	12	49				31	6	12	49	
<i>Tangara larvata</i>	2			1	3	1		1	3		1	4				3		1	4	

## APPENDIX 10. Continued.

Scientific name Family (no. of spp.) / species	PdO: MNT1/c <sup>a</sup>			PR: MNT2/c <sup>a</sup>			MNT1/c+MNT2/c <sup>a</sup>			PdO: TT1 <sup>a</sup>			PR: TT2 <sup>a</sup>			Complete study		
	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	R1 <sup>b</sup>	R2 <sup>b</sup>	Sum	FC <sup>b</sup>	Sum
<i>Tangara larini</i>					1			1									1	1
<i>Thraupis episcopus</i>	6			6				6									6	6
<i>Thraupis palmarum</i>	2			2				2									2	2
<i>Ramphocelus icteronotus</i>	12	1	13	15	15	27		1	28								27	1 28
<i>Piranga rubra</i>					2			2									2	2
<i>Chlorothraupis olivacea</i>	8	3	11	11	11	2	7	20	19	2	10	31	1				20	2 10 32
<i>Mitrospingus cassini</i>	6	1	5	12				6	1	5	12						6	1 5 12
<i>Tachyphonus luctuosus</i>	1			1				1									1	1
<i>Tachyphonus delarri</i>	26	27	39	92	56	16	58	130	82	43	97	222	4	4	5	5	91	43 97 231
CARDINALIDAE (3)																		
<i>Salpator maximus</i>	27	11	38	5	1	6	32	12	44								32	12 44
<i>Salpator grosus</i>	1			1	2	1	3	3	1	4							3	1 4
<i>Phrycticus ludovicianus</i>					1			1	1								1	1
EMBERIZIDAE (7)																		
<i>Rhodospingus cruentus</i>					1			1	1								1	1
<i>Volatinia jacarina</i>	1			1	1			1	2								2	2
<i>Tiaris obscurus</i>	3			3	1			1	4								4	4
<i>Oryzoborus angolensis</i>	11	2	4	17	9	2	2	13	20	4	6	30					20	4 6 30
<i>Sporophila corvina</i>	23	6	6	35	4			4	27	6	6	39					27	6 6 39
<i>Sporophila nigricollis</i>	4		1	5					4			1	5				4	1 5
<i>Arremon amantirostris</i>	6	2	6	14	12	2	6	20	18	4	12	34					1	19 4 12 35
ICTERIDAE (2)																		
<i>Cacicus microphylchus</i>					1			1	1								1	1
<i>Molothrus bonariensis</i>	2			2					2								2	2
SUM captures	972	162	339	1473	1150	252	410	1812	2122	414	749	3285	72	11	83	89	1 90	2283 426 749 3458
SUM species	123	44	58	123	101	44	49	101	144	58	66	144	27	5	27	25	1 25	146 57 65 146

## APPENDIX 11

Birds of Playa de Oro: body masses and morphometric data of living birds. Descriptive statistics for 145 bird species mist-netted, measured, and released between Aug. 1995 and Nov. 1996 in the community of Playa de Oro at elevations between c. 60 and 80 m a.s.l. The unsexed samples include immature and adult birds of both sexes. In a few cases I have listed freshly fledged juveniles separately from the unsexed sample in order to avoid exceptionally low minimum values, which would not be representative for the population as a whole. Whenever possible I also tried to present subsamples for adult females and males. The assignment of individuals to these subsamples of adult birds was mostly based on plumage coloration and not on skulking (Pyle *et al.* 1987: 9-11) or laparotomy (Risser 1971). The data should be treated with caution because, in some species, immatures of both sexes may have been recorded as adult females, and, in other cases, adult females may have been misidentified as immature males. To minimize the bias of incorrect sex and age determination, I opted to include, in the subsample for adult females, mostly those female-plumaged birds which have either developed incubation patches at some point in the mist-netting study or which were recaptured at prolonged intervals and did not indicate any change in plumage coloration, i.e., a change from immature to adult male plumage. Therefore, the resulting subsample of adult females was often smaller than the subsample of adult males for the same species. Sometimes I simply decided to form subsamples for 'female-plumaged' and 'male-plumaged' birds, i.e., if a reliable sex and age determination was rendered impossible. These samples are more likely to contain immature birds or individuals of the opposite sex. In the case of recaptured individuals for which some variables were measured repeatedly, I used their average values for the descriptive statistics. Thus the entire statistics are based on the number of individuals measured and not on the total number of measurements taken. For those species for which repeated measurements of recaptured individuals were obtained, I also presented the latter sample size. Exclusively for body masses, I opted to use the minimum and maximum values of the complete samples, i.e., before calculating average values for recaptures, because this variable fluctuated considerably for each individual depending on food availability, weather, time of day, season, and other factors. To minimize the impact caused by repeated mist netting of the same individuals at short intervals, I excluded the body masses of recaptures under the following conditions: (1) of birds recaptured within 24 h of their first capture as well as of individuals repeatedly retrapped within the same period during their first mist-netting session; (2) of birds repeatedly recaptured within 6 daylight hours of their last recapture in their second or later mist-netting sessions; (3) of juveniles still being fed by an adult, only the body mass taken after their first capture being used during their first mist-netting session. Abbreviations used: (a) descriptive statistics: 95% CL = 95% confidence limits of the mean for t-distributed small samples ( $p = 0.05$ ); N = number of individuals, in the case when no repeated measurements of recaptures were obtained; N (meas.) = total number of measurements; includes repeatedly measured recaptures, see comments above; N (ind.) = number of individuals; for recaptures I generally used the mean of the repeatedly measured variables in the descriptive statistics, see comments above. (b) measurements: BM = body mass; minimum values marked with an asterisk (\*) were larger and maximum values marked the same way were smaller in the sample of individuals, i.e., after calculating the means for the recaptures; TL = total length; FW = length of 'flattened' wing (Pyle *et al.* 1987: 4-5); RTL = tail length; BL = bill length; from the tip of the upper mandible to the base of the skull; EC = exposed culmen; from the bill tip to the edge of the skin on the frontal base of the upper mandible; PN = bill length, from the bill tip to the proximal end of the operculum (Hinkelmann & Schuchmann 1997); exclusively used for hummingbirds; BW1 = bill width, measured at the anterior end of the nostrils (Pyle *et al.* 1987: 7); BW2 = bill width, measured at the lateral base of the bill, just in front of the soft corners of the gape; Tar = length of tarsus.

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
ACCIPITRIDAE (1)												
<i>Buteo magnirostris</i>												
unsexed, adult	N	258.0	320.0	210.0	130.0	28.00	18.71			10.30		BL= bill tip to edge of feathering; EC= bill tip to edge of cere.
FALCONIDAE (1)												
<i>Micrastur ridgcolis interstes</i>												
unsexed, adult	N	169.0	330.0	165.0	147.0	22.35	14.80			8.43	59.44	BL= bill tip to edge of feathering; EC= bill tip to edge of cere.
ODONTOPHORIDAE (1)												
<i>Odonophorus erythrops parambae</i>												
female, adult	N		240.0	130.0	45.0		16.78			10.78		
RALLIDAE (2)												
<i>Laterallus albigularis albigularis</i>												
unsexed, immature	N	24.0	125.0	64.0	22.0	15.68	14.12			3.50	19.58	
<i>Neotres colombiana colombiana</i>												
unsexed	Min	71.0	165.0	98.0	30.0	21.19	20.12			5.04	27.98	1 adult and 1 immature.
	Max	75.0	175.0	100.0	30.0	22.06	21.19			5.53	30.12	
	Mean	73.00	170.00	99.00	30.00	21.63	20.66			5.29	29.05	
	SD	2.83	7.07	1.41		0.62	0.76			0.35	1.51	
	SE	2.00	5.00	1.00		0.43	0.53			0.24	1.07	
	95% CL	25.41	63.53	12.71		5.53	6.80			3.11	13.60	
N		2	2	2	1	2	2			2	2	
COLUMBIDAE (4)												
<i>Patagioenas goodsoni</i>												
unsexed	N	134.0	260.0	150.0	100.0		14.32			6.15		
<i>Leptotila pallida</i>												
unsexed	Min	135.0	245.0	133.0	90.0	18.36	14.69			4.33	24.92	
	Max	175.0	255.0	138.0	100.0	21.94	17.42			5.64	27.20	
	Mean	156.50	250.71	135.50	94.75	19.68	16.06			5.11	26.24	
	SD	13.35	3.45	1.51	2.71	1.34	1.06			0.46	0.85	
	SE	4.72	1.30	0.53	0.96	0.55	0.40			0.18	0.35	
	95% CL	11.16	3.19	1.26	2.27	1.40	0.98			0.43	0.89	
N		8	7	8	8	6	7			7	6	
<i>Leptotila pallida</i>												
unsexed, freshly fledged juvenile	N	91.0	225.0	125.0	80.0	21.11	19.13			7.65	26.30	
<i>Georgiopus veraqueus</i>												
unsexed	N	1	1	1	1	1	1			1	1	
<i>Georgiopus veraqueus</i>												
unsexed	Min	129.0	206.0	127.0	70.0	19.74	16.32			5.16	29.19	
	Max	180.0	235.0	139.0	81.0	21.80	18.30			6.42	33.16	
	Mean	151.75	221.83	131.33	73.33	20.64	17.31			5.81	31.44	
	SD	21.78	10.50	4.32	4.23	0.96	0.86			0.46	1.73	
	SE	8.89	4.28	1.76	1.73	0.48	0.43			0.19	0.86	
	95% CL	22.86	11.01	4.53	4.44	1.53	1.36			0.49	2.75	
N		6	6	6	6	4	4			6	4	
<i>Georgiopus veraqueus</i>												
female, adult	Min	135.5	220.0	128.0	70.0	19.74	16.96			5.16	29.19	
	Max	180.0	235.0	139.0	81.0	21.80	17.66			6.42	33.16	
	Mean	161.88	227.50	132.75	74.00	20.86	17.31			5.81	31.56	
	SD	19.41	6.45	4.65	5.23	1.04	0.49			0.52	2.09	
	SE	9.70	3.23	2.32	2.61	0.60	0.35			0.26	1.21	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Georgien veraguensis</i>	95% CL	30.88	10.27	7.39	8.32	2.59	4.45			0.82	5.20	
	N	4	4	4	4	3	2	2		4	3	
		134.0	206.0	130.0	73.0		16.32			5.43		
<i>Georgien montana montana</i> male	N	1	1	1	1		1			1		
	Min	108.0	200.0	130.0	62.0	18.70	11.69			4.14	22.13	
	Max	129.5	220.0	139.0	80.0	19.02	12.21			5.31	25.57	
	Mean	116.88	211.25	134.50	72.50	18.87	11.91			4.70	23.48	
	SD	9.08	8.54	3.70	7.72	0.16	0.27			0.48	1.83	
	SE	4.54	4.27	1.85	3.86	0.09	0.16			0.24	1.06	
<i>Georgien montana montana</i> female, adult	95% CL	14.44	13.59	5.88	12.29	0.40	0.67			0.76	4.55	
	N	4	4	4	4	3	3			4	3	
	Min	108.0	200.0	130.0	72.0	18.70	11.69			4.65	22.13	
	Max	116.0	220.0	139.0	76.0	18.89	11.82			4.68	25.57	
	Mean	112.00	210.00	134.50	74.00	18.80	11.76			4.67	23.85	
	SD	5.66	14.14	6.36	2.83	0.13	0.09			0.02	2.43	
<i>Georgien montana montana</i> male, adult	SE	4.00	10.00	4.50	2.00	0.09	0.07			0.02	1.72	
	95% CL	50.82	127.06	57.18	25.41	1.21	0.83			0.19	21.85	
	N	2	2	2	2	2	2			2	2	
	Min	114.0	210.0	134.0	62.0	19.02	12.21			4.14	22.75	
	Max	129.5	215.0	135.0	80.0	19.02	12.21			5.31	22.75	
	Mean	121.75	212.50	134.50	71.00	19.02	12.21			4.73	22.75	
CUCULIDAE (1) <i>Pipra minuta gracilis</i> unsexed	SD	10.96	3.54	0.71	12.73					0.83		
	SE	7.75	2.50	0.50	9.00					0.58		
	95% CL	98.47	31.77	6.35	114.36					7.43		
	N	2	2	2	2	1	1			2	1	
	Min	31.0	240.0	98.0	138.0	19.47	15.58			6.45	24.09	
	Max	38.5	260.0	107.0	150.0	22.93	17.01			7.75	25.77	
STRIGIDAE (1) <i>Strix virgata virgata</i> unsexed	Mean	35.18	252.14	102.57	143.57	21.12	16.48			7.16	24.80	
	SD	2.56	7.56	3.78	3.95	1.46	0.52			0.50	0.65	
	SE	0.97	2.86	1.43	1.49	0.60	0.20			0.19	0.27	
	95% CL	2.37	6.99	3.50	3.66	1.54	0.48			0.46	0.68	
	N (meas.)	8	7	7	7	6	7			7	6	
	N (ind.)	7	7	7	7	6	7			7	6	
CAPRIMULGIDAE (1) <i>Nyctidromus albigollis albigollis</i> female, adult	N									10.19	37.78	
	Min	275.0	315.0	221.0	155.0	29.96				1	1	
	Max											
TROCHILIDAE (14) <i>Glaucois aeneus columbianus</i> unsexed	N	39.0	230.0	142.0	111.0	17.67	10.75			5.97	20.34	This presumably ill bird was captured by hand in a topper-like condition; it died soon after.
	Min	4.5	100.0	47.0	28.0					4.20	2.86	
	Max	6.0	111.0	55.0	33.0					5.56	2.86	
	Mean	5.13	106.17	50.58	30.25					4.75	2.86	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Thineetes ruckeri ruckeri</i> unsexed	SD	0.53	3.43	2.75	1.54	30.0	26.46	29.72	3.64	4.28	2.21	
	SE	0.15	0.99	0.79	0.45	0.18	0.18	0.19	0.13	0.13	0.13	
	95% CL	0.34	2.18	1.74	0.98	0.41	0.41	0.41	0.29	0.29	0.29	
	N	12	12	12	12	12	11	12	12	12	1	
	Min	5.5	110.0	54.0	30.0	42.0	31.82	33.40	3.96	5.81	2.92	
	Max	8.0	128.0	63.0	42.0	35.61	29.54	31.79	3.81	5.03	2.64	
<i>Phaethornis yaruqui</i> unsexed	Mean	6.57	119.45	58.46	35.61	2.66	1.02	0.85	0.12	0.33	0.21	
	SD	0.47	3.94	2.16	2.66	0.23	0.09	0.08	0.04	0.03	0.05	
	SE	0.04	0.34	0.18	0.23	0.45	0.19	0.16	0.11	0.06	0.12	
	95% CL	0.08	0.67	0.37	0.45	1.40	121	112	7	135	15	
	N (meas.)	143	137	140	140	137	118	110	7	132	15	
	N (ind.)	135	135	137	137	137	118	110	7	132	15	
<i>Phaethornis yaruqui</i> unsexed	Min	4.5	132.0	52.0	47.0	44.67	33.44	34.85	2.85	3.93	2.14	
	Max	7.5	163.0	66.0	66.0	56.79	40.49	41.75	3.35	4.90	2.68	
	Mean	5.75	147.68	59.34	60.27	4.12	2.25	2.30	0.32	0.34	0.25	
	SD	0.58	5.68	2.74	2.76	0.36	0.20	0.23	0.11	0.03	0.07	
	SE	0.05	0.51	0.23	0.43	0.72	0.39	0.46	0.25	0.06	0.16	
	95% CL	0.09	1.01	0.45	0.87	1.50	137	103	9	144	12	
<i>Phaethornis yaruqui</i> female, adult	N (meas.)	155	127	150	132	132	137	103	9	144	12	
	N (ind.)	147	123	144	128	128	132	99	9	138	12	
	Min	5.0	140.0	52.0	55.0	37.35	38.38	38.38	3.93	5.71	2.86	
	Max	6.5	156.0	62.0	66.0	41.23	42.99	42.99	4.83	5.71	2.86	
	Mean	5.48	148.10	58.31	60.27	0.99	1.08	1.08	0.36	0.14	0.14	
	SD	0.45	4.30	1.99	2.76	0.17	0.19	0.19	0.06	0.07	0.07	
<i>Phaethornis yaruqui</i> male, adult	SE	0.07	0.68	0.31	0.43	0.34	0.40	0.40	0.11	0.23	0.23	
	95% CL	0.14	1.37	0.62	0.87	34	31	31	41	41	4	
	N	40	40	42	41	41	34	31	41	41	4	
	Min	5.0	136.0	57.0	47.0	38.62	39.04	39.04	4.36	5.74	2.58	
	Max	7.0	155.0	65.0	58.0	44.61	45.95	45.95	4.99	5.74	2.58	
	Mean	5.84	145.67	60.97	52.86	2.71	1.67	2.11	0.30	0.30	0.02	
<i>Phaethornis strigularis subufescens</i> unsexed	SD	0.45	4.82	2.07	2.71	0.32	0.44	0.44	0.05	0.05	0.01	
	SE	0.08	0.88	0.37	0.50	1.03	0.65	0.91	0.11	0.11	0.19	
	95% CL	0.16	1.80	0.76	1.03	28	23	23	33	33	2	
	N	32	30	31	29	25.0	17.82	18.87	4.63	4.63	1	
	N (meas.)	5.0	77.0	47.0	25.0	31.0	18.25	19.45	2.76	2.76	2.76	
	N (ind.)	1	1	1	1	1	1	1	1	1	1	
<i>Phaethornis strigularis subufescens</i> unsexed	Min	2.0	85.0	33.0	31.0	38.0	20.58	22.38	3.77	3.77	3.77	
	Max	3.0	93.0	37.0	38.0	35.44	19.75	21.09	3.30	3.30	3.30	
	Mean	2.63	90.11	35.00	35.44	2.51	0.74	0.92	0.32	0.32	0.10	
	SD	0.31	3.06	1.41	2.51	0.84	0.22	0.33	0.10	0.10	0.21	
	SE	0.09	1.02	0.43	0.84	1.93	0.50	0.77	0.21	0.21	0.21	
	95% CL	0.20	2.35	0.95	1.93	9	11	8	11	11	11	
	N	12	9	11	9	9	11	8	11	11	11	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Eiastores aquila heterura</i> unsexed	Min	9.0	117.0	65.0	44.0	23.56	24.24	3.78	5.11	4.05		
	Max	13.0*	135.0	78.0	55.0	28.96	28.56	4.00	6.64	4.95		
	Mean	10.87	125.84	71.17	49.75	26.22	25.57	3.89	6.03	4.67		
	SD	0.92	4.40	3.13	2.43	1.08	0.89	0.16	0.32	0.36		
	SE	0.13	0.65	0.44	0.34	0.16	0.17	0.11	0.05	0.16		
	95% CL	0.27	1.31	0.88	0.69	0.32	0.35	1.40	0.09	0.45		
	N (meas.)	55	48	54	52	48	30	2	52	5		
<i>Androdon aequatorialis</i> unsexed	N (ind.)	49	46	51	50	45	28	2	49	5		
	Min	6.5	131.0	62.0	40.0	37.35	38.17	3.14	4.45			
	Max	8.5	141.0	70.0	43.0	42.57	43.47	3.14	5.35			
	Mean	7.75	137.13	66.40	40.80	39.53	40.93	3.14	4.91			
	SD	0.59	3.00	2.37	0.92	1.79	2.18	0.35	0.35			
	SE	0.19	1.06	0.75	0.29	0.60	0.89	0.12	0.12			
	95% CL	0.42	2.51	1.69	0.66	1.38	2.29	0.29	0.29			
<i>Florisuga mellivora mellivora</i> unsexed	N	10	8	10	10	9	6	1	8			
	Min	7.0	111.0	65.0	35.0	18.08	20.28		4.43			
	Max	8.0	115.0	70.0	36.0	19.84	21.67		5.57			
	Mean	7.50	113.00	67.50	35.50	18.96	20.98		5.00			
	SD	0.71	2.83	3.54	0.71	1.24	0.98		0.81			
	SE	0.50	2.00	2.50	0.50	0.88	0.69		0.57			
	95% CL	6.35	25.41	31.77	6.35	11.18	8.83		7.24			
<i>Florisuga mellivora mellivora</i> female, adult	N	2	2	2	2	2	2	2	2			
	Min	7.0	111.0	65.0	35.0	18.08	20.28		5.57			
	Max	8.0	115.0	70.0	36.0	19.84	21.67		4.43			
	Mean	7.50	113.00	67.50	35.50	18.96	20.98		5.00			
	SD	0.71	2.83	3.54	0.71	1.24	0.98		0.81			
	SE	0.50	2.00	2.50	0.50	0.88	0.69		0.57			
	95% CL	6.35	25.41	31.77	6.35	11.18	8.83		7.24			
<i>Thalassania fannyi verticeps</i> male, adult	N	1	1	1	1	1	1	1	1			
	Min	4.0	90.0	51.0	27.0	19.70	21.73		3.72			
	Max	5.0	103.0	55.0	40.0	20.65	23.15		4.50			
	Mean	4.50	96.75	53.00	32.25	20.29	22.40		4.17			
	SD	0.41	5.56	1.63	5.56	0.52	0.71		0.33			
	SE	0.20	2.78	0.82	2.78	0.30	0.41		0.17			
	95% CL	0.65	8.85	2.60	8.85	1.28	1.77		0.53			
<i>Thalassania fannyi verticeps</i> male, adult	N	4	4	4	4	3	3	3	4			
	Min	5.0	103.0	55.0	40.0	19.70			4.16			
	Max	2.5	85.0	43.0	26.0	13.71	16.21		3.61			
	Mean	3.5	89.0	44.0	30.0	15.91	17.67		3.92			
	SD	3.17	86.33	43.33	28.67	14.76	16.94		3.78			
	SE	0.58	2.31	0.58	2.31	1.10	1.03		0.16			
	95% CL	0.33	1.33	0.33	1.33	0.64	0.73		0.09			
<i>Damophila julie feliciana</i> unsexed	N	3	3	3	3	3	2	2	3			
	Min	2.5	85.0	43.0	26.0	15.91	17.67		3.61			
	Max	3.5	89.0	44.0	30.0	15.91	17.67		3.92			
	Mean	3.17	86.33	43.33	28.67	14.76	16.94		3.78			
	SD	0.58	2.31	0.58	2.31	1.10	1.03		0.16			
	SE	0.33	1.33	0.33	1.33	0.64	0.73		0.09			
	95% CL	1.43	5.74	1.43	5.74	2.74	9.28		0.39			
<i>Damophila julie feliciana</i> female-plumaged	N	3	3	3	3	3	2	2	3			
	Min	2.5	85.0	43.0	26.0	15.91	17.67		3.61			
	Max	3.5	89.0	44.0	30.0	15.91	17.67		3.92			
	Mean	3.17	86.33	43.33	28.67	14.76	16.94		3.78			
	SD	0.58	2.31	0.58	2.31	1.10	1.03		0.16			
	SE	0.33	1.33	0.33	1.33	0.64	0.73		0.09			
	95% CL	1.43	5.74	1.43	5.74	2.74	9.28		0.39			

Inner rectrices: 22 mm; outer rectrices: 40 mm.



## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
<i>Damophila julie felicitiana</i> male, adult	Min	3.5	85.0	43.0	30.0		13.71	16.21		3.82			
	Max	3.5	89.0	44.0	30.0		14.66	16.21		3.92			
	Mean	3.50	87.00	43.50	30.00		14.19	16.21		3.87			
	SD	0.00	2.83	0.71	0.00		0.67			0.07			
	SE	0.00	2.00	0.50	0.00		0.48			0.05			
	95% CL	0.00	25.41	6.35	0.00		6.04			0.64			
<i>Amazilia tzacatl</i> juvunda unsexed	N	2	2	2	2		2	1		2			
	Min	4.0	97.0	53.0	29.0		21.58	23.31		4.73			
	Max	5.5	104.0	58.0	35.0		22.57	24.25		5.00			
	Mean	4.93	99.83	55.50	32.00		22.15	23.63		4.90			
	SD	0.45	2.40	1.76	2.00		0.35	0.42		0.10			
	SE	0.17	0.98	0.72	0.82		0.14	0.19		0.04			
<i>Amazilia amazilia amazilia</i> male	95% CL	0.42	2.52	1.85	2.10		0.37	0.53		0.11			
	N	7	6	6	6		6	5		6			
	Min	4.0	90.0	48.0	33.0		16.65	18.28		3.36			
	Max	5.0	95.0	57.0	35.0		17.81	19.87		4.16			
	Mean	4.40	92.60	53.40	33.75		17.11	19.16		3.84			
	SD	0.42	2.07	3.36	0.96		0.51	0.69		0.32			
<i>Amazilia rosenbergi</i> unsexed	SE	0.19	0.93	1.50	0.48		0.23	0.31		0.14			
	95% CL	0.52	2.57	4.17	1.52		0.63	0.85		0.39			
	N	5	5	5	4		5	5		5			
	Min	3.5	85.0	47.0	24.0		19.60	21.55		2.24			
	Max	5.0	101.0	58.0	35.0		23.30	24.49		3.20			
	Mean	4.25	93.28	52.69	28.80		21.72	23.11		2.84			
<i>Amazilia rosenbergi</i> female-plumaged	SD	0.37	3.83	2.70	2.55		0.79	0.69		0.38			
	SE	0.04	0.45	0.30	0.29		0.09	0.09		0.17			
	95% CL	0.08	0.89	0.59	0.58		0.19	0.18		0.47			
	N (meas.)	81	74	83	79		73	61		6			
	N (ind.)	81	73	82	78		72	61		5			
	N	25	22	25	25		21	13		1			
<i>Amazilia rosenbergi</i> male, adult	Min	3.5	85.0	47.0	24.0		20.19	21.94		3.20			
	Max	5.0	97.0	53.0	30.0		23.14	24.49		3.20			
	Mean	4.04	91.09	50.08	26.68		22.20	23.68		3.20			
	SD	0.32	3.26	1.66	1.55		0.65	0.74		0.33			
	SE	0.06	0.70	0.33	0.31		0.14	0.21		0.07			
	95% CL	0.13	1.45	0.68	0.64		0.30	0.45		0.14			
<i>Amazilia rosenbergi</i> male, adult	N	25	22	25	25		21	13		1			
	Min	3.5	85.0	48.0	25.0		19.60	21.55		2.24			
	Max	5.0	101.0	58.0	35.0		23.30	24.26		3.13			
	Mean	4.40	94.57	54.30	30.21		21.38	22.83		2.75			
	SD	0.34	3.42	1.97	2.15		0.71	0.53		0.37			
	SE	0.05	0.52	0.28	0.32		0.11	0.08		0.19			
<i>Amazilia rosenbergi</i> male, adult	95% CL	0.10	1.05	0.57	0.64		0.21	0.17		0.60			
	N (meas.)	48	44	50	47		45	41		5			
	N (ind.)	48	43	49	46		44	41		4			
	Min	3.5	85.0	47.0	24.0		19.60	21.55		2.24			
	Max	5.0	101.0	58.0	35.0		23.30	24.26		3.13			
	Mean	4.40	94.57	54.30	30.21		21.38	22.83		2.75			
<i>Amazilia rosenbergi</i> male, adult	SD	0.34	3.42	1.97	2.15		0.71	0.53		0.37			
	SE	0.05	0.52	0.28	0.32		0.11	0.08		0.19			
	95% CL	0.10	1.05	0.57	0.64		0.21	0.17		0.60			
	N (meas.)	48	44	50	47		45	41		5			
	N (ind.)	48	43	49	46		44	41		4			
	N	25	22	25	25		21	13		1			

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Chadophora urochrysia urochrysia</i> unsexed	Min	5.5	105.0	56.0	34.0		22.62	23.87	3.36	3.88	3.60	
	Max	8.0	124.0	74.0	46.0		25.25	26.89	3.36	5.20	3.60	
	Mean	6.65	113.82	64.46	38.42		23.58	25.31	3.36	4.82	3.60	
	SD	0.90	7.56	4.89	3.68		0.88	1.02		0.37		
	SE	0.25	2.28	1.36	1.06		0.25	0.36		0.11		
	95% CL	0.54	5.08	2.96	2.34		0.56	0.85		0.23		
	N (meas.)	18	11	13	12		12	8	1	12	1	
<i>Chadophora urochrysia urochrysia</i> female, adult	N (ind.)	13	11	13	12		12	8	1	12	1	
	Min	5.5	105.0	56.0	34.0		22.62	23.87		3.88	3.60	
	Max	6.5	115.0	65.0	39.0		24.22	25.58		5.20	3.60	
	Mean	6.06	108.71	61.25	36.25		23.29	24.77		4.76	3.60	
	SD	0.32	3.30	2.60	1.39		0.65	0.76		0.43		
	SE	0.11	1.25	0.92	0.49		0.24	0.38		0.15		
	95% CL	0.27	3.05	2.18	1.16		0.60	1.21		0.36		
<i>Chadophora urochrysia urochrysia</i> male, adult	N (meas.)	12	7	8	8		7	4		8	1	
	N (ind.)	8	7	8	8		7	4		8	1	
	Min	6.5	121.0	68.0	40.0		22.96	24.87	3.36	4.75		
	Max	8.0	124.0	74.0	46.0		25.25	26.89	3.36	5.17		
	Mean	7.60	122.75	69.60	42.75		23.98	25.86	3.36	4.96		
	SD	0.65	1.26	2.51	2.75		1.08	1.03		0.17		
	SE	0.29	0.63	1.12	1.38		0.48	0.51		0.09		
<i>Heliothya burroti</i> male, adult	95% CL	0.81	2.00	3.12	4.38		1.34	1.64		0.27		
	N (meas.)	6	4	5	4		5	4	1	4		
	N (ind.)	5	4	5	4		5	4	1	4		
	Min	4.5	105.0	65.0	34.0		15.23	17.97		3.89		
	Max	5.0	111.0	67.0	44.0		16.87	19.11		4.10		
	Mean	4.83	108.00	66.00	39.00		16.05	18.68		3.97		
	SD	0.29	4.24	1.00	7.07		0.82	0.62		0.12		
TROGONIDAE (2) <i>Trogon chionurus</i> female, adult	SE	0.17	3.00	0.58	5.00		0.47	0.36		0.07		
	95% CL	0.72	38.12	2.48	63.53		2.04	1.54		0.29		
	N	3	2	3	2		3	3		3		
	Min	88.0	280.0	141.0	144.0	25.71	20.34			16.42	12.27	
	Max											
	Mean											
	SD											
<i>Trogon rufus cupreicauda</i> unsexed	SE											
	95% CL											
	N											
	Min	53.0	240.0	114.0	132.0	16.64	14.55			11.66	11.26	
	Max	65.0	265.0	147.0	139.0	18.67	16.56			14.29	14.91	
	Mean	58.33	250.00	126.00	136.00	17.90	15.87			13.38	13.25	
	SD	6.11	13.23	18.25	3.61	1.10	1.14			1.49	1.85	
<i>Trogon rufus cupreicauda</i> female, adult	SE	3.53	7.64	10.54	2.08	0.64	0.66			0.86	1.07	
	95% CL	15.18	32.86	45.33	8.96	2.74	2.84			3.71	4.59	
	N	3	3	3	3	3	3			3	3	
	Min	53.0	240.0	114.0	132.0	16.64	14.55			11.66	13.57	
	Max	65.0	245.0	117.0	137.0	18.67	16.50			14.20	14.91	
	Mean	59.00	242.50	115.50	134.50	17.66	15.53			12.93	14.24	
	SD											

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>									
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)
<i>Trogon rufus capreicauda</i> male, adult	SD	8.49	3.54	2.12	3.54	1.44	1.38			1.80	0.95
	SE	6.00	2.50	1.50	2.50	1.01	0.97			1.27	0.67
	95% CL	76.24	31.77	19.06	31.77	12.90	12.39			16.14	8.51
	N	2	2	2	2	2	2			2	2
<i>Alcedinidae</i> (3) <i>Chloroceryle americana cabanisi</i> female, adult	N	57.0	265.0	147.0	139.0	18.40	16.56			14.29	11.26
		1	1	1	1	1	1			1	1
		31.0	190.0	81.0	57.0	44.64	40.51			8.70	7.57
		1	1	1	1	1	1			1	1
<i>Chloroceryle inda chocoensis</i> female, adult	Min	53.0*	220.0	96.0	59.0	48.59	44.03			10.57	8.44
	Max	58.0	230.0	100.0	65.0	50.00	44.03			11.59	9.41
	Mean	56.50	225.00	97.67	62.00	49.40	44.03			10.94	8.96
	SD	2.18	5.00	2.08	3.00	0.73				0.56	0.49
<i>Chloroceryle aenea aenea</i> female, adult	SE	1.26	2.89	1.20	1.73	0.42	0.00			0.32	0.28
	95% CL	5.41	12.42	5.17	7.45	1.81				1.40	1.21
	N (meas.)	4	3	3	3	3	2			3	4
	N (ind.)	3	3	3	3	3	1			3	3
<i>Momotidae</i> (2) <i>Electron platyrhynchum platyrhynchum</i> unsexed	N	15.0	140.0	61.0	38.0	30.62	26.60			6.85	6.22
		1	1	1	1	1	1			1	1
		76.0	364.0	125.0	194.0		32.86			16.45	
		1	1	1	1	1	1			1	1
<i>Berythobius martii senitrufig</i> unsexed	Min	121.0	370.0	145.0	170.0		36.30			13.10	
	Max	163.5	450.0	148.0	267.0		43.64			14.04	
	Mean	142.25	410.00	146.50	218.50		39.97			13.57	
	SD	30.05	56.57	2.12	68.59		5.19			0.66	
<i>Gallulidae</i> (1) <i>Gallula ruficauda melanogenia</i> unsexed	SE	21.25	40.00	1.50	48.50		3.67			0.47	
	95% CL	270.01	508.25	19.06	616.25		46.63			5.97	
	N	2	2	2	2	2	2			2	
		24.0	220.0	78.0	90.0	49.31	41.18			5.88	12.13
<i>Gallula ruficauda melanogenia</i> female, adult	Max	27.5	235.0	83.0	99.0	51.59	51.08			6.85	12.80
	Mean	25.86	229.50	81.00	94.80	50.45	47.54			6.37	12.37
	SD	1.21	5.96	1.67	3.19	1.61	3.55			0.41	0.37
	SE	0.46	2.43	0.68	1.43	1.14	1.45			0.17	0.21
<i>Gallula ruficauda melanogenia</i> female, adult	95% CL	1.12	6.25	1.76	3.97	14.49	3.73			0.43	0.92
	N	7	6	6	5	2	6			6	3
	Min	25.0	232.0	81.0	90.0		48.68			5.98	
	Max	26.5	232.0	81.0	90.0		48.68			5.98	
<i>Gallula ruficauda melanogenia</i> female, adult	Mean	25.75	232.00	81.00	90.00		48.68			5.98	
	SD	1.06									
	SE	0.75									
	95% CL	9.53									
<i>Gallula ruficauda melanogenia</i> female, adult	N	2	1	1	1	1	1			1	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Galbula ruficauda melanogenia</i> male, adult	Min	26.5	225.0	81.0	95.0	49.31	46.03			6.65	12.13	
	Max	26.5	230.0	83.0	95.0	51.59	50.00			6.85	12.80	
	Mean	26.50	227.50	82.00	95.00	50.45	48.02			6.75	12.47	
	SD	0.00	3.54	1.41	0.00	1.61	2.81			0.14	0.47	
	SE	0.00	2.50	1.00	0.00	1.14	1.99			0.10	0.34	
	95% CL	0.00	31.77	12.71	0.00	14.49	25.22			1.27	4.26	
	N	2	2	2	2	2	2			2	2	
<i>Galbula ruficauda melanogenia</i> male, recently fledged juvenile	N	22.0	175.0	78.0	66.0	27.45	24.79			5.48	12.19	
BUCCONIDAE (1) <i>Malacoptila panamensis polioptis</i> unsexed	Min	35.0	178.0	82.0	67.0	25.48	21.00		7.77	8.51	15.86	
	Max	49.5*	200.0	92.0	81.0	30.89	30.56		7.77	12.18	17.92	
	Mean	41.31	188.26	86.95	74.17	28.81	26.07		7.77	10.03	17.14	
	SD	3.02	6.35	3.19	3.88	1.60	2.80			1.12	0.69	
	SE	0.69	1.46	0.73	0.92	0.44	0.75			0.26	0.21	
	95% CL	1.45	3.06	1.54	1.93	0.97	1.61			0.56	0.46	
	N (meas.)	26	19	19	18	13	16		1	18	11	
<i>Malacoptila panamensis polioptis</i> female	N (ind.)	19	19	19	18	13	14		1	18	11	
<i>Malacoptila panamensis polioptis</i> male	Min	40.0	180.0	85.0	69.0	25.48	27.48			8.76	15.86	
	Max	45.0*	200.0	92.0	81.0	30.89	30.56			11.20	17.92	
	Mean	41.90	190.89	88.60	75.56	29.32	28.30			9.97	17.14	
	SD	0.91	6.68	2.50	4.00	1.69	1.16			0.82	0.82	
	SE	0.29	2.23	0.79	1.33	0.60	0.47			0.26	0.33	
	95% CL	0.65	5.13	1.79	3.08	1.41	1.22			0.59	0.86	
	N (meas.)	13	9	10	9	8	7			10	6	
<i>Malacoptila panamensis polioptis</i> male	N (ind.)	10	9	10	9	8	6			10	6	
CAPTITONIDAE (1) <i>Capito squamatus</i> unsexed	Min	35.0	178.0	82.0	67.0	27.04	21.00		7.77	8.51	16.26	
	Max	49.5*	195.0	91.0	77.0	29.93	28.20		7.77	12.18	17.87	
	Mean	40.35	186.00	85.25	72.25	27.99	24.08		7.77	10.10	17.15	
	SD	4.51	5.59	3.11	3.24	1.13	2.49			1.47	0.59	
	SE	1.60	1.86	1.10	1.15	0.51	0.94			0.52	0.26	
	95% CL	3.77	4.30	2.60	2.71	1.40	2.31			1.23	0.73	
	N (meas.)	12	9	8	8	5	8		1	8	5	
<i>Capito squamatus</i> female, adult	N (ind.)	8	9	8	8	5	7		1	8	5	
<i>Capito squamatus</i> female, adult	Min	57.5	175.0	81.0	51.0	22.53	19.82			9.19	21.79	
	Max	59.0	200.0	86.0	69.0	24.34	22.39			14.82	22.60	
	Mean	58.13	185.00	83.75	57.00	23.44	21.46			11.15	22.20	
	SD	0.63	13.23	2.06	10.39	1.28	1.14			2.55	0.57	
	SE	0.31	7.64	1.03	6.00	0.91	0.57			1.27	0.41	
	95% CL	1.00	32.86	3.28	25.82	11.50	1.82			4.05	5.15	
	N	4	3	4	3	2	4			4	2	
<i>Capito squamatus</i> female, adult	N	58.0	22.53	86.0	51.0	22.53	21.58			10.89	22.60	
<i>Capito squamatus</i> female, adult	N	1	1	1	1	1	1			1	1	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Capito squamatus</i> male, adult	Min	57.5	175.0	81.0	51.0	24.34	19.82			9.19	21.79	
	Max	59.0	200.0	84.0	69.0	24.34	22.39			14.82	21.79	
	Mean	58.17	185.00	83.00	60.00	24.34	21.42			11.24	21.79	
	SD	0.76	13.23	1.73	12.73		1.39			3.11		
	SE	0.44	7.64	1.00	9.00		0.80			1.80		
	95% CL	1.90	32.86	4.30	114.36		3.46			7.73		
	N	3	3	3	2	1	3			3	1	
RAMPHASTIDAE (1) <i>Pronglossus sanguineus</i> unsexed	Min	242.0	400.0	150.0	149.0	123.15	101.65		30.69	28.12	33.93	The bill patterns of some individuals
	Max	270.0	475.0	161.0	162.0	123.15	123.15		30.69	33.78	38.15	showed characteristics of either
	Mean	250.50	436.25	155.25	155.50	123.15	114.33		30.69	30.53	35.63	<i>P. sanguineus</i> or <i>P. erythrophagus</i> , and
	SD	13.10	30.65	4.57	9.19		10.39			2.92	2.23	those of others a mixture between
	SE	6.55	15.33	2.29	6.50		5.20			1.69	1.29	both taxa.
	95% CL	20.85	48.78	7.28	82.59		16.54			7.26	5.54	
	N	4	4	4	2	1	4		1	3	3	
PICIDAE (2) <i>Picumnus olivaceus harterti</i> unsexed	Min	10.5	90.0	51.0	26.0	11.73	10.57			4.53	11.55	
	Max	13.5	95.0	56.0	30.0	12.84	11.62			5.55	14.23	
	Mean	11.83	92.00	53.80	27.60	12.11	11.04			5.23	12.88	
	SD	1.20	2.74	1.92	1.82	0.44	0.46			0.40	1.04	
	SE	0.54	1.22	0.86	0.81	0.20	0.20			0.18	0.46	
	95% CL	1.49	3.40	2.39	2.26	0.55	0.57			0.50	1.29	
	N (meas.)	8	5	5	5	5	5			5	6	
<i>Picumnus olivaceus harterti</i> female, adult	N (ind.)	5	5	5	5	5	5			5	5	
	Min	11.0	90.0	51.0	26.0	11.87	10.73			5.29	11.55	
	Max	12.5	90.0	56.0	27.0	11.91	10.86			5.55	14.23	
	Mean	11.75	90.00	53.50	26.50	11.89	10.80			5.42	12.89	
	SD	1.06	0.00	3.54	0.71	0.03	0.09			0.18	1.90	
	SE	0.75	0.00	2.50	0.50	0.02	0.06			0.13	1.34	
	95% CL	9.53	0.00	31.77	6.35	0.29	0.83			1.65	17.03	
<i>Picumnus olivaceus harterti</i> male, adult	N (meas.)	2	2	2	2	3	2			2	3	
	N (ind.)	2	2	2	2	2	2			2	2	
	Min	10.5	90.0	53.0	26.0	11.73	10.57			4.53	12.23	
	Max	13.5	95.0	55.0	30.0	12.84	11.62			5.39	13.38	
	Mean	11.88	93.33	54.00	28.33	12.25	11.21			5.10	12.88	
	SD	1.52	2.89	1.00	2.08	0.56	0.56			0.49	0.59	
	SE	0.88	1.67	0.58	1.20	0.32	0.32			0.28	0.34	
<i>Veniliornis callionotus callionotus</i> unsexed	95% CL	3.76	7.17	2.48	5.17	1.39	1.39			1.22	1.46	
	N (meas.)	6	3	3	3	3	3			3	3	
	N (ind.)	3	3	3	3	3	3			3	3	
	Min	26.0	135.0	74.0	45.0	16.65	16.04			6.87	14.70	
	Max	27.5	140.0	75.0	47.0	18.78	16.04			8.25	14.96	
	Mean	26.75	137.50	74.50	46.00	17.72	16.04			7.56	14.83	
	SD	1.06	3.54	0.71	1.41	1.51				0.98	0.18	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Veniliornis callionotus callionotus</i> female, adult	SE	0.75	2.50	0.50	1.00	1.07				0.69	0.13	
	95% CL	9.53	31.77	6.35	12.71	13.53				8.77	1.65	
	N	2	2	2	2	2	1			2	2	
		26.0	135.0	74.0	47.0	16.65	16.04			6.87	14.96	
<i>Veniliornis callionotus callionotus</i> male, adult	N	1	1	1	1	1	1			1	1	
		27.5	140.0	75.0	45.0	18.78				8.25	14.70	
FURNARIIDAE (4)	N	1	1	1	1	1				1	1	
<i>Synallaxis brachyura chapmani</i> unsexed	Min	16.0	140.0	52.0	60.0	14.42	12.62			4.47	19.01	
	Max	22.0	165.0	60.0	81.0	16.98	14.89			5.53	22.35	
	Mean	18.97	154.28	56.23	73.48	15.80	13.70			5.05	20.96	
	SD	1.41	6.54	2.14	5.67	0.67	0.62			0.30	0.81	
	SE	0.26	1.46	0.42	1.24	0.15	0.12			0.06	0.17	
	95% CL	0.54	3.06	0.86	2.58	0.32	0.25			0.12	0.36	
	N (meas.)	42	21	27	22	24	33			27	27	
	N (ind.)	29	20	26	21	19	26			27	22	
<i>Hylactes virgatus assimilis</i> unsexed	Min	30.5	160.0	76.0	57.0	20.51	18.56		4.81	5.20	19.64	
	Max	39.0	185.0	88.0	72.0	24.11	21.76		4.81	6.95	23.15	
	Mean	34.16	171.56	83.04	65.46	22.68	20.42		4.81	6.11	21.34	
	SD	2.05	5.89	3.34	3.43	0.98	0.73			0.37	1.12	
	SE	0.44	1.20	0.68	0.70	0.24	0.16			0.08	0.27	
	95% CL	0.91	2.49	1.41	1.45	0.50	0.34			0.16	0.58	
	N (meas.)	35	25	24	24	21	25		1	23	22	
	N (ind.)	22	24	24	24	17	20		1	23	17	
<i>Automolus rubiginosus nigritanda</i> unsexed	Min	38.0	170.0	80.0	67.0	23.97	22.08			5.83	24.54	
	Max	54.5*	193.5	88.0	84.0	27.57	24.64			6.86	26.91	
	Mean	43.88	184.81	84.00	72.63	25.59	23.26			6.31	25.78	
	SD	3.81	7.76	2.56	4.96	1.40	0.99			0.29	0.94	
	SE	1.35	2.75	0.91	1.75	0.63	0.37			0.10	0.42	
	95% CL	3.18	6.49	2.14	4.14	1.74	0.91			0.25	1.17	
	N (meas.)	12	9	8	8	5	9			8	5	
	N (ind.)	8	8	8	8	5	7			8	5	
<i>Xenops minutus littoralis</i> unsexed	Min	10.0*	110.0	57.5	42.0	12.41	11.54		3.22	4.30	13.12	
	Max	13.5	125.0	68.0	52.0	14.61	13.44		3.29	5.28	16.15	
	Mean	11.92	116.60	63.07	47.28	13.66	12.55		3.26	4.66	14.59	
	SD	0.86	4.19	3.16	2.99	0.61	0.54		0.05	0.22	0.86	
	SE	0.17	0.99	0.67	0.70	0.15	0.11		0.04	0.05	0.20	
	95% CL	0.35	2.08	1.40	1.49	0.31	0.23		0.44	0.10	0.43	
	N (meas.)	44	21	24	20	18	30		2	25	21	
	N (ind.)	26	18	22	18	17	23		2	22	18	
DENDROCOLAPTIDAE (7)	Min	32.5	195.0	96.0	77.0	25.61	22.96		6.32	7.61	20.97	
<i>Dendrocincla fuliginosa ridgwayi</i> unsexed	Max	44.5*	225.0	112.0	96.0	31.36	28.45		7.30	9.13	25.84	
	Mean	39.17	212.47	104.41	85.94	29.55	25.97		6.67	8.13	23.31	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Glyptorhynchus spirurus subternus</i> unsexed	SD	3.66	11.76	4.90	6.35	1.82	1.76		0.54	0.46	1.41	
	SE	0.94	3.04	1.23	1.59	0.64	0.44		0.31	0.13	0.47	
	95% CL	2.03	6.52	2.61	3.38	1.52	0.94		1.35	0.28	1.08	
	N (meas.)	26	17	18	18	12	23		3	15	13	
	N (ind.)	15	15	16	16	8	16		3	13	9	
	Min	12.0	130.0	60.0	58.0	10.27	9.63		3.70	4.83	14.21	
<i>Dendrovolaptes sanctithomae colombianus</i> unsexed, immature	Max	16.0	150.0	72.0	74.0	13.32	11.84		4.48	5.79	16.72	
	Mean	14.00	137.68	66.85	64.88	11.89	10.59		4.06	5.39	15.66	
	SD	1.01	4.79	3.09	4.12	0.84	0.54		0.29	0.24	0.60	
	SE	0.15	0.75	0.45	0.63	0.15	0.08		0.09	0.04	0.11	
	95% CL	0.29	1.51	0.91	1.27	0.30	0.16		0.21	0.08	0.22	
	N (meas.)	86	41	47	43	44	55		10	39	45	
<i>Xiphorhynchus lachrymosus lachrymosus</i> unsexed, adult	N (ind.)	48	41	47	43	32	43		10	38	32	
	Min	68.0	280.0	126.0	125.0	42.10	37.24		10.03	25.37		
	Max	57.0	245.0	117.0	96.0	39.63	34.94		8.29	22.35		
	Mean	45.0*	210.0	97.0	85.0	34.39	29.30		6.60	20.40		
	SE	50.5*	235.0	118.0	100.0	36.17	33.79		7.88	22.58		
	N (ind.)	48.11	223.57	106.50	93.00	35.11	31.65		7.32	21.24		
<i>Xiphorhynchus erythroggius aquatorialis</i> unsexed	SD	1.76	9.45	7.04	5.57	0.80	1.50		0.45	0.95		
	SE	0.66	3.57	2.87	2.10	0.40	0.57		0.17	0.47		
	95% CL	1.62	8.74	7.38	5.15	1.28	1.39		0.41	1.50		
	N (meas.)	10	7	6	7	5	7		7	5		
	N (ind.)	7	7	6	7	4	7		7	4		
	Min	27.5	195.0	90.0	91.0	26.78	25.16		5.91	17.98		
<i>Lepidolaptes onclejei emeraldiae</i> unsexed, adult	Max	39.0	250.0	95.0	90.0	63.63	61.21		5.75	19.64		
	Mean	47.0*	255.0	100.0	106.0	65.03	64.67		6.72	22.50		
	SD	42.33	253.33	98.00	97.33	64.51	62.74		6.24	21.21		
	SE	2.89	2.89	2.65	8.08	0.77	1.76		0.49	1.45		
	95% CL	1.67	1.67	1.53	4.67	0.44	1.02		0.28	0.84		
	N (meas.)	5	3	3	3	3	3		1.20	3.60		
<sup>T</sup> <i>Thamnophilidae</i> (14) <i>Taraba major transandanus</i> unsexed	N (ind.)	3	3	3	3	3	3		3	3		
	Min	55.5	195.0	80.0	64.0	28.40	24.78		7.53	30.59		
	Max	65.5	200.0	93.0	81.0	30.71	26.52		8.83	34.36		
	Mean	59.50	196.67	88.33	75.00	29.74	25.66		8.21	32.86		
	SD	4.42	2.89	7.23	9.54	1.20	0.87		0.53	2.00		
	SE	2.21	1.67	4.18	5.51	0.69	0.50		0.27	1.16		
<i>Taraba major transandanus</i> unsexed	95% CL	7.03	7.17	17.97	23.70	2.97	2.16		0.85	4.97		
	N	4	3	3	3	3	3		4	3		



## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Tairāba major transandensis</i> female-plumaged	N	65.5	195.0	80.0	81.0	30.7	26.52			8.31	34.36	
<i>Tairāba major transandensis</i> male, adult	Min	55.5	195.0	92.0	64.0	28.40	24.78			7.53	30.59	
	Max	60.0	200.0	93.0	80.0	30.10	25.67			8.83	33.64	
	Mean	57.50	197.50	92.50	72.00	29.25	25.23			8.18	32.12	
	SD	2.29	3.54	0.71	11.31	1.20	0.63			0.65	2.16	
	SE	1.32	2.50	0.50	8.00	0.85	0.44			0.38	1.52	
	95% CL	5.69	31.77	6.35	101.65	10.80	5.65			1.61	19.38	
<i>Thamnophilus atrinucha atrinucha</i> unsexed	N	3	2	2	2	2	2			3	2	
	Min	21.5	145.0	65.0	51.0	19.34	16.12			6.35	19.15	
	Max	25.0	155.0	72.0	58.0	22.46	17.84			6.84	22.52	
	Mean	23.18	150.00	68.22	54.25	20.77	17.85			6.59	21.05	
	SD	1.12	2.67	1.79	2.60	1.10	1.26			0.19	1.17	
	SE	0.35	0.94	0.60	0.92	0.41	0.42			0.06	0.41	
	95% CL	0.80	2.23	1.37	2.18	1.01	0.97			0.15	0.98	
	N (meas.)	11	8	9	8	7	10			9	8	
<i>Thamnophilus atrinucha atrinucha</i> female-plumaged	N (ind.)	10	8	9	8	7	9			9	8	
	Min	21.5	150.0	68.0	56.0	19.34	16.12			6.35	20.46	
	Max	25.0*	155.0	72.0	58.0	22.46	17.84			6.71	22.52	
	Mean	22.44	152.50	69.33	57.00	20.70	17.16			6.49	21.26	
	SD	1.13	3.54	2.31	1.41	1.60	0.74			0.19	1.10	
	SE	0.56	2.50	1.33	1.00	0.92	0.37			0.11	0.64	
	95% CL	1.79	31.77	5.74	12.71	3.97	1.18			0.47	2.74	
	N (meas.)	5	2	3	2	3	5			3	3	
<i>Thamnophilus atrinucha atrinucha</i> male-plumaged	N (ind.)	4	2	3	2	3	4			3	3	
	Min	23.0	145.0	65.0	51.0	19.83	16.30			6.36	19.15	
	Max	25.0	150.0	69.0	57.0	21.73	19.90			6.84	22.39	
	Mean	23.67	149.17	67.67	53.33	20.82	18.40			6.64	20.92	
	SD	0.88	2.04	1.37	2.25	0.83	1.38			0.19	1.32	
	SE	0.36	0.83	0.56	0.92	0.41	0.62			0.08	0.59	
	95% CL	0.92	2.14	1.43	2.36	1.32	1.71			0.20	1.63	
<i>Dysithamnus puncticeps flemmingi</i> unsexed	N	6	6	6	6	4	5			6	5	
	Min	16.5	110.0	54.5	34.0	17.15	14.56			5.96	18.12	
	Max	17.5*	115.0	59.0	37.0	17.15	15.47			6.46	18.12	
	Mean	16.88	112.50	56.75	35.50	17.15	15.01			6.21	18.12	
	SD	0.53	3.54	3.18	2.12	0.64	0.64			0.35	0.35	
	SE	0.38	2.50	2.25	1.50	0.00	0.45			0.25	0.25	
	95% CL	4.76	31.77	28.59	19.06		5.75			3.18		
	N (meas.)	3	3	3	3	2	3			2	2	
<i>Myrmotherula pacifica</i> unsexed	N (ind.)	2	2	2	2	1	2			2	1	
	Min	8.5	85.0	49.0	23.0	15.06	10.86			4.32	16.16	
	Max	11.0	100.0	54.0	31.0	17.34	14.49			5.03	17.88	
	Mean	9.72	92.47	51.50	27.78	16.02	13.52			4.59	16.95	
	SD	0.62	3.54	1.67	2.18	0.81	0.98			0.20	0.62	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Myrmotherula pacifica</i> female, adult	SE	0.14	0.88	0.42	0.55	0.27	0.24			0.05	0.21	
	95% CL	0.29	1.89	0.89	1.16	0.62	0.52			0.10	0.47	
	N (meas.)	26	19	19	19	13	22			20	12	
	N (ind.)	20	16	16	16	9	16			17	9	
	Min	9.0	85.0	49.0	26.0	15.06	12.61			4.32	16.84	
	Max	11.0*	100.0	52.0	29.0	17.34	14.20			5.03	17.69	
	Mean	9.78	92.50	51.00	28.20	15.91	13.49			4.66	17.24	
	SD	0.57	5.59	1.22	1.30	1.25	0.81			0.26	0.43	
	SE	0.23	2.50	0.55	0.58	0.72	0.36			0.12	0.25	
	95% CL	0.60	6.94	1.52	1.62	3.10	1.00			0.32	1.06	
<i>Myrmotherula pacifica</i> male, adult	N (meas.)	8	6	6	6	5	7			5	5	
	N (ind.)	6	5	5	5	3	5			5	3	
	Min	8.5	90.0	49.0	23.0	15.44	13.33			4.32	16.49	
	Max	11.0*	95.0	54.0	31.0	16.12	14.26			4.71	17.88	
	Mean	9.72	92.43	52.25	27.19	15.70	13.85			4.54	17.12	
	SD	0.67	2.51	1.91	2.78	0.32	0.37			0.14	0.60	
	SE	0.24	0.95	0.67	0.98	0.16	0.14			0.05	0.30	
	95% CL	0.56	2.32	1.60	2.32	0.51	0.34			0.12	0.96	
	N (meas.)	12	9	10	10	6	11			10	5	
	N (ind.)	8	7	8	8	4	7			4	4	
<i>Myrmotherula fulviventris fulviventris</i> unsexed	Min	9.0	93.5	45.0	29.0	13.48	11.24		3.76	4.52	14.43	
	Max	12.5*	105.0	56.0	39.0	15.67	14.24		4.27	5.51	18.06	
	Mean	10.65	99.32	51.41	33.89	15.05	13.02		4.07	4.87	16.36	
	SD	0.59	3.55	2.19	2.42	0.62	0.80		0.17	0.20	0.87	
	SE	0.10	0.59	0.36	0.41	0.13	0.13		0.07	0.04	0.18	
	95% CL	0.20	1.20	0.73	0.83	0.26	0.27		0.18	0.07	0.37	
	N (meas.)	56	37	38	36	26	39		7	31	26	
	N (ind.)	38	36	37	35	24	35		6	31	24	
	Min	10.0	98.0	48.0	30.0	14.81	11.24		4.08	4.72	16.14	
	Max	12.0	100.0	53.0	36.0	15.53	14.05		4.27	5.51	17.81	
<i>Myrmotherula fulviventris fulviventris</i> female, adult	Mean	11.10	99.67	51.29	33.00	15.21	12.81		4.18	5.05	16.72	
	SD	0.61	0.82	1.60	2.00	0.32	1.02		0.13	0.34	0.75	
	SE	0.23	0.33	0.61	0.82	0.16	0.38		0.10	0.15	0.37	
	95% CL	0.56	0.86	1.48	2.10	0.51	0.94		1.21	0.42	1.19	
	N (meas.)	12	6	7	6	4	8		2	5	4	
	N (ind.)	7	6	7	6	4	7		2	5	4	
	Min	10.0*	93.5	48.0	30.0	13.48	12.21		3.76	4.77	14.92	
	Max	12.5*	105.0	55.0	39.0	15.67	14.24		4.15	5.02	17.78	
	Mean	10.94	100.23	51.82	33.73	14.95	13.18		4.02	4.88	16.13	
	SD	0.38	4.23	2.09	2.61	0.77	0.76		0.18	0.10	1.08	
<i>Myrmotherula fulviventris fulviventris</i> male, adult	SE	0.11	1.27	0.63	0.79	0.29	0.25		0.09	0.04	0.41	
	95% CL	0.26	2.84	1.40	1.75	0.71	0.58		0.29	0.09	1.00	
	N (meas.)	21	12	12	12	8	12		5	7	8	
	N (ind.)	11	11	11	11	7	9		4	7	7	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Myiotherula axillaris albicula</i> unsexed	Min	7.0	85.0	48.0	29.0	14.08	12.17		3.42	4.04	13.75	
	Max	10.0	100.0	54.0	34.0	14.99	13.66		3.76	4.84	15.61	
	Mean	8.48	92.46	50.83	31.09	14.48	12.89		3.59	4.35	15.03	
	SD	0.60	3.83	1.90	1.39	0.30	0.42		0.24	0.21	0.54	
	SE	0.11	0.77	0.39	0.30	0.08	0.09		0.17	0.05	0.16	
	95% CL	0.22	1.58	0.80	0.61	0.17	0.19		2.16	0.10	0.34	
	N (meas.)	41	27	27	24	17	26		2	25	16	
<i>Myiotherula axillaris albicula</i> female, adult	N (ind.)	30	25	24	22	14	21		2	22	12	
	Min	8.0	85.0	48.0	30.0	14.12	12.30		3.42	4.04	13.75	
	Max	10.0*	95.0	52.0	32.5	14.99	13.66		3.76	4.71	15.61	
	Mean	8.50	92.88	50.00	30.88	14.46	13.02		3.59	4.31	15.05	
	SD	0.49	3.56	1.60	0.88	0.36	0.47		0.24	0.27	0.88	
	SE	0.15	1.26	0.57	0.31	0.16	0.18		0.17	0.11	0.44	
	95% CL	0.35	2.98	1.34	0.73	0.45	0.43		2.16	0.28	1.39	
<i>Myiotherula axillaris albicula</i> male, adult	N (meas.)	15	9	10	10	7	10		2	8	6	
	N (ind.)	10	8	8	8	5	7		2	6	4	
	Min	7.5*	87.5	48.0	29.0	14.08	12.20		3.42	4.06	14.69	
	Max	9.0	100.0	54.0	34.0	14.87	13.35		4.69	5.56	15.56	
	Mean	8.54	92.55	51.80	31.44	14.55	12.94		4.35	5.18	15.18	
	SD	0.44	4.66	1.93	1.81	0.29	0.35		0.16	0.37	0.37	
	SE	0.14	1.47	0.61	0.60	0.11	0.11		0.05	0.17	0.17	
<i>Myiotherula schistator schistator</i> female, immature?	95% CL	0.32	3.33	1.38	1.39	0.26	0.25		0.12	0.11	0.47	
	N (meas.)	15	11	11	9	7	12		11	6	6	
	N (ind.)	10	10	10	9	7	10		10	5	5	
<i>Microtopias quizensis consobrina</i> male, adult	Min	8.5	90.0	53.0	26.0	12.09	11.02		4.06	4.06	15.85	
	Max	1	1	1	1	1	1		1	1	1	
	Mean	9.0	110.0	52.0	48.0	13.06	11.94		4.54	4.54	16.56	
	SD	1	1	1	1	1	1		1	1	1	
	SE	1	1	1	1	1	1		1	1	1	
	95% CL	1	1	1	1	1	1		1	1	1	
	N (ind.)	1	1	1	1	1	1		1	1	1	
<i>Cercomacra tyrannina tyrannina</i> unsexed	Min	15.0	120.0	55.0	44.0	15.46	13.68		4.80	5.11	19.49	
	Max	20.0	140.0	69.0	59.0	19.18	16.51		4.80	6.06	23.41	
	Mean	17.23	132.63	62.33	53.33	17.52	15.26		4.80	5.59	21.73	
	SD	1.09	5.12	2.97	3.33	0.83	0.74			0.22	0.90	
	SE	0.15	0.74	0.42	0.48	0.15	0.12			0.03	0.15	
	95% CL	0.31	1.49	0.85	0.97	0.30	0.24			0.06	0.31	
	N (meas.)	83	48	49	48	42	51		1	49	46	
<i>Cercomacra tyrannina tyrannina</i> female, adult	N (ind.)	50	48	49	48	33	40		1	38	36	
	Min	15.5*	125.0	56.0	44.0	16.06	14.24			5.34	19.49	
	Max	20.0	140.0	66.0	54.0	17.80	16.49			5.82	22.74	
	Mean	17.22	131.67	62.13	51.00	16.96	15.19			5.54	21.39	
	SD	1.21	6.00	3.18	3.20	0.61	0.87			0.15	0.93	
	SE	0.35	2.00	1.13	1.07	0.20	0.29			0.05	0.28	
	95% CL	0.77	4.61	2.66	2.46	0.47	0.67			0.12	0.63	
<i>Cercomacra tyrannina tyrannina</i> unsexed	N (meas.)	21	9	8	9	12	13			9	15	
	N (ind.)	12	9	8	9	9	9			9	11	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Cercomacra tyrannina tyrannina</i> male, adult	Min	15.5	128.0	61.0	49.0	16.83	14.71		4.80	5.31	20.47	
	Max	19.0	140.0	68.0	59.0	19.18	16.51		4.80	6.06	23.41	
	Mean	17.76	135.93	63.80	55.27	18.02	15.56		4.80	5.64	22.25	
	SD	0.86	3.79	1.78	2.74	0.73	0.57			0.24	0.80	
	SE	0.21	1.01	0.46	0.71	0.20	0.15			0.06	0.22	
	95% CL	0.44	2.19	0.99	1.52	0.44	0.33			0.14	0.48	
	N (meas.)	34	14	15	15	17	19		1	15	17	
<i>Hylophilax naenioides naenioides</i> unsexed	Min	14.5	100.0	57.0	29.0	15.38	13.81		4.11	5.32	19.41	
	Max	18.5	120.0	67.0	39.0	18.77	16.80		5.75	6.82	23.25	
	Mean	16.36	113.31	62.45	34.68	17.30	15.35		4.73	5.82	21.42	
	SD	0.90	4.55	2.30	2.08	0.83	0.75		0.51	0.35	0.86	
	SE	0.14	0.72	0.36	0.35	0.16	0.12		0.18	0.06	0.17	
	95% CL	0.28	1.46	0.73	0.71	0.33	0.24		0.42	0.13	0.34	
	N (meas.)	66	47	48	41	34	53		10	37	34	
<i>Hylophilax naenioides naenioides</i> female, adult	Min	14.5	105.0	59.0	31.0	15.59	13.92		4.40	5.50	20.54	
	Max	18.5	120.0	66.0	37.0	17.72	16.80		5.75	6.72	22.39	
	Mean	16.54	113.27	62.35	34.50	17.05	15.29		4.83	5.81	21.66	
	SD	1.04	5.00	2.27	2.12	0.73	0.81		0.62	0.36	0.57	
	SE	0.29	1.39	0.63	0.61	0.24	0.22		0.31	0.12	0.19	
	95% CL	0.63	3.02	1.37	1.35	0.56	0.49		0.99	0.28	0.44	
	N (meas.)	21	15	15	14	11	18		5	10	11	
<i>Hylophilax naenioides naenioides</i> male, adult	Min	13	13	13	12	9	13		4	9	9	
	Max	15.0	100.0	61.0	33.3	16.33	14.26		4.46	5.32	19.41	
	Mean	18.5*	120.0	67.0	39.0	18.77	16.78		4.93	6.00	23.25	
	SD	16.58	112.87	63.80	35.52	17.60	15.53		4.70	5.72	21.50	
	SE	0.87	5.66	1.68	1.49	0.70	0.73		0.33	0.19	1.01	
	95% CL	0.22	1.46	0.42	0.41	0.21	0.19		0.23	0.05	0.30	
	N (meas.)	31	20	21	17	16	24		3	17	16	
<i>Myrmeciza immaculata macrobryncha</i> unsexed	Min	39.0	170.0	81.0	71.0	20.64	19.36		6.09	6.46	31.85	
	Max	55.0*	195.0	88.0	80.0	25.31	21.98		6.09	7.73	36.14	
	Mean	44.48	184.55	83.47	75.50	23.37	20.94		6.09	6.95	34.29	
	SD	3.10	5.26	2.29	2.70	1.29	0.81			0.38	1.19	
	SE	0.71	1.21	0.53	0.66	0.36	0.20			0.09	0.32	
	95% CL	1.49	2.54	1.11	1.39	0.78	0.43			0.20	0.69	
	N (meas.)	27	20	20	18	16	20		1	18	17	
<i>Myrmeciza immaculata macrobryncha</i> female, adult	Min	44.0	170.0	81.0	71.0	22.77	19.36		6.09	6.68	35.53	
	Max	49.0*	185.0	84.0	75.0	24.56	21.79		6.09	7.36	35.04	
	Mean	46.29	180.83	82.50	73.00	23.28	20.69		6.09	7.07	34.13	
	SD	1.98	5.85	1.05	1.58	0.86	0.84			0.33	0.65	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Myrmeciza immaculata macrorhyncha</i> male, adult	SE	0.81	2.39	0.43	0.71	0.43	0.34			0.17	0.32	
	95% CL	2.08	6.13	1.10	1.96	1.36	0.88			0.53	1.03	
	N (meas.)	8	6	6	5	5	7		1	4	5	
	N (ind.)	6	6	6	5	4	6		1	4	4	
	Min	41.0*	185.0	81.0	73.0	21.62	19.56			6.46	33.77	
	Max	55.0*	190.0	88.0	77.0	24.44	21.57			7.37	36.14	
	Mean	44.92	186.44	83.38	75.21	23.71	20.83			6.86	34.82	
	SD	3.25	2.26	1.41	1.20	0.89	0.32			0.32	0.93	
	SE	1.15	0.80	0.92	0.53	0.54	0.36			0.11	0.38	
	95% CL	2.72	1.89	2.19	1.30	1.49	0.93			0.27	0.98	
<i>Myrmeciza exul maculifer</i> unsexed	N (meas.)	14	9	9	8	7	9		7	9	8	
	N (ind.)	8	8	8	7	5	6			8	6	
	Min	20.5	115.0	60.0	36.0	18.03	13.22		4.40	5.02	25.12	
	Max	28.5*	140.0	68.0	47.0	20.89	19.72		4.87	6.67	27.39	
	Mean	23.21	127.06	63.13	41.59	19.50	17.22		4.61	5.67	26.08	
	SD	1.58	5.43	2.43	2.44	0.93	1.37		0.16	0.41	0.63	
	SE	0.25	0.92	0.39	0.40	0.20	0.23		0.07	0.07	0.13	
	95% CL	0.50	1.87	0.79	0.81	0.43	0.47		0.17	0.14	0.28	
	N (meas.)	57	36	41	39	25	41		7	34	26	
	N (ind.)	40	35	39	37	21	35		6	34	22	
<i>Myrmeciza exul maculifer</i> female, adult	Min	21.5	118.0	60.0	37.0	18.15	16.69		4.40	5.30	25.12	
	Max	28.5*	135.0	66.0	43.0	19.83	19.66		4.87	6.01	27.08	
	Mean	23.58	126.38	63.30	40.63	18.93	17.56		4.59	5.68	26.24	
	SD	1.63	4.84	2.16	1.85	0.70	0.91		0.25	0.27	0.77	
	SE	0.52	1.71	0.68	0.65	0.31	0.30		0.14	0.10	0.32	
	95% CL	1.17	4.05	1.55	1.54	0.87	0.70		0.61	0.25	0.81	
	N (meas.)	18	9	11	9	7	13		4	7	8	
	N (ind.)	10	8	10	8	5	9		3	7	6	
	Min	21.0	125.0	61.0	37.0	18.03	13.70		4.54	5.40	25.25	
	Max	26.5*	140.0	68.0	46.0	20.89	19.72		4.66	6.17	27.39	
<i>Myrmeciza exul maculifer</i> male, adult	Mean	23.81	129.27	64.21	42.13	19.75	17.25		4.62	5.77	26.04	
	SD	1.45	4.57	2.36	2.42	0.89	1.40		0.07	0.29	0.64	
	SE	0.36	1.18	0.63	0.62	0.26	0.37		0.04	0.08	0.18	
	95% CL	0.77	2.53	1.36	1.34	0.57	0.81		0.17	0.19	0.40	
	N (meas.)	23	15	15	16	14	16		3	12	14	
	N (ind.)	16	15	14	15	12	14		3	12	12	
<i>Myrmeciza berlepschi</i> unsexed	Min	26.0	135.0	65.0	42.0	19.80	16.74			5.58	23.98	
	Max	32.0	150.0	70.0	50.0	21.73	19.82			6.52	27.54	
	Mean	28.04	141.42	67.43	45.15	20.76	18.26			5.94	25.78	
	SD	1.64	4.10	1.95	2.79	0.67	0.85			0.30	1.14	
	SE	0.44	1.18	0.52	0.77	0.21	0.24			0.08	0.36	
	95% CL	0.95	2.61	1.13	1.69	0.48	0.54			0.18	0.82	
	N (meas.)	20	12	14	13	12	14			14	12	
	N (ind.)	14	12	14	13	10	12			13	10	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>									
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)
<i>Myrmeciza berlepschi</i> female, adult	Min	26.0*	140.0	66.0	43.0	20.98	16.74			5.58	25.70
	Max	30.0*	140.0	70.0	48.0	21.33	18.64			5.64	26.22
	Mean	27.69	140.00	68.00	44.67	21.15	17.90			5.61	25.96
	SD	1.41	0.00	2.00	2.89	0.25	1.02			0.04	0.37
	SE	0.81	0.00	1.15	1.67	0.18	0.59			0.03	0.26
	95% CL	3.50	0.00	4.97	7.17	2.24	2.53			0.35	3.30
	N (meas.)	6	2	3	3	4	4			3	4
	N (ind.)	3	2	3	3	2	3			2	2
<i>Myrmeciza berlepschi</i> male, adult	Min	26.0*	135.0	65.0	42.0	19.80	17.16			5.78	23.98
	Max	32.0	150.0	70.0	49.0	21.73	18.82			6.52	27.54
	Mean	28.50	141.50	67.00	44.57	20.58	18.05			6.08	26.00
	SD	1.75	4.87	1.85	2.88	0.80	0.63			0.29	1.45
	SE	0.62	1.72	0.65	1.09	0.36	0.26			0.10	0.65
	95% CL	1.47	4.07	1.55	2.66	0.99	0.66			0.24	1.80
	N (meas.)	11	8	8	7	5	7			8	5
	N (ind.)	8	8	8	7	5	6			8	5
<i>Gymnophthys leucapsis aequatorialis</i> unsexed	Min	28.5	140.0	72.0	43.0	18.85	16.16		4.40	6.14	26.09
	Max	40.0*	160.0	83.0	52.0	22.12	19.08		4.90	7.41	30.05
	Mean	34.01	146.49	77.40	47.31	20.29	17.85		4.65	6.72	27.93
	SD	2.30	5.11	2.53	2.30	0.82	0.74		0.21	0.32	1.04
	SE	0.38	0.84	0.42	0.38	0.17	0.12		0.10	0.05	0.21
	95% CL	0.77	1.70	0.85	0.77	0.35	0.25		0.33	0.11	0.43
	N (meas.)	67	39	39	39	25	43		4	35	26
	N (ind.)	37	37	37	37	24	37		4	33	25
FORMICARIIDAE (2) <i>Formicarius nigricapillus destructus</i> unsexed	Min	49.0	160.0	80.0	50.0	21.22	17.96			6.34	27.67
	Max	64.0	180.0	90.0	61.0	23.60	20.06			7.84	34.82
	Mean	57.31	170.22	85.32	53.73	22.12	18.92			7.15	31.25
	SD	3.37	5.16	2.41	3.35	0.86	0.66			0.38	2.13
	SE	0.97	1.49	0.73	1.01	0.30	0.20			0.11	0.71
	95% CL	2.14	3.28	1.62	2.25	0.72	0.44			0.24	1.64
	N (meas.)	21	14	12	11	10	15			14	12
	N (ind.)	12	12	11	11	8	11			12	9
<i>Hypoleucos perspicillatus periphradmicus</i> unsexed	Min	41.0	130.0	77.0	25.0	19.77	17.16			6.07	33.91
	Max	42.5	135.0	80.0	30.0	19.77	18.61			6.70	33.91
	Mean	42.00	133.33	78.00	27.67	19.77	18.02			6.32	33.91
	SD	0.87	2.89	1.73	2.52		0.76			0.34	
	SE	0.50	1.67	1.00	1.45		0.44			0.19	
	95% CL	2.15	7.17	4.30	6.25		1.89			0.84	
	N (meas.)	3	3	3	3	1	3			3	1
	N (ind.)	3	3	3	3	1	3			3	1
TYRANIDAE (24) <i>Zimmerius thryopsis albigrularis</i> unsexed	Min	7.5	95.0	45.0	43.0	8.68	7.27			3.53	14.19
	Max	9.5	105.0	50.0	44.0	8.99	7.93			4.02	16.24
	Mean	8.50	100.00	48.00	43.50	8.87	7.55			3.79	15.42

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Ornithion brunneicapillus brunneicapillus</i> unsexed	SD	1.00	7.07	2.65	0.71	0.16	0.34			0.25	1.08	
	SE	0.58	5.00	1.53	0.50	0.09	0.20			0.14	0.63	
	95% CL	2.48	63.53	6.57	6.35	0.41	0.85			0.61	2.69	
	N	3	2	3	2	3	3			3	3	
	N	6.5	75.0	44.0	21.0	9.42				4.01	11.55	
<i>Myiopagis viridicata inoplacens</i> unsexed	Min	12.5	125.0	61.0	55.0	11.09	9.65			4.64	15.92	
	Max	14.5	135.0	68.0	61.0	12.38	11.17			5.41	19.13	
	Mean	13.25	130.00	64.00	57.33	11.73	10.13			5.01	17.62	
	SD	0.76	4.47	2.90	2.50	0.53	0.54			0.37	1.38	
	SE	0.31	1.83	1.18	1.02	0.22	0.22			0.15	0.62	
<i>Miomectes olivaceus hederaceus</i> unsexed	95% CL	0.80	4.69	3.04	2.63	0.55	0.56			0.39	1.71	
	N	6	6	6	6	6	6			6	5	
	Min	11.0*	115.0	58.0	42.0	12.52	10.62		3.48	4.60	13.89	
	Max	17.5	135.0	71.0	56.0	16.12	13.52		4.42	5.70	17.04	
	Mean	14.60	126.28	64.04	47.65	14.35	12.22		4.00	5.17	15.60	
<i>Miomectes olegineus pacificus</i> unsexed	SD	1.42	4.79	3.00	3.04	0.91	0.65		0.32	0.25	0.76	
	SE	0.13	0.46	0.29	0.30	0.10	0.06		0.13	0.02	0.09	
	95% CL	0.26	0.91	0.57	0.59	0.20	0.13		0.33	0.05	0.17	
	N (meas.)	182	118	120	115	86	134		6	113	89	
	N (ind.)	115	109	110	106	78	104		6	104	78	
<i>Lepidopogon superciliosus nansandinus</i> unsexed	Min	9.0	105.0	53.0	39.0	10.08	9.02		3.34	4.57	12.93	
	Max	13.0*	120.0	63.0	47.0	13.17	10.61		4.20	5.23	13.93	
	Mean	10.31	110.80	57.33	42.14	11.75	9.79		3.77	4.93	13.53	
	SD	0.86	4.46	2.66	2.26	0.94	0.42		0.25	0.25	0.32	
	SE	0.19	1.05	0.55	0.49	0.30	0.09		0.08	0.07	0.11	
<i>Lophortyx pileatus squamaerita</i> unsexed	95% CL	0.40	2.22	1.15	1.03	0.67	0.20		0.18	0.15	0.27	
	N (meas.)	24	20	24	22	11	22		10	14	10	
	N (ind.)	20	18	23	21	10	20		10	13	8	
	Min	10.0	120.0	61.0	49.0	12.41	11.81		3.89	4.52	13.06	
	Max	14.0	135.0	67.0	60.0	14.58	12.67		3.89	5.62	15.42	
<i>Lophortyx pileatus squamaerita</i> unsexed	Mean	12.54	126.38	63.25	54.46	13.56	12.35		3.89	5.20	14.47	
	SD	1.01	4.82	1.96	3.18	0.75	0.28		0.35	0.35	0.82	
	SE	0.28	1.34	0.57	0.88	0.25	0.09		0.10	0.10	0.27	
	95% CL	0.61	2.91	1.25	1.92	0.58	0.22		0.22	0.22	0.63	
	N (meas.)	15	14	12	13	10	9		1	12	10	
<i>Lophortyx pileatus squamaerita</i> unsexed	N (ind.)	13	13	12	13	9	9		1	12	9	
	Min	7.0	95.0	44.0	37.0	10.45	9.14		4.48	4.48	14.51	
	Max	8.5*	100.0	51.0	40.0	12.13	10.78		5.30	5.30	16.83	
	Mean	7.73	96.25	49.20	38.50	11.39	9.77		4.86	4.86	15.47	
	SD	0.48	2.50	3.03	1.29	0.65	0.63		0.30	0.30	0.93	
<i>Lophortyx pileatus squamaerita</i> unsexed	SE	0.21	1.25	1.36	0.65	0.29	0.28		0.13	0.13	0.42	
	95% CL	0.60	3.98	3.77	2.05	0.81	0.78		0.37	0.37	1.15	
	N (meas.)	8	4	5	4	6	8		6	6	6	



## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Tadriostrium cinereum sdateri</i> unsexed	N (ind.)	5	4	5	4	5	5			5	5	
	Min	6.5	90.0	42.0	28.0	14.19	12.68			5.00	17.93	
	Max	7.0*	95.0	43.0	39.0	15.52	13.92			5.17	19.04	
	Mean	6.56	91.25	42.75	32.00	14.86	13.40			5.10	18.49	
	SD	0.13	2.50	0.50	4.83	0.94	0.59			0.08	0.78	
	SE	0.06	1.25	0.25	2.42	0.66	0.29			0.04	0.55	
<i>Rhynchocyclus pacificus</i> unsexed	95% CL	0.20	3.98	0.80	7.69	8.45	0.93			0.13	7.05	
	N (meas.)	5	4	4	4	2	5			4	2	
	N (ind.)	4	4	4	4	2	4			4	2	
	Min	24.0*	150.0	70.0	58.0	15.59	11.46			9.86	17.04	
	Max	29.5	160.0	83.0	72.0	18.98	15.83			11.21	18.88	
	Mean	25.86	154.00	75.58	65.00	17.10	13.62			10.55	17.91	
<i>Tohmomyias flavovinctus</i> unsexed	SD	1.88	4.18	4.48	5.70	1.45	1.78			0.54	0.74	
	SE	0.77	1.87	1.83	2.55	0.59	0.73			0.22	0.30	
	95% CL	1.97	5.19	4.70	7.08	1.52	1.87			0.57	0.77	
	N (meas.)	10	5	7	6	7	7			7	7	
	N (ind.)	6	5	6	5	6	6			6	6	
	Min	13.5	120.0	62.0	46.0	13.45	11.87			6.98	14.97	
<i>Platyrinchus comatus superciliosus</i> unsexed	Max	15.5	125.0	63.0	49.0	13.45	11.87			7.16	14.97	
	Mean	14.50	122.50	62.50	47.50	13.45	11.87			7.07	14.97	
	SD	1.41	3.54	0.71	2.12					0.13		
	SE	1.00	2.50	0.50	1.50					0.09		
	95% CL	12.71	31.77	6.35	19.06					1.14		
	N	2	2	2	2	1	1			2	1	
<i>Terenotriccus erythrurus fulvicularis</i> unsexed	Min	9.0	75.0	51.0	20.0	11.66	9.15		6.35	7.25	12.34	
	Max	10.5	80.0	58.0	25.0	12.37	11.48		7.08	8.22	13.21	
	Mean	9.67	80.33	53.25	22.00	12.08	10.27		6.69	7.65	12.88	
	SD	0.48	3.75	2.05	1.94	0.37	0.59		0.37	0.30	0.33	
	SE	0.14	1.08	0.59	0.61	0.16	0.17		0.21	0.10	0.13	
	95% CL	0.31	2.38	1.30	1.39	0.45	0.38		0.91	0.22	0.34	
<i>Terenotriccus erythrurus fulvicularis</i> unsexed	N (meas.)	14	14	12	10	5	16		3	10	6	
	N (ind.)	12	12	12	10	5	12		3	10	6	
	Min	6.0	90.0	46.0	31.0	8.13	6.82		3.26	4.15	11.96	
	Max	8.5	100.0	52.0	42.0	10.29	8.14		3.26	4.92	16.01	
	Mean	7.13	94.19	48.97	36.44	9.27	7.67		3.26	4.51	14.39	
	SD	0.70	3.04	1.75	2.92	0.72	0.38			0.20	1.24	
<i>Myiobius atricaudus portoricensis</i> unsexed	SE	0.16	0.76	0.43	0.73	0.23	0.10			0.05	0.37	
	95% CL	0.35	1.62	0.90	1.56	0.52	0.22			0.11	0.83	
	N (meas.)	30	18	20	18	11	19		1	19	13	
	N (ind.)	18	16	17	16	10	14		1	16	11	
	Min	8.0*	115.0	55.0	55.0	10.43	7.84			4.82	14.91	
	Max	11.5	130.0	64.0	62.0	13.08	9.71			6.29	18.05	
<i>Myiobius atricaudus portoricensis</i> unsexed	Mean	9.84	122.33	59.28	59.21	11.66	8.68			5.27	16.76	
	SD	0.95	3.71	2.56	1.79	0.71	0.56			0.41	1.02	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Mjajobius subphureptigius aureatus</i> unsexed	SE	0.22	0.87	0.60	0.44	0.20	0.13			0.10	0.27	
	95% CL	0.47	1.84	0.92	0.43	0.28				0.20	0.59	
	N (meas.)	41	18	19	18	19	28			19	20	
	N (ind.)	18	18	18	17	13	18			18	14	
	Min	9.0*	105.0	55.0	44.0	12.06	8.83		4.23	5.37	14.64	
	Max	14.0*	125.0	68.0	55.0	14.21	11.42		4.55	6.26	17.78	
<i>Mjajobius subphureptigius aureatus</i> female-plumaged	Mean	11.42	117.33	61.24	50.61	13.13	9.92		4.44	5.75	16.38	
	SD	1.07	5.27	3.24	2.52	0.53	0.59		0.18	0.23	1.07	
	SE	0.18	0.96	0.56	0.44	0.12	0.10		0.11	0.04	0.23	
	95% CL	0.37	1.97	1.13	0.91	0.25	0.21		0.45	0.09	0.48	
	N (meas.)	82	31	36	34	31	49		3	32	36	
	N (ind.)	34	30	34	32	20	33		3	29	22	
<i>Mjajobius subphureptigius aureatus</i> male-plumaged, adult	Min	9.0*	105.0	57.0	46.0	12.48	8.83		4.54	5.70	14.64	
	Max	12.0	120.0	63.0	53.0	13.29	10.09		4.55	5.94	17.78	
	Mean	10.53	112.40	59.50	49.17	12.90	9.55		4.55	5.81	15.43	
	SD	1.05	5.59	1.97	2.48	0.40	0.43		0.01	0.12	1.56	
	SE	0.43	2.50	0.81	1.01	0.20	0.18		0.00	0.06	0.78	
	95% CL	1.11	6.95	2.07	2.61	0.63	0.45		0.06	0.19	2.49	
<i>Mjajobius subphureptigius aureatus</i> male-plumaged, adult	N (meas.)	10	5	6	6	6	6		2	5	6	
	N (ind.)	6	5	6	6	4	6		2	4	4	
	Min	11.5	114.0	61.0	48.0	12.57	9.40		4.23	5.32	16.24	
	Max	14.0*	125.0	67.0	55.0	14.21	11.43		4.23	6.04	17.80	
	Mean	12.30	119.00	64.29	51.86	13.32	10.28		4.23	5.76	17.02	
	SD	0.57	5.10	2.36	2.54	0.53	0.53		0.27	0.49	1.70	
<i>Mjajobius fasciatus crypserphus</i> unsexed	SE	0.16	2.08	0.89	0.96	0.16	0.15		0.10	0.15	0.15	
	95% CL	0.35	5.35	2.18	2.35	0.35	0.32		0.25	0.33	0.33	
	N (meas.)	37	6	7	7	16	21		1	7	17	
	N (ind.)	13	6	7	7	11	13		1	7	11	
	Min	9.5	120.0	58.0	52.0	12.45	10.28			5.40	15.48	
	Max	10.5	120.0	60.0	55.0	12.45	10.28			6.00	15.48	
<i>Empidonax virescens</i> unsexed	Mean	10.00	120.00	59.00	53.50	12.45	10.28			5.70	15.48	
	SD	0.71	0.00	1.41	2.12					0.42		
	SE	0.50	0.00	1.00	1.50					0.30		
	95% CL	6.35	0.00	12.71	19.06					3.81		
	N	2	2	2	2	1	1			2	1	
	N (ind.)	1	1	1	1	1	1			1	1	
<i>Colonia calons leucostotus</i> unsexed	Min	17.0	265	79.0	19.5		9.48			6.81		
	Max	17.0	265	79.0	19.5		9.48			6.81		
	Mean	17.0	265	79.0	19.5		9.48			6.81		
	SD	1.0	1.0	1.0	1.0		1.0			1.0		
	SE	0.35	0.35	0.35	0.35		0.35			0.35		
	95% CL	1.70	0.70	0.70	0.70		1.70			1.70		
<i>Rhytiperna holerythra rosenbergi</i> unsexed	N	1	1	1	1		1			1		
	N (ind.)	1	1	1	1		1			1		
	Min	24.0	155.0	80.0	63.0	15.94	11.57			6.54	17.76	
	Max	27.5	165.0	85.0	69.0	16.02	12.06			6.96	19.07	
	Mean	25.67	160.00	82.33	66.67	15.98	11.84			6.76	18.42	
	SD	1.50	1.50	1.50	1.50		1.50			1.50		

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
	SD	1.76	5.00	2.52	3.21	0.06	0.25			0.21		0.93	
	SE	1.01	2.89	1.45	1.86	0.04	0.14			0.12		0.66	
	95% CL	4.36	12.42	6.25	7.99	0.51	0.62			0.52		8.32	
	N	3	3	3	3	2	3			3		2	
<i>Mjoezetes granadensis occidentalis</i> unsexed	Min	26.0	160.0	81.0	66.0	14.48	12.17			6.88		16.67	
	Max	26.5	160.0	85.0	69.0	14.48	12.92			6.93		16.67	
	Mean	26.25	160.00	83.00	67.50	14.48	12.55			6.91		16.67	
	SD	0.35	0.00	2.83	2.12	0.53	0.53			0.04			
	SE	0.25	0.00	2.00	1.50	0.38	0.38			0.03			
	95% CL	3.18	0.00	25.41	19.06		4.76			0.32			
	N	2	2	2	2	1	2			2		1	
<i>Legatus leucophatus</i> (unknown sp.) unsexed	Min	23.0	150.0	82.0	56.0	13.17	10.91			7.89		16.14	
	Max	30.0	160.0	93.0	65.0	14.36	11.79			8.24		16.81	
	Mean	26.50	155.00	87.50	60.50	13.77	11.35			8.07		16.48	
	SD	4.95	7.07	7.78	6.36	0.84	0.62			0.25		0.47	
	SE	3.50	5.00	5.50	4.50	0.59	0.44			0.18		0.33	
	95% CL	44.47	63.53	69.88	57.18	7.56	5.59			2.22		4.26	
	N	2	2	2	2	2	2			2		2	
<i>Pachyrhamphus cinnamomeus cinnamomeus</i> unsexed	Min	19.0*	140.0	66.0	55.0	15.05	12.79			8.38		17.69	
	Max	23.0	150.0	81.0	57.0	16.42	13.40			9.68		19.54	
	Mean	21.75	145.25	74.00	56.00	15.57	13.10			8.94		18.39	
	SD	1.50	4.11	6.16	1.00	0.63	0.43			0.59		0.80	
	SE	0.75	2.06	3.08	0.58	0.32	0.31			0.29		0.40	
	95% CL	2.39	6.54	9.81	2.48	1.01	3.88			0.94		1.27	
	N (meas.)	5	4	4	3	4	2			4		4	
	N (ind.)	4	4	4	3	4	2			4		4	
<i>Pachyrhamphus albogriseus</i> (unknown sp.) female, immature	Min	17.5	130.0	64.0	50.0	13.48	11.27			7.03		18.52	
	Max	30.0	165.0	78.0	61.0	17.75	15.29			8.42		20.05	
	Mean	38.0	175.0	89.0	66.0	21.04	18.62			10.09		21.44	
	SD	33.46	173.33	86.33	63.17	19.60	16.87			9.46		20.64	
	SE	2.98	4.08	4.18	1.94	1.26	1.17			0.61		0.50	
<i>Platyptari homochrous homochrous</i> unsexed	Min	1.22	1.67	1.71	0.79	0.51	0.48			0.25		0.20	
	Max	3.12	4.28	4.39	2.04	1.32	1.23			0.64		0.53	
	Mean	2.17	2.97	3.05	1.41	0.91	0.85			0.45		0.37	
	SD	0.75	1.00	1.00	0.40	0.25	0.25			0.10		0.10	
	SE	0.38	0.50	0.50	0.20	0.13	0.13			0.05		0.05	
	95% CL	0.20	0.59	0.31	0.39	0.21	0.13			0.08		0.17	
	N (meas.)	7	6	6	6	6	6			6		6	
	N (ind.)	6	6	6	6	6	6			6		6	
PIPRIDAE (7) <i>Pipra merulidis minor</i> unsexed	Min	10.5	91.0	53.0	18.0	8.71	7.05			5.01		11.53	
	Max	18.0*	105.0	61.0	30.0	11.78	9.84			6.99		15.09	
	Mean	14.72	98.06	57.46	26.67	10.16	8.34			6.08		13.68	
	SD	1.02	3.00	1.60	2.03	0.85	0.68			0.45		0.70	
	SE	0.10	0.30	0.16	0.20	0.11	0.07			0.04		0.09	
	95% CL	0.20	0.59	0.31	0.39	0.21	0.13			0.08		0.17	
	N (meas.)	135	106	111	110	71	117			107		72	
	N (ind.)												

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Pipra mentalis minor</i> female, adult	N (ind.)	108	101	105	105	65	107		5	100	67	
	Min	13.5*	94.0	56.0	24.0	9.82	8.17			5.92	12.48	
	Max	18.0*	103.0	60.5	29.0	11.78	9.46			6.83	14.67	
	Mean	15.53	98.82	57.77	26.73	10.90	8.70			6.28	13.31	
	SD	0.93	2.82	1.62	1.29	0.71	0.41			0.33	0.61	
	SE	0.28	0.85	0.49	0.39	0.21	0.12			0.11	0.19	
	95% CL	0.62	1.90	1.09	0.87	0.48	0.28			0.24	0.43	
<i>Pipra mentalis minor</i> male, adult	N (meas.)	25	14	15	14	15	17			14	14	
	N (ind.)	11	11	11	11	11	11			10	10	
	Min	13.5	91.0	54.0	23.0	8.71	7.18			5.09	12.89	
	Max	15.5	105.0	59.0	28.0	11.38	9.44			6.95	14.83	
	Mean	14.70	97.67	57.02	26.02	9.55	7.99			6.03	13.97	
	SD	0.51	3.43	1.23	1.27	0.64	0.58			0.43	0.51	
	SE	0.09	0.64	0.23	0.24	0.14	0.10			0.08	0.11	
<i>Lepidobrix coronata minuscula</i> unsexed	95% CL	0.19	1.31	0.47	0.48	0.28	0.21			0.16	0.22	
	N (meas.)	36	30	30	30	23	33			30	24	
	N (ind.)	31	29	29	29	22	31			29	23	
	Min	7.5	80.0	52.0	15.0	7.50	6.07		3.11	4.26	11.96	
	Max	11.0*	95.0	58.0	29.0	10.02	8.00		3.82	5.59	14.77	
	Mean	9.09	86.49	56.12	23.69	8.76	7.15		3.39	4.98	13.37	
	SD	0.78	3.71	1.27	3.02	0.71	0.54		0.23	0.31	0.64	
<i>Lepidobrix coronata minuscula</i> female, adult	SE	0.10	0.51	0.17	0.40	0.12	0.08		0.07	0.05	0.11	
	95% CL	0.21	1.02	0.34	0.80	0.24	0.15		0.16	0.09	0.22	
	N (meas.)	81	57	61	63	40	64		13	51	43	
	N (ind.)	56	53	56	57	35	51		11	46	36	
	Min	7.5*	80.0	53.0	15.0	7.77	6.72		3.11	4.64	12.61	
	Max	11.0*	95.0	58.0	28.0	10.02	8.00		3.82	5.59	14.40	
	Mean	9.60	87.64	55.83	23.69	9.23	7.45		3.49	5.11	13.46	
<i>Lepidobrix coronata minuscula</i> male, adult	SD	0.53	3.81	1.09	2.89	0.58	0.39		0.25	0.27	0.51	
	SE	0.10	0.76	0.21	0.56	0.14	0.08		0.10	0.06	0.12	
	95% CL	0.21	1.57	0.44	1.14	0.30	0.16		0.26	0.12	0.26	
	N (meas.)	35	26	27	29	18	28		7	23	18	
	N (ind.)	27	25	26	27	17	25		6	21	17	
	Min	7.5	80.0	52.0	17.0	7.50	6.07		3.15	4.26	11.96	
	Max	9.5*	90.0	58.0	29.0	8.94	7.44		3.26	5.47	14.77	
<i>Manacus manacus bangsi</i> unsexed	Mean	8.27	84.53	56.50	23.83	8.10	6.64		3.20	4.79	13.23	
	SD	0.42	2.95	1.42	2.87	0.44	0.46		0.06	0.30	0.84	
	SE	0.10	0.76	0.34	0.68	0.13	0.12		0.03	0.08	0.22	
	95% CL	0.21	1.63	0.71	1.43	0.28	0.25		0.14	0.16	0.48	
	N (meas.)	29	15	18	18	16	20		3	15	20	
	N (ind.)	18	15	18	18	12	15		3	15	14	
	Min	14.5	95.0	49.0	22.0	10.27	8.72		3.87	5.62	16.63	
<i>Manacus manacus bangsi</i> unsexed	Max	21.0	110.0	58.0	34.0	12.89	11.83		5.16	7.02	21.88	
	Mean	17.61	101.83	53.48	28.89	11.64	10.10		4.18	6.26	19.20	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Manacus manacus bangsi</i> female, adult	SD	1.37	3.34	1.66	2.00	0.57	0.59		0.33	0.32	1.16	
	SE	0.11	0.28	0.13	0.17	0.06	0.05		0.10	0.03	0.11	
	95% CL	0.22	0.56	0.27	0.33	0.11	0.10		0.21	0.05	0.22	
	N (meas.)	219	144	154	147	125	174		12	144	128	
	N (ind.)	153	141	152	145	106	144		12	139	108	
	Min	14.5*	95.0	50.0	22.0	10.47	9.01		3.94	5.62	16.90	
	Max	19.0	105.0	56.0	34.0	12.59	11.17		4.29	6.88	21.17	
<i>Manacus manacus bangsi</i> male, adult	Mean	16.94	100.78	52.93	28.88	11.62	10.05		4.11	6.21	18.85	
	SD	1.02	3.13	1.53	2.64	0.52	0.59		0.14	0.36	0.88	
	SE	0.19	0.60	0.28	0.50	0.11	0.11		0.07	0.07	0.18	
	95% CL	0.38	1.24	0.57	1.02	0.22	0.22		0.23	0.15	0.37	
	N (meas.)	47	29	31	29	28	40		4	27	31	
	N (ind.)	30	27	30	28	23	29		4	25	24	
	Min	16.0*	95.0	50.0	23.0	10.59	9.01		3.87	5.65	19.11	
<i>Machaeropterus deliciosus</i> unsexed	Max	21.0	110.0	58.0	34.0	12.70	11.00		5.16	6.78	21.88	
	Mean	19.02	103.29	52.88	28.42	11.74	10.03		4.23	6.12	20.33	
	SD	0.86	4.14	2.03	1.97	0.58	0.53		0.47	0.25	0.67	
	SE	0.15	0.85	0.38	0.39	0.13	0.09		0.19	0.05	0.15	
	95% CL	0.30	1.75	0.79	0.81	0.26	0.19		0.49	0.11	0.31	
	N (meas.)	57	25	29	26	30	44		6	25	30	
	N (ind.)	33	24	28	25	21	32		6	23	21	
<i>Machaeropterus deliciosus</i> male, adult	Min	12.0	88.0	59.0	16.0	9.33	8.37		3.69	5.21	15.16	
	Max	17.5	95.0	64.0	24.0	11.07	9.35		3.69	5.92	16.97	
	Mean	13.67	91.22	60.67	19.56	10.03	9.01		3.69	5.48	16.04	
	SD	2.00	2.49	1.66	2.70	0.60	0.30			0.26	0.58	
	SE	0.67	0.83	0.55	0.90	0.23	0.10			0.09	0.20	
	95% CL	1.54	1.91	1.27	2.07	0.55	0.23			0.22	0.48	
	N	9	9	9	9	7	9		1	8	8	
<i>Chloropipo holochlora litae</i> unsexed	Min	14.0	88.0	61.0	16.0	10.08	9.03		3.69	5.52	15.74	
	Max	16.0	95.0	64.0	23.0	10.28	9.34		3.69	5.92	16.97	
	Mean	14.83	92.00	62.33	19.00	10.18	9.14		3.69	5.72	16.36	
	SD	1.04	3.61	1.53	3.61	0.14	0.17			0.28	0.87	
	SE	0.60	2.08	0.88	2.08	0.10	0.10			0.20	0.61	
	95% CL	2.59	8.96	3.79	8.96	1.27	0.43			2.54	7.81	
	N	3	3	3	3	2	3		1	2	2	
<i>Chloropipo holochlora litae</i> unsexed	Min	14.0*	112.0	61.0	38.0	10.68	9.18			5.68	12.77	
	Max	18.0*	121.0	72.0	46.0	13.52	11.52			6.96	15.39	
	Mean	16.08	117.30	67.25	41.57	12.57	10.54			6.44	13.85	
	SD	0.83	3.25	3.24	2.28	0.90	0.79			0.37	0.84	
	SE	0.20	0.84	0.81	0.61	0.32	0.20			0.09	0.26	
	95% CL	0.43	1.80	1.72	1.31	0.75	0.42			0.20	0.60	
	N (meas.)	44	16	16	14	16	23			17	18	
	N (ind.)	17	15	16	14	8	16			16	10	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Schiffornis turdina rosenbergi</i> unsexed	Min	29.5	155.0	79.0	54.0	12.90				6.20		
	Max	32.5*	160.0	86.0	67.0	13.36				6.34		
	Mean	30.75	157.50	82.50	60.50	13.13				6.27		
	SD	1.77	3.54	4.95	9.19	0.33				0.10		
	SE	1.25	2.50	3.50	6.50	0.23				0.07		
	95% CL	15.88	31.77	44.47	82.59	2.92				0.89		
	N (meas.)	3	2	2	2	2				2		
	N (ind.)	2	2	2	2	2				2		
<i>Sapayoa aenigma</i> unsexed	Min	18.5	140.0	78.0	53.0	15.58	12.60			8.26	11.73	
	Max	25.0	150.0	84.0	65.0	17.61	14.58			9.92	14.49	
	Mean	20.68	144.73	80.09	58.70	16.50	13.45			9.10	13.24	
	SD	1.71	3.58	1.76	3.47	0.71	0.66			0.48	0.74	
	SE	0.52	1.08	0.53	1.10	0.24	0.21			0.14	0.24	
	95% CL	1.15	2.41	1.18	2.48	0.54	0.47			0.32	0.53	
	N (meas.)	22	11	11	10	10	14			11	13	
	N (ind.)	11	11	11	10	9	10			11	10	
<i>Sapayoa aenigma</i> female, adult	Min	19.0	140.0	78.0	57.0	16.19	12.80			8.26	13.11	
	Max	25.0	150.0	81.0	65.0	17.48	14.22			9.08	13.65	
	Mean	21.69	143.75	79.50	60.50	16.72	13.68			8.84	13.30	
	SD	2.53	4.79	1.73	3.42	0.67	0.62			0.39	0.30	
	SE	1.26	2.39	0.87	1.71	0.39	0.31			0.19	0.17	
	95% CL	4.02	7.62	2.76	5.44	1.67	0.99			0.62	0.75	
	N (meas.)	8	4	4	4	3	6			4	4	
	N (ind.)	4	4	4	4	3	4			4	3	
<i>Sapayoa aenigma</i> male, adult	Min	19.5*	145.0	80.0	53.0	15.74	12.88			8.72	12.65	
	Max	22.0*	147.0	84.0	62.0	17.61	14.58			9.70	13.81	
	Mean	20.40	145.40	81.00	57.75	16.55	13.54			9.25	13.16	
	SD	0.43	0.89	1.73	3.77	0.72	0.74			0.37	0.51	
	SE	0.19	0.40	0.77	1.89	0.32	0.37			0.17	0.25	
	95% CL	0.54	1.11	2.15	6.01	0.90	1.18			0.46	0.81	
	N (meas.)	11	5	5	4	5	6			5	6	
	N (ind.)	5	5	5	4	5	4			5	4	
<i>VIREONIDAE (2)</i> <i>Vireo olivaceus olivaceus</i> unsexed	Min	14.0	130.0	69.0	49.0	13.84	11.99			4.74	18.16	
	Max	14.5	130.0	70.0	50.0	15.93	13.06			4.99	19.68	
	Mean	14.25	130.00	69.50	49.50	14.89	12.53			4.87	18.92	
	SD	0.35	0.00	0.71	0.71	1.48	0.76			0.18	1.07	
	SE	0.25	0.00	0.50	0.50	1.05	0.54			0.12	0.76	
	95% CL	3.18	0.00	6.35	6.35	13.28	6.80			1.59	9.66	
	N	2	2	2	2	2	2			2	2	
	N (ind.)	10.5*	100.0	55.0	34.0	13.01	11.01			4.14	15.54	
<i>Hylophilus ochraceiceps bulamensis</i> unsexed	Min	13.5*	115.0	60.0	48.0	15.31	12.28			4.82	17.88	
	Max	11.80	108.00	57.20	38.80	14.44	11.57			4.49	16.82	
	Mean											
	SD	0.45	4.83	1.40	3.74	0.75	0.50			0.22	0.75	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
TURDIDAE (2) <i>Catharus ustulatus swainsoni</i> unsexed	SE	0.14	1.53	0.44	1.18	0.28	0.17			0.07		0.29	
	95% CL	0.32	3.46	1.00	2.67	0.70	0.38			0.16		0.70	
	N (meas.)	19	11	10	10	10	10			10		10	
	N (ind.)	10	10	10	10	7	9			10		7	
	Min	26.5	160.0	93.0	62.0	12.22	11.66			5.40		25.02	
	Max	31.5	170.0	100.0	72.0	14.11	12.42			6.08		27.61	
	Mean	28.92	165.00	96.00	66.20	13.34	12.00			5.71		26.33	
	SD	1.72	5.00	2.61	4.49	0.90	0.33			0.26		1.12	
	SE	0.70	2.24	1.06	2.01	0.45	0.15			0.11		0.56	
	95% CL	1.80	6.21	2.74	5.58	1.42	0.40			0.28		1.78	
<i>Turdus daguae</i> unsexed	N	6	5	6	5	4	5			6		4	
	Min	46.0	185.0	90.0	70.0	17.13	14.17		4.32	5.79		24.80	
	Max	59.0*	205.0	112.0	86.0	20.88	19.18		5.81	7.86		28.98	
	Mean	52.11	195.24	104.98	77.21	18.94	16.66		5.09	6.66		26.66	
	SD	2.76	6.02	3.21	3.65	0.97	1.10		0.52	0.41		1.13	
	SE	0.37	0.78	0.42	0.49	0.18	0.15		0.21	0.06		0.18	
	95% CL	0.73	1.57	0.85	0.98	0.36	0.30		0.54	0.11		0.36	
	N (meas.)	71	60	61	58	33	59		6	54		45	
	N (ind.)	57	59	58	56	30	53		6	51		41	
HIRUNINIDAE (2) <i>Neochelidon tibialis minima</i> unsexed, adult	N	10.5	115.0	88.0	45.0	7.16	6.21		4.81	10.08			
	Min	12.5	120.0	102.0	45.0	8.86	6.99		5.15	10.07			
	Max	14.0	130.0	108.0	50.0	9.38	8.20		5.79	10.76			
	Mean	13.25	125.00	104.67	47.33	9.12	7.55		5.56	10.34			
	SD	0.75	5.00	3.06	2.52	0.26	0.61		0.36	0.37			
	SE	0.43	2.89	1.76	1.45	0.15	0.35		0.21	0.21			
	95% CL	1.86	12.42	7.59	6.25	0.65	1.52		0.88	0.92			
	N (meas.)	4	3	3	3	3	3		3	3			
	N (ind.)	3	3	3	3	3	3		3	3			
TROGLODYTIDAE (5) <i>Thryothorus nigricapillus connectens</i> unsexed	Min	18.5	120.0	56.0	42.0	15.49	13.87		4.80	20.26			
	Max	24.5	145.0	70.0	55.0	21.00	18.32		5.79	25.99			
	Mean	21.15	133.16	63.42	48.11	18.49	16.50		5.34	23.60			
	SD	1.83	6.71	4.48	3.69	1.48	1.40		0.25	1.40			
	SE	0.41	1.54	1.03	0.87	0.40	0.35		0.06	0.37			
	95% CL	0.86	3.23	2.16	1.84	0.86	0.75		0.12	0.81			
	N (meas.)	31	19	19	18	19	21		21	19			
	N (ind.)	20	19	19	18	14	16		19	14			
	Min	14.5*	110.0	54.0	34.0	17.36	15.12		4.06	19.74			
	Max	18.0	120.0	57.0	40.0	19.71	17.54		4.86	21.40			
<i>Thryothorus leucopogon leucopogon</i> unsexed	Mean	16.54	114.00	55.60	36.80	18.15	16.25		4.38	20.32			
	SD	1.10	4.18	1.14	2.28	1.09	0.89		0.29	0.74			



## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Henicorhina leucosticta inornata</i> unsexed	SE	0.45	1.87	0.51	1.02	0.55	0.36			0.13	0.37	
	95% CL	1.15	5.19	1.42	2.83	1.74	0.93			0.36	1.19	
	N (meas.)	8	5	5	5	5	8			5	5	
	N (ind.)	6	5	5	5	4	6			5	4	
	Min	14.5	95.0	47.0	23.0	16.47	14.14			4.35	21.06	
<i>Cyporphinus phaeocephalus phaeocephalus</i> unsexed, adult	Max	17.0	110.0	57.0	33.0	18.43	16.10			5.24	24.94	
	Mean	16.13	101.67	52.44	28.11	17.57	14.79			4.73	23.41	
	SD	0.84	5.00	2.65	3.33	0.61	0.79			0.34	1.44	
	SE	0.27	1.67	0.88	1.11	0.23	0.30			0.11	0.55	
	95% CL	0.60	3.84	2.04	2.56	0.56	0.73			0.26	1.33	
<i>Cyporphinus phaeocephalus phaeocephalus</i> unsexed, adult	N (meas.)	13	9	9	9	7	7			9	7	
	N (ind.)	10	9	9	9	7	7			9	7	
	Min	23.0	115.0	60.0	36.0	20.99	19.81			4.06	24.30	
	Max	17.5	100.0	54.0	19.0	17.57	15.80			4.32	22.54	
	Mean	21.5*	115.0	62.0	28.0	21.24	19.35			6.02	25.56	
<i>Microcerallus marginatus occidentalis</i> unsexed	SE	19.02	108.11	57.61	23.37	19.51	17.56			5.04	23.83	
	SD	0.88	3.97	2.21	2.97	1.09	0.94			0.43	0.92	
	SE	0.19	0.91	0.51	0.68	0.29	0.23			0.10	0.25	
	95% CL	0.40	1.92	1.06	1.43	0.63	0.48			0.20	0.53	
	N (meas.)	47	23	24	24	17	22			25	21	
<i>Polioptila (1)</i> <i>Microbatas cinereiventris cinereiventris</i> unsexed	N (ind.)	21	19	19	19	14	17			20	14	
	Min	10.5	90.0	47.0	24.0	18.34	15.18			3.19	4.10	
	Max	14.0*	112.0	58.0	32.0	21.25	18.96			4.34	5.38	
	Mean	11.70	102.13	52.71	28.26	19.64	16.89			3.63	4.75	
	SD	0.56	5.94	2.51	1.99	0.97	0.99			0.32	0.34	
<i>Parulidae (6)</i> <i>Sciturus noveboracensis</i> unsexed	SE	0.10	1.05	0.44	0.37	0.25	0.18			0.11	0.07	
	95% CL	0.20	2.14	0.89	0.76	0.54	0.38			0.25	0.14	
	N (meas.)	45	34	35	30	16	33			9	26	
	N (ind.)	34	32	33	29	15	29			9	24	
	Min	14.0	130.0	72.0	58.0		12.03			4.44		
<i>Geothlypis semiflava semiflava</i> unsexed	Max	14.5	127.0	58.0	52.0	13.98	12.51			4.51	21.61	
	Mean	17.0	130.0	59.0	58.0	14.57	12.68			5.17	22.77	
	SD	15.50	129.00	58.33	54.33	14.28	12.60			4.82	22.19	
	SE	0.76	1.00	0.33	1.86	0.30	0.09			0.19	0.58	
	95% CL	3.29	4.30	1.43	7.99	3.75	1.08			0.83	7.37	
<i>Geothlypis semiflava semiflava</i> female-plumaged	N (meas.)	3	3	3	3	2	2			3	2	
	N (ind.)	14.5	130.0	58.0	52.0	13.98				5.17	21.61	
	Min	1	1	1	1	0				1	1	
	Max	14.5	130.0	58.0	52.0	13.98				5.17	21.61	
	Mean	14.5	130.0	58.0	52.0	13.98				5.17	21.61	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
<i>Geothlypis semiflava semiflava</i> male, adult	Min	15.0	127.0	58.0	53.0	14.57	12.51			4.51		22.77	
	Max	17.0	130.0	59.0	58.0	14.57	12.68			4.77		22.77	
	Mean	16.00	128.50	58.50	55.50	14.57	12.60			4.64		22.77	
	SD	1.41	2.12	0.71	3.54		0.12			0.18			
	SE	1.00	1.50	0.50	2.50		0.09			0.13			
	95% CL	12.71	19.06	6.35	31.77		1.08			1.65			
	N	2	2	2	2	1	2			2		1	
<i>Geothlypis auricularis auricularis</i> unsexed	Min	9.5*	110.0	54.0	41.5	11.51	10.03			4.11		19.08	
	Max	11.0*	120.0	59.0	47.0	13.85	12.78			4.38		20.70	
	Mean	10.17	115.00	56.33	44.25	13.05	11.71			4.28		20.11	
	SD	0.26	4.47	2.07	1.99	0.87	0.96			0.11		0.68	
	SE	0.11	1.83	0.84	0.81	0.36	0.39			0.05		0.28	
	95% CL	0.27	4.69	2.17	2.09	0.92	1.01			0.14		0.72	
	N (meas.)	8	7	7	7	7	7			6		7	
<i>Geothlypis auricularis auricularis</i> female, adult	N (ind.)	6	6	6	6	6	6			5		6	
	Min	10.0	110.0	54.0	41.5	11.51	10.03			4.23		19.08	
	Max	11.0*	115.0	54.0	44.0	13.44	11.79			4.35		20.34	
	Mean	10.25	112.50	54.00	42.75	12.48	10.91			4.29		19.71	
	SD	0.35	3.54	0.00	1.77	1.36	1.25			0.09		0.89	
	SE	0.25	2.50	0.00	1.25	0.97	0.88			0.06		0.63	
	95% CL	3.18	31.77	0.00	15.88	12.26	11.21			0.79		8.00	
<i>Geothlypis auricularis auricularis</i> male, adult	N (meas.)	3	3	3	3	3	3			3		3	
	N (ind.)	2	2	2	2	2	2			2		2	
	Min	9.5*	110.0	56.0	43.0	12.53	11.59			4.11		19.43	
	Max	10.5	120.0	59.0	47.0	13.85	12.78			4.38		20.70	
	Mean	10.13	116.25	57.50	45.00	13.34	12.11			4.27		20.31	
	SD	0.25	4.79	1.29	1.83	0.56	0.61			0.14		0.60	
	SE	0.13	2.39	0.65	0.91	0.28	0.31			0.08		0.30	
<i>Oporornis philadelphia</i> male, adult	95% CL	0.40	7.62	2.05	2.91	0.90	0.98			0.35		0.95	
	N (meas.)	5	4	4	4	4	4			3		4	
	N (ind.)	4	4	4	4	4	4			3		4	
	Min	11.0	120.0	62.0	50.0		11.68			4.52			
	Max	12.0	125.0	65.0	43.0	11.95	11.57			3.77		19.65	
	Mean	11.5	122.5	63.5	46.5								
	N	1	1	1	1	1	1			1		1	
<i>Oporornis agilis</i> unsexed, immature	N	1	1	1	1	1	1			1		1	
	Min	12.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
<i>Basiluterus rubicunda semicinctus</i> unsexed	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	
	Min	11.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
<i>Basiluterus rubicunda semicinctus</i> unsexed	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	
	Min	11.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
<i>Basiluterus rubicunda semicinctus</i> unsexed	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	
	Min	11.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
<i>Basiluterus rubicunda semicinctus</i> unsexed	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	
	Min	11.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
<i>Basiluterus rubicunda semicinctus</i> unsexed	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	
	Min	11.0	110.0	56.0	41.0	12.40	10.68			5.08		20.55	
<i>Basiluterus rubicunda semicinctus</i> unsexed	Max	15.5*	130.0	65.0	50.0	14.83	12.64			6.63		22.78	
	Mean	13.54	120.00	60.92	46.83	13.64	11.38			5.60		21.81	
	SD	1.00	5.22	2.47	2.72	0.88	0.55			0.48		0.71	
	SE	0.29	1.51	0.71	0.79	0.28	0.16			0.14		0.22	
	95% CL	0.64	3.32	1.57	1.73	0.63	0.35			0.30		0.51	
	N (meas.)	23	12	12	12	15	18			12		15	
	N (ind.)	12	12	12	12	10	12			12		10	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
THERAPIDAE (18) <i>Coereba flaccola intermedia</i> unsexed	Min	8.0	82.0	48.0	24.0	12.77	11.50			3.90	13.95	
	Max	12.0*	97.0	57.0	32.0	14.47	13.69			4.93	17.07	
	Mean	9.31	90.72	52.20	28.86	13.76	12.65			4.31	15.27	
	SD	0.74	3.93	3.10	1.98	0.51	0.61			0.22	0.88	
	SE	0.15	0.82	0.65	0.42	0.13	0.13			0.05	0.21	
	95% CL	0.32	1.70	1.34	0.88	0.27	0.28			0.10	0.45	
	N (meas.)	30	25	24	19	25	19			25	19	
	N (ind.)	23	23	23	22	16	21			23	17	
		15.5	113.0	63.0	32.0		12.84		4.22			
	N	1	1	1	1		1		1			
<i>Chlorophanes spiza exul</i> female, adult	N	14.0	115.0	65.0	45.0		11.62			5.04		
<i>Dacnis cayana bairdiana</i> female	N	1	1	1	1					1		
<i>Dacnis egregia aequatorialis</i> unsexed	Min	13.5	105.0	57.0	37.0	11.56	9.91			4.48	14.46	
	Max	13.5	110.0	60.0	41.0	11.56	10.07			4.89	14.46	
	Mean	13.50	107.50	58.50	39.00	11.56	9.99			4.69	14.46	
	SD		3.54	2.12	2.83		0.11			0.29		
	SE		2.50	1.50	2.00		0.08			0.20		
	95% CL		31.77	19.06	25.41		1.02			2.60		
	N	1	2	2	2	1	2			2	1	
<i>Dacnis venusta fuliginata</i> female, adult	N	15.5	110.0	62.0	33.0		10.58		4.00			
<i>Dacnis berlepschi</i> unsexed	Min	11.5	110.0	61.0	40.0	13.41	11.66			4.50	14.78	
	Max	16.0	118.0	65.0	44.0	13.41	13.03			4.76	14.78	
	Mean	13.38	114.00	62.25	41.67	13.41	12.17			4.65	14.78	
	SD	2.06	4.00	1.89	2.08		0.64			0.11		
	SE	1.03	2.31	0.95	1.20		0.32			0.05		
	95% CL	3.27	9.94	3.01	5.17		1.02			0.17		
	N	4	3	4	3	1	4			4	1	
<i>Euphonia lanirostris hypoxantha</i> unsexed	Min	13.5	100.0	61.0	36.0	10.82	8.91			6.40	14.70	
	Max	15.5	120.0	64.0	39.0	11.88	10.35			6.49	14.82	
	Mean	14.50	110.00	62.50	37.50	11.35	9.63			6.45	14.76	
	SD	1.41	14.14	2.12	2.12	0.75	1.02			0.06	0.08	
	SE	1.00	10.00	1.50	1.50	0.53	0.72			0.05	0.06	
	95% CL	12.71	127.06	19.06	19.06	6.73	9.15			0.57	0.76	
	N	2	2	2	2	2	2			2	2	
<i>Euphonia lanirostris hypoxantha</i> female, adult	N	13.5	100.0	61.0	36.0	10.82	8.91			6.49	14.70	
<i>Euphonia lanirostris hypoxantha</i> female, adult	N	1	1	1	1	1	1			1	1	
<i>Euphonia xanthogaster chocoensis</i> unsexed	Min	9.5	85.0	54.0	26.0	8.59	7.37			4.83	14.14	
	Max	17.0*	100.0	63.0	37.0	10.63	9.20			6.51	16.27	
	Mean	13.08	95.45	57.79	31.37	9.76	8.14			5.55	15.18	
	SD	1.06	4.11	2.44	3.42	0.53	0.46			0.41	0.67	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>									
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)
<i>Euphonia xanthogaster choacensis</i> female, adult	SE	0.19	0.74	0.44	0.61	0.11	0.08			0.07	0.15
	95% CL	0.39	1.51	0.89	1.25	0.23	0.17			0.15	0.31
	N (meas.)	46	33	32	32	28	39			33	26
	N (ind.)	31	31	31	31	22	30			31	21
	Min	12.5*	90.0	54.0	26.0	9.08	7.38			5.16	14.40
	Max	17.0*	95.0	58.0	31.0	10.05	8.71			5.63	15.93
	Mean	13.57	94.00	55.92	28.25	9.76	8.11			5.43	14.91
	SD	0.59	2.00	1.63	2.09	0.46	0.53			0.21	0.72
	SE	0.24	0.82	0.66	0.85	0.23	0.24			0.09	0.36
	95% CL	0.62	2.10	1.71	2.20	0.72	0.66			0.22	1.14
<i>Euphonia xanthogaster choacensis</i> male, adult	N (meas.)	16	7	7	7	8	11			7	7
	N (ind.)	6	6	6	6	4	5			6	4
	Min	12.0	90.0	56.0	28.0	9.36	7.37			4.96	14.45
	Max	14.5	100.0	63.0	37.0	10.40	8.68			6.42	16.02
	Mean	12.98	98.21	59.43	34.21	9.92	8.07			5.63	15.55
	SD	0.68	3.02	2.17	2.39	0.43	0.43			0.38	0.49
	SE	0.18	0.81	0.58	0.64	0.15	0.11			0.10	0.17
	95% CL	0.39	1.74	1.26	1.38	0.36	0.25			0.22	0.41
	N (meas.)	17	15	14	14	9	16			14	9
	N (ind.)	14	14	14	14	8	14			12	8
<i>Tangara larvata fanny</i> unsexed	Min	15.5	120.0	67.0	46.0	10.96	9.22			5.12	16.04
	Max	16.5	125.0	71.0	47.0	12.95	9.69			5.47	17.33
	Mean	16.00	121.67	68.67	46.33	11.79	9.46			5.29	16.53
	SD	0.50	2.89	2.08	0.58	1.04	0.24			0.18	0.70
	SE	0.29	1.67	1.20	0.33	0.60	0.14			0.10	0.40
	95% CL	1.24	7.17	5.17	1.43	2.57	0.58			0.44	1.73
	N (meas.)	4	3	3	3	3	3			3	3
	N (ind.)	3	3	3	3	3	3			3	3
	N	17.5	115.0	64.0	38.0		9.85			5.44	
	N	1	1	1	1		1			1	
<i>Thraupis episcopus quaresia</i> unsexed	Min	31.5	150.0	79.0	61.0	14.50	12.40			6.84	17.69
	Max	35.0	170.0	87.0	67.0	16.51	13.80			8.21	20.28
	Mean	33.33	160.00	82.67	63.60	15.43	13.07			7.49	19.36
	SD	1.60	7.07	3.27	2.41	0.77	0.53			0.50	1.05
	SE	0.65	2.89	1.33	1.08	0.35	0.21			0.20	0.47
	95% CL	1.68	7.42	3.43	2.99	0.96	0.55			0.53	1.30
	N	6	6	6	5	5	6			6	5
	Min	30.5	145.0	83.0	54.0	15.13	12.17			6.33	19.14
	Max	34.5	160.0	90.0	64.0	15.13	13.74			6.85	19.14
	Mean	32.50	152.50	86.50	59.00	15.13	12.96			6.59	19.14
<i>Thraupis palmarum violillanata</i> unsexed	SD	2.83	10.61	4.95	7.07		1.11			0.37	
	SE	2.00	7.50	3.50	5.00		0.78			0.26	
	95% CL	25.41	95.30	44.47	63.53		9.97			3.30	
	N	2	2	2	2	1	2			2	1

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	Tl (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Ramphocelus icteronotus</i> unsexed	Min	28.5	165.0	76.0	61.0	18.32	14.63			8.00	21.24	
	Max	38.5	180.0	87.0	79.0	20.61	18.16			9.98	24.43	
	Mean	33.43	173.60	81.19	71.16	19.32	15.51			9.20	22.91	
	SD	2.72	4.62	2.98	4.06	0.79	0.84			0.54	1.01	
	SE	0.52	0.92	0.58	0.81	0.26	0.19			0.10	0.34	
	95% CL	1.08	1.91	1.20	1.68	0.61	0.39			0.21	0.77	
	N (meas.)	28	25	26	25	9	21			27	9	
<i>Ramphocelus icteronotus</i> female-plumaged	N (ind.)	27	25	26	25	9	20			27	9	
	Min	28.5	165.0	76.0	61.0	19.20	14.74			8.38	21.95	
	Max	38.5	180.0	82.0	78.0	20.56	18.16			9.98	22.77	
	Mean	32.46	171.23	79.62	70.33	19.88	15.53			9.44	22.36	
	SD	3.00	4.46	2.06	4.54	0.96	0.98			0.41	0.58	
	SE	0.80	1.24	0.57	1.31	0.68	0.31			0.11	0.41	
	95% CL	1.73	2.69	1.25	2.88	0.64	0.70			0.24	0.52	
<i>Ramphocelus icteronotus</i> male, adult	N	14	13	13	12	2	10			14	2	
	Min	31.5	172.0	80.0	68.0	18.32	14.63			8.00	21.24	
	Max	38.5	180.0	87.0	73.0	19.34	15.88			9.67	24.43	
	Mean	34.86	177.00	83.57	70.86	18.79	15.24			8.84	22.66	
	SD	2.30	3.46	2.51	1.77	0.51	0.50			0.58	1.62	
	SE	0.87	1.41	0.95	0.67	0.30	0.21			0.22	0.94	
	95% CL	2.13	3.64	2.32	1.64	1.28	0.53			0.54	4.03	
<i>Pranga rubra rubra</i> male	N (meas.)	8	6	7	7	3	7			7	3	
	N (ind.)	7	6	7	7	3	6			7	3	
	Min	29.5	180.0	92.0	68.0		12.20			8.80		
	Max	30.5	180.0	93.0	73.0		13.44			9.14		
	Mean	30.00	180.00	92.50	70.50		12.82			8.97		
	SD	0.71	0.00	0.71	3.54		0.88			0.24		
	SE	0.50	0.00	0.50	2.50		0.62			0.17		
<i>Chlorothraupis olivacea</i> unsexed	95% CL	6.35	0.00	6.35	31.77		7.88			2.16		
	N	2	2	2	2		2			2		
	Min	35.0	155.0	81.0	56.0	19.74	16.26		7.53	8.90	20.73	
	Max	45.0	175.0	93.0	67.0	23.00	19.41		7.53	10.50	22.20	
	Mean	39.43	164.95	86.62	61.11	21.26	18.40		7.53	9.64	21.51	
	SD	2.39	6.66	3.47	3.08	1.12	0.91			0.47	0.51	
	SE	0.52	1.53	0.76	0.73	0.34	0.23			0.11	0.17	
<i>Mitrispingus casinii casinii</i> unsexed	95% CL	1.09	3.21	1.58	1.53	0.76	0.48			0.22	0.39	
	N (meas.)	31	21	23	20	12	18		1	22	10	
	N (ind.)	21	19	21	18	11	16		1	20	9	
	Min	37.5	175.0	84.0	73.0	20.16	17.90			7.31	24.05	
	Max	44.0*	185.0	88.0	78.0	21.32	19.67			7.87	26.00	
	Mean	39.74	181.67	86.17	75.00	20.74	19.02			7.57	24.81	
	SD	2.48	4.08	1.47	1.67	0.61	0.70			0.19	0.84	
<i>Mitrispingus casinii casinii</i> unsexed	SE	1.01	1.67	0.60	0.68	0.31	0.31			0.08	0.42	
	95% CL	2.60	4.28	1.54	1.76	0.97	0.86			0.19	1.33	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
<i>Tachyphonus luctuosus panamensis</i> female-plumaged immature	N (meas.)	11	7	6	6	6	9	8		6		8	
	N (ind.)	6	6	6	6	4	5	5		6		4	
<i>Tachyphonus delatii</i> unsexed	N	13.0	125.0	56.0	52.0	13.15	12.75			6.47		16.19	
	Min	15.5*	126.0	60.0	50.0	12.97	11.07		4.45	5.47		16.84	
	Max	23.5*	150.0	77.0	66.0	15.45	13.80		4.86	7.62		19.88	
	Mean	19.19	138.41	68.12	58.01	14.38	12.34		4.70	6.51		18.29	
	SD	1.82	5.49	4.18	3.57	0.58	0.63		0.16	0.47		0.83	
	SE	0.19	0.61	0.45	0.39	0.09	0.07		0.07	0.05		0.12	
	95% CL	0.38	1.21	0.89	0.78	0.17	0.14		0.17	0.10		0.24	
<i>Tachyphonus delatii</i> female, adult	N (meas.)	212	93	100	96	70	133		6	92		77	
	N (ind.)	93	81	87	83	46	86		6	79		48	
<i>Tachyphonus delatii</i> male, adult	Min	15.5*	126.0	60.0	50.0	13.46	11.07		4.62	5.68		17.01	
	Max	23.0*	145.0	70.0	59.0	15.45	13.16		4.86	7.10		18.89	
	Mean	17.75	134.84	65.01	55.35	14.34	12.09		4.71	6.34		17.94	
	SD	1.13	5.16	2.51	2.42	0.61	0.56		0.13	0.42		0.62	
	SE	0.21	1.03	0.48	0.47	0.19	0.11		0.08	0.09		0.18	
	95% CL	0.44	2.13	0.99	0.98	0.44	0.22		0.33	0.18		0.39	
	N (meas.)	70	30	34	33	20	44		3	30		23	
<i>Tachyphonus delatii</i> male, adult	N (ind.)	28	25	27	26	10	27		3	24		12	
	Min	18.0*	132.0	60.0	56.0	13.61	11.26		4.45	5.76		16.84	
	Max	23.5*	150.0	77.0	66.0	15.44	13.85		4.83	7.62		19.87	
	Mean	20.69	141.04	71.11	60.54	14.53	12.55		4.70	6.57		18.55	
	SD	1.11	4.57	3.55	1.99	0.55	0.64		0.21	0.50		0.86	
	SE	0.18	0.90	0.67	0.38	0.11	0.11		0.12	0.10		0.18	
	95% CL	0.35	1.85	1.38	0.79	0.23	0.22		0.53	0.21		0.36	
<i>Cardinalidae</i> (3) <i>Saltator maximus maximus</i> unsexed	N (meas.)	91	31	32	31	31	56		3	29		35	
	N (ind.)	40	26	28	27	24	35		3	24		24	
<i>Saltator grosus saturatus</i> unsexed	Min	41.0*	187.0	88.0	77.0	19.95	17.65			9.45		23.09	
	Max	57.0*	215.0	102.0	93.0	23.84	20.38			10.99		25.94	
	Mean	47.02	201.97	93.31	85.64	21.88	19.15			10.36		24.56	
	SD	3.29	6.70	3.68	3.84	1.02	0.79			0.35		0.76	
	SE	0.58	1.24	0.65	0.73	0.20	0.14			0.06		0.15	
	95% CL	1.18	2.55	1.33	1.49	0.41	0.29			0.13		0.30	
	N (meas.)	44	30	32	28	29	33			31		31	
<i>Saltator grosus saturatus</i> unsexed	N (ind.)	32	29	32	28	26	31			31		27	
	Min	45.5	190.0	87.0	79.0	18.99	17.53			11.10		19.41	
	Max	54.5	220.0	98.0	85.0	22.25	19.35			11.84		23.58	
	Mean	48.75	206.67	93.67	82.67	20.62	18.57			11.36		21.50	
	SD	4.99	15.28	5.86	3.21	2.31	0.94			0.41		2.95	
	SE	2.88	8.82	3.38	1.86	1.63	0.54			0.24		2.09	
	95% CL	12.41	37.95	14.56	7.99	20.71	2.33			1.03		26.49	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Saltator grossus saturatus</i> female, adult	N (means)	4	3	3	3	2	3	3	3	3	2	
	N (ind.)	3	3	3	3	2	3	3	3	3	2	
		45.5	190.0	87.0	79.0	18.99	17.53			11.10	19.41	
	N	1	1	1	1	1	1			1	1	
	Min	46.0*	210.0	96.0	84.0	22.25	18.82			11.15	23.58	
<i>Saltator grossus saturatus</i> male, adult	Max	54.5	220.0	98.0	85.0	22.25	19.35			11.84	23.58	
	Mean	50.38	215.00	97.00	84.50	22.25	19.09			11.50	23.58	
	SD	5.83	7.07	1.41	0.71		0.37			0.49		
	SE	4.13	5.00	1.00	0.50		0.26			0.34		
	95% CL	52.41	63.53	12.71	6.35		3.37			4.38		
<i>Phenictus ludovicianus</i> male, immature	N (means)	3	2	2	2	1	2	2	2	2	1	
	N (ind.)	2	2	2	2	1	2			2	1	
		44.5	195.0	103.0	70.0	20.01	18.44			9.50	22.53	
	N	1	1	1	1	1	1			1	1	
	Min											
EXERCIZADA (7)												
<i>Rhodospingus cruentus</i> male, immature	N	9.5	105.0	54.0	39.0	11.73	10.94			4.98	14.34	
	Min	9.0	105.0	50.0	40.0	11.34	10.45			5.37	16.75	
	Max	10.5	105.0	52.0	41.0	11.56	11.22			5.49	16.87	
	Mean	9.75	105.00	51.00	40.50	11.45	10.84			5.43	16.81	
	SD	1.06	0.00	1.41	0.71	0.16	0.54			0.08	0.08	
<i>Volatinia jacarina peruviana</i> male, immature	SE	0.75	0.00	1.00	0.50	0.11	0.38			0.06	0.06	
	95% CL	9.53	0.00	12.71	6.35	1.40	4.89			0.76	0.76	
	N	2	2	2	2	2	2			2	2	
	Min	10.0	95.0	50.0	39.0	9.47	8.12			4.99	15.03	
	Max	11.5	100.0	55.0	40.0	10.19	8.88			5.21	16.99	
<i>Turdus obscurus pauper</i> unsexed	Mean	10.50	98.75	53.00	39.50	9.73	8.56			5.12	16.00	
	SD	0.71	2.50	2.16	0.58	0.32	0.37			0.10	1.02	
	SE	0.35	1.25	1.08	0.29	0.16	0.19			0.05	0.51	
	95% CL	1.13	3.98	3.44	0.92	0.52	0.59			0.16	1.62	
	N	4	4	4	4	4	4			4	4	
<i>Oryzoborus angolensis funereus</i> unsexed	Min	10.5	110.0	52.0	47.0	11.17	10.42			6.46	14.69	
	Max	13.5	126.0	60.0	55.0	14.01	12.92			8.09	16.99	
	Mean	12.24	116.85	55.73	50.85	12.73	11.44			7.15	16.02	
	SD	0.91	4.37	2.27	2.06	0.73	0.63			0.44	0.59	
	SE	0.20	0.98	0.51	0.46	0.17	0.14			0.10	0.14	
<i>Oryzoborus angolensis funereus</i> female, adult	95% CL	0.43	2.04	1.06	0.96	0.37	0.29			0.21	0.29	
	N (means)	27	20	21	20	19	23			19	19	
	N (ind.)	20	20	20	20	18	20			19	18	
	Min	11.0	110.0	52.0	47.0	12.05	10.86			6.65	15.47	
	Max	13.5	120.0	57.0	54.0	13.58	12.66			8.09	16.99	
<i>Oryzoborus angolensis funereus</i> unsexed	Mean	12.25	116.50	55.00	50.75	12.89	11.43			7.25	16.21	
	SD	0.85	4.41	2.07	2.38	0.47	0.53			0.52	0.53	
	SE	0.30	1.56	0.73	0.84	0.18	0.19			0.20	0.20	
	95% CL											
	N											



## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Tar (mm)	Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)			
<i>Oryzoborus angolensis funereus</i> male, adult	95% CL	0.71	3.68	1.73	1.99	0.44	0.44			0.48		0.49	
	N (meas.)	11	8	8	8	7	9			7		7	
	N (ind.)	8	8	8	8	7	8			7		7	
	Min	12.0	115.0	55.0	50.0	11.17	10.42			6.46		14.69	
	Max	13.5	124.0	60.0	55.0	14.01	12.92			7.03		16.16	
	Mean	12.80	116.80	57.50	51.60	12.46	11.61			6.77		15.58	
	SD	0.67	4.02	2.06	2.07	1.26	0.91			0.24		0.65	
	SE	0.30	1.80	0.92	0.93	0.63	0.41			0.11		0.33	
	95% CL	0.83	5.00	2.56	2.57	2.00	1.13			0.30		1.04	
	N (meas.)	8	5	6	5	5	7			5		5	
<i>Sponophila corrina ophthalnica</i> unsexed	N (ind.)	5	5	5	5	4	5			5		4	
	Min	8.5	95.0	48.0	38.0	9.82	8.68			5.59		13.69	
	Max	12.0	110.0	59.0	46.0	12.06	10.58			7.25		16.15	
	Mean	10.61	103.44	52.89	42.50	10.70	9.84			6.27		14.89	
	SD	0.78	3.68	2.19	1.96	0.48	0.49			0.42		0.76	
	SE	0.15	0.71	0.42	0.39	0.10	0.10			0.08		0.16	
	95% CL	0.31	1.46	0.87	0.79	0.20	0.20			0.17		0.33	
	N (meas.)	38	27	27	26	25	30			29		23	
	N (ind.)	27	27	27	26	25	26			27		23	
	Min	10.5	100.0	48.0	40.0	10.10	9.47			6.06		14.14	
<i>Sponophila corrina ophthalnica</i> female, adult	Max	11.5	110.0	55.0	46.0	12.06	10.44			7.25		15.72	
	Mean	10.96	105.83	52.50	42.60	10.98	9.99			6.62		14.96	
	SD	0.37	3.76	2.51	2.70	0.65	0.36			0.50		0.75	
	SE	0.14	1.54	1.02	1.21	0.24	0.14			0.19		0.33	
	95% CL	0.34	3.95	2.63	3.35	0.60	0.33			0.46		0.93	
	N (meas.)	9	6	6	5	7	8			8		5	
	N (ind.)	7	6	6	5	7	7			7		5	
	Min	8.5	95.0	52.0	40.0	9.82	8.68			5.59		13.69	
	Max	12.0	110.0	59.0	45.0	10.99	10.58			6.69		16.15	
	Mean	10.44	102.75	53.83	42.92	10.50	9.66			6.12		15.05	
<i>Sponophila corrina ophthalnica</i> male, adult	SD	0.91	4.20	1.90	1.51	0.38	0.58			0.32		0.87	
	SE	0.26	1.21	0.55	0.43	0.12	0.17			0.09		0.26	
	95% CL	0.58	2.67	1.21	0.96	0.26	0.37			0.20		0.58	
	N (meas.)	17	12	12	12	11	14			12		11	
	N (ind.)	12	12	12	12	11	12			12		11	
<i>Sponophila nigricollis sivida</i> unsexed	Min	7.5	95.0	50.0	39.0	8.51	7.52			5.13		13.70	
	Max	8.5	100.0	52.0	42.0	9.14	8.06			5.75		14.92	
	Mean	8.00	97.50	51.00	40.50	8.80	7.81			5.50		14.33	
	SD	0.58	2.89	1.15	1.29	0.31	0.28			0.26		0.50	
	SE	0.29	1.44	0.58	0.65	0.16	0.14			0.13		0.25	
	95% CL	0.92	4.59	1.84	2.05	0.50	0.45			0.42		0.79	
	N (meas.)	5	4	4	4	4	4			4		4	
	N (ind.)	4	4	4	4	4	4			4		4	

## APPENDIX 11. Continued.

Family (no. of spp.) / species / sample	Descriptive statistics <sup>a</sup>	Measurements <sup>b</sup>										Remarks
		BM (g)	TL (mm)	FW (mm)	RTL (mm)	BL (mm)	EC (mm)	PN (mm)	BW1 (mm)	BW2 (mm)	Tar (mm)	
<i>Arremon aurantirostris occidentalis</i> unsexed	Min	23.5*	135.0	64.0	50.0	14.42	13.58		5.97	6.58	23.50	
	Max	29.5	155.0	79.0	67.0	16.53	14.70		5.97	7.62	26.14	
	Mean	25.96	143.18	70.21	58.06	15.41	14.16		5.97	7.18	25.05	
	SD	1.49	5.45	3.91	4.89	0.69	0.38			0.36	0.93	
	SE	0.35	1.32	0.90	1.19	0.19	0.09			0.08	0.25	
	95% CL	0.74	2.80	1.88	2.52	0.42	0.20			0.18	0.54	
	N (meas.)	31	17	19	17	14	20		1	18	16	
	N (ind.)	18	17	19	17	13	17		1	18	14	
ICTERIDAE (2)												
<i>Cacicus microrhynchus pacificus</i>		75.0	240.0	131.0	92.0	29.31	28.94			10.31	28.68	
male, adult	N	1	1	1	1	1	1			1	1	
<i>Molothrus bonariensis aequatorialis</i> unsexed	Min	46.5	185.0	98.0	71.0	19.56	18.93			6.97	23.90	
	Max	52.5	190.0	105.0	81.0	19.61	19.10			7.62	24.90	
	Mean	49.50	187.50	101.50	76.00	19.59	19.02			7.30	24.40	
	SD	4.24	3.54	4.95	7.07	0.04	0.12			0.46	0.71	
	SE	3.00	2.50	3.50	5.00	0.02	0.09			0.32	0.50	
	95% CL	38.12	31.77	44.47	63.53	0.32	1.08			4.13	6.35	
	N	2	2	2	2	2	2			2	2	
<i>Molothrus bonariensis aequatorialis</i> female, adult		46.5	185.0	98.0	71.0	19.56	18.93			6.97	24.90	
	N	1	1	1	1	1	1			1	1	
<i>Molothrus bonariensis aequatorialis</i> male, adult		52.5	190.0	105.0	81.0	19.61	19.10			7.62	23.90	
	N	1	1	1	1	1	1			1	1	

## APPENDIX 12A

Standardized mist-netting and MTW surveys of transect MNT1: number of birds captured/recorded per species, type of record, and breeding/non-breeding status in the transect area. List of the 268 bird species recorded between Aug. 1995 and Mar. 1998 in the area of transects MNT1 (Fig. 5) and MNT2 (Fig. 8). All landbird species recorded during standardized and non-standardized surveys within 100 m of the transects were included. *Lurocalis semitorquatus* was present at both transects; however, the species was systematically overlooked and misidentified, and thus could not be included in the analysis (cf. Appendix 6, *Nyctiphrynus rosenbergi*). Most waterbirds, like frigatebirds, cormorants, ducks, herons, and gulls, followed the course of the Río Santiago on passage, and thus were not included because trees and shrubs obstructed the view of the river from any position on the transects. Only the heron *Butorides striata* was observed once at the backwater pond in the first section of MNT1, and the sandpiper *Actitis macularius* was sometimes heard from the start sections of both transects, which is why the latter two species were included. Species nesting within a radius of about 100 m from the transect during the study period were defined as breeding species of the transect area. By this definition the transect area of MNT1 was c. 15.6 ha. Larger species nesting outside the area were also counted as breeding species when their territories or home ranges obviously covered at least a part of the transect area. Abbreviations used: (a) species recorded: + = recorded in the transect area of MNT1; – = not recorded in the transect area of MNT1; exclusively recorded in the area of MNT2; (b) type of record: for species exclusively recorded during non-standardized surveys; vi = visual observation; au = acoustical record; tr = tape recording; mn = mist-netted; (c) status (resident/seasonal status): br = breeding species in the transect area; breeding either confirmed or suspected; nbv = non-breeding visitor; used here for stragglers, foraging visitors, and short-distance migrants; NN-mi = Nearctic-Neotropical migrant; mi = migrant of other origin; i.e., intra-Neotropical migrants and others; (d) mist-netting surveys (cf. Chapter 4): MNT1/I, MNT1/II, and MNT1/III = mist-netting surveys; MNT1/I-III = complete standardized mist-netting study; CAP1 = sum of first captures and recaptures mist-netted for the first time in the corresponding survey; CAP2 = sum of first captures and all types of recaptures;  $\Sigma$ FC2 = sum of birds captured for the first time in the standardized study, excluding all types of recaptures; note: the total number of individuals captured might be slightly smaller than indicated by the sum of first captures, because not all species and individuals could be marked permanently;  $\Sigma$ CAP2 = sum of all captures, including recaptures; (e) MTW study (cf. Chapter 4): MNT1/1, MNT1/2, MNT1/3, and MNT1/4 = MTW surveys;  $\Sigma$ MNT1/1-4 = sum of all MTW surveys; note: the number of birds recorded includes repeated records of the same individuals and, therefore, can be considerably higher than the number of individuals present in the transect area.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>						Transect-mapping (MTW) study <sup>e</sup>			
				MNT1/I		MNT1/II		MNT1/III		(number of birds recorded)			
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	MNT1/1	MNT1/2	MNT1/3	MNT1/4
TINAMIDAE (3)													
<i>Tinamus major</i>	–												
<i>Crypturellus berlepschi</i>	+	br	br									1	1
<i>Crypturellus soui</i>	+	br	br							10	19	23	42
ARDEIDAE (1)													
<i>Butorides striata</i>	+	vi	br										
CATHARTIDAE (3)													
<i>Sarcophagus papa</i>	+	vi	nbv										
<i>Coragyps atratus</i>	–												
<i>Cathartes aura</i>	+		br										
ACCIPITRIDAE (12)													
<i>Pandion haliaetus</i>	+	vi	NN-mi								1	2	15
<i>Leptodon cayanensis</i>	–												18

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-napping (MTW) study <sup>e</sup> (number of birds recorded)			
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		MNT1/1	MNT1/2	MNT1/3	ΣMNT1/1-4
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣCAP2	ΣCAP2	ΣCAP2	ΣCAP2				
<i>Elanoides forficatus</i>	+	vi	mi														
<i>Ictinia plumbea</i>	+	vi	nbv														
<i>Accipiter superciliosus</i>	—																
<i>Accipiter bicolor</i>	—																
<i>Leucopernis plumbeus</i>	—																
<i>Leucopernis semiplumbus</i>	—																
<i>Leucopernis princeps</i>	+	vi	nbv														
<i>Buteo magnirostris</i>	+	br	br											2	1	1	5
<i>Buteo brachyurus</i>	+	vi	nbv														9
<i>Spizaetus tyrannus</i>	+	au/tr	br														
FALCONIDAE (5)																	
<i>Micrastur ruficollis</i>	—																
<i>Micrastur semitorquatus</i>	—																
<i>Herpetotheres cachimans</i>	+		br													2	2
<i>Falco ruficularis</i>	—																
<i>Falco peregrinus</i>	—																
CRACIDAE (2)																	
<i>Onychia erythroptera</i>	+	au	nbv														
<i>Penelope purpurascens</i>	+	au	nbv														
ODONTOPHORIDAE (2)																	
<i>Odontophorus erythrops</i>	+	br	br											2	1		5
<i>Rhychortyx cinctus</i>	+	br	br												7	2	9
RALLIDAE (3)																	
<i>Laterallus albigularis</i>	+	br	br			1	1	1	1	1	1	1	1	2	1	5	6
<i>Anaerolimnas concolor</i>	+	br	br												4		4
<i>Neotres colombiana</i>	+	br	br			2	2	2	2	2	2	2	2				
SCOLOPACIDAE (1)																	
<i>Actitis macularia</i>	+	vi, au	NN-mi														
COLUMBIDAE (7)																	
<i>Pangaea speciosa</i>	+	br	br											1	6	6	19
<i>Pangaea subvincta</i>	+	br	br											1	5	3	18
<i>Pangaea godoni</i>	+	br	br											5	8	7	4
<i>Clavus pretiosa</i>	+	au	nbv														
<i>Leptotila pallida</i>	+	br	br	1	1	1	1	2	3	4	5	4	6	4	5	26	41
<i>Geotrygon veraguensis</i>	+	br	br	1	1	1	1	1	1	3	3	1	1	1	1		2
<i>Geotrygon montana</i>	+	br	br			1	1	1	1	1	1	1	1				
PSITTACIDAE (6)																	
<i>Ara ambiguus</i>	+	au	nbv														
<i>Touit dilectissimus</i>	+	au, tr	nbv												3	25	28
<i>Pionopsitta pulchra</i>	+	br	br														

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>						Transect-napping (MTW) study <sup>e</sup>				
				MNT1/I	MNT1/II	MNT1/III	MNT1/III	CAP1	CAP2	MNT1/I	MNT1/2	MNT1/3	MNT1/4	ΣMNT1/I-4
<i>Pionus menisemus</i>	+		br								5	23	7	35
<i>Pionus chalcopterus</i>	+		nbv								1	9	15	
<i>Amazona farinosa</i>	+		nbv									5	8	13
<b>CUCULIDAE (6)</b>														
<i>Piaya cayana</i>	+		br								2	2		4
<i>Piaya minuta</i>	+		br										2	2
<i>Crotophaga ani</i>	+	vi	nbv		1	1	2	2						
<i>Crotophaga sulcirostris</i>	–													
<i>Tapera naevia</i>	+	vi, au	br											
<i>Neomorphus radiololus</i>	–													
<b>STRIGIDAE (4)</b>														
<i>Megascops centralis</i>	–													
<i>Glauclidium grisiceps</i>	–													
<i>Pulsatrix perspicillata</i>	–													
<i>Strix virgata</i>	+		br	1	1					1	1	2	4	7
<b>NYCTIBIDAE (1)</b>														
<i>Nyctibius griseus</i>	+		br									1	1	2
<b>CAPRIMULGIDAE (2)</b>														
<i>Nyctidromus albigollis</i>	+		br							2		2		4
<i>Nyctiphrynus rosenbergi</i>	+		br								2	2		4
<b>APODIDAE (6)</b>														
<i>Streptoprocne zonaris</i>	+		nbv										20	20
<i>Cypseloides nutilus</i>	–													
<i>Chaetura pelagica</i>	+		NN-mi							20			9	29
<i>Chaetura spinicaudus</i>	+		br							2		69	15	86
<i>Chaetura cinereiventris</i>	–													
<i>Paryptila cayennensis</i>	+		nbv								2	1		3
<b>TROCHILIDAE (15)</b>														
<i>Glauis aeneus</i>	+		br	4	4	5	5	1	1		10		1	1
<i>Threnetes ruckeri</i>	+		br	25	28	21	21	17	17		63		28	88
<i>Phaethornis yaruqui</i>	+		br	21	24	19	20	12	13		52		17	40
<i>Phaethornis strigularis</i>	+		br	1	1	3	3	1	1		5		5	7
<i>Eutoxeres aquila</i>	+		br	3	3	1	1	3	4		7		8	
<i>Androdon aequatorialis</i>	+		nbv	2	2	3	3				5		5	5
<i>Florisuga mellivora</i>	+		br	1	1	1	1				2		1	1
<i>Popelairia conversii</i>	+		nbv								1		1	
<i>Thalurania fannyi</i>	+		br	1	1	1	1				2		2	
<i>Damophila julie</i>	+		br	1	1			1	1		2		1	1
<i>Amazilia tzacatl</i>	+		br	4	4			1	1		5		10	24
<i>Amazilia amabilis</i>	+		nbv			3	3	1	1		4			

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-napping (MTW) study <sup>e</sup>			
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		(number of birds recorded)			
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	MNT1/1	MNT1/2	MNT1/3	ΣMNT1/1-4
<i>Amazilia rosebergi</i>	+		br	11	11	20	20	5	5	5	5	36	36	10	15	13	20
<i>Chalybura urochrysa</i>	+		br	2	4	1	1	1	3	4	8						58
<i>Heliophrys barroti</i>	+		br	1	1			1	1	2	2			5	4	1	4
TROGONIDAE (3)																	
<i>Trogon comptus</i>	+		br											1	1		2
<i>Trogon chinourus</i>	+		br											3	4		8
<i>Trogon rufus</i>	+	au	br														
ALCEDINIDAE (4)																	
<i>Megasceryle torquata</i>	+	vi, au	br														
<i>Chloroceryle americana</i>	+		br	1	1					1	1						
<i>Chloroceryle inda</i>	+		br	1	1	1	3			2	4						
<i>Chloroceryle aenea</i>	–																
MOMOTIDAE (2)																	
<i>Electron platyrhynchum</i>	+		br											4		1	5
<i>Barophobergus martii</i>	+		br							2	3			2	3	1	11
GAULBULIDAE (1)																	
<i>Galbula ruficauda</i>	+		br	1	1	2	2	1	1	4	4			1	3	2	8
BUCCONIDAE (3)																	
<i>Nysialus radiatus</i>	+		br														4
<i>Malacoptila panamensis</i>	+		br	5	6					5	6			1		1	3
<i>Micromonacha lanceolata</i>	–																
CAPTIONIDAE (1)																	
<i>Capito squamatus</i>	+		br					2	2	2	2	2	2	3	2		6
RAMPHASTIDAE (3)																	
<i>Preroglossus sanguineus</i>	+		br			1	1			1	1						5
<i>Ramphastos brevis</i>	+		br											1			7
<i>Ramphastos suainsonii</i>	+		br			1	1			1	1	1	1	5	2	2	9
PICIDAE (8)																	
<i>Picumnus olivaceus</i>	+		br	2	2	2	2	3	3	5	7						4
<i>Picus lineae</i>	+	vi, au	br														
<i>Celex loritatus</i>	+		br												1	2	5
<i>Dryocopus lineatus</i>	+		br											1	2	1	5
<i>Melanerpes pucherani</i>	+		br											6	4	3	13
<i>Veniliornis kirbyi</i>	+		br												2	2	5
<i>Veniliornis callonotus</i>	+		br	1	1			1	1	2	2				1	1	3
<i>Campephilus gayaquilensis</i>	+	vi	br														
FURNARIIDAE (5)																	
<i>Synallaxis brachyura</i>	+		br	12	14	10	11	5	5	22	30			26	52	51	172
<i>Hylocichla ustulata</i>	+		br	2	3	1	1	5	6	6	10			3	5	6	21
<i>Automolus rubiginosus</i>	+		br			1	1	1	2	2	3				1	8	11

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)					
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		MNT1/1	MNT1/2	MNT1/3	MNT1/4	ΣMNT1/1-4	
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2						
<i>Xenops minutus</i>	+		br	7	8	5	5	6	7	7	7	5	5	5	6	3	3	14	
<i>Sclerurus mexicanus</i>	–																		
DENDROCOLAPTIDAE (8)																			
<i>Dendrocincla fuliginosa</i>	+		br	2	4	4	4	2	2	2	6	10	10	2	1	1	3	3	
<i>Glyphorynchus spirurus</i>	+		br	8	9	7	8	14	19	19	21	36	36	2	5	10	3	20	
<i>Dendrocolaptes sanctibonae</i>	+		br											2	1	6	9		
<i>Xiphorhynchus lachrymosus</i>	+		br					1	1	1	1	1	1	4	3	10	5	22	
<i>Xiphorhynchus erythropygius</i>	+		br	1	2	2	3	2	2	2	3	7	7	2	5	4	1	12	
<i>Lepidocolaptes souleyetii</i>	+		br	1	1						1	1	1	1	1	1	1	1	
<i>Campylorhamphus trochilrostris</i>	+		br	1	2	1	2				2	4	4	1	2	1	1	5	
<i>Campylorhamphus pusillus</i>	–																		
THAMNOPHILIDAE (18)																			
<i>Cymbilaimus lineatus</i>	+		br											1	2	1	3	7	
<i>Taraba major</i>	+		br	1	1	1	1				2	2	2	7	2	12	10	31	
<i>Thamnophilus atrinucha</i>	+		br			2	2				2	2	2	3	3	3	5	14	
<i>Thamnisteres anabatinus</i>	+	au	br			1	1				1	1	1	1	1	1	3	5	
<i>Dysithamnus puncticeps</i>	+		br																
<i>Myrmotherula ignota</i>	+		br			2	2	4	4		9	12	12	18	23	25	32	98	
<i>Myrmotherula pacifica</i>	+		br	6	6	5	5	7	8	14	14	19	19	2	4	3	1	10	
<i>Myrmotherula fulviventris</i>	+		br	6	6	5	5	3	3	8	10	10	10	4	9	11	14	38	
<i>Myrmotherula axillaris</i>	+		br	5	5	2	2	3	3	1	1	1	1						
<i>Myrmotherula schisticolor</i>	+		nbv					1	1	1	1	1	1						
<i>Microtopias quixensis</i>	+		br					1	1	1	1	1	1	3	4	6	17	30	
<i>Cercomacra tyrannina</i>	+		br	15	25	9	11	9	13	28	49	49	49	28	50	51	57	186	
<i>Hylophylax naevioides</i>	+		br	2	4	4	5	2	2	6	6	11	11	5	5	2	2	9	
<i>Myrmeciza immaculata</i>	+		br	4	4	4	4	1	1	1	7	9	9	3	3	4	1	11	
<i>Myrmeciza exul</i>	+		br	10	12	3	3	4	4	13	19	19	19	24	18	49	48	139	
<i>Myrmeciza berlepschi</i>	+		br			5	5	2	2	5	7	7	7	1	8	14	11	34	
<i>Gymnophytis leucaspis</i>	+		br	2	2	6	6	2	2	2	10	10	10		2	2		4	
<i>Phaenostictus mckeani</i>	–																		
FORMICARIIDAE (2)																			
<i>Formicarius nigricapillus</i>	+		br	1	1	2	2	1	1	1	3	4	4	2	6	5	3	16	
<i>Hylopesus perspicillatus</i>	+		br														1	1	
TYRANNIDAE (41)																			
<i>Phyllonotus griseiceps</i>	+	au	br																
<i>Zimmerius chrysops</i>	+		br					1	1	1	1	1	1		2	11	17	30	
<i>Oreobion brunneipectus</i>	+		br	1	1									1	2	2	1	6	
<i>Camptostoma obsoletum</i>	+	vi, au	br																
<i>Tyrannulus clatus</i>	+		br											8	5		5	18	
<i>Myiophobus caniceps</i>	+		br													1	3	4	



## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>								Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)						
				MNT1/I		MNT1/II		MNT1/III		MNT1/III		MNT1/I		MNT1/2		MNT1/3	MNT1/4	ΣMNT1/1-4
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣFe2	ΣCAP2	MNT1/1	MNT1/2			
<i>Myiopagis viridicincta</i>	+		nbv			1	1	1	1	2	2							
<i>Mionectes olivaceus</i>	+		br	9	14	7	9	11	13	22	36							
<i>Mionectes olagineus</i>	+		br	2	2	3	5	1	1	5	8							
<i>Leptopogon superciliosus</i>	+		br	4	4	3	3	2	2	8	9			2	2	3	3	7
<i>Myiornis atricapillus</i>	+		br											2	4	9	9	24
<i>Lophortyx pileatus</i>	+		br					2	2	2	2			11	9	8	8	36
<i>Todirostrum nigriceps</i>	+		br											1	1	1	1	3
<i>Todirostrum cinereum</i>	+		br			2	2			2	2			8	8	11	9	36
<i>Rhynchocyclus pacificus</i>	+		br			4	4	1	1	4	5							
<i>Tolmomyias flavotectus</i>	+		br	1	1					1	1			1	5	3	4	13
<i>Platyrinchus coronatus</i>	+		br	4	4	1	1	1	1	5	6				1		7	8
<i>Terenotriccus erythrus</i>	+		br	4	5	5	6	2	2	7	13			1	1		2	2
<i>Myiobius atricaudus</i>	+		br	7	9	6	7	5	7	12	23			3	1	1	1	5
<i>Myiobius sulphureipygius</i>	+		br	7	13	7	8	5	12	10	33							
<i>Myiophobus fasciatus</i>	+		br	2	2					2	2				1			1
<i>Coniopus cooperi</i>	+	vi	NN-mi															
<i>Empidonax virescens</i>	+		NN-mi											1			4	5
<i>Colonia colonus</i>	+	vi, au, mn	br															
<i>Artita spadiceus</i>	+		br												1	1	3	4
<i>Rhytipterna bolerythra</i>	—																	
<i>Styraxes albobasis</i>	—																	
<i>Myiarchus tuberculifer</i>	+	vi, au, tr	br															1
<i>Megarynchus pitangua</i>	+		br											6	7	14	8	35
<i>Myiozetetes cayanensis</i>	+		br											4	14	17	5	40
<i>Myiozetetes granadensis</i>	+		br	1	1					1	1			2				2
<i>Coniopus albocinctus</i>	+		br															
<i>Myiodiastor maculatus</i>	—																	
<i>Legatus leucophaeus</i>	+		br					2	2	2	2			6	1	8	16	31
<i>Tyrannus melancholicus</i>	+		br											3	3	1	1	8
<i>Tyrannus niveigularis</i>	+		mi													1	3	4
<i>Pachyrhamphus cinnamomeus</i>	+		br	2	2	2	3			4	5			7	9	5	11	32
<i>Pachyrhamphus albobasis</i>	—																	
<i>Platysaris homochrous</i>	+		nbv															
<i>Tityra semifasciata</i>	+	vi	br			4	4	2	2	6	6							
<i>Tityra inquisitor</i>	+	vi	nbv															
COTINGIDAE (4)																		
<i>Lipaugus unirufus</i>	—																	
<i>Cotinga nattererii</i>	+	vi	br															
<i>Carpodectes hopkei</i>	—																	
<i>Querula purpurata</i>	+		br													3		3

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup>			
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		MNT1/VI		MNT1/VII	
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣCAP2	ΣF2	MNT1/I	MNT1/II	MNT1/III	MNT1/IV
PTIRIDAE (7)																	
<i>Pipra mentalis</i>	+		br	4	4	5	5	6	7	11	16	1				1	1
<i>Lepidobrix coronata</i>	+		br	4	6	4	4	4	5	9	15	2	2	3	3	3	10
<i>Manacus manacus</i>	+		br	25	29	20	27	22	24	51	80	17	33	32	36	36	118
<i>Machaeropterus deliciosus</i>	+		nbv			1	1	2	2	3	3						
<i>Chloropipo holochlora</i>	+		br	3	10	3	6	2	4	3	20						
<i>Schiffornis turdina</i>	–																
<i>Sapayoa aenigma</i>	+		br	2	2	5	5	2	2	6	9	3	5	8	13	29	29
VIREONIDAE (3)																	
<i>Vireo olivaceus</i>	+		NN–mi			2	2			2	2						
<i>Hylophilus decuratus</i>	+		br									13	13	21	10	57	57
<i>Hylophilus ochraceiceps</i>	+		br	2	2	2	2	2	3	3	7	1	2	1	2	6	6
TURDIDAE (2)																	
<i>Catharus ustulatus</i>	+		NN–mi	1	1			1	1	2	2						
<i>Turdus daguae</i>	+		br	6	8	4	6	2	2	10	16	1	3	1	4	9	9
HIRUNDINIDAE (8)																	
<i>Progne chalybea</i>	+	vi	nbv														
<i>Progne subis</i>	–																
<i>Tachycineta bicolor</i>	–																
<i>Neochelidon tibialis</i>	+		br			1	1			1	1	2	5	5	6	18	18
<i>Stelgidopteryx ruficollis</i>	+		br			2	3	1	1	3	4	1		7		8	8
<i>Riparia riparia</i>	+	vi	NN–mi														
<i>Hirundo rustica</i>	+	vi	NN–mi														
<i>Petrochelidon pyrrhonota</i>	+	vi	NN–mi														
TROGLODYTIDAE (8)																	
<i>Campylorhynchus zonatus</i>	+		br									1	6	3	10	10	10
<i>Odontorchilus branickii</i>	–																
<i>Thryothorus nigricapillus</i>	+		br	3	3	8	8	4	7	12	18	10	11	17	9	47	47
<i>Thryothorus leucopogon</i>	+		br	1	1			1	1	2	2	4	6	21	15	46	46
<i>Troglodytes aedon</i>	+		br										2	1	3	3	3
<i>Henicorhina leucosticta</i>	+		br	1	1	2	2			3	3	7	5	4	3	19	19
<i>Cyporhynchus phaeocephalus</i>	+		nbv			1	1			1	1						
<i>Microcerculus marginatus</i>	+		br	4	6	3	4	1	2	7	12	3	7	8	10	28	28
POLIOPTILIDAE (3)																	
<i>Microbatas cinereiventris</i>	+		br	5	5	4	4			8	9	3	5	7	8	23	23
<i>Poliopitila plumbea</i>	+		br									4	2	2		8	8
<i>Poliopitila schistaceigula</i>	+	vi, au, tr	br														
PARULIDAE (8)																	
<i>Dendroica striata</i>	+	vi	NN–mi														
<i>Dendroica fusca</i>	+	vi	NN–mi														

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)			
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		MNT1/1	MNT1/2	MNT1/3	Σ MNT1/1-4
				CAPI	CAP2	CAPI	CAP2	CAPI	CAP2	Σ Fe2	Σ CAP2	Σ Fe2	Σ CAP2				
<i>Seturus noveboracensis</i>	+	mn	NN-mi														
<i>Geothlypis semiflava</i>	+		br	1	1	1	1										8
<i>Geothlypis auricularis</i>	+		br	1	1	3	3	4	4								
<i>Oporornis philadelphia</i>	+	mn	NN-mi														
<i>Oporornis agilis</i>	+		NN-mi					1	1								
<i>Basiluterus fuscicauda</i>	+		br	3	7	8	9	3	4	8	20						12
<b>THRAUPIDAE (27)</b>																	
<i>Coreba flaveola</i>	+		br	2	2	5	7	10	11	15	20			14	12	23	63
<i>Cyanerpes caeruleus</i>	+		br											2	1		3
<i>Cyanerpes cyaneus</i>	+		br											2	1	4	7
<i>Chlorophanes spiza</i>	+		br												1		1
<i>Dacnis cayana</i>	+		br													1	1
<i>Dacnis egregia</i>	+		br			1	1			1	1			3			3
<i>Dacnis venusta</i>	+		nbv														
<i>Dacnis berlepschi</i>	+	vi	br													2	2
<i>Erythrolipis salmoni</i>	—																
<i>Euphonia laminirostris</i>	+		br	1	1			1	1	2	2					1	1
<i>Euphonia xanthogaster</i>	+		br	6	7	6	7	5	7	14	21			12	9	12	46
<i>Euphonia minuta</i>	+	vi, au	br														
<i>Euphonia fulvica</i>	+		br														
<i>Tangara palmeri</i>	+	au	br													1	1
<i>Tangara cyanicollis</i>	+		br														
<i>Tangara larriata</i>	+		br			1	1	2	2	2	3			4	4	5	18
<i>Tangara johannae</i>	+		br														
<i>Tangara lavinia</i>	+		br											1	3	4	8
<i>Thraupis episcopus</i>	+		br	4	4					4	4			5	7	5	28
<i>Thraupis palmarum</i>	+		br					1	1	1	1			2	7		9
<i>Ramphocelus icteronotus</i>	+		br	2	2	3	3	1	1	6	6			50	91	54	245
<i>Piranga rubra</i>	+		NN-mi											1			1
<i>Chlorothraupis olivacea</i>	+		br	2	2	2	2	5	5	7	9			10	16	11	53
<i>Mitrospingus cassinii</i>	+		br	4	5	3	4	2	2	5	11			5	2		9
<i>Tachyphonus luctuosus</i>	+	mn, vi	nbv														
<i>Tachyphonus delatrii</i>	+		br	18	45	11	16	14	17	24	78			52	52	48	234
<i>Heterospingus xanthopygius</i>	+		br												6	6	12
<b>CARDINALIDAE (4)</b>																	
<i>Salpator maxinus</i>	+		br	9	10	10	11	12	12	24	33			18	32	30	101
<i>Salpator atripennis</i>	+		br											2	4	7	16
<i>Salpator grosus</i>	+		br			1	1			1	1			8	3	3	23
<i>Pheucticus ludovicianus</i>	—																

## APPENDIX 12A. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup>			
				MNT1/I		MNT1/II		MNT1/III		MNT1/IV		MNT1/V		MNT1/1-4		(number of birds recorded)	
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣF2	ΣCAP2	MNT1/1	MNT1/2	MNT1/3	MNT1/4
EMBERIZIDAE (10)																	
<i>Rhodospingus cruentus</i>	–																
<i>Volatinia jacarina</i>	+		nbv														
<i>Tiaris obscurus</i>	+		br														
<i>Oryzoborus angolensis</i>	+		br	4	4	3	4	5	6	11	14						1
<i>Sporophila corina</i>	+		br	8	10	10	12	6	7	22	29	4	4	1	8	17	
<i>Sporophila luctuosa</i>	–																
<i>Sporophila nigricollis</i>	+		br			1	1	2	3	3	4	2	1	1	4		
<i>Sporophila telasco</i>	+	vi	nbv														
<i>Arremon aurantiivestris</i>	+		br	3	3	4	5	1	4	5	12	6	2	3	11		
<i>Arremonops conirostris</i>	+	au	nbv														
ICTERIDAE (6)																	
<i>Cacicus microhryncus</i>	+		br											4	6	3	13
<i>Amblycercus holosericeus</i>	+		br									1	3	1	5		
<i>Zarhynchus wagleri</i>	+	vi, au	br														
<i>Molothrus bonariensis</i>	+		br														
<i>Molothrus oryzivorus</i>	+		br			1	1	1	1	2	2	7	1	1	9		
<i>Dolichonyx oryzivorus</i>	+	vi	NN-mi													1	1
Total of birds captured / recorded	231			350	449	354	401	296	349	827	1199	609	803	1021	1136	3569	
Total number of species				80	80	88	88	86	86	117	117	105	111	120	126	162	

## APPENDIX 12B

Standardized mist-netting and MTW surveys of transect MNT2: number of birds captured/recorded per species, type of record, and breeding/non-breeding status in the transect area. List of the 268 bird species recorded between Aug. 1995 and Mar. 1998 in the area of transects MNT1 (Fig. 5) and MNT2 (Fig. 8). See Appendix 12a for details on which species were excluded from the analysis and on the meaning of the abbreviations used. The only difference between the meaning of the abbreviations described in Appendix 12a and their meaning in the list presented below is that here all data refer to the conditions encountered in the transect area of MNT2 (c. 14.1 ha) and not MNT1.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>						Transect-mapping (MTW) study <sup>e</sup>								
				MNT2/I		MNT2/II		MNT2/III		MNT2/I-III		(number of birds recorded)						
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣCAP2	ΣF2	MNT2/1	MNT2/2	MNT2/3	MNT2/4	ΣMNT2/1-4		
TINAMIDAE (3)																		
<i>Tinamus major</i>	+		br											3	4	3	7	17
<i>Crypturellus berlepschi</i>	+		br														1	1
<i>Crypturellus soui</i>	+		br											9	6	3	4	22
ARDEIDAE (1)																		
<i>Butorides striata</i>	—																	
CATHARTIDAE (3)																		
<i>Sarcornomphus papa</i>	+	vi	nbv															
<i>Coragyps atratus</i>	+	vi	nbv															
<i>Cathartes aura</i>	+		br													1		1
ACCIPITRIDAE (12)																		
<i>Pandion haliaetus</i>	+	vi	NN-mi															
<i>Lepidodon cayanensis</i>	+		br													1		1
<i>Elanoides forficatus</i>	+	vi	mi															
<i>Ictinia plumbea</i>	+	vi	nbv															
<i>Accipiter superciliosus</i>	+	vi	br															
<i>Accipiter bicolor</i>	+	vi	br															
<i>Leucopternis plumbeus</i>	+	vi	br											2	1			3
<i>Leucopternis semiplumbeus</i>	+	vi	br															
<i>Leucopternis princeps</i>	+	vi	nbv															
<i>Buteo magnirostris</i>	+	vi, au	br															
<i>Buteo brachyurus</i>	+	vi	nbv															
<i>Spizaetus tyrannus</i>	—																	
FALCONIDAE (5)																		
<i>Micrastur ruficollis</i>	+	mn, au	br															
<i>Micrastur semitorquatus</i>	+		br													2		2
<i>Herpetotheres cachimans</i>	+		br											1		1		2
<i>Falco ruficularis</i>	+	vi	br															
<i>Falco peregrinus</i>	+	vi	NN-mi															
CRACIDAE (2)																		
<i>Ortalis erythroptera</i>	—																	

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup>			
				MNT2/I		MNT2/II		MNT2/III		MNT2/I-III		MNT2/1	MNT2/2	MNT2/3	MNT2/4	ΣMNT2/1-4	
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣFC2	ΣCAP2						
<i>Penelope purpurascens</i>	+		nbv												1		1
ODONTOPHORIDAE (2)																	
<i>Odontophorus erythrops</i>	+		br	1	1					1	1	2	6	4		24	
<i>Rhinchorhix cinereus</i>	+		br										3	1		4	
RALLIDAE (3)																	
<i>Lanius albicollis</i>	+		br												1	1	2
<i>Amazilia bicolor</i>	+		br									4	1	10	2	2	17
<i>Neotoma floridana</i>	–																
SCOLOPACIDAE (1)																	
<i>Actitis macularia</i>	+	vi, au	NN-mi														
COLUMBIDAE (7)																	
<i>Columba speciosa</i>	+		nbv										1			1	
<i>Columba subimmaculata</i>	+		br											6	7		
<i>Columba goodsoni</i>	+		br									5	3	10	10	28	
<i>Claytonia pretiosa</i>	–																
<i>Leptotila pallida</i>	+		br	2	2		2	2	2	4	4	16	9	11	19	55	
<i>Geotrygon venusta</i>	+		br	1	1	2	2		3	3	3		2	2		4	
<i>Geotrygon montana</i>	+		br	1	1	2	2		3	3	3						
PSITTACIDAE (6)																	
<i>Ana ambigua</i>	+		nbv											2	2		
<i>Touit dilectissimus</i>	–																
<i>Pionopsitta pulchra</i>	+		br									11	2	20	18	51	
<i>Pionus menstruus</i>	+		br											12	12	12	
<i>Pionus chalcophaps</i>	+		br									4		27	10	41	
<i>Amazona farrinosa</i>	+		br									3	2	5	7	17	
CUCULIDAE (6)																	
<i>Piaya cayana</i>	+	vi, au	br														
<i>Piaya minuta</i>	+		br	1	1	2	2	2	2	5	5		1	1	2		
<i>Crotophaga ani</i>	+	vi	nbv														
<i>Crotophaga sulcirostris</i>	+	vi	nbv														
<i>Tapera naevia</i>	–																
<i>Neomorphus radiolosus</i>	+	au, tr	nbv														
STRIGIDAE (4)																	
<i>Megascops centralis</i>	+		br									1	1	1		3	
<i>Glaucidium griseiceps</i>	+	au	nbv														
<i>Pulsatrix perspicillata</i>	+		br										2	2		4	
<i>Strix virgata</i>	–																
NYCTIBIDAE (1)																	
<i>Nyctibius griseus</i>	–																

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>								Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)													
				MNT2/I		MNT2/II		MNT2/III		MNT2/IV		MNT2/I-III		MNT2/I-4											
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣF2	ΣCAP2	MNT2/1	MNT2/2	MNT2/3	MNT2/4	ΣMNT2/1-4									
CAPRIMULGIDAE (2)																									
<i>Nyctidromus albigollis</i>	+		br													2	2	1	5						
<i>Nyctipyrnus rosenbergi</i>	+		br												1	1	6	2	10						
APODIDAE (6)																									
<i>Streptoprocne zonaris</i>	+		nbv												1			5	6						
<i>Cypseloides nutilus</i>	+	vi	nbv																						
<i>Chaetura pelagica</i>	+	vi	NN-mi																						
<i>Chaetura spinicaudus</i>	+		br														1	3	4						
<i>Chaetura cinereiventris</i>	+	vi	nbv																						
<i>Panyptila cayennensis</i>	+	vi	nbv																						
TROCHILIDAE (15)																									
<i>Glaucidis aeneus</i>	+		br					1	1	1	1							1	1						
<i>Threnetes ruckeri</i>	+		br					22	25	49	63					26	22	9	84						
<i>Phaethornis yaruqui</i>	+		br					24	27	70	75				10	9	25	16	60						
<i>Phaethornis strigularis</i>	+		br					1	1	5	5						2	1	3						
<i>Eutoxeres aquila</i>	+		br					18	21	14	16				3	1	2	6	12						
<i>Androdon aquatorialis</i>	+		nbv														3	1	4						
<i>Florisuga mellivora</i>	+	vi	br																						
<i>Popelairia conversii</i>	+	vi	nbv																						
<i>Thalurania fannyi</i>	+	mn, vi	br																						
<i>Damophila julie</i>	+	vi	nbv																						
<i>Amazilia tzacatl</i>	+	vi	br																						
<i>Amazilia amabilis</i>	–																								
<i>Amazilia rosenbergi</i>	+		br					9	9	11	15				4	18	18	18	58						
<i>Chalybura urochrysa</i>	+		br					1	1	5	9				2	1	2	3	8						
<i>Heliothryx barroti</i>	+		br													1			1						
TROGONIDAE (3)																									
<i>Trogon comptus</i>	+		br													1	7	2	10						
<i>Trogon chionurus</i>	+		br					1	1						3	8	3	5	19						
<i>Trogon rufus</i>	+		br								3		3		3										
ALCEDINIDAE (4)																									
<i>Megascyle torquata</i>	+		br												1			1	2						
<i>Chloroceryle americana</i>	+	vi	br																						
<i>Chloroceryle inda</i>	+		br												1										
<i>Chloroceryle alcyon</i>	+		br												1	1	1								
MOMOTIDAE (2)																									
<i>Electron platyrhynchos</i>	+		br					1	1						1	1	16	9	42						
<i>Baryphibicus martii</i>	+		br					2	2						2	3	8	4	17						
GALBULIDAE (1)																									
<i>Galbula ruficauda</i>	+		br					1	1						1										



## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>								Transect-mapping (MTW) study <sup>e</sup>			
				MNT2/I		MNT2/II		MNT2/III		MNT2/I-III		(number of birds recorded)			
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣFC2	ΣCAP2	MNT2/1	MNT2/2	MNT2/3	MNT2/4
BUCCONIDAE (3)															
<i>Nyctalus radiatus</i>	+	au	nbv												
<i>Malacoptila panamensis</i>	+	br	br	6	8	6	7	5	5	13	20		2	2	4
<i>Micromonacha lanceolata</i>	+	vi, au	br												
CAPTIONIDAE (1)															
<i>Capito squamatus</i>	+	br	br	2	2					2	2	1		1	2
RAMPHASTIDAE (3)															
<i>Pteroglossus sanguineus</i>	+	br	br					2	2	2	2		3		6
<i>Ramphastos brevis</i>	+	br	br									1		5	6
<i>Ramphastos swainsonii</i>	+	br	br									5	3	11	3
PICIDAE (8)															
<i>Picumnus olivaceus</i>	–														
<i>Piculus litae</i>	+	br	br											1	1
<i>Celeus loritanus</i>	+	br	br											2	3
<i>Dryocopus lineatus</i>	+	br	br									1			1
<i>Melanerpes pucherani</i>	+	br	br										2		2
<i>Veniliornis kirkii</i>	+	br	br										2	1	3
<i>Veniliornis callonotus</i>	–														
<i>Campephilus guyaquilensis</i>	+	br	br											2	1
FURNARIIDAE (5)															
<i>Synallaxis brachyura</i>	+	br	br	3	3					3	3	2	11	11	15
<i>Hylocistes virgatus</i>	+	br	br	8	9	7	8	6	6	16	23	8	11	6	7
<i>Automolus rubiginosus</i>	+	br	br	4	4	3	4	1	2	5	10	2	2	3	7
<i>Xenops minutus</i>	+	br	br	6	6	6	7	5	5	12	18	1	4	1	6
<i>Sclerurus mexicanus</i>	+	br	br											1	1
DENDROCOLAPTIDAE (8)															
<i>Dendrocincla fuliginosa</i>	+	br	br	4	4	3	5	2	3	6	12		3	4	7
<i>Glyptorhynchus spirurus</i>	+	br	br	4	5	10	15	6	11	13	31	1	2	1	5
<i>Dendrocolaptes sanctithomae</i>	+	br	br					1	1	1	1	2		3	4
<i>Xiphothynchus lachrymosus</i>	+	br	br									2	3	3	5
<i>Xiphothynchus erythroggius</i>	+	br	br			2	2			2	2	5	2	5	17
<i>Lepidocolaptes souleyetii</i>	–														
<i>Camptylorhynchus trochilirostris</i>	+	nbv	nbv					1	1	1	1				
<i>Camptylorhynchus pusillus</i>	+	br	br									3		1	4
THAMNOPHILIDAE (18)															
<i>Gymbidaimus lineatus</i>	+	vi, au	br												
<i>Tanaba major</i>	+	br	br			1	1			1	1				
<i>Thamnophilus atrinucha</i>	+	br	br	3	3	2	2	4	4	8	9	6	3	2	5
<i>Thamnisteris andabatius</i>	+	br	br										1	4	5
<i>Dysithamnus puncticeps</i>	+	br	br	1	1	1	1			1	2	1		7	2
															10

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Misc-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup>							
				MNT2/I		MNT2/II		MNT2/III		MNT2/I-III		MNT2/I		MNT2/2		MNT2/3		MNT2/4		ΣMNT2/I-4	
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣF&2	ΣCAP2	ΣF&2	ΣCAP2	MNT2/1	MNT2/2	MNT2/2	MNT2/3	MNT2/4	MNT2/4	ΣMNT2/I-4	
<i>Myrmotherula ignota</i>	+		br													1	2	5	8		
<i>Myrmotherula pacifica</i>	+		br	5	5			1	1	6	6			10	4	14	18	46			
<i>Myrmotherula fusciventris</i>	+		br	9	10	4	4	8	15	15	29			11	8	6	5	30			
<i>Myrmotherula axillaris</i>	+		br	8	9	9	10	6	6	18	25			11	14	16	15	56			
<i>Myrmotherula schisticolor</i>	-																				
<i>Microlophus quixensis</i>	+		br																		
<i>Cercomacra tyrannina</i>	+		br	13	22	5	6	5	6	15	34			37	18	35	30	120			
<i>Hylophylax naevoides</i>	+		br	12	13	11	14	10	16	22	43			7	6	8	10	31			
<i>Myrmeciza immaculata</i>	+		br	4	4	5	7	4	5	10	16			3	5	4	4	16			
<i>Myrmeciza exsul</i>	+		br	12	14	7	7	9	12	23	33			29	26	46	34	135			
<i>Myrmeciza berlepschi</i>	+		br	6	6	2	2	4	4	8	12			10	8	10	14	42			
<i>Gymnophylus leucaspis</i>	+		br	5	7	13	29	10	14	20	50			16	7	10	10	43			
<i>Phaenostictus mckeani</i>	+		br												1			1			
FORMICARIIDAE (2)																					
<i>Formicarius nigricapillus</i>	+		br	2	3	4	6	6	6	9	15			10	15	13	1	39			
<i>Hylopezus perspicillatus</i>	+		br			3	4			3	4			11	12	16	19	58			
TYRANNIDAE (41)																					
<i>Phyllomyias griseiceps</i>	-																				
<i>Zimmerius chrysops</i>	+		br											1		5	4	10			
<i>Oreithion brunneicapillus</i>	+		br												1			1			
<i>Camptostoma obsoletum</i>	-																				
<i>Tyrannulus elatus</i>	-																				
<i>Myiopagis caniceps</i>	+	au	br					1	1	1	1										
<i>Myiopagis viridicincta</i>	+		nbv					33	42	63	115			6	7	1	9	23			
<i>Mionectes olivaceus</i>	+		br	29	46	20	27														
<i>Mionectes olagineus</i>	+		br	1	2	3	3	2	3	6	8										
<i>Lepidopogon superciliosus</i>	+		br	2	3	1	1	1	1	4	5					2	1	3			
<i>Myiornis atricapillus</i>	+		br													1	4	10	15		
<i>Lophortyx pileatus</i>	+		br			2	2	1	1	2	3			4	4	1	2	11			
<i>Todirostrum nigriceps</i>	+		br											2	2	3	3	5			
<i>Todirostrum cinereum</i>	+		br					1	1	2	3			4			1	11			
<i>Rhynchocyclus pacificus</i>	+		br	2	2			1	1	2	3				1	2	2	3			
<i>Tolmomyias flavotectus</i>	+		br			1	1			1	1						1	1			
<i>Platyrinchus coronatus</i>	+		br	3	3	2	2	1	1	5	6			5	4	4	7	20			
<i>Terenotriccus erythronus</i>	+		br	6	6	4	6	2	2	10	14					1	1	2			
<i>Myiobius atricaudus</i>	+		br	1	1	2	6	2	3	2	10										
<i>Myiobius sulphureipygus</i>	+		br	11	21	9	13	8	11	20	45					1		1			
<i>Myiophobus fasciatus</i>	-																				
<i>Conopus cooperi</i>	+	vi	NN-mi																		
<i>Empidonax urensens</i>	+		NN-mi					1	1	1	1										

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>								Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)			
				MNT2/I				MNT2/II				MNT2/III			
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣFC2	ΣCAP2
<i>Colonia colinus</i>	+		br												2
<i>Artila spadiceus</i>	–														
<i>Rhytiperna holerythra</i>	+		br												
<i>Syrtes albogriseus</i>	+	vi, au	nbv			1	1							1	1
<i>Myiarchus tuberculifer</i>	–														
<i>Megarynchus pitangua</i>	+	vi, au	nbv												
<i>Myiozetetes cayanensis</i>	+		br												
<i>Myiozetetes granudensis</i>	+	vi, au, tr	br												
<i>Conopias albovittatus</i>	+		br												
<i>Myiodynastes maculatus</i>	+	vi	nbv												
<i>Legatus leucophaius</i>	+		br												
<i>Tyrannus melancholicus</i>	+	vi, au	br												
<i>Tyrannus niveigularis</i>	+		mi												
<i>Pachyrhamphus cinnamomeus</i>	+		br												
<i>Pachyrhamphus albogriseus</i>	+		nbv												
<i>Platypsaris homochrous</i>	+	vi	nbv												
<i>Tityra semifasciata</i>	+	vi	br												
<i>Tityra inquisitor</i>	–														
COTINGIDAE (4)															
<i>Lipaugus unirufus</i>	+	au, tr	nbv												
<i>Cotinga nattererii</i>	–														
<i>Carpodectes hopkei</i>	+	vi	nbv												
<i>Querula purpurata</i>	+		br												
PYRIDAE (7)															
<i>Pipra mentalis</i>	+		br	30	34	12	12	35	41	67	87	5	12	2	6
<i>Lepidothrix coronata</i>	+		br	13	16	14	17	16	17	33	50	17	13	9	5
<i>Manacus manacus</i>	+		br	30	42	26	29	28	35	70	106	7		6	13
<i>Machaeropterus deliciosus</i>	+		nbv	6	9	3	6	1	1	1	1				
<i>Chloropipo holochlora</i>	+		br	1	2	1	1	6	7	12	22				
<i>Schiffornis turdina</i>	+		nbv	1	2	1	1	1	1	2	3				
<i>Sapayoa aenigma</i>	+		br	3	4	2	2	2	3	5	9	5	3	9	8
VIREONIDAE (3)															
<i>Vireo olivaceus</i>	+	vi	NN-mi												
<i>Hylophilus decuratus</i>	+		br												
<i>Hylophilus ochraceiceps</i>	+		br	2	3	3	3	1	3	5	9	3	4	9	7
TURDIDAE (2)															
<i>Catharus ustulatus</i>	+		NN-mi	2	2			2	2	4	4				
<i>Turdus daque</i>	+		br	8	10	4	5	14	18	23	33	5	8	6	13
HIRUNINIDAE (8)															
<i>Progne subis</i>	+	vi	nbv												

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup>													
				MNT2/I		MNT2/II		MNT2/III		MNT2/I-III		MNT2/1		MNT2/2		MNT2/3		MNT2/4									
				CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	ΣF62	ΣCAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2	CAP1	CAP2								
<i>Progne subis</i>	+	vi	NN-mi																								
<i>Tachycineta bicolor</i>	+	vi	NN-mi																								
<i>Neochelidon tibialis</i>	+		br																								
<i>Stelgidopteryx ruficollis</i>	+		br																								
<i>Riparia riparia</i>	+	vi	NN-mi																								
<i>Hirundo rustica</i>	+	vi	NN-mi																								
<i>Petrochelidon pyrrhonota</i>	+	vi	NN-mi																								
TROGLODYTIDAE (8)																											
<i>Campylorhynchus zonatus</i>	–																										
<i>Odonotrichilus bryanckii</i>	+	au, tr	nbv																								
<i>Thryothorus nigricapillus</i>	+		br	4	5	1	1	1	1	5	7	4	7	4	1	9	3	3	17								
<i>Thryothorus leucopogon</i>	+		br	1	1	3	4	1	1	4	6	13	6	17	29	22	81										
<i>Troglodytes aedon</i>	+	vi	nbv																								
<i>Henicorhina leucosticta</i>	+		br	1	2	2	2	2	2	5	6	5	6	1													
<i>Cyphorhinus phaeocephalus</i>	–																										
<i>Microcerculus marginatus</i>	+		br	7	10	10	15	5	13	15	38	6	9	16	9	40											
POLIOPTILIDAE (3)																											
<i>Microbatas cinereiventris</i>	+		br	11	13	7	9	7	8	18	30	9	17	19	13	58											
<i>Polioptila plumbea</i>	–																										
<i>Polioptila schistaceigula</i>	+		br									2	1														
PARULIDAE (8)																											
<i>Dendroica striata</i>	–																										
<i>Dendroica fusca</i>	–																										
<i>Seiurus noveboracensis</i>	–																										
<i>Geothlypis semiflava</i>	–		br	1	2					1	2																
<i>Geothlypis auricularis</i>	+																										
<i>Oporornis philadelphia</i>	–																										
<i>Oporornis agilis</i>	–																										
<i>Basileuterus fulvicauda</i>	+		br	1	1	3	3	1	1	4	5			1	1	2											
THRAUPIDAE (27)																											
<i>Coereba flaveola</i>	+		br	2	4					2	4			1	3												
<i>Cyanerpes caeruleus</i>	+	vi	br																								
<i>Cyanerpes cyaneus</i>	–																										
<i>Chlorophanes spiza</i>	+	vi	br																								
<i>Dacnis cayana</i>	+		br	1	1					1	1																
<i>Dacnis egregia</i>	+		br	1	1					1	1																
<i>Dacnis venusta</i>	+	vi	nbv																								
<i>Dacnis berlepschi</i>	+		br	3	3					3	3			3	6	9											
<i>Erythrolithpis salmوني</i>	+	au, tr	nbv																								
<i>Euphonia lanitirostris</i>	+	vi	nbv																								
<i>Euphonia xanthogaster</i>	+		br	5	6	5	5	6	8	14	19			8	9	9	9								35		

## APPENDIX 12B. Continued.

Family (no. of spp.) / species	Species recorded <sup>a</sup>	Type of record <sup>b</sup>	Status <sup>c</sup>	Mist-netting surveys <sup>d</sup>										Transect-mapping (MTW) study <sup>e</sup> (number of birds recorded)			
				MNT2/I					MNT2/II					MNT2/III			
				CAPI	CAP2	CAPI	CAP2	CAPI	CAPI	CAP2	CAPI	CAP2	CAPI	CAPI	CAP2	ΣCAP2	ΣMNT2/I-III
<i>Euphonia minuta</i>	+	br	br													1	1
<i>Euphonia fulvicrisa</i>	+	vi, au	br														
<i>Tangara palmeri</i>	+	br	br											2		2	4
<i>Tangara cyanicollis</i>	–																
<i>Tangara larvata</i>	+		br														
<i>Tangara johannae</i>	+		br											2		3	8
<i>Tangara lavinia</i>	+		br														
<i>Thraupis episcopus</i>	+		br													3	1
<i>Thraupis palmarum</i>	+	vi	br													1	1
<i>Ramphocelus icteronotus</i>	+		br														
<i>Pinanga rubra</i>	+		NN-mi														
<i>Chlorothraupis olivacea</i>	+		br														
<i>Mitrospingus castaneus</i>	+		br														
<i>Tachyphonus luctuosus</i>	+	vi	nbv														
<i>Tachyphonus delatrii</i>	+		br														
<i>Heterospingus xanthopygius</i>	+		br														
CARDINALIDAE (4)																	
<i>Salpator maximus</i>	+		br														
<i>Salpator arripennis</i>	+		br														
<i>Salpator grosus</i>	+		br														
<i>Phaeucticus ludovicianus</i>	+		NN-mi														
EMBERIZIDAE (10)																	
<i>Rhodospingus cruentus</i>	+		nbv														
<i>Volatinia jacarina</i>	+		nbv														
<i>Tiaris obscurus</i>	+		nbv														
<i>Oryzoborus angolensis</i>	+		br														
<i>Sporophila corvina</i>	+		br														
<i>Sporophila luctuosa</i>	+	vi	nbv														
<i>Sporophila nigricollis</i>	+		br														
<i>Sporophila telasco</i>	+	vi	nbv														
<i>Arremon aurantivestris</i>	+		br														
<i>Arremonops contrivestris</i>	–																
ICTERIDAE (6)																	
<i>Cactus microhynchus</i>	+		br														
<i>Amblycercus holosericeus</i>	–																
<i>Zarhynchus wagleri</i>	+		br														
<i>Molothrus bonariensis</i>	–																
<i>Molothrus oryzivorus</i>	+		nbv														
<i>Dolichonyx oryzivorus</i>	–																
Total of birds captured / recorded				452	567	367	459	398	501	992	1527	614	587	858	738	2797	
Total number of species	231			69	69	65	65	73	73	96	96	86	93	112	104	144	

## APPENDIX 13A

Standardized and non-standardized surveys of transect MNT1: influence of taxonomic affinities on bird species detectability. Comparative effectiveness of the number of bird species detected per taxonomic group during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 80-82, Influence of taxonomic affinities). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha), were included (cf. Appendix 12a). Bird families represented by only a small number of species were grouped when they shared similarities in their behavioral characteristics or in their general detectability. Abbreviations used: (a) Data set: total records = all species recorded during standardized and non-standardized surveys; MN+MTW studies = species recorded during standardized mist-netting and MTW surveys; additional records = species recorded exclusively during non-standardized mist-netting and observation hours; exclusively MN = species that during standardized surveys were detected exclusively by mist netting; MN>2xMTW = species for which the mean number of birds captured per mist-netting survey was more than twice the mean number of birds recorded per MTW survey; note: the number of birds captured/recorded includes recaptures and repeated records of the same individuals, and may be greater than the number of individuals present in the transect area during the surveys; MN=MTW = species for which the mean number of birds captured per mist-netting survey was equal to twice the mean number of birds recorded per MTW survey; MTW>2xMN = species for which the mean number of birds recorded per MTW survey was more than twice the mean number of birds captured per mist-netting survey; exclusively MTW = species that during standardized surveys were detected exclusively by MTW; MN: MNT1/I, MN: MNT1/II, and MN: MNT1/III = species captured per standardized mist-netting survey; MN: MNT1/I-III = all species captured during the standardized mist-netting study (surveys MNT1/I through MNT1/III); mean MN study = mean of species captured during the three standardized mist-netting surveys of the transect; MTW: MNT1/1, MTW: MNT1/2, MTW: MNT1/3, and MTW: MNT1/4 = species recorded per MTW survey; MTW: MNT1/1+2 and MTW: MNT1/3+4 = species recorded in the combined MTW surveys (MNT1/1 + MNT1/2 and MNT1/3 + MNT1/4); MTW: MNT1/1-4 = all species recorded during the MTW study (surveys MNT1/1 through MNT1/4); mean MTW study = mean of species recorded during the four MTW surveys of the transect; (b) N sp.: number of species captured/recorded; (c) % N row: percent of species recorded in each bird group of the total number of species represented in each data set; shows for each data set how the species were distributed over the bird groups; (d) % N tot. records: percent of species represented in each data set of the total number of species recorded per bird group during the complete study of the transect; shows how well each bird group was represented in each data set in relation to the total number of species recorded per group in the transect area; (e) % N MN+MTW: percent of species represented in each data set of the total number of species recorded per bird group during standardized mist-netting and MTW surveys; shows how well each bird group was represented in each data set in relation to the total number of species recorded per group in the standardized studies. Note: the data sets 'exclusively MN' through 'exclusively MTW' refer only to the standardized mist-netting and MTW studies, which is why their percentages of the total number of species recorded per group during standardized and non-standardized surveys together are not shown.

## APPENDIX 13A. Continued.

Data set <sup>a</sup>	All species				Non-Passerines				Passerines				Suboscine Passerines			
	N sp. <sup>b</sup>	% N tot. row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N tot. row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N tot. row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N tot. row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	124.9	84	36.4	100.0	131.3	147	63.6	100.0	121.5	75	32.5	100.0	113.6
MN+MTW studies	185	100.0	80.1	100.0	64	34.6	76.2	100.0	121	65.4	82.3	100.0	66	35.7	88.0	100.0
Additional records	46	100.0	19.9	24.9	20	43.5	23.8	31.3	26	56.5	17.7	21.5	9	19.6	12.0	13.6
Exclusively MN	23	100.0		12.4	8	34.8		12.5	15	65.2		12.4	8	34.8		12.1
MN>2xMTW	19	100.0		10.3	5	26.3		7.8	14	73.7		11.6	9	47.4		13.6
MN=MTW	30	100.0		16.2	10	33.3		15.6	20	66.7		16.5	11	36.7		16.7
MTW>2xMN	45	100.0		24.3	8	17.8		12.5	37	82.2		30.6	22	48.9		33.3
Exclusively MTW	68	100.0		36.8	33	48.5		51.6	35	51.5		28.9	16	23.5		24.2
MN: MNT1/I	80	100.0	34.6	43.2	22	27.5	26.2	34.4	58	72.5	39.5	47.9	35	43.8	46.7	53.0
MN: MNT1/II	88	100.0	38.1	47.6	21	23.9	25.0	32.8	67	76.1	45.6	55.4	39	44.3	52.0	59.1
MN: MNT1/III	86	100.0	37.2	46.5	20	23.3	23.8	31.3	66	76.7	44.9	54.5	39	45.3	52.0	59.1
MN: MNT1/I+II	117	100.0	50.6	63.2	31	26.5	36.9	48.4	86	73.5	58.5	71.1	50	42.7	66.7	75.8
Mean MN study	85	100.0	36.7	45.8	21	24.8	25.0	32.8	64	75.2	43.3	52.6	38	44.5	50.2	57.1
MTW: MNT1/I	105	100.0	45.5	56.8	30	28.6	35.7	46.9	75	71.4	51.0	62.0	42	40.0	56.0	63.6
MTW: MNT1/2	111	100.0	48.1	60.0	33	29.7	39.3	51.6	78	70.3	53.1	64.5	44	39.6	58.7	66.7
MTW: MNT1/3	120	100.0	51.9	64.9	38	31.7	45.2	59.4	82	68.3	55.8	67.8	47	39.2	62.7	71.2
MTW: MNT1/4	126	100.0	54.5	68.1	43	34.1	51.2	67.2	83	65.9	56.5	68.6	48	38.1	64.0	72.7
MTW: MNT1/I+2	130	100.0	56.3	70.3	40	30.8	47.6	62.5	90	69.2	61.2	74.4	51	39.2	68.0	77.3
MTW: MNT1/3+4	151	100.0	65.4	81.6	53	35.1	63.1	82.8	98	64.9	66.7	81.0	54	35.8	72.0	81.8
MTW: MNT1/I+4	162	100.0	70.1	87.6	56	34.6	66.7	87.5	106	65.4	72.1	87.6	58	35.8	77.3	87.9
Mean MTW study	116	100.0	50.0	62.4	36	31.2	42.9	56.3	80	68.8	54.1	65.7	45	39.2	60.3	68.6



## APPENDIX 13A. Continued.

Data set <sup>a</sup>	Oscine Passerines					Tiniamidae, Ardeidae, Cracidae, Odontophoridae, Rallidae, Scolopacidae					Cathartidae, Accipitridae, Falconidae					Columbidae				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	72	31.2	100.0	4.8	100.0	130.9	11	4.8	100.0	157.1	10	4.3	100.0	333.3	7	3.0	100.0	116.7		
MN+MTW studies	55	29.7	76.4	3.8	63.6	100.0	7	3.8	63.6	100.0	3	1.6	30.0	100.0	6	3.2	85.7	100.0		
Additional records	17	37.0	23.6	8.7	36.4	30.9	4	8.7	36.4	57.1	7	15.2	70.0	233.3	1	2.2	14.3	16.7		
Exclusively MN	7	30.4	12.7	1	4.3		1	4.3		14.3		0	0.0	0.0	1	4.3		16.7		
MN>2xMTW	5	26.3	9.1	0	0.0		0	0.0		0.0		0	0.0	0.0	0	0.0		0.0		
MN=MTW	9	30.0	16.4	0	0.0		0	0.0		0.0		0	0.0	0.0	1	3.3		16.7		
MTW>2xMN	15	33.3	27.3	1	2.2		1	2.2		14.3		0	0.0	0.0	1	2.2		16.7		
Exclusively MTW	19	27.9	34.5	5	7.4		5	7.4		71.4		3	4.4	100.0	3	4.4		50.0		
MN: MNT1/I	23	28.8	31.9	0	0.0	41.8	0	0.0	0.0	0.0		0	0.0	0.0	2	2.5	28.6	33.3		
MN: MNT1/II	28	31.8	38.9	1	1.1	50.9	1	1.1	9.1	14.3		0	0.0	0.0	2	2.3	28.6	33.3		
MN: MNT1/III	27	31.4	37.5	1	1.2	49.1	1	1.2	9.1	14.3		0	0.0	0.0	3	3.5	42.9	50.0		
MN: MNT1/I+II	36	30.8	50.0	2	1.7	65.5	2	1.7	18.2	28.6		0	0.0	0.0	3	2.6	42.9	50.0		
Mean MN study	26	30.7	36.1	1	0.8	47.3	1	0.8	6.1	9.5		0	0.0	0.0	2	2.8	33.3	38.9		
MTW: MNT1/I	33	31.4	45.8	3	2.9	60.0	3	2.9	27.3	42.9		1	1.0	10.0	33.3	5	4.8	71.4	83.3	
MTW: MNT1/2	34	30.6	47.2	3	2.7	61.8	3	2.7	27.3	42.9		2	1.8	20.0	66.7	5	4.5	71.4	83.3	
MTW: MNT1/3	35	29.2	48.6	5	4.2	63.6	5	4.2	45.5	71.4		2	1.7	20.0	66.7	4	3.3	57.1	66.7	
MTW: MNT1/4	35	27.8	48.6	5	4.0	63.6	5	4.0	45.5	71.4		3	2.4	30.0	100.0	4	3.2	57.1	66.7	
MTW: MNT1/I+2	39	30.0	54.2	3	2.3	70.9	3	2.3	27.3	42.9		2	1.5	20.0	66.7	5	3.8	71.4	83.3	
MTW: MNT1/3+4	44	29.1	61.1	6	4.0	80.0	6	4.0	54.5	85.7		3	2.0	30.0	100.0	4	2.6	57.1	66.7	
MTW: MNT1/I-4	48	29.6	66.7	6	3.7	87.3	6	3.7	54.5	85.7		3	1.9	30.0	100.0	5	3.1	71.4	83.3	
Mean MTW study	34	29.7	47.6	4	3.5	62.3	4	3.5	36.4	57.1		2	1.7	20.0	66.7	5	3.9	64.3	75.0	

## APPENDIX 13A. Continued.

Data set <sup>a</sup>	Psittacidae			Cuculidae			Strigidae, Nyctibiidae, Caprimulgidae			Apodidae		
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	6	2.6	100.0	150.0	4	1.7	100.0	200.0	4	1.7	100.0	100.0
MN+MTW studies	4	2.2	66.7	100.0	2	1.1	50.0	100.0	4	2.2	100.0	100.0
Additional records	2	4.3	33.3	50.0	2	4.3	50.0	100.0	0	0.0	0.0	0.0
Exclusively MN	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN=MTW	0	0.0		0.0	1	3.3		50.0	0	0.0		0.0
MTW>2xMN	0	0.0		0.0	0	0.0		0.0	1	2.2		25.0
Exclusively MTW	4	5.9		100.0	1	1.5		50.0	3	4.4		75.0
MN: MNT1/I	0	0.0	0.0	0.0	0	0.0	0.0	0.0	1	1.3	25.0	25.0
MN: MNT1/II	0	0.0	0.0	0.0	1	1.1	25.0	50.0	0	0.0	0.0	0.0
MN: MNT1/III	0	0.0	0.0	0.0	1	1.2	25.0	50.0	0	0.0	0.0	0.0
MN: MNT1/I+II	0	0.0	0.0	0.0	1	0.9	25.0	50.0	1	0.9	25.0	25.0
Mean MN study	0	0.0	0.0	0.0	1	0.8	16.7	33.3	0	0.4	8.3	8.3
MTW: MNT1/I	1	1.0	16.7	25.0	0	0.0	0.0	0.0	2	1.9	50.0	50.0
MTW: MNT1/2	2	1.8	33.3	50.0	1	0.9	25.0	50.0	2	1.8	50.0	50.0
MTW: MNT1/3	4	3.3	66.7	100.0	1	0.8	25.0	50.0	4	3.3	100.0	100.0
MTW: MNT1/4	3	2.4	50.0	75.0	1	0.8	25.0	50.0	1	0.8	25.0	25.0
MTW: MNT1/I+2	2	1.5	33.3	50.0	1	0.8	25.0	50.0	3	2.3	75.0	75.0
MTW: MNT1/3+4	4	2.6	66.7	100.0	2	1.3	50.0	100.0	4	2.6	100.0	100.0
MTW: MNT1/I+4	4	2.5	66.7	100.0	2	1.2	50.0	100.0	4	2.5	100.0	100.0
Mean MTW study	3	2.2	41.7	62.5	1	0.6	18.8	37.5	2	1.9	56.3	56.3

## APPENDIX 13A. Continued.

Data set <sup>a</sup>	Trochilidae				Trogonidae, Alcedinidae, Momotidae, Columbidae, Bucconidae				Caprimulgidae, Ramphastidae, Picidae				Furnariidae, Dendrocolaptidae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	15	6.5	100.0	100.0	11	4.8	100.0	122.2	12	5.2	100.0	120.0	11	4.8	100.0	100.0
MN+MTW studies	15	8.1	100.0	100.0	9	4.9	81.8	100.0	10	5.4	83.3	100.0	11	5.9	100.0	100.0
Additional records	0	0.0	0.0	0.0	2	4.3	18.2	22.2	2	4.3	16.7	20.0	0	0.0	0.0	0.0
Exclusively MN	4	17.4	26.7	26.7	2	8.7		22.2	0	0.0		0.0	0	0.0		0.0
MN>2xMTW	3	15.8	20.0	20.0	1	5.3		11.1	1	5.3		10.0	2	10.5		18.2
MN=MTW	6	20.0	40.0	40.0	1	3.3		11.1	1	3.3		10.0	5	16.7		45.5
MTW>2xMN	2	4.4	13.3	13.3	0	0.0		0.0	3	6.7		30.0	3	6.7		27.3
Exclusively MTW	0	0.0	0.0	0.0	5	7.4		55.6	5	7.4		50.0	1	1.5		9.1
MN: MNT1/I	13	16.3	86.7	86.7	4	5.0	36.4	44.4	2	2.5	16.7	20.0	8	10.0	72.7	72.7
MN: MNT1/II	12	13.6	80.0	80.0	2	2.3	18.2	22.2	3	3.4	25.0	30.0	8	9.1	72.7	72.7
MN: MNT1/III	11	12.8	73.3	73.3	1	1.2	9.1	11.1	3	3.5	25.0	30.0	8	9.3	72.7	72.7
MN: MNT1/I-III	15	12.8	100.0	100.0	4	3.4	36.4	44.4	5	4.3	41.7	50.0	10	8.5	90.9	90.9
Mean MN study	12	14.2	80.0	80.0	2	2.8	21.2	25.9	3	3.1	22.2	26.7	8	9.4	72.7	72.7
MTW: MNT1/I	5	4.8	33.3	33.3	6	5.7	54.5	66.7	5	4.8	41.7	50.0	9	8.6	81.8	81.8
MTW: MNT1/2	7	6.3	46.7	46.7	4	3.6	36.4	44.4	6	5.4	50.0	60.0	10	9.0	90.9	90.9
MTW: MNT1/3	7	5.8	46.7	46.7	4	3.3	36.4	44.4	5	4.2	41.7	50.0	9	7.5	81.8	81.8
MTW: MNT1/4	8	6.3	53.3	53.3	5	4.0	45.5	55.6	10	7.9	83.3	100.0	8	6.3	72.7	72.7
MTW: MNT1/I+2	7	5.4	46.7	46.7	6	4.6	54.5	66.7	8	6.2	66.7	80.0	11	8.5	100.0	100.0
MTW: MNT1/3+4	10	6.6	66.7	66.7	6	4.0	54.5	66.7	10	6.6	83.3	100.0	10	6.6	90.9	90.9
MTW: MNT1/I-4	11	6.8	73.3	73.3	7	4.3	63.6	77.8	10	6.2	83.3	100.0	11	6.8	100.0	100.0
Mean MTW study	7	5.8	45.0	45.0	5	4.1	43.2	52.8	7	5.6	54.2	65.0	9	7.8	81.8	81.8

## APPENDIX 13A. Continued.

Data set <sup>a</sup>	Thamnophilidae, Formicariidae					Tyrannidae, Cotingidae, Pipridae					Vireonidae, Turdidae					Hirundinidae				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>		N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>		N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>		N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	
Total records	19	8.2	100.0	105.6		45	19.5	100.0	121.6		5	2.2	100.0	100.0		6	2.6	100.0	300.0	
MN+MTW studies	18	9.7	94.7	100.0		37	20.0	82.2	100.0		5	2.7	100.0	100.0		2	1.1	33.3	100.0	
Additional records	1	2.2	5.3	5.6		8	17.4	17.8	21.6		0	0.0	0.0	0.0		4	8.7	66.7	200.0	
Exclusively MN	1	4.3		5.6		7	30.4		18.9		2	8.7		40.0		0	0.0		0.0	
MN>2xMTW	2	10.5		11.1		5	26.3		13.5		1	5.3		20.0		0	0.0		0.0	
MN=MTW	2	6.7		11.1		4	13.3		10.8		1	3.3		20.0		1	3.3		50.0	
MTW>2xMN	10	22.2		55.6		9	20.0		24.3		0	0.0		0.0		1	2.2		50.0	
Exclusively MTW	3	4.4		16.7		12	17.6		32.4		1	1.5		20.0		0	0.0		0.0	
MN: MNT1/I	10	12.5	52.6	55.6		17	21.3	37.8	45.9		3	3.8	60.0	60.0		0	0.0	0.0	0.0	
MN: MNT1/II	13	14.8	68.4	72.2		18	20.5	40.0	48.6		3	3.4	60.0	60.0		2	2.3	33.3	100.0	
MN: MNT1/III	12	14.0	63.2	66.7		19	22.1	42.2	51.4		3	3.5	60.0	60.0		1	1.2	16.7	50.0	
MN: MNT1/I+III	15	12.8	78.9	83.3		25	21.4	55.6	67.6		4	3.4	80.0	80.0		2	1.7	33.3	100.0	
Mean MN study	12	13.8	61.4	64.8		18	21.3	40.0	48.6		3	3.5	60.0	60.0		1	1.2	16.7	50.0	
MTW: MNT1/I	13	12.4	68.4	72.2		20	19.0	44.4	54.1		3	2.9	60.0	60.0		2	1.9	33.3	100.0	
MTW: MNT1/2	15	13.5	78.9	83.3		19	17.1	42.2	51.4		3	2.7	60.0	60.0		1	0.9	16.7	50.0	
MTW: MNT1/3	16	13.3	84.2	88.9		22	18.3	48.9	59.5		3	2.5	60.0	60.0		2	1.7	33.3	100.0	
MTW: MNT1/4	16	12.7	84.2	88.9		24	19.0	53.3	64.9		3	2.4	60.0	60.0		1	0.8	16.7	50.0	
MTW: MNT1/I+2	16	12.3	84.2	88.9		24	18.5	53.3	64.9		3	2.3	60.0	60.0		2	1.5	33.3	100.0	
MTW: MNT1/3+4	17	11.3	89.5	94.4		27	17.9	60.0	73.0		3	2.0	60.0	60.0		2	1.3	33.3	100.0	
MTW: MNT1/I+4	17	10.5	89.5	94.4		30	18.5	66.7	81.1		3	1.9	60.0	60.0		2	1.2	33.3	100.0	
Mean MTW study	15	13.0	78.9	83.3		21	18.4	47.2	57.4		3	2.6	60.0	60.0		2	1.3	25.0	75.0	

## APPENDIX 13A. Continued.

Data set <sup>a</sup>	Troglodytidae, Polioptilidae				Parulidae, Thrupidae, Cardinalidae, Emberrizidae, Icteridae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	10	4.3	100.0	111.1	51	22.1	100.0	130.8
MN+MTW studies	9	4.9	90.0	100.0	39	21.1	76.5	100.0
Additional records	1	2.2	10.0	11.1	12	26.1	23.5	30.8
Exclusively MN	1	4.3		11.1	4	17.4		10.3
MN>2xMTW	0	0.0		0.0	4	21.1		10.3
MN=MTW	3	10.0		33.3	4	13.3		10.3
MTW>2xMN	2	4.4		22.2	12	26.7		30.8
Exclusively MTW	3	4.4		33.3	15	22.1		38.5
MN: MNT1/I	5	6.3	50.0	55.6	15	18.8	29.4	38.5
MN: MNT1/II	5	5.7	50.0	55.6	18	20.5	35.3	46.2
MN: MNT1/III	3	3.5	30.0	33.3	20	23.3	39.2	51.3
MN: MNT1/I-III	6	5.1	60.0	66.7	24	20.5	47.1	61.5
Mean MN study	4	5.1	43.3	48.1	18	20.9	34.6	45.3
MTW: MNT1/I	6	5.7	60.0	66.7	22	21.0	43.1	56.4
MTW: MNT1/2	8	7.2	80.0	88.9	22	19.8	43.1	56.4
MTW: MNT1/3	8	6.7	80.0	88.9	22	18.3	43.1	56.4
MTW: MNT1/4	6	4.8	60.0	66.7	25	19.8	49.0	64.1
MTW: MNT1/I+2	8	6.2	80.0	88.9	26	20.0	51.0	66.7
MTW: MNT1/3+4	8	5.3	80.0	88.9	31	20.5	60.8	79.5
MTW: MNT1/I-4	8	4.9	80.0	88.9	35	21.6	68.6	89.7
Mean MTW study	7	6.1	70.0	77.8	23	19.7	44.6	58.3

## APPENDIX 13B

Standardized and non-standardized surveys of transect MNT2: influence of taxonomic affinities on bird species detectability. Comparative effectiveness of the number of bird species detected per taxonomic group during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 80-82, Influence of taxonomic affinities). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT2 (transect area c. 14.1 ha), were included (cf. Appendix 12b). Bird families represented by only a small number of species were grouped when they shared similarities in their behavioral characteristics or in their general detectability. See Appendix 13a for details on the data sets and abbreviations used.

Data set <sup>a</sup>	All species				Non-Passerines				Passerines				Suboscine Passerines			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	138.3	92	39.8	100.0	153.3	139	60.2	100.0	129.9	75	32.5	100.0	119.0
MN+MTW studies	167	100.0	72.3	100.0	60	35.9	65.2	100.0	107	64.1	77.0	100.0	63	37.7	84.0	100.0
Additional records	64	100.0	27.7	38.3	32	50.0	34.8	53.3	32	50.0	23.0	29.9	12	18.8	16.0	19.0
Exclusively MN	23	100.0		13.8	5	21.7		8.3	18	78.3		16.8	10	43.5		15.9
MN>2xMTW	15	100.0		9.0	4	26.7		6.7	11	73.3		10.3	9	60.0		14.3
MN=MTW	31	100.0		18.6	7	22.6		11.7	24	77.4		22.4	13	41.9		20.6
MTW>2xMN	27	100.0		16.2	6	22.2		10.0	21	77.8		19.6	13	48.1		20.6
Exclusively MTW	71	100.0		42.5	38	53.5		63.3	33	46.5		30.8	18	25.4		28.6
MN: MNT2/I	69	100.0	29.9	41.3	16	23.2	17.4	26.7	53	76.8	38.1	49.5	32	46.4	42.7	50.8
MN: MNT2/II	65	100.0	28.1	38.9	12	18.5	13.0	20.0	53	81.5	38.1	49.5	36	55.4	48.0	57.1
MN: MNT2/III	73	100.0	31.6	43.7	13	17.8	14.1	21.7	60	82.2	43.2	56.1	36	49.3	48.0	57.1
MN: MNT2/I-III	96	100.0	41.6	57.5	22	22.9	23.9	36.7	74	77.1	53.2	69.2	45	46.9	60.0	71.4
Mean MN study	69	100.0	29.9	41.3	14	19.8	14.9	22.8	55	80.2	39.8	51.7	35	50.2	46.2	55.0
MTW: MNT2/I	86	100.0	37.2	51.5	26	30.2	28.3	43.3	60	69.8	43.2	56.1	36	41.9	48.0	57.1
MTW: MNT2/2	93	100.0	40.3	55.7	30	32.3	32.6	50.0	63	67.7	45.3	58.9	39	41.9	52.0	61.9
MTW: MNT2/3	112	100.0	48.5	67.1	41	36.6	44.6	68.3	71	63.4	51.1	66.4	45	40.2	60.0	71.4
MTW: MNT2/4	104	100.0	45.0	62.3	42	40.4	45.7	70.0	62	59.6	44.6	57.9	39	37.5	52.0	61.9
MTW: MNT2/1+2	112	100.0	48.5	67.1	36	32.1	39.1	60.0	76	67.9	54.7	71.0	46	41.1	61.3	73.0
MTW: MNT2/3+4	132	100.0	57.1	79.0	52	39.4	56.5	86.7	80	60.6	57.6	74.8	50	37.9	66.7	79.4
MTW: MNT2/1-4	144	100.0	62.3	86.2	55	38.2	59.8	91.7	89	61.8	64.0	83.2	53	36.8	70.7	84.1
Mean MTW study	99	100.0	42.7	59.1	35	35.2	37.8	57.9	64	64.8	46.0	59.8	40	40.3	53.0	63.1

## APPENDIX 13B. Continued.

Data set <sup>a</sup>	Oscine Passerines					Tinnamidae, Ardeidae, Gracidae, Odontophoridae, Rallidae, Scolopacidae					Cathartidae, Accipitridae, Falconidae					Columbidae				
	N	% N	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>				
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>																
Total records	64	27.7	100.0	145.5	9	3.9	100.0	112.5	19	8.2	100.0	380.0	6	2.6	100.0	100.0				
MN+MTW studies	44	26.3	68.8	100.0	8	4.8	88.9	100.0	5	3.0	26.3	100.0	6	3.6	100.0	100.0				
Additional records	20	31.3	31.3	45.5	1	1.6	11.1	12.5	14	21.9	73.7	280.0	0	0.0	0.0	0.0				
Exclusively MN	8	34.8		18.2	0	0.0		0.0	0	0.0		0.0	1	4.3		16.7				
MN>2xMTW	2	13.3		4.5	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0				
MN=MTW	11	35.5		25.0	0	0.0		0.0	0	0.0		0.0	1	3.2		16.7				
MTW>2xMN	8	29.6		18.2	1	3.7		12.5	0	0.0		0.0	1	3.7		16.7				
Exclusively MTW	15	21.1		34.1	7	9.9		87.5	5	7.0		100.0	3	4.2		50.0				
MN: MNT2/I	21	30.4	32.8	47.7	1	1.4	11.1	12.5	0	0.0	0.0	0.0	3	4.3	50.0	50.0				
MN: MNT2/II	17	26.2	26.6	38.6	0	0.0	0.0	0.0	0	0.0	0.0	0.0	2	3.1	33.3	33.3				
MN: MNT2/III	24	32.9	37.5	54.5	0	0.0	0.0	0.0	0	0.0	0.0	0.0	1	1.4	16.7	16.7				
MN: MNT2/IIII	29	30.2	45.3	65.9	1	1.0	11.1	12.5	0	0.0	0.0	0.0	3	3.1	50.0	50.0				
Mean MN study	21	30.0	32.3	47.0	0	0.5	3.7	4.2	0	0.0	0.0	0.0	2	2.9	33.3	33.3				
MTW: MNT2/I	24	27.9	37.5	54.5	4	4.7	44.4	50.0	1	1.2	5.3	20.0	2	2.3	33.3	33.3				
MTW: MNT2/2	24	25.8	37.5	54.5	4	4.3	44.4	50.0	2	2.2	10.5	40.0	4	4.3	66.7	66.7				
MTW: MNT2/3	26	23.2	40.6	59.1	6	5.4	66.7	75.0	4	3.6	21.1	80.0	3	2.7	50.0	50.0				
MTW: MNT2/4	23	22.1	35.9	52.3	8	7.7	88.9	100.0	0	0.0	0.0	0.0	4	3.8	66.7	66.7				
MTW: MNT2/1+2	30	26.8	46.9	68.2	4	3.6	44.4	50.0	2	1.8	10.5	40.0	4	3.6	66.7	66.7				
MTW: MNT2/3+4	30	22.7	46.9	68.2	8	6.1	88.9	100.0	4	3.0	21.1	80.0	5	3.8	83.3	83.3				
MTW: MNT2/1-4	36	25.0	56.3	81.8	8	5.6	88.9	100.0	5	3.5	26.3	100.0	5	3.5	83.3	83.3				
Mean MTW study	24	24.6	37.9	55.1	6	5.6	61.1	68.8	2	1.8	9.2	35.0	3	3.3	54.2	54.2				



## APPENDIX 13B. Continued.

Data set <sup>a</sup>	Psittacidae				Cuculidae				Strigidae, Nyctibiidae, Caprimulgidae				Apodidae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	5	2.2	100.0	100.0	5	2.2	100.0	500.0	5	2.2	100.0	125.0	6	2.6	100.0	300.0
MN+MTW studies	5	3.0	100.0	100.0	1	0.6	20.0	100.0	4	2.4	80.0	100.0	2	1.2	33.3	100.0
Additional records	0	0.0	0.0	0.0	4	6.3	80.0	400.0	1	1.6	20.0	25.0	4	6.3	66.7	200.0
Exclusively MN	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN>2xMTW	0	0.0	0.0	0.0	1	6.7	0.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN=MTW	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MTW>2xMN	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Exclusively MTW	5	7.0	0.0	100.0	0	0.0	0.0	0.0	4	5.6	0.0	100.0	2	2.8	0.0	100.0
MN: MNT2/I	0	0.0	0.0	0.0	1	1.4	20.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT2/II	0	0.0	0.0	0.0	1	1.5	20.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT2/III	0	0.0	0.0	0.0	1	1.4	20.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT2/I-III	0	0.0	0.0	0.0	1	1.0	20.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Mean MN study	0	0.0	0.0	0.0	1	1.4	20.0	100.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MTW: MNT2/I	3	3.5	60.0	60.0	0	0.0	0.0	0.0	2	2.3	40.0	50.0	1	1.2	16.7	50.0
MTW: MNT2/2	2	2.2	40.0	40.0	0	0.0	0.0	0.0	3	3.2	60.0	75.0	0	0.0	0.0	0.0
MTW: MNT2/3	4	3.6	80.0	80.0	1	0.9	20.0	100.0	4	3.6	80.0	100.0	1	0.9	16.7	50.0
MTW: MNT2/4	4	3.8	80.0	80.0	1	1.0	20.0	100.0	3	2.9	60.0	75.0	2	1.9	33.3	100.0
MTW: MNT2/I+2	3	2.7	60.0	60.0	0	0.0	0.0	0.0	3	2.7	60.0	75.0	1	0.9	16.7	50.0
MTW: MNT2/3+4	5	3.8	100.0	100.0	1	0.8	20.0	100.0	4	3.0	80.0	100.0	2	1.5	33.3	100.0
MTW: MNT2/I-4	5	3.5	100.0	100.0	1	0.7	20.0	100.0	4	2.8	80.0	100.0	2	1.4	33.3	100.0
Mean MTW study	3	3.3	65.0	65.0	1	0.5	10.0	50.0	3	3.0	60.0	75.0	1	1.0	16.7	50.0

## APPENDIX 13B. Continued.

Data set <sup>a</sup>	Trochilidae				Trogonidae, Alcedinidae, Momotidae, Galbulidae, Bucconidae				Capitonidae, Ramphastidae, Picidae				Fumariidae, Dendrocolaptidae			
	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	14	6.1	100.0	155.6	13	5.6	100.0	130.0	10	4.3	100.0	100.0	12	5.2	100.0	100.0
MN+MTW studies	9	5.4	64.3	100.0	10	6.0	76.9	100.0	10	6.0	100.0	100.0	12	7.2	100.0	100.0
Additional records	5	7.8	35.7	55.6	3	4.7	23.1	30.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Exclusively MN	0	0.0		0.0	4	17.4		40.0	0	0.0		0.0	1	4.3		8.3
MN>2xMTW	2	13.3		22.2	1	6.7		10.0	0	0.0		0.0	3	20.0		25.0
MN=MTW	5	16.1		55.6	0	0.0		0.0	1	3.2		10.0	2	6.5		16.7
MTW>2xMN	0	0.0		0.0	3	11.1		30.0	1	3.7		10.0	3	11.1		25.0
Exclusively MTW	2	2.8		22.2	2	2.8		20.0	8	11.3		80.0	3	4.2		25.0
MN: MNT2/I	6	8.7	42.9	66.7	4	5.8	30.8	40.0	1	1.4	10.0	10.0	6	8.7	50.0	50.0
MN: MNT2/II	6	9.2	42.9	66.7	3	4.6	23.1	30.0	0	0.0	0.0	0.0	6	9.2	50.0	50.0
MN: MNT2/III	7	9.6	50.0	77.8	3	4.1	23.1	30.0	1	1.4	10.0	10.0	7	9.6	58.3	58.3
MN: MNT2/IIII	7	7.3	50.0	77.8	8	8.3	61.5	80.0	2	2.1	20.0	20.0	9	9.4	75.0	75.0
Mean MN study	6	9.2	45.2	70.4	3	4.8	25.6	33.3	1	1.0	6.7	6.7	6	9.2	52.8	52.8
MTW: MNT2/I	5	5.8	35.7	55.6	4	4.7	30.8	40.0	4	4.7	40.0	40.0	9	10.5	75.0	75.0
MTW: MNT2/2	6	6.5	42.9	66.7	5	5.4	38.5	50.0	4	4.3	40.0	40.0	8	8.6	66.7	66.7
MTW: MNT2/3	7	6.3	50.0	77.8	5	4.5	38.5	50.0	6	5.4	60.0	60.0	10	8.9	83.3	83.3
MTW: MNT2/4	8	7.7	57.1	88.9	5	4.8	38.5	50.0	7	6.7	70.0	70.0	7	6.7	58.3	58.3
MTW: MNT2/1+2	6	5.4	42.9	66.7	6	5.4	46.2	60.0	7	6.3	70.0	70.0	10	8.9	83.3	83.3
MTW: MNT2/3+4	8	6.1	57.1	88.9	6	4.5	46.2	60.0	9	6.8	90.0	90.0	11	8.3	91.7	91.7
MTW: MNT2/1-4	9	6.3	64.3	100.0	6	4.2	46.2	60.0	10	6.9	100.0	100.0	11	7.6	91.7	91.7
Mean MTW study	7	6.6	46.4	72.2	5	4.8	36.5	47.5	5	5.3	52.5	52.5	9	8.6	70.8	70.8

## APPENDIX 13B. Continued.

Data set <sup>a</sup>	Thamnophilidae, Formicariidae				Tyrannidae, Cotingidae, Pipridae				Vireonidae, Turdidae				Hirundinidae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	19	8.2	100.0	105.6	44	19.0	100.0	133.3	5	2.2	100.0	125.0	8	3.5	100.0	400.0
MN+MTW studies	18	10.8	94.7	100.0	33	19.8	75.0	100.0	4	2.4	80.0	100.0	2	1.2	25.0	100.0
Additional records	1	1.6	5.3	5.6	11	17.2	25.0	33.3	1	1.6	20.0	25.0	6	9.4	75.0	300.0
Exclusively MN	1	4.3		5.6	8	34.8		24.2	1	4.3		25.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	6	40.0		18.2	0	0.0		0.0	0	0.0		0.0
MN=MTW	7	22.6		38.9	4	12.9		12.1	2	6.5		50.0	0	0.0		0.0
MTW>2xMN	6	22.2		33.3	4	14.8		12.1	0	0.0		0.0	0	0.0		0.0
Exclusively MTW	4	5.6		22.2	11	15.5		33.3	1	1.4		25.0	2	2.8		100.0
MN: MNT2/I	12	17.4	63.2	66.7	14	20.3	31.8	42.4	3	4.3	60.0	75.0	0	0.0	0.0	0.0
MN: MNT2/II	13	20.0	68.4	72.2	17	26.2	38.6	51.5	2	3.1	40.0	50.0	0	0.0	0.0	0.0
MN: MNT2/III	11	15.1	57.9	61.1	18	24.7	40.9	54.5	3	4.1	60.0	75.0	0	0.0	0.0	0.0
MN: MNT2/I-III	14	14.6	73.7	77.8	22	22.9	50.0	66.7	3	3.1	60.0	75.0	0	0.0	0.0	0.0
Mean MN study	12	17.4	63.2	66.7	16	23.7	37.1	49.5	3	3.9	53.3	66.7	0	0.0	0.0	0.0
MTW: MNT2/I	14	16.3	73.7	77.8	13	15.1	29.5	39.4	2	2.3	40.0	50.0	1	1.2	12.5	50.0
MTW: MNT2/2	16	17.2	84.2	88.9	15	16.1	34.1	45.5	3	3.2	60.0	75.0	1	1.1	12.5	50.0
MTW: MNT2/3	16	14.3	84.2	88.9	19	17.0	43.2	57.6	3	2.7	60.0	75.0	2	1.8	25.0	100.0
MTW: MNT2/4	15	14.4	78.9	83.3	17	16.3	38.6	51.5	3	2.9	60.0	75.0	1	1.0	12.5	50.0
MTW: MNT2/1+2	17	15.2	89.5	94.4	19	17.0	43.2	57.6	3	2.7	60.0	75.0	2	1.8	25.0	100.0
MTW: MNT2/3+4	16	12.1	84.2	88.9	23	17.4	52.3	69.7	3	2.3	60.0	75.0	2	1.5	25.0	100.0
MTW: MNT2/1-4	17	11.8	89.5	94.4	25	17.4	56.8	75.8	3	2.1	60.0	75.0	2	1.4	25.0	100.0
Mean MTW study	15	15.4	80.3	84.7	16	16.2	36.4	48.5	3	2.8	55.0	68.8	1	1.3	15.6	62.5

## APPENDIX 13B. Continued.

Data set <sup>a</sup>	Troglodytidae, Polioptilidae				Parulidae, Thraupidae, Cardinalidae, Embertiidae, Icteridae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	8	3.5	100.0	133.3	43	18.6	100.0	134.4
MN+MTW studies	6	3.6	75.0	100.0	32	19.2	74.4	100.0
Additional records	2	3.1	25.0	33.3	11	17.2	25.6	34.4
Exclusively MN	0	0.0		0.0	7	30.4		21.9
MN>2xMTW	0	0.0		0.0	2	13.3		6.3
MN=MTW	4	12.9		66.7	5	16.1		15.6
MTW>2xMN	1	3.7		16.7	7	25.9		21.9
Exclusively MTW	1	1.4		16.7	11	15.5		34.4
MN: MNT2/I	5	7.2	62.5	83.3	13	18.8	30.2	40.6
MN: MNT2/II	5	7.7	62.5	83.3	10	15.4	23.3	31.3
MN: MNT2/III	5	6.8	62.5	83.3	16	21.9	37.2	50.0
MN: MNT2/I-III	5	5.2	62.5	83.3	21	21.9	48.8	65.6
Mean MN study	5	7.2	62.5	83.3	13	18.8	30.2	40.6
MTW: MNT2/1	6	7.0	75.0	100.0	15	17.4	34.9	46.9
MTW: MNT2/2	5	5.4	62.5	83.3	15	16.1	34.9	46.9
MTW: MNT2/3	5	4.5	62.5	83.3	16	14.3	37.2	50.0
MTW: MNT2/4	4	3.8	50.0	66.7	15	14.4	34.9	46.9
MTW: MNT2/1+2	6	5.4	75.0	100.0	19	17.0	44.2	59.4
MTW: MNT2/3+4	5	3.8	62.5	83.3	20	15.2	46.5	62.5
MTW: MNT2/1-4	6	4.2	75.0	100.0	25	17.4	58.1	78.1
Mean MTW study	5	5.1	62.5	83.3	15	15.4	35.5	47.7

## APPENDIX 13C

Standardized and non-standardized surveys of the transects MNT1 and MNT2: influence of taxonomic affinities on bird species detectability. Comparative effectiveness of the number of bird species detected per taxonomic group during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete studies of both transects (cf. p. 80-82, Influence of taxonomic affinities). A total of 268 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha) and MNT2 (c. 14.1 ha), were included (cf. Appendices 12a and 12b). Bird families represented by only a small number of species were grouped when they shared similarities in their behavioral characteristics or in their general detectability. See Appendix 13a for details on the data sets and abbreviations used. The following additional abbreviations were used here: (a) data sets: MN: MNT1+MNT2 = all species captured during the standardized mist-netting studies of MNT1 (surveys MNT1/1 through MNT1/III) and MNT2 (MNT2/1 through MNT2/III); mean MN studies = mean of species captured in the six standardized mist-netting studies of MNT1 (MNT1/1 through MNT1/4) and MNT2 (MNT2/1 through MNT2/4); mean MTW studies = mean of species recorded during the MTW studies of MNT1 (MNT1/1 through MNT1/4) and MNT2 (MNT2/1 through MNT2/4); mean MTW studies = mean of species recorded during the eight MTW surveys of MNT1 and MNT2.

Data set <sup>a</sup>	All species						Non-Passerines						Passerines						Suboscine Passerines					
	% N		% N tot.		% N		% N		% N tot.		% N		% N		% N tot.		% N		% N		% N tot.		% N	
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	268	100.0	100.0	126.4	104	38.8	100.0	135.1	164	61.2	100.0	121.5	85	31.7	100.0	114.9								
MN+MTW studies	212	100.0	79.1	100.0	77	36.3	74.0	100.0	135	63.7	82.3	100.0	74	34.9	87.1	100.0								
Additional records	56	100.0	20.9	26.4	27	48.2	26.0	35.1	29	51.8	17.7	21.5	11	19.6	12.9	14.9								
Exclusively MN	25	100.0		11.8	8	32.0		10.4	17	68.0		12.6	8	32.0		10.8								
MN>2xMTW	22	100.0		10.4	8	36.4		10.4	14	63.6		10.4	10	45.5		13.5								
MN=MTW	36	100.0		17.0	10	27.8		13.0	26	72.2		19.3	13	36.1		17.6								
MTW>2xMN	52	100.0		24.5	11	21.2		14.3	41	78.8		30.4	26	50.0		35.1								
Exclusively MTW	77	100.0		36.3	40	51.9		51.9	37	48.1		27.4	17	22.1		23.0								
MN: MNT1+MNT2	135	100.0	50.4	63.7	37	27.4	35.6	48.1	98	72.6	59.8	72.6	57	42.2	67.1	77.0								
Mean MN studies	77	100.0	28.7	36.2	17	22.6	16.7	22.5	60	77.4	36.3	44.1	36	47.1	42.5	48.9								
MTW: MNT1+MNT2	187	100.0	69.8	88.2	69	36.9	66.3	89.6	118	63.1	72.0	87.4	66	35.3	77.6	89.2								
Mean MTW studies	107	100.0	40.0	50.5	35	33.0	34.0	45.9	72	67.0	43.8	53.1	43	39.7	50.0	57.4								

## APPENDIX 13C. Continued.

Data set <sup>a</sup>	Oscine Passerines						Tinamidae, Ardeidae, Gracidae, Odontophoridae, Rallidae, Scolopacidae						Cathartidae, Accipitridae, Falconidae						Columbidae					
	N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.	
	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	79	29.5	100.0	129.5	12	4.5	100.0	133.3	20	7.5	100.0	333.3	7	2.6	100.0	116.7								
MN+MTW studies	61	28.8	77.2	100.0	9	4.2	75.0	100.0	6	2.8	30.0	100.0	6	2.8	85.7	100.0								
Additional records	18	32.1	22.8	29.5	3	5.4	25.0	33.3	14	25.0	70.0	233.3	1	1.8	14.3	16.7								
Exclusively MN	9	36.0		14.8	1	4.0		11.1	0	0.0		0.0	1	4.0		16.7								
MN>2xMTW	4	18.2		6.6	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0								
MN=MTW	13	36.1		21.3	0	0.0		0.0	0	0.0		0.0	1	2.8		16.7								
MTW>2xMN	15	28.8		24.6	2	3.8		22.2	0	0.0		0.0	1	1.9		16.7								
Exclusively MTW	20	26.0		32.8	6	7.8		66.7	6	7.8		100.0	3	3.9		50.0								
MN: MNT1+MNT2	41	30.4	51.9	67.2	3	2.2	25.0	33.3	0	0.0	0.0	0.0	3	2.2	42.9	50.0								
Mean MN studies	23	30.4	29.5	38.3	1	0.7	4.2	5.6	0	0.0	0.0	0.0	2	2.8	31.0	36.1								
MTW: MNT1+MNT2	52	27.8	65.8	85.2	8	4.3	66.7	88.9	6	3.2	30.0	100.0	5	2.7	71.4	83.3								
Mean MTW studies	29	27.3	37.0	48.0	5	4.4	39.6	52.8	2	1.8	9.4	31.3	4	3.6	55.4	64.6								

Data set <sup>a</sup>	Bittacidae						Cuculidae						Strigidae, Nyctibiidae, Caprimulgidae						Apodidae					
	N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.	
	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	6	2.2	100.0	120.0	6	2.2	100.0	300.0	7	2.6	100.0	116.7	6	2.2	100.0	150.0								
MN+MTW studies	5	2.4	83.3	100.0	2	0.9	33.3	100.0	6	2.8	85.7	100.0	4	1.9	66.7	100.0								
Additional records	1	1.8	16.7	20.0	4	7.1	66.7	200.0	1	1.8	14.3	16.7	2	3.6	33.3	50.0								
Exclusively MN	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0								
MN>2xMTW	0	0.0		0.0	1	4.5		50.0	0	0.0		0.0	0	0.0		0.0								
MN=MTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0								
MTW>2xMN	0	0.0		0.0	0	0.0		0.0	1	1.9		16.7	0	0.0		0.0								
Exclusively MTW	5	6.5		100.0	1	1.3		50.0	5	6.5		83.3	4	5.2		100.0								
MN: MNT1+MNT2	0	0.0	0.0	0.0	1	0.7	16.7	50.0	1	0.7	14.3	16.7	0	0.0	0.0	0.0								
Mean MN studies	0	0.0	0.0	0.0	1	1.1	13.9	41.7	0	0.2	2.4	2.8	0	0.0	0.0	0.0								
MTW: MNT1+MNT2	5	2.7	83.3	100.0	2	1.1	33.3	100.0	6	3.2	85.7	100.0	4	2.1	66.7	100.0								
Mean MTW studies	3	2.7	47.9	57.5	1	0.6	10.4	31.3	3	2.5	37.5	43.8	2	1.4	25.0	37.5								

## APPENDIX 13C. Continued.

Data set <sup>a</sup>	Trochilidae				Trogonidae, Alcedinidae, Momotidae, Galbulidae, Bucconidae				Capitonidae, Ramphastidae, Picidae				Furnariidae, Dendrocolapidae			
	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	15	5.6	100.0	100.0	13	4.9	100.0	108.3	12	4.5	100.0	100.0	13	4.9	100.0	100.0
MN+MTW studies	15	7.1	100.0	100.0	12	5.7	92.3	100.0	12	5.7	100.0	100.0	13	6.1	100.0	100.0
Additional records	0	0.0	0.0	0.0	1	1.8	7.7	8.3	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Exclusively MN	2	8.0	13.3	13.3	4	16.0		33.3	0	0.0		0.0	0	0.0		0.0
MN>2xMTW	5	22.7	33.3	33.3	1	4.5		8.3	1	4.5		8.3	3	13.6		23.1
MN=MTW	6	16.7	40.0	40.0	1	2.8		8.3	2	5.6		16.7	4	11.1		30.8
MTW>2xMN	2	3.8	13.3	13.3	3	5.8		25.0	2	3.8		16.7	4	7.7		30.8
Exclusively MTW	0	0.0	0.0	0.0	3	3.9		25.0	7	9.1		58.3	2	2.6		15.4
MN: MNT1+MNT2	15	11.1	100.0	100.0	9	6.7	69.2	75.0	5	3.7	41.7	41.7	11	8.1	84.6	84.6
Mean MN studies	9	11.9	61.1	61.1	3	3.7	21.8	23.6	2	2.2	13.9	13.9	7	9.3	55.1	55.1
MTW: MNT1+MNT2	13	7.0	86.7	86.7	8	4.3	61.5	66.7	12	6.4	100.0	100.0	13	7.0	100.0	100.0
Mean MTW studies	7	6.2	44.2	44.2	5	4.4	36.5	39.6	6	5.5	49.0	49.0	9	8.2	67.3	67.3

Data set <sup>a</sup>	Thamnophilidae, Formicariidae				Tyrannidae, Coringidae, Pipridae				Vireonidae, Turdidae				Hirundinidae			
	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N tot.	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	20	7.5	100.0	100.0	52	19.4	100.0	126.8	5	1.9	100.0	100.0	8	3.0	100.0	400.0
MN+MTW studies	20	9.4	100.0	100.0	41	19.3	78.8	100.0	5	2.4	100.0	100.0	2	0.9	25.0	100.0
Additional records	0	0.0	0.0	0.0	11	19.6	21.2	26.8	0	0.0	0.0	0.0	6	10.7	75.0	300.0
Exclusively MN	1	4.0	5.0	5.0	7	28.0		17.1	2	8.0		40.0	0	0.0		0.0
MN>2xMTW	0	0.0	0.0	0.0	7	31.8		17.1	0	0.0		0.0	0	0.0		0.0
MN=MTW	4	11.1	20.0	20.0	5	13.9		12.2	2	5.6		40.0	0	0.0		0.0
MTW>2xMN	11	21.2	55.0	55.0	11	21.2		26.8	0	0.0		0.0	2	3.8		100.0
Exclusively MTW	4	5.2	20.0	20.0	11	14.3		26.8	1	1.3		20.0	0	0.0		0.0
MN: MNT1+MNT2	16	11.9	80.0	80.0	30	22.2	57.7	73.2	4	3.0	80.0	80.0	2	1.5	25.0	100.0
Mean MN studies	12	15.4	59.2	59.2	17	22.3	33.0	41.9	3	3.7	56.7	56.7	1	0.7	6.3	25.0
MTW: MNT1+MNT2	19	10.2	95.0	95.0	34	18.2	65.4	82.9	3	1.6	60.0	60.0	2	1.1	25.0	100.0
Mean MTW studies	15	14.1	75.6	75.6	19	17.4	35.8	45.4	3	2.7	57.5	57.5	1	1.3	17.2	68.8



## APPENDIX 13C. Continued.

Data set <sup>a</sup>	Troglodytidae, Polioptilidae				Parulidae, Thraupidae, Cardinalidae, Emberizidae, Icteridae			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	11	4.1	100.0	110.0	55	20.5	100.0	125.0
MN+MTW studies	10	4.7	90.9	100.0	44	20.8	80.0	100.0
Additional records	1	1.8	9.1	10.0	11	19.6	20.0	25.0
Exclusively MN	1	4.0		10.0	6	24.0		13.6
MN>2xMTW	0	0.0		0.0	4	18.2		9.1
MN=MTW	3	8.3		30.0	8	22.2		18.2
MTW>2xMN	2	3.8		20.0	11	21.2		25.0
Exclusively MTW	4	5.2		40.0	15	19.5		34.1
MN: MNT1+MNT2	6	4.4	54.5	60.0	29	21.5	52.7	65.9
Mean MN studies	5	6.1	42.4	46.7	15	20.0	27.9	34.8
MTW: MNT1+MNT2	9	4.8	81.8	90.0	38	20.3	69.1	86.4
Mean MTW studies	6	5.6	54.5	60.0	19	17.7	34.5	43.2

# APPENDIX 14A

Standardized and non-standardized surveys of transect MNT1: influence of body size on bird species detectability. Comparative effectiveness of the number of bird species detected per body mass class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 82f; Influence of body size). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha), were included (cf. Appendix 12a). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 18a for the mean values of body masses of unsexed samples, which I used here for assignment to the corresponding body mass class (BMC). The logarithmic scale for the BMCs was selected in accordance with Terborgh *et al.* (1990: 225).

Data set <sup>a</sup>	All species					BMC1 (2-4g)					BMC2 (5-8g)					BMC3 (9-16g)				
	N	% N	% N tot.	% N	N	% N	% N tot.	% N	N	% N	% N	% N tot.	% N	N	% N	% N	% N tot.	% N	N	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	124.9	4	1.7	100.0	100.0	23	10.0	100.0	115.0	61	26.4	100.0	119.6				
MN+MTW studies	185	100.0	80.1	100.0	4	2.2	100.0	100.0	20	10.8	87.0	100.0	51	27.6	83.6	100.0				
Additional records	46	100.0	19.9	24.9	0	0.0	0.0	0.0	3	6.5	13.0	15.0	10	21.7	16.4	19.6				
Exclusively MN	23	100.0		12.4	0	0.0		0.0	3	13.0		15.0	12	52.2		23.5				
MN>2xMTW	19	100.0		10.3	1	5.3		25.0	3	15.8		15.0	10	52.6		19.6				
MN=MTW	30	100.0		16.2	3	10.0		75.0	4	13.3		20.0	8	26.7		15.7				
MTW>2xMN	45	100.0		24.3	0	0.0		0.0	5	11.1		25.0	11	24.4		21.6				
Exclusively MTW	68	100.0		36.8	0	0.0		0.0	5	7.4		25.0	10	14.7		19.6				
MN: MNT1/I	80	100.0	34.6	43.2	3	3.8	75.0	75.0	11	13.8	47.8	55.0	29	36.3	47.5	56.9				
MN: MNT1/II	88	100.0	38.1	47.6	3	3.4	75.0	75.0	11	12.5	47.8	55.0	32	36.4	52.5	62.7				
MN: MNT1/III	86	100.0	37.2	46.5	3	3.5	75.0	75.0	10	11.6	43.5	50.0	34	39.5	55.7	66.7				
MN: MNT1/I-III	117	100.0	50.6	63.2	4	3.4	100.0	100.0	15	12.8	65.2	75.0	41	35.0	67.2	80.4				
Mean MN study	85	100.0	36.7	45.8	3	3.5	75.0	75.0	11	12.6	46.4	53.3	32	37.4	51.9	62.1				
MTW: MNT1/I	105	100.0	45.5	56.8	1	1.0	25.0	25.0	13	12.4	56.5	65.0	25	23.8	41.0	49.0				
MTW: MNT1/2	111	100.0	48.1	60.0	2	1.8	50.0	50.0	14	12.6	60.9	70.0	24	21.6	39.3	47.1				
MTW: MNT1/3	120	100.0	51.9	64.9	2	1.7	50.0	50.0	14	11.7	60.9	70.0	27	22.5	44.3	52.9				
MTW: MNT1/4	126	100.0	54.5	68.1	3	2.4	75.0	75.0	11	8.7	47.8	55.0	33	26.2	54.1	64.7				
MTW: MNT1/1+2	130	100.0	56.3	70.3	2	1.5	50.0	50.0	15	11.5	65.2	75.0	31	23.8	50.8	60.8				
MTW: MNT1/3+4	151	100.0	65.4	81.6	4	2.6	100.0	100.0	16	10.6	69.6	80.0	37	24.5	60.7	72.5				
MTW: MNT1/1-4	162	100.0	70.1	87.6	4	2.5	100.0	100.0	17	10.5	73.9	85.0	39	24.1	63.9	76.5				
Mean MTW study	116	100.0	50.0	62.4	2	1.7	50.0	50.0	13	11.3	56.5	65.0	27	23.6	44.7	53.4				

## APPENDIX 14A. Continued.

Data set <sup>a</sup>	BMC4 (17-32g)					BMC5 (33-64g)					BMC6 (65-128g)					BMC7 (129-256g)				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>				
Total records	39	16.9	100.0	118.2	49	21.2	100.0	122.5	16	6.9	100.0	133.3	21	9.1	100.0	123.5				
MN+MTW studies	33	17.8	84.6	100.0	40	21.6	81.6	100.0	12	6.5	75.0	100.0	17	9.2	81.0	100.0				
Additional records	6	13.0	15.4	18.2	9	19.6	18.4	22.5	4	8.7	25.0	33.3	4	8.7	19.0	23.5				
Exclusively MN	3	13.0		9.1	3	13.0		7.5	2	8.7		16.7	0	0.0		0.0				
MN>2xMTW	1	5.3		3.0	4	21.1		10.0	0	0.0		0.0	0	0.0		0.0				
MN=MTW	8	26.7		24.2	6	20.0		15.0	0	0.0		0.0	1	3.3		5.9				
MTW>2xMN	12	26.7		36.4	13	28.9		32.5	0	0.0		0.0	3	6.7		17.6				
Exclusively MTW	9	13.2		27.3	14	20.6		35.0	10	14.7		83.3	13	19.1		76.5				
MN: MNT1/I	17	21.3	43.6	51.5	17	21.3	34.7	42.5	0	0.0	0.0	0.0	3	3.8	14.3	17.6				
MN: MNT1/II	18	20.5	46.2	54.5	19	21.6	38.8	47.5	1	1.1	6.3	8.3	3	3.4	14.3	17.6				
MN: MNT1/III	17	19.8	43.6	51.5	19	22.1	38.8	47.5	1	1.2	6.3	8.3	2	2.3	9.5	11.8				
MN: MNT1/I-III	24	20.5	61.5	72.7	26	22.2	53.1	65.0	2	1.7	12.5	16.7	4	3.4	19.0	23.5				
Mean MN study	17	20.5	44.4	52.5	18	21.7	37.4	45.8	1	0.8	4.2	5.6	3	3.1	12.7	15.7				
MTW: MNT1/1	21	20.0	53.8	63.6	26	24.8	53.1	65.0	5	4.8	31.3	41.7	10	9.5	47.6	58.8				
MTW: MNT1/2	23	20.7	59.0	69.7	28	25.2	57.1	70.0	6	5.4	37.5	50.0	11	9.9	52.4	64.7				
MTW: MNT1/3	23	19.2	59.0	69.7	30	25.0	61.2	75.0	5	4.2	31.3	41.7	14	11.7	66.7	82.4				
MTW: MNT1/4	23	18.3	59.0	69.7	30	23.8	61.2	75.0	5	4.0	31.3	41.7	13	10.3	61.9	76.5				
MTW: MNT1/1+2	27	20.8	69.2	81.8	31	23.8	63.3	77.5	8	6.2	50.0	66.7	11	8.5	52.4	64.7				
MTW: MNT1/3+4	26	17.2	66.7	78.8	36	23.8	73.5	90.0	8	5.3	50.0	66.7	16	10.6	76.2	94.1				
MTW: MNT1/1-4	30	18.5	76.9	90.9	37	22.8	75.5	92.5	10	6.2	62.5	83.3	17	10.5	81.0	100.0				
Mean MTW study	23	19.5	57.7	68.2	29	24.7	58.2	71.3	5	4.5	32.8	43.8	12	10.4	57.1	70.6				

## APPENDIX 14A. Continued.

Data set <sup>a</sup>	BMC8 (257-512g)					BMC9 (513-1024g)					BMC10 (1025-2048g) & BMC11 (2049-4096g)					
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	6	2.6	100.0	200.0	6	2.6	100.0	150.0	6	2.6	100.0	600.0	6	2.6	100.0	600.0
MN+MTW studies	3	1.6	50.0	100.0	4	2.2	66.7	100.0	1	0.5	16.7	100.0	5	10.9	83.3	500.0
Additional records	3	6.5	50.0	100.0	2	4.3	33.3	50.0	5	10.9	83.3	500.0				
Exclusively MN	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN=MTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MTW>2xMN	0	0.0		0.0	1	2.2		25.0	0	0.0		0.0	0	0.0		0.0
Exclusively MTW	3	4.4		100.0	3	4.4		75.0	1	1.5		100.0				
MN: MNT1/I	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT1/II	0	0.0	0.0	0.0	1	1.1	16.7	25.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT1/III	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN: MNT1/I+III	0	0.0	0.0	0.0	1	0.9	16.7	25.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Mean MN study	0	0.0	0.0	0.0	0	0.4	5.6	8.3	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MTW: MNT1/I	3	2.9	50.0	100.0	1	1.0	16.7	25.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MTW: MNT1/2	2	1.8	33.3	66.7	0	0.0	0.0	0.0	1	0.9	16.7	100.0	1	0.9	16.7	100.0
MTW: MNT1/3	1	0.8	16.7	33.3	3	2.5	50.0	75.0	1	0.8	16.7	100.0	1	0.8	16.7	100.0
MTW: MNT1/4	3	2.4	50.0	100.0	4	3.2	66.7	100.0	1	0.8	16.7	100.0	1	0.8	16.7	100.0
MTW: MNT1/I+2	3	2.3	50.0	100.0	1	0.8	16.7	25.0	1	0.8	16.7	100.0	1	0.8	16.7	100.0
MTW: MNT1/3+4	3	2.0	50.0	100.0	4	2.6	66.7	100.0	1	0.7	16.7	100.0	1	0.7	16.7	100.0
MTW: MNT1/I+4	3	1.9	50.0	100.0	4	2.5	66.7	100.0	1	0.6	16.7	100.0	1	0.6	16.7	100.0
Mean MTW study	2	1.9	37.5	75.0	2	1.7	33.3	50.0	1	0.6	12.5	75.0	1	0.6	12.5	75.0

## APPENDIX 14B

Standardized and non-standardized surveys of transect MNT2: influence of body size on bird species detectability. Comparative effectiveness of the number of bird species detected per body mass class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p.82f, Influence of body size). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT2 (transect area c. 14.1 ha), were included (cf. Appendix 12b). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 19a for the mean values of the body masses of unsexed samples, which I used here for assignment to the corresponding body mass class (BMC). The logarithmic scale for the BMCs was selected in accordance with Terborgh *et al.* (1990: 225).

Data set <sup>a</sup>	All species						BMC1 (2-4g)						BMC2 (5-8g)						BMC3 (9-16g)					
	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	138.3	4	1.7	100.0	200.0	18	7.8	100.0	120.0	58	25.1	100.0	131.8								
MN+MTW studies	167	100.0	72.3	100.0	2	1.2	50.0	100.0	15	9.0	83.3	100.0	44	26.3	75.9	100.0								
Additional records	64	100.0	27.7	38.3	2	3.1	50.0	100.0	3	4.7	16.7	20.0	14	21.9	24.1	31.8								
Exclusively MN	23	100.0		13.8	0	0.0		0.0	0	0.0		0.0	13	56.5		29.5								
MN>2xMTW	15	100.0		9.0	1	6.7		50.0	1	6.7		6.7	9	60.0		20.5								
MN=MTW	31	100.0		18.6	1	3.2		50.0	4	12.9		26.7	10	32.3		22.7								
MTW>2xMN	27	100.0		16.2	0	0.0		0.0	1	3.7		6.7	4	14.8		9.1								
Exclusively MTW	71	100.0		42.5	0	0.0		0.0	9	12.7		60.0	8	11.3		18.2								
MN: MNT2/I	69	100.0	29.9	41.3	2	2.9	50.0	100.0	4	5.8	22.2	26.7	26	37.7	44.8	59.1								
MN: MNT2/II	65	100.0	28.1	38.9	2	3.1	50.0	100.0	5	7.7	27.8	33.3	22	33.8	37.9	50.0								
MN: MNT2/III	73	100.0	31.6	43.7	2	2.7	50.0	100.0	6	8.2	33.3	40.0	30	41.1	51.7	68.2								
MN: MNT2/I-III	96	100.0	41.6	57.5	2	2.1	50.0	100.0	6	6.3	33.3	40.0	36	37.5	62.1	81.8								
Mean MN study	69	100.0	29.9	41.3	2	2.9	50.0	100.0	5	7.2	27.8	33.3	26	37.7	44.8	59.1								
MTW: MNT2/I	86	100.0	37.2	51.5	1	1.2	25.0	50.0	7	8.1	38.9	46.7	20	23.3	34.5	45.5								
MTW: MNT2/2	93	100.0	40.3	55.7	1	1.1	25.0	50.0	10	10.8	55.6	66.7	22	23.7	37.9	50.0								
MTW: MNT2/3	112	100.0	48.5	67.1	2	1.8	50.0	100.0	11	9.8	61.1	73.3	26	23.2	44.8	59.1								
MTW: MNT2/4	104	100.0	45.0	62.3	2	1.9	50.0	100.0	10	9.6	55.6	66.7	20	19.2	34.5	45.5								
MTW: MNT2/1+2	112	100.0	48.5	67.1	1	0.9	25.0	50.0	12	10.7	66.7	80.0	25	22.3	43.1	56.8								
MTW: MNT2/3+4	132	100.0	57.1	79.0	2	1.5	50.0	100.0	12	9.1	66.7	80.0	28	21.2	48.3	63.6								
MTW: MNT2/1-4	144	100.0	62.3	86.2	2	1.4	50.0	100.0	15	10.4	83.3	100.0	31	21.5	53.4	70.5								
Mean MTW study	99	100.0	42.7	59.1	2	1.5	37.5	75.0	10	9.6	52.8	63.3	22	22.3	37.9	50.0								

## APPENDIX 14B. Continued.

Data set <sup>a</sup>	BMC4 (17-32g)					BMC5 (33-64g)					BMC6 (65-128g)					BMC7 (129-256g)				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	
Total records	39	16.9	100.0	134.5	48	20.8	100.0	133.3	18	7.8	100.0	180.0	20	8.7	100.0	20	8.7	100.0	125.0	
MN+MTW studies	29	17.4	74.4	100.0	36	21.6	75.0	100.0	10	6.0	55.6	100.0	16	9.6	80.0	16	9.6	80.0	100.0	
Additional records	10	15.6	25.6	34.5	12	18.8	25.0	33.3	8	12.5	44.4	80.0	4	6.3	20.0	4	6.3	20.0	25.0	
Exclusively MN	4	17.4		13.8	5	21.7		13.9	1	4.3		10.0	0	0.0		0	0.0		0.0	
MN>2xMTW	1	6.7		3.4	3	20.0		8.3	0	0.0		0.0	0	0.0		0	0.0		0.0	
MN=MTW	6	19.4		20.7	9	29.0		25.0	0	0.0		0.0	1	3.2		1	3.2		6.3	
MTW>2xMN	9	33.3		31.0	5	18.5		13.9	4	14.8		40.0	3	11.1		3	11.1		18.8	
Exclusively MTW	9	12.7		31.0	14	19.7		38.9	5	7.0		50.0	12	16.9		12	16.9		75.0	
MN: MNT2/I	18	26.1	46.2	62.1	14	20.3	29.2	38.9	1	1.4	5.6	10.0	3	4.3	15.0	3	4.3	15.0	18.8	
MN: MNT2/II	15	23.1	38.5	51.7	17	26.2	35.4	47.2	3	4.6	16.7	30.0	1	1.5	5.0	1	1.5	5.0	6.3	
MN: MNT2/III	15	20.5	38.5	51.7	16	21.9	33.3	44.4	2	2.7	11.1	20.0	2	2.7	10.0	2	2.7	10.0	12.5	
MN: MNT2/I-III	20	20.8	51.3	69.0	22	22.9	45.8	61.1	5	5.2	27.8	50.0	4	4.2	20.0	4	4.2	20.0	25.0	
Mean MN study	16	23.2	41.0	55.2	16	22.7	32.6	43.5	2	2.9	11.1	20.0	2	2.9	10.0	2	2.9	10.0	12.5	
MTW: MNT2/I	17	19.8	43.6	58.6	18	20.9	37.5	50.0	7	8.1	38.9	70.0	9	10.5	45.0	9	10.5	45.0	56.3	
MTW: MNT2/2	17	18.3	43.6	58.6	22	23.7	45.8	61.1	6	6.5	33.3	60.0	9	9.7	45.0	9	9.7	45.0	56.3	
MTW: MNT2/3	20	17.9	51.3	69.0	25	22.3	52.1	69.4	7	6.3	38.9	70.0	11	9.8	55.0	11	9.8	55.0	68.8	
MTW: MNT2/4	20	19.2	51.3	69.0	23	22.1	47.9	63.9	7	6.7	38.9	70.0	13	12.5	65.0	13	12.5	65.0	81.3	
MTW: MNT2/1+2	21	18.8	53.8	72.4	25	22.3	52.1	69.4	8	7.1	44.4	80.0	12	10.7	60.0	12	10.7	60.0	75.0	
MTW: MNT2/3+4	25	18.9	64.1	86.2	28	21.2	58.3	77.8	8	6.1	44.4	80.0	15	11.4	75.0	15	11.4	75.0	93.8	
MTW: MNT2/1-4	25	17.4	64.1	86.2	31	21.5	64.6	86.1	9	6.3	50.0	90.0	16	11.1	80.0	16	11.1	80.0	100.0	
Mean MTW study	19	18.7	47.4	63.8	22	22.3	45.8	61.1	7	6.8	37.5	67.5	11	10.6	52.5	11	10.6	52.5	65.6	

## APPENDIX 14B. Continued.

Data set <sup>a</sup>	BMC8 (257-512g)					BMC9 (513-1024g)					BMC10 (1025-2048g) & BMC11 (2049-4096g)				
	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N <sup>b</sup> sp.	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>
Total records	11	4.8	100.0	220.0	220.0	8	3.5	100.0	133.3	7	3.0	100.0	175.0	175.0	175.0
MN+MTW studies	5	3.0	45.5	100.0	6	3.6	75.0	100.0	4	2.4	57.1	100.0	100.0	100.0	100.0
Additional records	6	9.4	54.5	120.0	2	3.1	25.0	33.3	3	4.7	42.9	75.0	75.0	75.0	75.0
Exclusively MN	0	0.0		0.0	0.0	0	0.0		0.0	0	0.0		0.0	0.0	0.0
MN>2xMTW	0	0.0		0.0	0.0	0	0.0		0.0	0	0.0		0.0	0.0	0.0
MN=MTW	0	0.0		0.0	0.0	0	0.0		0.0	0	0.0		0.0	0.0	0.0
MTW>2xMN	1	3.7		20.0	20.0	0	0.0		0.0	0	0.0		0.0	0.0	0.0
Exclusively MTW	4	5.6		80.0	80.0	6	8.5		100.0	4	5.6		100.0	100.0	100.0
MN: MNT2/I	1	1.4	9.1	20.0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
MN: MNT2/II	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
MN: MNT2/III	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
MN: MNT2/I+II	1	1.0	9.1	20.0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Mean MN study	0	0.5	3.0	6.7	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
MTW: MNT2/I	4	4.7	36.4	80.0	2	2.3	25.0	33.3	1	1.2	14.3	25.0	25.0	25.0	25.0
MTW: MNT2/2	2	2.2	18.2	40.0	3	3.2	37.5	50.0	1	1.1	14.3	25.0	25.0	25.0	25.0
MTW: MNT2/3	3	2.7	27.3	60.0	5	4.5	62.5	83.3	2	1.8	28.6	50.0	50.0	50.0	50.0
MTW: MNT2/4	2	1.9	18.2	40.0	4	3.8	50.0	66.7	3	2.9	42.9	75.0	75.0	75.0	75.0
MTW: MNT2/1+2	4	3.6	36.4	80.0	3	2.7	37.5	50.0	1	0.9	14.3	25.0	25.0	25.0	25.0
MTW: MNT2/3+4	4	3.0	36.4	80.0	6	4.5	75.0	100.0	4	3.0	57.1	100.0	100.0	100.0	100.0
MTW: MNT2/1-4	5	3.5	45.5	100.0	6	4.2	75.0	100.0	4	2.8	57.1	100.0	100.0	100.0	100.0
Mean MTW study	3	2.8	25.0	55.0	4	3.5	43.8	58.3	2	1.8	25.0	43.8	43.8	43.8	43.8



## APPENDIX 14C

Standardized and non-standardized surveys of the transects MNT1 and MNT2: influence of body size on bird species detectability. Comparative effectiveness of the number of bird species detected per body mass class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of both transects (cf. p. 82f; Influence of body size). A total of 268 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha) and MNT2 (c. 14.1 ha), were included (cf. Appendices 12a and 12b). See Appendices 13a and 13c for details on the data sets and abbreviations used, and Appendices 18a and 19a for the mean values of the body masses of unsexed samples, which I used here for assignment to the corresponding body mass class (BMC). The logarithmic scale for the BMCs was selected in accordance with Terborgh *et al.* (1990: 225).

Data set <sup>a</sup>	All species						BMC1 (2-4g)						BMC2 (5-8g)						BMC3 (9-16g)					
	% N		% N tot.	% N	% N		% N		% N tot.	% N	% N		% N	% N		% N tot.	% N	% N		% N	% N		% N tot.	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	268	100.0	100.0	126.4	4	1.5	100.0	100.0	23	8.6	100.0	109.5	67	25.0	100.0	100.0	55	25.9	82.1	17.9	21.8	20.0	121.8	
MN+MTW studies	212	100.0	79.1	100.0	4	1.9	100.0	100.0	21	9.9	91.3	100.0	55	25.9	82.1	100.0	55	25.9	82.1	17.9	21.8	20.0	121.8	
Additional records	56	100.0	20.9	26.4	0	0.0	0.0	0.0	2	3.6	8.7	9.5	12	21.4	17.9	9.5	12	21.4	17.9	9.5	12	21.4	17.9	
Exclusively MN	25	100.0	11.8	11.8	0	0.0	0.0	0.0	2	8.0	8.0	9.5	11	44.0	20.0	9.5	11	44.0	20.0	9.5	11	44.0	20.0	
MN>2xMTW	22	100.0	10.4	10.4	1	4.5	25.0	25.0	4	18.2	18.2	19.0	13	59.1	23.6	19.0	13	59.1	23.6	19.0	13	59.1	23.6	
MN=MTW	36	100.0	17.0	17.0	3	8.3	75.0	75.0	4	11.1	11.1	19.0	10	27.8	18.2	19.0	10	27.8	18.2	19.0	10	27.8	18.2	
MTW>2xMN	52	100.0	24.5	24.5	0	0.0	0.0	0.0	5	9.6	23.8	23.8	12	23.1	21.8	23.8	12	23.1	21.8	23.8	12	23.1	21.8	
Exclusively MTW	77	100.0	36.3	36.3	0	0.0	0.0	0.0	6	7.8	11.7	28.6	9	11.7	16.4	28.6	9	11.7	16.4	28.6	9	11.7	16.4	
MN: MNT1+MNT2	135	100.0	50.4	63.7	4	3.0	100.0	100.0	15	11.1	65.2	71.4	46	34.1	68.7	71.4	46	34.1	68.7	71.4	46	34.1	68.7	
Mean MN studies	77	100.0	28.7	36.2	3	3.3	62.5	62.5	8	10.2	34.1	37.3	29	37.5	43.0	37.3	29	37.5	43.0	37.3	29	37.5	43.0	
MTW: MNT1+MNT2	187	100.0	69.8	88.2	4	2.1	100.0	100.0	19	10.2	82.6	90.5	44	23.5	65.7	90.5	44	23.5	65.7	90.5	44	23.5	65.7	
Mean MTW studies	107	100.0	40.0	50.5	2	1.6	43.8	43.8	11	10.5	48.9	53.6	25	23.0	36.8	53.6	25	23.0	36.8	53.6	25	23.0	36.8	

Data set <sup>a</sup>	BMC4 (17-32g)						BMC5 (33-64g)						BMC6 (65-128g)						BMC7 (129-256g)					
	% N		% N tot.	% N	% N		% N		% N tot.	% N	% N		% N	% N		% N tot.	% N	% N		% N	% N		% N tot.	% N
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	45	16.8	100.0	118.4	57	21.3	100.0	123.9	21	7.8	100.0	161.5	23	8.6	100.0	161.5	23	8.6	100.0	161.5	23	8.6	100.0	121.1
MN+MTW studies	38	17.9	84.4	100.0	46	21.7	80.7	100.0	13	6.1	61.9	100.0	19	9.0	82.6	100.0	19	9.0	82.6	100.0	19	9.0	82.6	100.0
Additional records	7	12.5	15.6	18.4	11	19.6	19.3	23.9	8	14.3	38.1	61.5	4	7.1	17.4	61.5	4	7.1	17.4	61.5	4	7.1	17.4	21.1
Exclusively MN	5	20.0	13.2	13.2	5	20.0	10.9	10.9	2	8.0	8.0	15.4	0	0.0	0.0	15.4	0	0.0	0.0	15.4	0	0.0	0.0	0.0
MN>2xMTW	1	4.5	2.6	2.6	3	13.6	6.5	6.5	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MN=MTW	9	25.0	23.7	23.7	9	25.0	19.6	19.6	0	0.0	0.0	0.0	1	2.8	5.3	0.0	1	2.8	5.3	0.0	1	2.8	5.3	5.3
MTW>2xMN	12	23.1	31.6	31.6	13	25.0	28.3	28.3	4	7.7	28.3	30.8	4	7.7	21.1	30.8	4	7.7	21.1	30.8	4	7.7	21.1	21.1
Exclusively MTW	11	14.3	28.9	28.9	16	20.8	34.8	34.8	7	9.1	28.3	53.8	14	18.2	73.7	53.8	14	18.2	73.7	53.8	14	18.2	73.7	73.7
MN: MNT1+MNT2	27	20.0	60.0	71.1	30	22.2	52.6	65.2	6	4.4	28.6	46.2	5	3.7	21.7	46.2	5	3.7	21.7	46.2	5	3.7	21.7	26.3
Mean MN studies	17	21.7	37.0	43.9	17	22.1	29.8	37.0	1	1.7	6.3	10.3	2	3.0	10.1	10.3	2	3.0	10.1	10.3	2	3.0	10.1	12.3
MTW: MNT1+MNT2	33	17.6	73.3	86.8	41	21.9	71.9	89.1	11	5.9	52.4	84.6	19	10.2	82.6	84.6	19	10.2	82.6	84.6	19	10.2	82.6	100.0
Mean MTW studies	21	19.1	45.6	53.9	25	23.6	44.3	54.9	6	5.6	28.6	46.2	11	10.5	48.9	46.2	11	10.5	48.9	46.2	11	10.5	48.9	59.2

## APPENDIX 14C. Continued.

Data set <sup>a</sup>	BMC8 (257-512g)					BMC9 (513-1024g)					BMC10 (1025-2048g) & BMC11 (2049-4096g)				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>
Total records	11	4.1	100.0	183.3	183.3	9	3.4	100.0	150.0	150.0	8	3.0	100.0	200.0	200.0
MN+MTW studies	6	2.8	54.5	100.0	100.0	6	2.8	66.7	100.0	100.0	4	1.9	50.0	100.0	100.0
Additional records	5	8.9	45.5	83.3	83.3	3	5.4	33.3	50.0	50.0	4	7.1	50.0	100.0	100.0
Exclusively MN	0	0.0		0.0	0.0	0	0.0		0.0	0.0	0	0.0		0.0	0.0
MN>2xMTW	0	0.0		0.0	0.0	0	0.0		0.0	0.0	0	0.0		0.0	0.0
MN=MTW	0	0.0		0.0	0.0	0	0.0		0.0	0.0	0	0.0		0.0	0.0
MTW>2xMN	1	1.9		16.7	16.7	1	1.9		16.7	16.7	0	0.0		0.0	0.0
Exclusively MTW	5	6.5		83.3	83.3	5	6.5		83.3	83.3	4	5.2		100.0	100.0
MN: MNT1+MNT2	1	0.7	9.1	16.7	16.7	1	0.7	11.1	16.7	16.7	0	0.0	0.0	0.0	0.0
Mean MN studies	0	0.2	1.5	2.8	2.8	0	0.2	1.9	2.8	2.8	0	0.0	0.0	0.0	0.0
MTW: MNT1+MNT2	6	3.2	54.5	100.0	100.0	6	3.2	66.7	100.0	100.0	4	2.1	50.0	100.0	100.0
Mean MTW studies	3	2.3	22.7	41.7	41.7	3	2.6	30.6	45.8	45.8	1	1.2	15.6	31.3	31.3

## APPENDIX 15A

Standardized and non-standardized surveys of transect MNT1: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability. Comparative effectiveness of the number of bird species detected per cohort during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 83-85, Influence of breeding/non-breeding status and territory/home range size). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha), were included (cf. Appendix 12a). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 9 for the definitions of territory and home range sizes, courtship behavior, types of migrants, and related aspects.

Data set <sup>a</sup>	All species						Breeding species						Occupants of small territories or small home ranges (≤10 ha)						Occupants of medium-sized territories or medium-sized home ranges (11–30 ha)					
	N			% N tot.			N			% N tot.			N			% N tot.			N			% N tot.		
	sp. <sup>b</sup>	row <sup>c</sup>	% N	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	% N	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	% N	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	% N	records <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	% N	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	100.0	124.9	183	79.2	100.0	100.0	110.9	102	44.2	100.0	100.0	108.5	46	19.9	100.0	100.0	46	19.9	100.0	100.0	115.0
MN+MTW studies	185	100.0	80.1	100.0	100.0	165	89.2	90.2	90.2	100.0	94	50.8	92.2	92.2	100.0	40	21.6	87.0	87.0	40	21.6	87.0	100.0	100.0
Additional records	46	100.0	19.9		24.9	18	39.1	9.8		10.9	8	17.4	7.8		8.5	6	13.0	13.0		6	13.0	13.0		15.0
Exclusively MN	23	100.0			12.4	13	56.5			7.9	4	17.4			4.3	3	13.0			3	13.0			7.5
MN>2xMTW	19	100.0			10.3	19	100.0			11.5	13	68.4			13.8	2	10.5			2	10.5			5.0
MN=MTW	30	100.0			16.2	28	93.3			17.0	12	40.0			12.8	10	33.3			10	33.3			25.0
MTW>2xMN	45	100.0			24.3	45	100.0			27.3	33	73.3			35.1	7	15.6			7	15.6			17.5
Exclusively MTW	68	100.0			36.8	60	88.2			36.4	32	47.1			34.0	18	26.5			18	26.5			45.0
MN: MNT1/I	80	100.0	34.6		43.2	78	97.5	42.6		47.3	46	57.5	45.1		48.9	13	16.3	28.3		13	16.3	28.3		32.5
MN: MNT1/II	88	100.0	38.1		47.6	80	90.9	43.7		48.5	47	53.4	46.1		50.0	17	19.3	37.0		17	19.3	37.0		42.5
MN: MNT1/III	86	100.0	37.2		46.5	78	90.7	42.6		47.3	47	54.7	46.1		50.0	14	16.3	30.4		14	16.3	30.4		35.0
MN: MNT1/I-III	117	100.0	50.6		63.2	105	89.7	57.4		63.6	62	53.0	60.8		66.0	22	18.8	47.8		22	18.8	47.8		55.0
Mean MN study	85	100.0	36.7		45.8	79	92.9	43.0		47.7	47	55.1	45.8		49.6	15	17.3	31.9		15	17.3	31.9		36.7
MTW: MNT1/I	105	100.0	45.5		56.8	101	96.2	55.2		61.2	66	62.9	64.7		70.2	21	20.0	45.7		21	20.0	45.7		52.5
MTW: MNT1/2	111	100.0	48.1		60.0	109	98.2	59.6		66.1	67	60.4	65.7		71.3	25	22.5	54.3		25	22.5	54.3		62.5
MTW: MNT1/3	120	100.0	51.9		64.9	115	95.8	62.8		69.7	71	59.2	69.6		75.5	26	21.7	56.5		26	21.7	56.5		65.0
MTW: MNT1/4	126	100.0	54.5		68.1	120	95.2	65.6		72.7	74	58.7	72.5		78.7	25	19.8	54.3		25	19.8	54.3		62.5
MTW: MNT1/1+2	130	100.0	56.3		70.3	125	96.2	68.3		75.8	75	57.7	73.5		79.8	30	23.1	65.2		30	23.1	65.2		75.0
MTW: MNT1/3+4	151	100.0	65.4		81.6	142	94.0	77.6		86.1	86	57.0	84.3		91.5	33	21.9	71.7		33	21.9	71.7		82.5
MTW: MNT1/1-4	162	100.0	70.1		87.6	152	93.8	83.1		92.1	90	55.6	88.2		95.7	37	22.8	80.4		37	22.8	80.4		92.5
Mean MTW study	116	100.0	50.0		62.4	111	96.3	60.8		67.4	70	60.2	68.1		73.9	24	21.0	52.7		24	21.0	52.7		60.6

## APPENDIX 15A. Continued.

Data set <sup>a</sup>	Occupants of large territories or large home ranges (31-90 ha)					Occupants of very large territories or very large home ranges (≥91 ha)					Occupants of display territories or foraging territories					Lek-forming species				
	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>
Total records	12	5.2	100.0	120.0	150.0	3	1.3	100.0	4.3	111.1	10	4.3	100.0	4.3	100.0	10	4.3	100.0	100.0	100.0
MN+MTW studies	10	5.4	83.3	100.0	100.0	2	1.1	66.7	100.0	100.0	9	4.9	90.0	100.0	100.0	10	5.4	100.0	100.0	100.0
Additional records	2	4.3	16.7	20.0	50.0	1	2.2	33.3	50.0	11.1	1	2.2	10.0	11.1	0.0	0	0.0	0.0	0.0	0.0
Exclusively MN	0	0.0		0.0	0.0	0	0.0		0.0	44.4	4	17.4		44.4		2	8.7		20.0	20.0
MN>2xMTW	0	0.0		0.0	0.0	0	0.0		0.0	22.2	2	10.5		22.2		2	10.5		20.0	20.0
MN=MTW	0	0.0		0.0	0.0	0	0.0		0.0	0.0	0	0.0		0.0		6	20.0		60.0	60.0
MTW>2xMN	2	4.4		20.0	0.0	0	0.0		0.0	33.3	3	6.7		33.3		0	0.0		0.0	0.0
Exclusively MTW	8	11.8		80.0	100.0	2	2.9		100.0	0.0	0	0.0		0.0		0	0.0		0.0	0.0
MN: MNT1/I	1	1.3	8.3	10.0	0.0	0	0.0	0.0	0.0	88.9	8	10.0	80.0	55.6	100.0	10	12.5	100.0	100.0	100.0
MN: MNT1/II	1	1.1	8.3	10.0	0.0	0	0.0	0.0	0.0	55.6	5	5.7	50.0	100.0	100.0	10	11.4	100.0	100.0	100.0
MN: MNT1/III	0	0.0		0.0	0.0	0	0.0		0.0	9.3	9	10.5	90.0	100.0	80.0	8	9.3	80.0	80.0	80.0
MN: MNT1/I-III	2	1.7	16.7	20.0	0.0	0	0.0	0.0	0.0	100.0	9	7.7	90.0	100.0	100.0	10	8.5	100.0	100.0	100.0
Mean MN study	1	0.8	5.6	6.7	0.0	0	0.0	0.0	0.0	81.5	7	8.7	73.3	81.5	93.3	9	11.0	93.3	93.3	93.3
MTW: MNT1/I	5	4.8	41.7	50.0	50.0	1	1.0	33.3	50.0	33.3	3	2.9	30.0	33.3	50.0	5	4.8	50.0	50.0	50.0
MTW: MNT1/2	5	4.5	41.7	50.0	50.0	1	0.9	33.3	50.0	33.3	3	2.7	30.0	33.3	50.0	8	7.2	80.0	80.0	80.0
MTW: MNT1/3	7	5.8	58.3	70.0	100.0	2	1.7	66.7	100.0	44.4	4	3.3	40.0	44.4	50.0	5	4.2	50.0	50.0	50.0
MTW: MNT1/4	9	7.1	75.0	90.0	100.0	2	1.6	66.7	100.0	44.4	4	3.2	40.0	44.4	60.0	6	4.8	60.0	60.0	60.0
MTW: MNT1/1+2	7	5.4	58.3	70.0	100.0	2	1.5	66.7	100.0	33.3	3	2.3	30.0	33.3	80.0	8	6.2	80.0	80.0	80.0
MTW: MNT1/3+4	10	6.6	83.3	100.0	100.0	2	1.3	66.7	100.0	55.6	5	3.3	50.0	55.6	60.0	6	4.0	60.0	60.0	60.0
MTW: MNT1/1-4	10	6.2	83.3	100.0	100.0	2	1.2	66.7	100.0	55.6	5	3.1	50.0	55.6	80.0	8	4.9	80.0	80.0	80.0
Mean MTW study	7	5.6	54.2	65.0	75.0	2	1.3	50.0	75.0	38.9	4	3.0	35.0	38.9	60.0	6	5.2	60.0	60.0	60.0

## APPENDIX 15A. Continued.

Data set <sup>a</sup>	Non-breeding visitors (all types of migrants & stragglers)				Non-territorial dispersing species (stragglers & short-distance migrants)				Non-territorial long-distance migrants				Long-distance migrants which establish temporary foraging territories			
	N sp.	% row <sup>b</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	N sp.	% row <sup>b</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	N sp.	% row <sup>b</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	N sp.	% row <sup>b</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	48	20.8	100.0	240.0	29	12.6	100.0	223.1	16	6.9	100.0	400.0	3	1.3	100.0	100.0
MN+MTW studies	20	10.8	41.7	100.0	13	7.0	44.8	100.0	4	2.2	25.0	100.0	3	1.6	100.0	100.0
Additional records	28	60.9	58.3	140.0	16	34.8	55.2	123.1	12	26.1	75.0	300.0	0	0.0	0.0	0.0
Exclusively MN	10	43.5		50.0	7	30.4		53.8	3	13.0		75.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN=MTW	2	6.7		10.0	2	6.7		15.4	0	0.0		0.0	0	0.0		0.0
MTW>2xMN	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
Exclusively MTW	8	11.8		40.0	4	5.9		30.8	1	1.5		25.0	3	4.4		100.0
MN: MNT1/I	2	2.5	4.2	10.0	1	1.3	3.4	7.7	1	1.3	6.3	25.0	0	0.0	0.0	0.0
MN: MNT1/II	8	9.1	16.7	40.0	7	8.0	24.1	53.8	1	1.1	6.3	25.0	0	0.0	0.0	0.0
MN: MNT1/III	8	9.3	16.7	40.0	6	7.0	20.7	46.2	2	2.3	12.5	50.0	0	0.0	0.0	0.0
MN: MNT1/I-III	12	10.3	25.0	60.0	9	7.7	31.0	69.2	3	2.6	18.8	75.0	0	0.0	0.0	0.0
Mean MN study	6	7.1	12.5	30.0	5	5.5	16.1	35.9	1	1.6	8.3	33.3	0	0.0	0.0	0.0
MTW: MNT1/I	4	3.8	8.3	20.0	1	1.0	3.4	7.7	1	1.0	6.3	25.0	2	1.9	66.7	66.7
MTW: MNT1/2	2	1.8	4.2	10.0	2	1.8	6.9	15.4	0	0.0	0.0	0.0	0	0.0	0.0	0.0
MTW: MNT1/3	5	4.2	10.4	25.0	4	3.3	13.8	30.8	0	0.0	0.0	0.0	1	0.8	33.3	33.3
MTW: MNT1/4	6	4.8	12.5	30.0	3	2.4	10.3	23.1	1	0.8	6.3	25.0	2	1.6	66.7	66.7
MTW: MNT1/1+2	5	3.8	10.4	25.0	2	1.5	6.9	15.4	1	0.8	6.3	25.0	2	1.5	66.7	66.7
MTW: MNT1/3+4	9	6.0	18.8	45.0	6	4.0	20.7	46.2	1	0.7	6.3	25.0	2	1.3	66.7	66.7
MTW: MNT1/1-4	10	6.2	20.8	50.0	6	3.7	20.7	46.2	1	0.6	6.3	25.0	3	1.9	100.0	100.0
Mean MTW study	4	3.7	8.9	21.3	3	2.2	8.6	19.2	1	0.4	3.1	12.5	1	1.1	41.7	41.7

## APPENDIX 15B

Standardized and non-standardized surveys of transect MNT2: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability. Comparative effectiveness of the number of bird species detected per cohort during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 83-85, Influence of breeding/non-breeding status and territory/home range size). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT2 (transect c. 14.1 ha), were included (cf. Appendix 12b). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 9 for the definitions of territory and home range sizes, courtship behavior, types of migrants, and related aspects.

Data set <sup>a</sup>	All species						Breeding species						Occupants of small territories or small home ranges (≤10 ha)						Occupants of medium-sized territories or medium-sized home ranges (11-30 ha)					
	N	% N	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>				
	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	records <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	records <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	records <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	records <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	records <sup>d</sup>				
Total records	231	100.0	100.0	138.3	170	73.6	100.0	114.1	91	39.4	100.0	111.0	40	17.3	100.0	111.1	36	21.6	90.0	111.1				
MN+MTW studies	167	100.0	72.3	100.0	149	89.2	87.6	100.0	82	49.1	90.1	100.0	36	21.6	90.0	100.0	36	21.6	90.0	100.0				
Additional records	64	100.0	27.7	38.3	21	32.8	12.4	14.1	9	14.1	9.9	11.0	4	6.3	10.0	11.1	4	6.3	10.0	11.1				
Exclusively MN	23	100.0		13.8	12	52.2		8.1	7	30.4		8.5	3	13.0		8.3				8.3				
MN>2xMTW	15	100.0		9.0	15	100.0		10.1	7	46.7		8.5	3	20.0		8.3				8.3				
MN=MTW	31	100.0		18.6	31	100.0		20.8	20	64.5		24.4	5	16.1		13.9				13.9				
MTW>2xMN	27	100.0		16.2	27	100.0		18.1	20	74.1		24.4	5	18.5		13.9				13.9				
Exclusively MTW	71	100.0		42.5	64	90.1		43.0	28	39.4		34.1	20	28.2		55.6				55.6				
MN: MNT2/I	69	100.0	29.9	41.3	67	97.1	39.4	45.0	45	65.2	49.5	54.9	10	14.5	25.0	27.8				27.8				
MN: MNT2/II	65	100.0	28.1	38.9	63	96.9	37.1	42.3	38	58.5	41.8	46.3	12	18.5	30.0	33.3				33.3				
MN: MNT2/III	73	100.0	31.6	43.7	64	87.7	37.6	43.0	40	54.8	44.0	48.8	9	12.3	22.5	25.0				25.0				
MN: MNT2/I+III	96	100.0	41.6	57.5	85	88.5	50.0	57.0	54	56.3	59.3	65.9	16	16.7	40.0	44.4				44.4				
Mean MN study	69	100.0	29.9	41.3	65	93.7	38.0	43.4	41	59.4	45.1	50.0	10	15.0	25.8	28.7				28.7				
MTW: MNT2/I	86	100.0	37.2	51.5	85	98.8	50.0	57.0	50	58.1	54.9	61.0	18	20.9	45.0	50.0				50.0				
MTW: MNT2/2	93	100.0	40.3	55.7	93	100.0	54.7	62.4	57	61.3	62.6	69.5	20	21.5	50.0	55.6				55.6				
MTW: MNT2/3	112	100.0	48.5	67.1	110	98.2	64.7	73.8	62	55.4	68.1	75.6	25	22.3	62.5	69.4				69.4				
MTW: MNT2/4	104	100.0	45.0	62.3	98	94.2	57.6	65.8	56	53.8	61.5	68.3	22	21.2	55.0	61.1				61.1				
MTW: MNT2/1+2	112	100.0	48.5	67.1	111	99.1	65.3	74.5	65	58.0	71.4	79.3	26	23.2	72.2	72.2				72.2				
MTW: MNT2/3+4	132	100.0	57.1	79.0	125	94.7	73.5	83.9	70	53.0	76.9	85.4	30	22.7	75.0	83.3				83.3				
MTW: MNT2/1-4	144	100.0	62.3	86.2	137	95.1	80.6	91.9	75	52.1	82.4	91.5	33	22.9	82.5	91.7				91.7				
Mean MTW study	99	100.0	42.7	59.1	97	97.7	56.8	64.8	56	57.0	61.8	68.6	21	21.5	53.1	59.0				59.0				

## APPENDIX 15B. Continued.

Data set <sup>a</sup>	Occupants of large territories or large home ranges (31-90 ha)					Occupants of very large territories or very large home ranges ( $\geq 91$ ha)					Occupants of display territories or foraging territories					Lek-forming species				
	N	% row <sup>c</sup>	% N tot.	records <sup>d</sup>	MN+MTW <sup>e</sup>	N	% row <sup>c</sup>	% N tot.	records <sup>d</sup>	MN+MTW <sup>e</sup>	N	% row <sup>c</sup>	% N tot.	records <sup>d</sup>	MN+MTW <sup>e</sup>	N	% row <sup>c</sup>	% N tot.	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	18	7.8	100.0	138.5	3	1.3	100.0	100.0	0.0	0.0	8	3.5	100.0	114.3	10	4.3	100.0	125.0		
MN+MTW studies	13	7.8	72.2	100.0	3	1.8	100.0	100.0	0.0	0.0	7	4.2	87.5	100.0	8	4.8	80.0	100.0		
Additional records	5	7.8	27.8	38.5	0	0.0	0.0	0.0	0.0	0.0	1	1.6	12.5	14.3	2	3.1	20.0	25.0		
Exclusively MN	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	2	8.7	28.6	28.6	0	0.0	0.0	0.0		
MN>2xMTW	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	1	6.7	14.3	14.3	4	26.7	50.0	50.0		
MN=MTW	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	2	6.5	28.6	28.6	4	12.9	50.0	50.0		
MTW>2xMN	1	3.7	7.7	7.7	0	0.0	0.0	0.0	0.0	0.0	1	3.7	14.3	14.3	0	0.0	0.0	0.0		
Exclusively MTW	12	16.9	92.3	92.3	3	4.2	100.0	100.0	0.0	0.0	1	1.4	14.3	14.3	0	0.0	0.0	0.0		
MN: MNT2/I	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	4	5.8	50.0	57.1	8	11.6	80.0	100.0		
MN: MNT2/II	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	5	7.7	62.5	71.4	8	12.3	80.0	100.0		
MN: MNT2/III	1	1.4	5.6	7.7	0	0.0	0.0	0.0	0.0	0.0	6	8.2	75.0	85.7	8	11.0	80.0	100.0		
MN: MNT2/I-III	1	1.0	5.6	7.7	0	0.0	0.0	0.0	0.0	0.0	6	6.3	75.0	85.7	8	8.3	80.0	100.0		
Mean MN study	0	0.5	1.9	2.6	0	0.0	0.0	0.0	0.0	0.0	5	7.2	62.5	71.4	8	11.6	80.0	100.0		
MTW: MNT2/I	7	8.1	38.9	53.8	0	0.0	0.0	0.0	0.0	0.0	3	3.5	37.5	42.9	7	8.1	70.0	87.5		
MTW: MNT2/2	6	6.5	33.3	46.2	0	0.0	0.0	0.0	0.0	0.0	4	4.3	50.0	57.1	6	6.5	60.0	75.0		
MTW: MNT2/3	9	8.0	50.0	69.2	3	2.7	100.0	100.0	0.0	0.0	3	2.7	37.5	42.9	8	7.1	80.0	100.0		
MTW: MNT2/4	6	5.8	33.3	46.2	2	1.9	66.7	66.7	0.0	0.0	4	3.8	50.0	57.1	8	7.7	80.0	100.0		
MTW: MNT2/1+2	9	8.0	50.0	69.2	0	0.0	0.0	0.0	0.0	0.0	4	3.6	50.0	57.1	7	6.3	70.0	87.5		
MTW: MNT2/3+4	10	7.6	55.6	76.9	3	2.3	100.0	100.0	0.0	0.0	4	3.0	50.0	57.1	8	6.1	80.0	100.0		
MTW: MNT2/1-4	13	9.0	72.2	100.0	3	2.1	100.0	100.0	0.0	0.0	5	3.5	62.5	71.4	8	5.6	80.0	100.0		
Mean MTW study	7	7.1	38.9	53.8	1	1.3	41.7	41.7	0.0	0.0	4	3.5	43.8	50.0	7	7.3	72.5	90.6		



## APPENDIX 15B. Continued.

Data set <sup>a</sup>	Non-breeding visitors (all types of migrants & stragglers)						Non-territorial dispersing species (stragglers & short-distance migrants)						Non-territorial long-distance migrants						Long-distance migrants which establish temporary foraging territories					
	% N			% N tot.			% N			% N tot.			% N			% N tot.			% N			% N tot.		
	sp. <sup>b</sup>	row <sup>c</sup>	row <sup>c</sup>	records <sup>d</sup>	% N	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	row <sup>c</sup>	records <sup>d</sup>	% N	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	row <sup>c</sup>	records <sup>d</sup>	% N	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	row <sup>c</sup>	records <sup>d</sup>	% N	MN+MTW <sup>e</sup>
Total records	61	26.4	100.0	338.9	44	19.0	100.0	338.5	14	6.1	100.0	700.0	3	1.3	100.0	100.0	3	1.3	100.0	3	1.8	100.0	100.0	100.0
MN+MTW studies	18	10.8	29.5	100.0	13	7.8	29.5	100.0	2	1.2	14.3	100.0	3	1.8	100.0	100.0	3	1.8	100.0	3	1.8	100.0	100.0	100.0
Additional records	43	67.2	70.5	238.9	31	48.4	70.5	238.5	12	18.8	85.7	600.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
Exclusively MN	11	47.8		61.1	8	34.8		61.5	2	8.7		100.0	1	4.3			1	4.3					33.3	33.3
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0			0	0.0					0.0	0.0
MN=MTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0			0	0.0					0.0	0.0
MTW>2xMN	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0			0	0.0					0.0	0.0
Exclusively MTW	7	9.9		38.9	5	7.0		38.5	0	0.0		0.0	2	2.8			2	2.8					66.7	66.7
MN: MNT2/I	2	2.9	3.3	11.1	1	1.4	2.3	7.7	1	1.4	7.1	50.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MN: MNT2/II	2	3.1	3.3	11.1	2	3.1	4.5	15.4	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MN: MNT2/III	9	12.3	14.8	50.0	6	8.2	13.6	46.2	2	2.7	14.3	100.0	1	1.4	33.3	33.3	1	1.4	33.3	1	1.4	33.3	33.3	33.3
MN: MNT2/I-III	11	11.5	18.0	61.1	8	8.3	18.2	61.5	2	2.1	14.3	100.0	1	1.0	33.3	33.3	1	1.0	33.3	1	1.0	33.3	33.3	33.3
Mean MN study	4	6.3	7.1	24.1	3	4.3	6.8	23.1	1	1.4	7.1	50.0	0	0.5	11.1	11.1	0	0.5	11.1	0	0.5	11.1	11.1	11.1
MTW: MNT2/I	1	1.2	1.6	5.6	1	1.2	2.3	7.7	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MTW: MNT2/2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MTW: MNT2/3	2	1.8	3.3	11.1	2	1.8	4.5	15.4	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MTW: MNT2/4	6	5.8	9.8	33.3	4	3.8	9.1	30.8	0	0.0	0.0	0.0	2	1.9	66.7	66.7	2	1.9	66.7	2	1.9	66.7	66.7	66.7
MTW: MNT2/1+2	1	0.9	1.6	5.6	1	0.9	2.3	7.7	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0
MTW: MNT2/3+4	7	5.3	11.5	38.9	5	3.8	11.4	38.5	0	0.0	0.0	0.0	2	1.5	66.7	66.7	2	1.5	66.7	2	1.5	66.7	66.7	66.7
MTW: MNT2/1-4	7	4.9	11.5	38.9	5	3.5	11.4	38.5	0	0.0	0.0	0.0	2	1.4	66.7	66.7	2	1.4	66.7	2	1.4	66.7	66.7	66.7
Mean MTW study	2	2.3	3.7	12.5	2	1.8	4.0	13.5	0	0.0	0.0	0.0	1	0.5	16.7	16.7	1	0.5	16.7	1	0.5	16.7	16.7	16.7

## APPENDIX 15C

Standardized and non-standardized surveys of the transects MNT1 and MNT2: influence of breeding/non-breeding status, territory/home range size, and courtship behavior on bird species detectability. Comparative effectiveness of the number of bird species detected per cohort during standardized mist-netting and transect-mapping (MTW) surveys, as well as during non-standardized mist-netting and observation hours, and the complete study of both transects (cf. p. 83-85, Influence of breeding/non-breeding status and territory/home range size). A total of 268 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha) and MNT2 (c. 14.1 ha), were included (cf. Appendices 12a and 12b). See Appendices 13a and 13c for details on the data sets and abbreviations used, and Appendix 9 for the definitions of territory and home range sizes, courtship behavior, types of migrants, and related aspects.

Data set <sup>a</sup>	All species						Breeding species						Occupants of small territories or small home ranges ( $\leq 10$ ha)						Occupants of medium-sized territories or medium-sized home ranges (11-30 ha)					
	N			% N tot.			N			% N tot.			N			% N tot.			N			% N tot.		
	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>
Total records	268		100.0	100.0	100.0	126.4	202		75.4	100.0	100.0	107.4	104		38.8	100.0	100.0	103.0	53		19.8	100.0	100.0	110.4
MN+MTW studies	212		100.0	79.1	100.0	100.0	188		88.7	93.1	100.0	100.0	101		47.6	97.1	100.0	100.0	48		22.6	90.6	100.0	100.0
Additional records	56		100.0	20.9		26.4	14		25.0	6.9		7.4	3		5.4	2.9		3.0	5		8.9	9.4		10.4
Exclusively MN	25		100.0	11.8		11.8	11		44.0			5.9	5		20.0			5.0	3		12.0			6.3
MN>2xMTW	22		100.0	10.4		10.4	22		100.0			11.7	12		54.5			11.9	3		13.6			6.3
MN=MTW	36		100.0	17.0		17.0	34		94.4			18.1	19		52.8			18.8	9		25.0			18.8
MTW>2xMN	52		100.0	24.5		24.5	51		98.1			27.1	35		67.3			34.7	10		19.2			20.8
Exclusively MTW	77		100.0	36.3		36.3	70		90.9			37.2	30		39.0			29.7	23		29.9			47.9
MN: MNT1+MNT2	135		100.0	50.4		63.7	118		87.4		58.4	62.8	71		52.6		68.3	70.3	25		18.5		47.2	52.1
Mean MN studies	77		100.0	28.7		36.2	72		93.7		35.6	38.3	44		57.3		42.3	43.6	13		16.5		23.9	26.4
MTW: MNT1+MNT2	187		100.0	69.8		88.2	177		94.7		87.6	94.1	96		51.3		92.3	95.0	45		24.1		84.9	93.8
Mean MTW studies	107		100.0	40.0		50.5	105		97.7		51.8	53.3	63		58.6		60.3	62.1	23		21.8		44.1	48.7

Data set <sup>a</sup>	Occupants of large territories or large home ranges (31-90 ha)						Occupants of very large territories or very large home ranges ( $\geq 91$ ha)						Occupants of display territories or foraging territories						Lek-forming species					
	N			% N tot.			N			% N tot.			N			% N tot.			N			% N tot.		
	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>	sp.	b	N	% N	row <sup>c</sup>	records <sup>d</sup>
Total records	21		7.8	100.0	123.5	4		1.5	100.0	133.3	10	3.7	10		111.1	10	3.7	100.0	10		3.7	100.0	100.0	100.0
MN+MTW studies	17		8.0	81.0	100.0	3		1.4	75.0	100.0	9	4.2	9		100.0	10	4.7	100.0	10		4.7	100.0	100.0	100.0
Additional records	4		7.1	19.0	23.5	1		1.8	25.0	33.3	1	1.8	1		11.1	0	0.0	0.0	0		0.0	0.0	0.0	0.0
Exclusively MN	0		0.0		0.0	0		0.0		0.0	2	8.0	2		22.2	1	4.0		0		0.0			10.0
MN>2xMTW	0		0.0		0.0	0		0.0		0.0	4	18.2	4		44.4	3	13.6		3		13.6			30.0
MN=MTW	0		0.0		0.0	0		0.0		0.0	0	0.0	0		0.0	6	16.7		6		16.7			60.0
MTW>2xMN	3		5.8	17.6		17.6	0		0.0	0.0	3	5.8	3		33.3	0	0.0		0		0.0			0.0
Exclusively MTW	14		18.2	82.4		82.4	3		3.9	100.0	0	0.0	0		0.0	0	0.0		0		0.0			0.0
MN: MNT1+MNT2	3		2.2	14.3		17.6	0		0.0	0.0	9	6.7	9		90.0	10	7.4	100.0	10		7.4	100.0	100.0	100.0
Mean MN studies	1		0.7	2.4		2.9	0		0.0	0.0	6	8.0	6		61.7	68.5	9	11.3	9		86.7			86.7
MTW: MNT1+MNT2	17		9.1	81.0	100.0	3		1.6	75.0	100.0	7	3.7	7		70.0	77.8	9	4.8	9		90.0			90.0
Mean MTW studies	7		6.5	33.3	41.2	1		1.3	34.4	45.8	4	3.3	4		35.0	38.9	7	6.2	7		66.3			66.3

## APPENDIX 15C. Continued.

Data set <sup>a</sup>	Non-breeding visitors (all types of migrants & stragglers)					Non-territorial dispersing species (stragglers & short-distance migrants)					Non-territorial long-distance migrants					Long-distance migrants which establish temporary foraging territories				
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	% N MN+MTW <sup>e</sup>
Total records	66	24.6	100.0	275.0	43	16.0	100.0	268.8	20	7.5	100.0	400.0	3	1.1	100.0	100.0	100.0	100.0	100.0	100.0
MN+MTW studies	24	11.3	36.4	100.0	16	7.5	37.2	100.0	5	2.4	25.0	100.0	3	1.4	100.0	100.0	100.0	100.0	100.0	100.0
Additional records	42	75.0	63.6	175.0	27	48.2	62.8	168.8	15	26.8	75.0	300.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exclusively MN	14	56.0		58.3	10	40.0		62.5	4	16.0		80.0	0	0.0		0.0	0.0		0.0	0.0
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0.0		0.0	0.0
MN=MTW	2	5.6		8.3	2	5.6		12.5	0	0.0		0.0	0	0.0		0.0	0.0		0.0	0.0
MTW>2xMN	1	1.9		4.2	0	0.0		0.0	0	0.0		0.0	1	1.9		33.3	33.3		33.3	33.3
Exclusively MTW	7	9.1		29.2	4	5.2		25.0	1	1.3		20.0	2	2.6		66.7	66.7		66.7	66.7
MN: MNT1+MNT2	17	12.6	25.8	70.8	12	8.9	27.9	75.0	4	3.0	20.0	80.0	1	0.7	33.3	33.3	33.3		33.3	33.3
Mean MN studies	5	6.3	7.3	20.1	4	4.6	8.1	21.9	1	1.5	5.8	23.3	0	0.2	5.6	5.6	5.6		5.6	5.6
MTW: MNT1+MNT2	10	5.3	15.2	41.7	6	3.2	14.0	37.5	1	0.5	5.0	20.0	3	1.6	100.0	100.0	100.0		100.0	100.0
Mean MTW studies	3	2.3	3.8	10.4	1	1.3	3.2	8.6	0	0.2	1.3	5.0	1	0.8	29.2	29.2	29.2		29.2	29.2

## APPENDIX 16A

Standardized and non-standardized surveys of transect MNT1: influence of habitat selection on bird species detectability. Comparative effectiveness of the number of bird species detected per general habitat class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 85-88, Influence of habitat.). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha), were included (cf. Appendix 12a). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 8 for the habitat selection of each species.

Data set <sup>a</sup>	All species						Forest						Forest / open country edge						River and stream edges					
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N now <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N now <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	124.9	103	44.6	100.0	117.0	59	25.5	100.0	128.3	17	7.4	100.0	170.0								
MN+MTW studies	185	100.0	80.1	100.0	88	47.6	85.4	100.0	46	24.9	78.0	100.0	10	5.4	58.8	100.0								
Additional records	46	100.0	19.9	24.9	15	32.6	14.6	17.0	13	28.3	22.0	28.3	7	15.2	41.2	70.0								
Exclusively MN	23	100.0		12.4	10	43.5		11.4	6	26.1		13.0	2	8.7		20.0								
MN>2xMTW	19	100.0		10.3	10	52.6		11.4	1	5.3		2.2	2	10.5		20.0								
MN=MTW	30	100.0		16.2	16	53.3		18.2	8	26.7		17.4	3	10.0		30.0								
MTW>2xMN	45	100.0		24.3	17	37.8		19.3	14	31.1		30.4	0	0.0		0.0								
Exclusively MTW	68	100.0		36.8	35	51.5		39.8	17	25.0		37.0	3	4.4		30.0								
MN: MNT1/I	80	100.0	34.6	43.2	42	52.5	40.8	47.7	13	16.3	22.0	28.3	6	7.5	35.3	60.0								
MN: MNT1/II	88	100.0	38.1	47.6	42	47.7	40.8	47.7	25	28.4	42.4	54.3	6	6.8	35.3	60.0								
MN: MNT1/III	86	100.0	37.2	46.5	41	47.7	39.8	46.6	20	23.3	33.9	43.5	5	5.8	29.4	50.0								
MN: MNT1/II+III	117	100.0	50.6	63.2	53	45.3	51.5	60.2	29	24.8	49.2	63.0	7	6.0	41.2	70.0								
Mean MN study	85	100.0	36.7	45.8	42	49.2	40.5	47.3	19	22.8	32.8	42.0	6	6.7	33.3	56.7								
MTW: MNT1/I	105	100.0	45.5	56.8	51	48.6	49.5	58.0	25	23.8	42.4	54.3	4	3.8	23.5	40.0								
MTW: MNT1/2	111	100.0	48.1	60.0	53	47.7	51.5	60.2	29	26.1	49.2	63.0	3	2.7	17.6	30.0								
MTW: MNT1/3	120	100.0	51.9	64.9	61	50.8	59.2	69.3	29	24.2	49.2	63.0	5	4.2	29.4	50.0								
MTW: MNT1/4	126	100.0	54.5	68.1	60	47.6	58.3	68.2	35	27.8	59.3	76.1	6	4.8	35.3	60.0								
MTW: MNT1/I+2	130	100.0	56.3	70.3	63	48.5	61.2	71.6	33	25.4	55.9	71.7	5	3.8	29.4	50.0								
MTW: MNT1/3+4	151	100.0	65.4	81.6	73	48.3	70.9	83.0	38	25.2	64.4	82.6	8	5.3	47.1	80.0								
MTW: MNT1/I+4	162	100.0	70.1	87.6	78	48.1	75.7	88.6	40	24.7	67.8	87.0	8	4.9	47.1	80.0								
Mean MTW study	116	100.0	50.0	62.4	56	48.7	54.6	63.9	30	25.5	50.0	64.1	5	3.9	26.5	45.0								

## APPENDIX 16A. Continued.

Data set <sup>a</sup>	Open country and settlements				Species without habitat preferences			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	50	21.6	100.0	128.2	2	0.9	100.0	100.0
MN+MTW studies	39	21.1	78.0	100.0	2	1.1	100.0	100.0
Additional records	11	23.9	22.0	28.2	0	0.0	0.0	0.0
Exclusively MN	5	21.7		12.8	0	0.0		0.0
MN>2xMTW	6	31.6		15.4	0	0.0		0.0
MN=MTW	3	10.0		7.7	0	0.0		0.0
MTW>2xMN	14	31.1		35.9	0	0.0		0.0
Exclusively MTW	11	16.2		28.2	2	2.9		100.0
MN: MNT1/I	19	23.8	38.0	48.7	0	0.0	0.0	0.0
MN: MNT1/II	15	17.0	30.0	38.5	0	0.0	0.0	0.0
MN: MNT1/III	20	23.3	40.0	51.3	0	0.0	0.0	0.0
MN: MNT1/I-III	28	23.9	56.0	71.8	0	0.0	0.0	0.0
Mean MN study	18	21.3	36.0	46.2	0	0.0	0.0	0.0
MTW: MNT1/I	24	22.9	48.0	61.5	1	1.0	50.0	50.0
MTW: MNT1/2	26	23.4	52.0	66.7	0	0.0	0.0	0.0
MTW: MNT1/3	25	20.8	50.0	64.1	0	0.0	0.0	0.0
MTW: MNT1/4	23	18.3	46.0	59.0	2	1.6	100.0	100.0
MTW: MNT1/1+2	28	21.5	56.0	71.8	1	0.8	50.0	50.0
MTW: MNT1/3+4	30	19.9	60.0	76.9	2	1.3	100.0	100.0
MTW: MNT1/1-4	34	21.0	68.0	87.2	2	1.2	100.0	100.0
Mean MTW study	25	21.2	49.0	62.8	1	0.6	37.5	37.5

## APPENDIX 16B

Standardized and non-standardized surveys of transect MNT2: influence of habitat selection on bird species detectability. Comparative effectiveness of the number of bird species detected per general habitat class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 85-88, Influence of habitat). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT2 (transect area c. 14.1 ha), were included (cf. Appendix 12b). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 8 for the habitat selection of each species.

Data set <sup>a</sup>	All species						Forest						Forest / open country edge						River and stream edges					
	N			% N			N			% N			N			% N			N			% N		
	sp.	% N	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	% N	sp.	% N	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	% N	sp.	% N	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	% N	sp.	% N	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	% N
Total records	231	100.0		100.0	138.3		119	51.5		100.0	120.2		54	23.4		100.0	150.0		15	6.5		100.0	150.0	
MN+MTW studies	167	100.0		72.3	100.0		99	59.3		83.2	100.0		36	21.6		66.7	100.0		10	6.0		66.7	100.0	
Additional records	64	100.0		27.7	38.3		20	31.3		16.8	20.2		18	28.1		33.3	50.0		5	7.8		33.3	50.0	
Exclusively MN	23	100.0			13.8		9	39.1			9.1		7	30.4			19.4		2	8.7			20.0	
MN>2xMTW	15	100.0			9.0		9	60.0			9.1		4	26.7			11.1		1	6.7			10.0	
MN=MTW	31	100.0			18.6		22	71.0			22.2		6	19.4			16.7		2	6.5			20.0	
MTW>2xMN	27	100.0			16.2		16	59.3			16.2		5	18.5			13.9		0	0.0			0.0	
Exclusively MTW	71	100.0			42.5		43	60.6			43.4		14	19.7			38.9		5	7.0			50.0	
MN: MNT2/I	69	100.0		29.9	41.3		44	63.8		37.0	44.4		15	21.7		27.8	41.7		3	4.3		20.0	30.0	
MN: MNT2/II	65	100.0		28.1	38.9		45	69.2		37.8	45.5		12	18.5		22.2	33.3		2	3.1		13.3	20.0	
MN: MNT2/III	73	100.0		31.6	43.7		41	56.2		34.5	41.4		18	24.7		33.3	50.0		4	5.5		26.7	40.0	
MN: MNT2/I+III	96	100.0		41.6	57.5		56	58.3		47.1	56.6		22	22.9		40.7	61.1		5	5.2		33.3	50.0	
Mean MN study	69	100.0		29.9	41.3		43	62.8		36.4	43.8		15	21.7		27.8	41.7		3	4.3		20.0	30.0	
MTW: MNT2/I	86	100.0		37.2	51.5		54	62.8		45.4	54.5		18	20.9		33.3	50.0		4	4.7		26.7	40.0	
MTW: MNT2/2	93	100.0		40.3	55.7		62	66.7		52.1	62.6		16	17.2		29.6	44.4		4	4.3		26.7	40.0	
MTW: MNT2/3	112	100.0		48.5	67.1		75	67.0		63.0	75.8		22	19.6		40.7	61.1		5	4.5		33.3	50.0	
MTW: MNT2/4	104	100.0		45.0	62.3		69	66.3		58.0	69.7		17	16.3		31.5	47.2		5	4.8		33.3	50.0	
MTW: MNT2/I+2	112	100.0		48.5	67.1		71	63.4		59.7	71.7		22	19.6		40.7	61.1		6	5.4		40.0	60.0	
MTW: MNT2/3+4	132	100.0		57.1	79.0		86	65.2		72.3	86.9		25	18.9		46.3	69.4		7	5.3		46.7	70.0	
MTW: MNT2/I+4	144	100.0		62.3	86.2		90	63.5		75.6	90.9		29	20.1		53.7	80.6		8	5.6		53.3	80.0	
Mean MTW study	99	100.0		42.7	59.1		65	65.8		54.6	65.7		18	18.5		33.8	50.7		5	4.6		30.0	45.0	

## APPENDIX 16B. Continued.

Data set <sup>a</sup>	Open country and settlements				Species without habitat preferences				
	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	
Total records	38	16.5	100.0	181.0	5	2.2	100.0	500.0	
MN+MTW studies	21	12.6	55.3	100.0	1	0.6	20.0	100.0	
Additional records	17	26.6	44.7	81.0	4	6.3	80.0	400.0	
Exclusively MN	5	21.7		23.8	0	0.0		0.0	
MN>2xMTW	1	6.7		4.8	0	0.0		0.0	
MN=MTW	1	3.2		4.8	0	0.0		0.0	
MTW>2xMN	6	22.2		28.6	0	0.0		0.0	
Exclusively MTW	8	11.3		38.1	1	1.4		100.0	
MN: MNT2/I	7	10.1	18.4	33.3	0	0.0	0.0	0.0	
MN: MNT2/II	6	9.2	15.8	28.6	0	0.0	0.0	0.0	
MN: MNT2/III	10	13.7	26.3	47.6	0	0.0	0.0	0.0	
MN: MNT2/I-III	13	13.5	34.2	61.9	0	0.0	0.0	0.0	
Mean MN study	8	11.1	20.2	36.5	0	0.0	0.0	0.0	
MTW: MNT2/1	9	10.5	23.7	42.9	1	1.2	20.0	100.0	
MTW: MNT2/2	11	11.8	28.9	52.4	0	0.0	0.0	0.0	
MTW: MNT2/3	10	8.9	26.3	47.6	0	0.0	0.0	0.0	
MTW: MNT2/4	12	11.5	31.6	57.1	1	1.0	20.0	100.0	
MTW: MNT2/1+2	12	10.7	31.6	57.1	1	0.9	20.0	100.0	
MTW: MNT2/3+4	13	9.8	34.2	61.9	1	0.8	20.0	100.0	
MTW: MNT2/1-4	16	11.1	42.1	76.2	1	0.7	20.0	100.0	
Mean MTW study	11	10.6	27.6	50.0	1	0.5	10.0	50.0	



## APPENDIX 16C

Standardized and non-standardized surveys of the transects MNT1 and MNT2: influence of habitat selection on bird species detectability. Comparative effectiveness of the number of bird species detected per general habitat class during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of both transects (cf. p. 85-88, Influence of habitat). A total of 268 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha) and MNT2 (c. 14.1 ha), were included (cf. Appendices 12a and 12b). See Appendices 13a and 13c for details on the data sets and abbreviations used, and Appendix 9 for the habitat selection of each species.

Data set <sup>a</sup>	All species						Forest						Forest / open country edge						River and stream edges					
	N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.		N		% N		% N tot.	
	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	268	100.0	100.0	100.0	100.0	126.4	126	47.0	126	47.0	100.0	115.6	63	23.5	19	7.1	100.0	158.3	12	5.7	19	7.1	100.0	158.3
MN+MTW studies	212	100.0	79.1	100.0	79.1	100.0	109	51.4	109	51.4	86.5	100.0	49	23.1	12	5.7	63.2	100.0	7	2.5	12	5.7	63.2	100.0
Additional records	56	100.0	20.9	100.0	20.9	26.4	17	30.4	17	30.4	13.5	15.6	14	25.0	7	12.5	36.8	58.3	7	12.5	7	12.5	36.8	58.3
Exclusively MN	25	100.0				11.8	10	40.0	10	40.0		9.2	6	24.0	3	12.0		25.0	3	12.0	3	12.0		25.0
MN>2xMTW	22	100.0				10.4	11	50.0	11	50.0		10.1	3	13.6	2	9.1		16.7	2	9.1	2	9.1		16.7
MN=MTW	36	100.0				17.0	20	55.6	20	55.6		18.3	10	27.8	2	5.6		16.7	2	5.6	2	5.6		16.7
MTW>2xMN	52	100.0				24.5	26	50.0	26	50.0		23.9	11	21.2	1	1.9		8.3	1	1.9	1	1.9		8.3
Exclusively MTW	77	100.0				36.3	42	54.5	42	54.5		38.5	19	24.7	4	5.2		33.3	4	5.2	4	5.2		33.3
MN: MNT1+MNT2	135	100.0	50.4	100.0	50.4	63.7	67	49.6	67	49.6	53.2	61.5	30	22.2	8	5.9	42.1	66.7	8	5.9	8	5.9	42.1	66.7
Mean MN studies	77	100.0	28.7	100.0	28.7	36.2	43	55.3	43	55.3	33.7	39.0	17	22.3	4	5.6	22.8	36.1	4	5.6	4	5.6	22.8	36.1
MTW: MNT1+MNT2	187	100.0	69.8	100.0	69.8	88.2	99	52.9	99	52.9	78.6	90.8	43	23.0	9	4.8	47.4	75.0	9	4.8	9	4.8	47.4	75.0
Mean MTW studies	107	100.0	40.0	100.0	40.0	50.5	61	56.6	61	56.6	48.1	55.6	24	22.3	5	4.2	23.7	37.5	5	4.2	5	4.2	23.7	37.5

Data set <sup>a</sup>	Open country and settlements						Species without habitat preferences					
	N		% N		% N tot.		N		% N		% N tot.	
	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp. <sup>b</sup>	row <sup>c</sup>	sp. <sup>b</sup>	row <sup>c</sup>	records <sup>d</sup>	MN+MTW <sup>e</sup>
Total records	55	20.5	100.0	100.0	100.0	137.5	5	1.9	5	1.9	100.0	250.0
MN+MTW studies	40	18.9	72.7	100.0	72.7	100.0	2	0.9	2	0.9	40.0	100.0
Additional records	15	26.8	27.3	37.5	27.3	37.5	3	5.4	3	5.4	60.0	150.0
Exclusively MN	6	24.0				15.0	0	0.0	0	0.0		0.0
MN>2xMTW	6	27.3				15.0	0	0.0	0	0.0		0.0
MN=MTW	4	11.1				10.0	0	0.0	0	0.0		0.0
MTW>2xMN	14	26.9				35.0	0	0.0	0	0.0		0.0
Exclusively MTW	10	13.0				25.0	2	2.6	2	2.6		100.0
MN: MNT1+MNT2	30	22.2	54.5	100.0	54.5	75.0	0	0.0	0	0.0		0.0
Mean MN studies	13	16.7	23.3	32.1	23.3	32.1	0	0.0	0	0.0		0.0
MTW: MNT1+MNT2	34	18.2	61.8	85.0	61.8	85.0	2	1.1	2	1.1	40.0	100.0
Mean MTW studies	18	16.3	31.8	43.8	31.8	43.8	1	0.6	1	0.6	12.5	31.3

## APPENDIX 17A

Standardized and non-standardized surveys of transect MNT1: influence of main survey stratum on bird species detectability. Comparative effectiveness of the number of bird species detected per main survey stratum during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 88, Influence of main survey stratum). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha), were included (cf. Appendix 12a). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 9 for the use of strata by each species and the definition of the term 'main survey stratum'.

Data set <sup>a</sup>	All species						Ground						Undergrowth						Understory					
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	231	100.0	100.0	124.9	19	8.2	100.0	126.7	65	28.1	100.0	106.6	36	15.6	100.0	112.5	36	15.6	100.0	112.5	36	15.6	100.0	112.5
MN+MTW studies	185	100.0	80.1	100.0	15	8.1	78.9	100.0	61	33.0	93.8	100.0	32	17.3	88.9	100.0	32	17.3	88.9	100.0	32	17.3	88.9	100.0
Additional records	46	100.0	19.9	24.9	4	8.7	21.1	26.7	4	8.7	6.2	6.6	4	8.7	11.1	12.5	4	8.7	11.1	12.5	4	8.7	11.1	12.5
Exclusively MN	23	100.0	12.4	10.3	3	13.0	20.0	20.0	15	65.2	72.3	24.6	2	8.7	6.3	6.3	2	8.7	6.3	6.3	2	8.7	6.3	6.3
MN>2xMTW	19	100.0	10.3	10.3	1	5.3	6.7	6.7	11	57.9	18.0	18.0	5	26.3	15.6	15.6	5	26.3	15.6	15.6	5	26.3	15.6	15.6
MN=MTW	30	100.0	16.2	16.2	2	6.7	13.3	13.3	15	50.0	24.6	24.6	11	36.7	34.4	34.4	11	36.7	34.4	34.4	11	36.7	34.4	34.4
MTW>2xMN	45	100.0	24.3	24.3	2	4.4	13.3	13.3	16	35.6	26.2	26.2	6	13.3	18.8	18.8	6	13.3	18.8	18.8	6	13.3	18.8	18.8
Exclusively MTW	68	100.0	36.8	36.8	7	10.3	46.7	46.7	4	5.9	7.2	7.2	8	11.8	25.0	25.0	8	11.8	25.0	25.0	8	11.8	25.0	25.0
MN: MNT1/I	80	100.0	34.6	43.2	4	5.0	21.1	26.7	47	58.8	72.3	77.0	17	21.3	47.2	53.1	17	21.3	47.2	53.1	17	21.3	47.2	53.1
MN: MNT1/II	88	100.0	38.1	47.6	5	5.7	26.3	33.3	48	54.5	73.8	78.7	20	22.7	55.6	62.5	20	22.7	55.6	62.5	20	22.7	55.6	62.5
MN: MNT1/III	86	100.0	37.2	46.5	7	8.1	36.8	46.7	46	53.5	70.8	75.4	20	23.3	56.6	62.5	20	23.3	56.6	62.5	20	23.3	56.6	62.5
MN: MNT1/II-III	117	100.0	50.6	63.2	8	6.8	42.1	53.3	57	48.7	87.7	93.4	24	20.5	66.7	75.0	24	20.5	66.7	75.0	24	20.5	66.7	75.0
Mean MN study	85	100.0	36.7	45.8	5	6.3	28.1	35.6	47	55.5	72.3	77.0	19	22.4	52.8	59.4	19	22.4	52.8	59.4	19	22.4	52.8	59.4
MTW: MNT1/I	105	100.0	45.5	56.8	7	6.7	36.8	46.7	33	31.4	50.8	54.1	21	20.0	58.3	65.6	21	20.0	58.3	65.6	21	20.0	58.3	65.6
MTW: MNT1/2	111	100.0	48.1	60.0	7	6.3	36.8	46.7	36	32.4	55.4	59.0	24	21.6	66.7	75.0	24	21.6	66.7	75.0	24	21.6	66.7	75.0
MTW: MNT1/3	120	100.0	51.9	64.9	9	7.5	47.4	60.0	38	31.7	58.5	62.3	23	19.2	63.9	71.9	23	19.2	63.9	71.9	23	19.2	63.9	71.9
MTW: MNT1/4	126	100.0	54.5	68.1	9	7.1	47.4	60.0	39	31.0	60.0	63.9	21	16.7	58.3	65.6	21	16.7	58.3	65.6	21	16.7	58.3	65.6
MTW: MNT1/1+2	130	100.0	56.3	70.3	8	6.2	42.1	53.3	41	31.5	63.1	67.2	26	20.0	72.2	81.3	26	20.0	72.2	81.3	26	20.0	72.2	81.3
MTW: MNT1/3+4	151	100.0	65.4	81.6	11	7.3	57.9	73.3	46	30.5	70.8	75.4	28	18.5	77.8	87.5	28	18.5	77.8	87.5	28	18.5	77.8	87.5
MTW: MNT1/1-4	162	100.0	70.1	87.6	12	7.4	63.2	80.0	46	28.4	70.8	75.4	30	18.5	83.3	93.8	30	18.5	83.3	93.8	30	18.5	83.3	93.8
Mean MTW study	116	100.0	50.0	62.4	8	6.9	42.1	53.3	37	31.6	56.2	59.8	22	19.3	61.8	69.5	22	19.3	61.8	69.5	22	19.3	61.8	69.5

## APPENDIX 17A. Continued.

Data set <sup>a</sup>	Subcanopy				Canopy				Treetops, dead snags, and outer foliage				Airspace			
	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	30	13.0	100.0	120.0	43	18.6	100.0	126.5	14	6.1	100.0	200.0	24	10.4	100.0	218.2
MN+MTW studies	25	13.5	83.3	100.0	34	18.4	79.1	100.0	7	3.8	50.0	100.0	11	5.9	45.8	100.0
Additional records	5	10.9	16.7	20.0	9	19.6	20.9	26.5	7	15.2	50.0	100.0	13	28.3	54.2	118.2
Exclusively MN	3	13.0		12.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	1	5.3		2.9	1	5.3		14.3	0	0.0		0.0
MN=MTW	0	0.0		0.0	0	0.0		0.0	1	3.3		14.3	1	3.3		9.1
MTW>2xMN	7	15.6		28.0	10	22.2		29.4	3	6.7		42.9	1	2.2		9.1
Exclusively MTW	15	22.1		60.0	23	33.8		67.6	2	2.9		28.6	9	13.2		81.8
MN: MNT1/I	3	3.8	10.0	12.0	5	6.3	11.6	14.7	4	5.0	28.6	57.1	0	0.0	0.0	0.0
MN: MNT1/II	5	5.7	16.7	20.0	6	6.8	14.0	17.6	2	2.3	14.3	28.6	2	2.3	8.3	18.2
MN: MNT1/III	4	4.7	13.3	16.0	5	5.8	11.6	14.7	3	3.5	21.4	42.9	1	1.2	4.2	9.1
MN: MNT1/I-III	10	8.5	33.3	40.0	11	9.4	25.6	32.4	5	4.3	35.7	71.4	2	1.7	8.3	18.2
Mean MN study	4	4.7	13.3	16.0	5	6.3	12.4	15.7	3	3.5	21.4	42.9	1	1.2	4.2	9.1
MTW: MNT1/I	12	11.4	40.0	48.0	22	21.0	51.2	64.7	5	4.8	35.7	71.4	5	4.8	20.8	45.5
MTW: MNT1/2	16	14.4	53.3	64.0	18	16.2	41.9	52.9	5	4.5	35.7	71.4	5	4.5	20.8	45.5
MTW: MNT1/3	14	11.7	46.7	56.0	22	18.3	51.2	64.7	5	4.2	35.7	71.4	9	7.5	37.5	81.8
MTW: MNT1/4	19	15.1	63.3	76.0	23	18.3	53.5	67.6	7	5.6	50.0	100.0	8	6.3	33.3	72.7
MTW: MNT1/1+2	17	13.1	56.7	68.0	25	19.2	58.1	73.5	5	3.8	35.7	71.4	8	6.2	33.3	72.7
MTW: MNT1/3+4	20	13.2	66.7	80.0	28	18.5	65.1	82.4	7	4.6	50.0	100.0	11	7.3	45.8	100.0
MTW: MNT1/1-4	22	13.6	73.3	88.0	34	21.0	79.1	100.0	7	4.3	50.0	100.0	11	6.8	45.8	100.0
Mean MTW study	15	13.2	50.8	61.0	21	18.4	49.4	62.5	6	4.8	39.3	78.6	7	5.8	28.1	61.4

## APPENDIX 17B

Standardized and non-standardized surveys of transect MNT2: influence of main survey stratum on bird species detectability. Comparative effectiveness of the number of bird species detected per main survey stratum during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of the transect (cf. p. 88, Influence of main survey stratum). A total of 231 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT2 (transect area c. 14.1 ha), were included (cf. Appendix 12b). See Appendix 13a for details on the data sets and abbreviations used, and Appendix 9 for the use of strata by each species and the definition of the term 'main survey stratum'.

	All species						Ground						Undergrowth						Understory												
	N		% N tot.		% N		N		% N tot.		% N		N		% N tot.		N		% N tot.		N		% N tot.		N		% N tot.				
	sp.	b	row	c	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp.	b	row	c	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp.	b	row	c	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp.	b	row	c	records <sup>d</sup>	MN+MTW <sup>e</sup>	sp.	b	row	c	records <sup>d</sup>	MN+MTW <sup>e</sup>	
Data set <sup>a</sup>																															
Total records	231	100.0			100.0	138.3	17	7.4			100.0	113.3	62	26.8			100.0	112.7	34	14.7			100.0	113.3						113.3	
MN+MTW studies	167	100.0			72.3	100.0	15	9.0			88.2	100.0	55	32.9			88.7	100.0	30	18.0			88.2	100.0						100.0	
Additional records	64	100.0			27.7	38.3	2	3.1			11.8	13.3	7	10.9			11.3	12.7	4	6.3			11.8	13.3						13.3	
Exclusively MN	23	100.0				13.8	1	4.3				6.7	13	56.5				23.6	6	26.1				20.0						20.0	
MN>2xMTW	15	100.0				9.0	1	6.7				6.7	9	60.0				16.4	5	33.3				16.7						16.7	
MN=MTW	31	100.0				18.6	3	9.7				20.0	20.0	19	61.3			34.5	5	16.1				16.7						16.7	
MTW>2xMN	27	100.0				16.2	2	7.4				13.3	10	37.0				18.2	8	29.6				26.7						26.7	
Exclusively MTW	71	100.0				42.5	8	11.3				53.3	4	5.6				7.3	6	8.5				20.0						20.0	
MN; MNT/2/I	69	100.0			29.9	41.3	6	8.7			35.3	40.0	44	63.8			71.0	80.0	13	18.8			38.2	43.3						43.3	
MN; MNT/2/II	65	100.0			28.1	38.9	6	9.2			35.3	40.0	39	60.0			62.9	70.9	15	23.1			44.1	50.0						50.0	
MN; MNT/2/III	73	100.0			31.6	43.7	3	4.1			17.6	20.0	45	61.6			72.6	81.8	19	26.0			55.9	63.3						63.3	
MN; MNT/2/I-III	96	100.0			41.6	57.5	7	7.3			21.2	46.7	51	53.1			82.3	92.7	24	25.0			70.6	80.0						80.0	
Mean MN study	69	100.0			29.9	41.3	5	7.2			29.4	33.3	43	61.8			68.8	77.6	16	22.7			46.1	52.2						52.2	
MTW; MNT/2/I	86	100.0			37.2	51.5	7	8.1			41.2	46.7	34	39.5			54.8	61.8	19	22.1			55.9	63.3						63.3	
MTW; MNT/2/2	93	100.0			40.3	55.7	9	9.7			52.9	60.0	34	36.6			54.8	61.8	19	20.4			55.9	63.3						63.3	
MTW; MNT/2/3	112	100.0			48.5	67.1	12	10.7			70.6	80.0	38	33.9			61.3	69.1	18	16.1			52.9	60.0						60.0	
MTW; MNT/2/4	104	100.0			45.0	62.3	13	12.5			76.5	86.7	35	33.7			56.5	63.6	18	17.3			52.9	60.0						60.0	
MTW; MNT/2/I+2	112	100.0			48.5	67.1	9	8.0			52.9	60.0	37	33.0			59.7	67.3	23	20.5			67.6	76.7						76.7	
MTW; MNT/2/3+4	132	100.0			57.1	79.0	14	10.6			82.4	93.3	39	29.5			62.9	70.9	21	15.9			61.8	70.0						70.0	
MTW; MNT/2/I-4	144	100.0			62.3	86.2	14	9.7			82.4	93.3	42	29.2			67.7	76.4	24	16.7			70.6	80.0						80.0	
Mean MTW study	99	100.0			42.7	59.1	10	10.4			60.3	68.3	35	35.7			56.9	64.1	19	18.7			54.4	61.7						61.7	

## APPENDIX 17B. Continued.

Data set <sup>a</sup>	Subcanopy				Canopy				Treetops, dead snags, and outer foliage				Airspace			
	N sp. <sup>b</sup>	% N row. <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row. <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row. <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>	N sp. <sup>b</sup>	% N row. <sup>c</sup>	% N tot. records <sup>d</sup>	% N MN+MTW <sup>e</sup>
Total records	36	15.6	100.0	144.0	37	16.0	100.0	142.3	15	6.5	100.0	300.0	30	13.0	100.0	272.7
MN+MTW studies	25	15.0	69.4	100.0	26	15.6	70.3	100.0	5	3.0	33.3	100.0	11	6.6	36.7	100.0
Additional records	11	17.2	30.6	44.0	11	17.2	29.7	42.3	10	15.6	66.7	200.0	19	29.7	63.3	172.7
Exclusively MN	0	0.0		0.0	2	8.7		7.7	1	4.3		20.0	0	0.0		0.0
MN>2xMTW	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0
MN=MTW	3	9.7		12.0	1	3.2		3.8	0	0.0		0.0	0	0.0		0.0
MTW>2xMN	3	11.1		12.0	2	7.4		7.7	2	7.4		40.0	0	0.0		0.0
Exclusively MTW	19	26.8		76.0	21	29.6		80.8	2	2.8		40.0	11	15.5		100.0
MN: MNT2/I	1	1.4	2.8	4.0	4	5.8	10.8	15.4	1	1.4	6.7	20.0	0	0.0	0.0	0.0
MN: MNT2/II	3	4.6	8.3	12.0	0	0.0	0.0	0.0	2	3.1	13.3	40.0	0	0.0	0.0	0.0
MN: MNT2/III	3	4.1	8.3	12.0	1	1.4	2.7	3.8	2	2.7	13.3	40.0	0	0.0	0.0	0.0
MN: MNT2/I-III	6	6.3	16.7	24.0	5	5.2	13.5	19.2	3	3.1	20.0	60.0	0	0.0	0.0	0.0
Mean MN study	2	3.4	6.5	9.3	2	2.4	4.5	6.4	2	2.4	11.1	33.3	0	0.0	0.0	0.0
MTW: MNT2/I	8	9.3	22.2	32.0	12	14.0	32.4	46.2	1	1.2	6.7	20.0	5	5.8	16.7	45.5
MTW: MNT2/2	14	15.1	38.9	56.0	11	11.8	29.7	42.3	3	3.2	20.0	60.0	3	3.2	10.0	27.3
MTW: MNT2/3	16	14.3	44.4	64.0	17	15.2	45.9	65.4	2	1.8	13.3	40.0	9	8.0	30.0	81.8
MTW: MNT2/4	18	17.3	50.0	72.0	11	10.6	29.7	42.3	2	1.9	13.3	40.0	7	6.7	23.3	63.6
MTW: MNT2/1+2	16	14.3	44.4	64.0	18	16.1	48.6	69.2	3	2.7	20.0	60.0	6	5.4	20.0	54.5
MTW: MNT2/3+4	22	16.7	61.1	88.0	22	16.7	59.5	84.6	3	2.3	20.0	60.0	11	8.3	36.7	100.0
MTW: MNT2/1-4	25	17.4	69.4	100.0	24	16.7	64.9	92.3	4	2.8	26.7	80.0	11	7.6	36.7	100.0
Mean MTW study	14	14.2	38.9	56.0	13	12.9	34.5	49.0	2	2.0	13.3	40.0	6	6.1	20.0	54.5

## APPENDIX 17C

Standardized and non-standardized surveys of the transects MNT1 and MNT2: influence of main survey stratum on bird species detectability. Comparative effectiveness of the number of bird species detected per main survey stratum during standardized mist-netting and transect-mapping (MTW) surveys, the complete standardized studies, as well as during non-standardized mist-netting and observation hours, and the complete study of both transects (cf. p. 85-88, Influence of main survey stratum). A total of 268 bird species, recorded between Aug. 1995 and Mar. 1998 within 100 m of MNT1 (transect area c. 15.6 ha) and MNT2 (c. 14.1 ha), were included (cf. Appendices 12a and 12b). See Appendices 13a and 13c for details on the data sets and abbreviations used, and Appendix 9 for the use of strata by each species and the definition of the term 'main survey stratum'.

Data set <sup>a</sup>	All species						Ground						Ungrowth						Understory					
	N			% N			% N			% N			% N			% N			% N			% N		
	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>
Total records	268	100.0	100.0	126.4	22	8.2	100.0	129.4	72	26.9	100.0	109.1	39	14.6	100.0	108.3								
MN+MTW studies	212	100.0	79.1	100.0	17	8.0	77.3	100.0	66	31.1	91.7	100.0	36	17.0	92.3	100.0								
Additional records	56	100.0	20.9	26.4	5	8.9	22.7	29.4	6	10.7	8.3	9.1	3	5.4	7.7	8.3								
Exclusively MN	25	100.0	11.8	3	12.0	17.6	14	56.0	21.2	4	16.0	11.1												
MN>2xMTW	22	100.0	10.4	1	4.5	5.9	13	59.1	19.7	6	27.3	16.7												
MN=MTW	36	100.0	17.0	2	5.6	11.8	20	55.6	30.3	9	25.0	25.0												
MTW>2xMN	52	100.0	24.5	4	7.7	23.5	14	26.9	21.2	11	21.2	30.6												
Exclusively MTW	77	100.0	36.3	7	9.1	41.2	5	6.5	7.6	6	7.8	16.7												
MN: MNT1+MNT2	135	100.0	50.4	63.7	10	7.4	45.5	58.8	61	45.2	84.7	92.4	30	22.2	76.9	83.3								
Mean MN studies	77	100.0	28.7	36.2	5	6.7	23.5	30.4	45	58.4	62.3	67.9	17	22.6	44.4	48.1								
MTW: MNT1+MNT2	187	100.0	69.8	88.2	14	7.5	63.6	82.4	52	27.8	72.2	78.8	32	17.1	82.1	88.9								
Mean MTW studies	107	100.0	40.0	50.5	9	8.5	41.5	53.7	36	33.5	49.8	54.4	20	19.0	52.2	56.6								

Data set <sup>a</sup>	Subcanopy						Canopy						Treetops, dead snags, and outer foliage						Airspace					
	N			% N			% N			% N			% N			% N			% N			% N		
	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>	sp. <sup>b</sup>	row <sup>c</sup>	tot. <sup>d</sup>
Total records	39	14.6	100.0	118.2	45	16.8	100.0	118.4	19	7.1	100.0	211.1	32	11.9	100.0	246.2								
MN+MTW studies	33	15.6	84.6	100.0	38	17.9	84.4	100.0	9	4.2	47.4	100.0	13	6.1	40.6	100.0								
Additional records	6	10.7	15.4	18.2	7	12.5	15.6	18.4	10	17.9	52.6	111.1	19	33.9	59.4	146.2								
Exclusively MN	3	12.0		9.1	0	0.0		0.0	1	4.0		11.1	0	0.0		0.0								
MN>2xMTW	0	0.0		0.0	1	4.5		2.6	1	4.5		11.1	0	0.0		0.0								
MN=MTW	2	5.6		6.1	2	5.6		5.3	1	2.8		11.1	0	0.0		0.0								
MTW>2xMN	7	13.5		21.2	10	19.2		26.3	4	7.7		44.4	2	3.8		15.4								
Exclusively MTW	21	27.3		63.6	25	32.5		65.8	2	2.6		22.2	11	14.3		84.6								
MN: MNT1+MNT2	12	8.9	30.8	36.4	13	9.6	28.9	34.2	7	5.2	36.8	77.8	2	1.5	6.3	15.4								
Mean MN studies	3	4.1	8.1	9.6	4	4.6	7.8	9.2	2	3.0	12.3	25.9	1	0.7	1.6	3.8								
MTW: MNT1+MNT2	30	16.0	76.9	90.9	38	20.3	84.4	100.0	8	4.3	42.1	88.9	13	7.0	40.6	100.0								
Mean MTW studies	15	13.7	37.5	44.3	17	15.9	37.8	44.7	4	3.5	19.7	41.7	6	6.0	19.9	49.0								

## APPENDIX 18A

MTW-study: detection threshold distance, abundance, population density, and biomass of the bird community in the transect area of MNT1. The detection threshold distances and effective detection areas are shown for all 268 bird species recorded between Aug. 1995 and Mar. 1998 within 100 m of the transects MNT1 and MNT2 (see Appendix 12a for details). For species recorded only in the transect area of MNT2, the values are stated in '[...]' brackets. The population data are shown exclusively for the 162 species recorded in the MTW study of MNT1 between Feb. and Nov. 1997. The results may not be representative for other areas of Playa de Oro, even where similar habitat is present (e.g., continuous *terra firme* forest), and should be regarded as preliminary. Whenever I assumed that abundance, population density, and biomass density were considerably overestimated due to methodological biases or small sample size, the results are written in italics. Abbreviations used and explanations: (a) body mass: here, I used the mean values for unsexed samples (cf. Appendices 9 and 11); (b) average detection threshold distance (Ave. DTD): estimated mean perpendicular distance from the transect for which as many individuals of a certain species are detected beyond as are missed within; approximately the distance at which the loudest common sounds emitted by a bird species first become audible to an experienced observer under average environmental conditions (meteorological and topographical conditions, level of background noise, etc.); in general, the DTDs stated here refer to the main habitat of each species, e.g., wet tropical forest in the case of forest species and semi-open country in the case of non-forest species; for species usually not detected by voice but visually (compare column 'type of record' in Appendix 6), I used a corresponding estimate of a 'visual' DTD, which was explicitly adapted to the environmental conditions of the transect areas of MNT1 and MNT2; i.e., the visual DTD for the Cathartidae was greater for MNT1 than for MNT2 (200 vs. 150 m, respectively), due to the fact that the landscape at the former transect was more open than at the latter, so that large soaring birds could be recorded there at a greater distance; (c) effective detection threshold distance (Eff. DTD): the probability of detecting territories that are located at the periphery of the detection area of a transect increases with the number of MTW surveys carried out; therefore, the effective DTD increases accordingly; in the case of MNT1, the effective DTD was obtained by adding 30.5 % to the value of the average DTD (see p. 113 for details); the same percentage was used for species for which the calculation was founded on the number of displaying males, because their number was determined on the basis of four complete MTW surveys; thus, I assumed that the relationship between average DTD and effective DTD would be similar as in species establishing territories in pairs or family groups; for species that could not be analyzed in units of territories or displaying males, the effective DTD is identical to the average DTD and, for that reason, was not stated for them; (d) effective detection area (Eff. DA): the area effectively surveyed for each species in the complete MTW-study, calculated as the product of twice the effective DTD (or the 'average DTD' for species that could not be analyzed in units of territories or displaying males) and the transect length (here 625 m); the product was divided by 10 000 in order to obtain the result in 'hectares'; (e) number of territories (No. terr.): for species establishing and vocally advertising territories in pairs or family groups, the number of territories was determined by putting each record on a map; records obtained in different transect sections but during the same sample and observations of intra-specific territorial disputes, as well as the accumulation of records obtained during different MTW samples, facilitated the determination of the tentative limits between territories and their number; territories located at the ends of the transect were counted in 1/4-fractions of one territory (e.g., 0.25, 0.50, and 0.75 territories), depending on their relative size and position; likewise, territories much larger than the 'effective detection area' were also counted in 1/4-fractions of one territory; (f) number of displaying males (No. displ. MM): for species of which the males establish and vocally advertise display territories (e.g., *Lophortyx pileatus*) or leks (e.g., some Pipridae) in order to attract females, I used the maximum number of displaying males recorded during single MTW samples at the lek sites or in display territories for the calculation of the population data; for these species all records of females, which in contrast to the males are basically silent, were ignored; for species of which individuals of both sexes vocalize frequently also apart from leks (e.g., hummingbirds), as well as for species that are usually silent, I used other methods (see below); (g) units per kilometer transect (Units/km trans.): number of territories or displaying males per kilometer transect; (h) units per km<sup>2</sup> (Units/km<sup>2</sup>): number of territories or displaying males per square kilometer; calculated by multiplying the effective detection area's fraction of one square kilometer by the number of territories or the number of displaying males recorded; (i) units per transect area (Units/trans. area): number of territories or

displaying males per transect area, which is defined as the area within 100 m of the transect; the transect area of MNT1 was c. 15.6 ha and is shown in Fig. 5; (j) individuals per unit (Ind./unit): factor for the calculation of the total number of individuals per area (absolute population density); in general, I used a factor of 2.5 individuals per unit, assuming equal sex ratio and that, based on a year-round average, about one juvenile or immature is present per two reproductive pairs; in the case of species regularly forming extended family groups (*Odontophorus*, *Pteroglossus*, *Ramphastos*, *Querula*, *Campylorhynchus*, and others), I used the estimated average number of individuals per group for the calculations; (k) maximum number of individuals (Max. no. ind.): for a few resident species that rarely vocalize and, in addition, may not form pairs (e.g., *Terenotriccus* and *Myiobius* flycatchers), I used the maximum number of unsexed/unaged individuals recorded during the MTW study for the calculations; (l) average number of individuals (Ave. no. ind.): for the following species and bird groups I used the average maximum number of unsexed/unaged individuals recorded in the MTW surveys for the calculations: (1) mostly silent species with large home ranges, which may form foraging associations (e.g., Cathartidae); (2) hummingbirds, because they are fast moving, often erratic in occurrence, do not form permanent pairs, and in most species both sexes vocalize rather frequently; (3) species frequently participating in erratically moving foraging flocks (e.g., swifts, parrots, swallows, and a few tanager species); (4) non-breeding visitors not always present in the transect area (e.g., stragglers and migrants); (m) number of individuals per km transect (No. ind./km): the number of individuals per kilometer transect; either the maximum or average number of individuals, depending on the species or bird group (see above); only stated for species that could not be analyzed in units of territories or displaying males; (n) number of individuals per km<sup>2</sup> (No. ind./km<sup>2</sup>): absolute population density within an area of one square kilometer; for species that could be analyzed in units of territories or displaying males, it was calculated by multiplying the units per square kilometer by the number of individuals per unit; for species that could not be analyzed in units of territories or displaying males, it was calculated by multiplying the effective detection areas fraction of one square kilometer by either the maximum number of individuals or the average number of individuals (see above); (o) number of individuals per transect area (No. ind./trans. area): absolute population density within the transect area of c. 15.6 ha; (p) biomass density: here, calculated as the product of the mean body mass in grams and the number of individuals per square kilometer. See p. 110-115, Estimation of population densities on the basis of transect-mapping data, for further details on the methodology used for the calculation of the population data and p. 164-166, How real are the modeled community data based on transect mapping?, on identified biases.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup> trans.	Units/ <sup>i</sup> trans. area	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass P density (g/km <sup>2</sup> )
<b>TINAMIDAE (3)</b>															
<i>Tinamus major</i>	[1052]	[400]	[522.0]	[65.3]											
<i>Crypturellus berlepschi</i>	523	200	261.0	32.6	0.50		0.8	1.5	0.2	2.5			3.8	0.6	2005.8
<i>Crypturellus soui</i>	217	275	358.9	44.9	5.00		8.0	11.1	1.7	2.5			27.9	4.3	6046.7
<b>ARDEIDAE (1)</b>															
<i>Buorides striata</i>	212	40		5.0											
<b>CATHARTIDAE (3)</b>															
<i>Sarcocamphus papa</i>	3375	200		25.0											
<i>Coragyps atratus</i>	[2081]	[200]		[25.0]											
<i>Cathartes aura</i>	1467	200		25.0											
<b>ACCIPITRIDAE (12)</b>															
<i>Pandion haliaetus</i>	1486	200		25.0											
<i>Leptodon cayanensis</i>	[484]	[400]	[522.0]	[65.3]											
<i>Elanoides forficatus</i>	442	175		21.9											
<i>Ictinia plumbea</i>	247	175		21.9											



## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind. <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<i>Accipiter superciliosus</i>	[98]	[100]	[130.5]	[16.3]												
<i>Accipiter bicolor</i>	[341]	[325]	[424.1]	[53.0]												
<i>Leucopernis plumbeus</i>	[482]	[375]	[489.4]	[61.2]												
<i>Leucopernis empiplumbus</i>	[288]	[325]	[424.1]	[53.0]												
<i>Leucopernis princeps</i>	1000	400		50.0	1.00		1.6	2.0	0.3	2.5				5.1	0.8	1374.2
<i>Buteo magnirostris</i>	269	300	391.5	48.9												
<i>Buteo brachyurus</i>	495	225		28.1												
<i>Spizella tyrannus</i>	1035	500	652.5	81.6												
FALCONIDAE (5)																
<i>Micrastur ruficollis</i>	[179]	[225]	[293.6]	[36.7]												
<i>Micrastur semitorquatus</i>	[702]	[400]	[522.0]	[65.3]												
<i>Herpotheres achimans</i>	668	450	587.3	73.4	0.25		0.4	0.3	0.1	2.5				0.9	0.1	568.8
<i>Falco rufigularis</i>	[166]	[200]	[261.0]	[32.6]												
<i>Falco peregrinus</i>	[782]	[200]		[25.0]												
CRACIDAE (2)																
<i>Oridalis erythrops</i>	632	250		31.3												
<i>Penelope purpurascens</i>	2060	250		31.3												
ONOSTORHIDAE (2)																
<i>Odonophorus erythrops</i>	280	325	424.1	53.0	2.25		3.6	4.2	0.7	4.0				17.0	2.6	4753.3
<i>Rhynchortyx cinctus</i>	158	275	358.9	44.9	3.25		5.2	7.2	1.1	2.5				18.1	2.8	2861.7
RALLIDAE (3)																
<i>Laterallus albigularis</i>	47	150	195.8	24.5	4.00		6.4	16.3	2.6	2.5				40.9	6.4	1920.8
<i>Amazilia concolor</i>	133	200	261.0	32.6	2.00		3.2	6.1	1.0	2.5				15.3	2.4	2038.3
<i>Neotrex colombiana</i>	73	20	26.1	3.3												
SCOLOPACIDAE (1)																
<i>Actitis macularia</i>	40	60		7.5												
COLUMBIDAE (7)																
<i>Pangaea speciosa</i>	244	125	163.1	20.4	2.50		4.0	12.3	1.9	2.5				30.7	4.8	7478.9
<i>Pangaea subrupea</i>	172	250	326.3	40.8	3.00		4.8	7.4	1.1	2.5				18.4	2.9	3163.2
<i>Pangaea goodsoni</i>	134	200	261.0	32.6	3.00		4.8	9.2	1.4	2.5				23.0	3.6	3080.5
<i>Clavis pretiosa</i>	67	225		28.1												
<i>Lepidoptila</i>	157	150	195.8	24.5	8.50		13.6	34.7	5.4	2.5				86.8	13.5	13 634.7
<i>Geotrygon venegensis</i>	152	25	32.6	4.1	1.00		1.6	24.5	3.8	2.5				67.3	9.6	9318.0
<i>Geotrygon montana</i>	117	125	163.1	20.4												
PSITTACIDAE (6)																
<i>Ara ambiguus</i>	1348	400		50.0												
<i>Touit dilectissimus</i>	65	275		34.4												
<i>Pionopsitta pulchra</i>	150	225		28.1										3.50	5.6	1866.7
<i>Pionus menstruus</i>	247	300		37.5										4.50	7.2	2964.0
<i>Pionus chalcopernus</i>	210	300		37.5										2.50	4.0	1400.0
<i>Amazona farina</i>	610	450		56.3										1.25	2.0	1355.6

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass P <sup>p</sup> density (g/km <sup>2</sup> )
CUCULIDAE (6)															
<i>Piaya cayana</i>	108	110	143.6	17.9	2.00		3.2	11.1	1.7	2.5			27.9	4.3	3009.4
<i>Piaya minuta</i>	35	60	78.3	9.8	1.00		1.6	10.2	1.6	2.5			25.5	4.0	894.0
<i>Crotophaga ani</i>	105	90		11.3											
<i>Crotophaga sulcirostris</i>	[82]	[90]		[11.3]											
<i>Tapera naevia</i>	52	250	326.3	40.8											
<i>Neomorphus radiolatus</i>	[340]	[125]	[163.1]	[20.4]											
STRIGIDAE (4)															
<i>Megascops centralis</i>	[105]	[125]	[163.1]	[20.4]											
<i>Glauclidium grisiceps</i>	[51]	[250]	[326.3]	[40.8]											
<i>Pulsatrix perspicillata</i>	[87.3]	[300]	[391.5]	[48.9]											
<i>Strix virgata</i>	250	225	293.6	36.7	0.50		0.8	1.4	0.2	2.5			3.4	0.5	851.4
NYCTIBIDAE (1)															
<i>Nyctibius griseus</i>	185	200	261.0	32.6	0.50		0.8	1.5	0.2	2.5			3.8	0.6	708.8
CAPRIMULGIDAE (2)															
<i>Nyctidromus albigollis</i>	53	225	293.6	36.7	1.25		2.0	3.4	0.5	2.5			8.5	1.3	451.3
<i>Nyctiphrynus rosenbergi</i>	52	200	261.0	32.6	1.50		2.4	4.6	0.7	2.5			11.5	1.8	597.7
APODIDAE (6)															
<i>Streptoprocne zonaris</i>	98	150		18.8							2.75	4.4	14.7	2.3	1437.3
<i>Cypseloides nutilus</i>	[21]	[125]		[15.6]											
<i>Chaetura pelagica</i>	24	75		9.4	24						7.25	11.6	77.3	12.1	1856.0
<i>Chaetura spinicaudus</i>	15	50		6.3							10.25	16.4	164.0	25.6	2460.0
<i>Chaetura cinereiventris</i>	[14]	[75]		[9.4]											
<i>Panyptila cayennensis</i>	21	60		7.5							0.75	1.2	10.0	1.6	210.0
TROCHILIDAE (15)															
<i>Glaucois aeneus</i>	5	55		6.9							0.25	0.4	3.6	0.6	18.2
<i>Threnetes ruckeri</i>	6.5	60		7.5							9.25	14.8	123.3	19.2	801.7
<i>Phaethornis yaruqui</i>	6	85		10.6							3.75	6.0	35.3	5.5	211.8
<i>Phaethornis strigularis</i>	2.5	35		4.4							1.00	1.6	22.9	3.6	57.1
<i>Eutoxeres aquila</i>	11	55		6.9											
<i>Androdon aequatorialis</i>	7.5	100		12.5							0.50	0.8	4.0	0.6	30.0
<i>Florisuga mellivora</i>	7.5	60		7.5							0.25	0.4	3.3	0.5	25.0
<i>Popelairia conversii</i>	3	30		3.8							0.25	0.4	6.7	1.0	20.0
<i>Thalurania fannyi</i>	4.5	50		6.3											
<i>Damaphila julie</i>	3	35		4.4							0.25	0.4	5.7	0.9	17.1
<i>Amazilia tzacatl</i>	5	60		7.5							2.50	4.0	33.3	5.2	166.7
<i>Amazilia anabialis</i>	4.5	40		5.0											
<i>Amazilia rosenbergi</i>	4	55		6.9							5.75	9.2	83.6	13.0	334.5
<i>Chalybura urochrysa</i>	7	45		5.6											
<i>Heliothryx barroti</i>	5	40		5.0							2.25	3.6	45.0	7.0	225.0

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind. <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<b>TROGONIDAE (3)</b>																
<i>Trogon comptus</i>	104	225	293.6	36.7	0.50		0.8	1.4	0.2	2.5				3.4	0.5	354.2
<i>Trogon chionurus</i>	88	200	261.0	32.6	2.50		4.0	7.7	1.2	2.5				19.2	3.0	1685.8
<i>Trogon rufus</i>	58	200	261.0	32.6												
<b>ALCEDINIDAE (4)</b>																
<i>Megasceryle torquata</i>	317	150	195.8	24.5												
<i>Chlomeryle americana</i>	37.5	60	78.3	9.8												
<i>Chlomeryle inda</i>	56.5	60	78.3	9.8												
<i>Chlomeryle aenea</i>	[15]	[30]	[39.2]	[4.9]												
<b>MOMOTIDAE (2)</b>																
<i>Electron platyrhynchos</i>	76	250	326.3	40.8	0.50		0.8	1.2	0.2	2.5				3.1	0.5	233.0
<i>Barphibengus martii</i>	142	250	326.3	40.8	1.50		2.4	3.7	0.6	2.5				9.2	1.4	1305.7
<b>GALBULIDAE (1)</b>																
<i>Galbula ruficauda</i>	26	175	228.4	28.5	2.25		3.6	7.9	1.2	2.5				19.7	3.1	512.3
<b>BUCCONIDAE (3)</b>																
<i>Nyctalus radiatus</i>	61	175	228.4	28.5	1.00		1.6	3.5	0.5	2.5				8.8	1.4	534.2
<i>Malacoptila panamensis</i>	41	40	52.2	6.5	2.00		3.2	30.7	4.8	2.5				76.6	12.0	3141.8
<i>Micromonacha lanceolata</i>	[19]	[75]	[97.9]	[12.2]												
<b>CARTONIDAE (1)</b>																
<i>Capito squamatus</i>	58	60	78.3	9.8	1.00		1.6	10.2	1.6	3.5				35.8	5.6	2074.1
<b>RAMPHASTIDAE (3)</b>																
<i>Pteroglossus sanguineus</i>	250	175	228.4	28.5	1.00		1.6	3.5	0.5	4.0				14.0	2.2	3500.0
<i>Ramphastos brevis</i>	424	325	424.1	53.0	0.50		0.8	0.9	0.1	3.5				3.3	0.5	1399.6
<i>Ramphastos swainsonii</i>	622	450	587.3	73.4	1.00		1.6	1.4	0.2	3.5				4.8	0.7	2965.7
<b>PICIDAE (8)</b>																
<i>Picumnus olivaceus</i>	12	35	45.7	5.7	1.25		2.0	21.9	3.4	2.5				54.7	8.5	656.8
<i>Picus liae</i>	53	100	130.5	16.3												
<i>Celex loriatius</i>	77	225	293.6	36.7	0.50		0.8	1.4	0.2	2.5				3.4	0.5	262.2
<i>Dryocopus lineatus</i>	184	250	326.3	40.8	1.00		1.6	2.5	0.4	2.5				6.1	1.0	1128.0
<i>Melanerpes pucherani</i>	63	175	228.4	28.5	2.00		3.2	7.0	1.1	2.5				17.5	2.7	1103.4
<i>Veniliornis kirkii</i>	37	125	163.1	20.4	1.00		1.6	4.9	0.8	2.5				12.3	1.9	453.6
<i>Veniliornis collonotus</i>	27	125	163.1	20.4	1.00		1.6	4.9	0.8	2.5				12.3	1.9	331.0
<i>Campephilus guyanensis</i>	242	225	293.6	36.7												
<b>FURNARIIDAE (5)</b>																
<i>Synallaxis brachyura</i>	19	60	78.3	9.8	7.00		11.2	71.5	11.2	2.5				178.8	27.9	3397.2
<i>Flycatcher virgatus</i>	34	200	261.0	32.6	1.50		2.4	4.6	0.7	2.5				11.5	1.8	390.8
<i>Automolus rubiginosus</i>	44	125	163.1	20.4	2.00		3.2	9.8	1.5	2.5				24.5	3.8	1078.9
<i>Xenops minutus</i>	12	75	97.9	12.2	2.00		3.2	16.3	2.6	2.5				40.9	6.4	490.4
<i>Sclerurus mexicanus</i>	[25]	[200]	[261.0]	[32.6]												
<b>DENDROCOLAPTIDAE (8)</b>																
<i>Dendrocincla fuliginosa</i>	39	150	195.8	24.5	1.00		1.6	4.1	0.6	2.5				10.2	1.6	398.5
<i>Glyphornis pitarus</i>	14	60	78.3	9.8	2.50		4.0	25.5	4.0	2.5				63.9	10.0	894.0

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<i>Dendrocolaptes sanctithomae</i>	68	125	163.1	20.4	0.50		0.8	2.5	0.4	2.5			6.1		1.0	416.9
<i>Xiphorhynchus lachrymosus</i>	56	175	228.4	28.5	2.00		3.2	7.0	1.1	2.5			17.5	2.7		980.8
<i>Xiphorhynchus erythrops</i>	48	100	130.5	16.3	0.75		1.2	4.6	0.7	2.5			11.5	1.8		551.7
<i>Lepidocolaptes sudleyi</i>	27.5	125	163.1	20.4	0.25		0.4	1.2	0.2	2.5			3.1	0.5		84.3
<i>Campylorhynchus trochilostrius</i>	42	150	195.8	24.5	1.00		1.6	4.1	0.6	2.5			10.2		1.6	429.1
<i>Campylorhynchus pusillus</i>	[40]	[125]	[163.1]	[20.4]												
THAMNOPHILIDAE (18)																
<i>Cymbilaimus lineatus</i>	35	110	143.6	17.9	1.00		1.6	5.6	0.9	2.5			13.9		2.2	487.6
<i>Taraba major</i>	60	200	261.0	32.6	1.75		2.8	5.4	0.8	2.5			13.4	2.1		804.6
<i>Thamnophilus atrinucha</i>	23	110	143.6	17.9	2.00		3.2	11.1	1.7	2.5			27.9	4.3		640.9
<i>Thamnistes anabatensis</i>	21	75	97.9	12.2												
<i>Dysithamnus puncticeps</i>	17	125	163.1	20.4	0.50		0.8	2.5	0.4	2.5			6.1		1.0	104.2
<i>Myiurotherula ignota</i>	7	100	130.5	16.3	1.00		1.6	6.1	1.0	2.5			15.3	2.4		107.3
<i>Myiurotherula pacifica</i>	9.5	100	130.5	16.3	4.00		6.4	24.5	3.8	2.5			61.3	9.6		582.4
<i>Myiurotherula fulviventris</i>	10.5	60	78.3	9.8	2.00		3.2	20.4	3.2	2.5			51.1	8.0		536.4
<i>Myiurotherula axillaris</i>	8.5	100	130.5	16.3	2.50		4.0	15.3	2.4	2.5			38.3	6.0		325.7
<i>Myiurotherula schisticolor</i>	8.5	60		7.5												
<i>Microhopia quixensis</i>	9	125	163.1	20.4	3.00		4.8	14.7	2.3	2.5			36.8	5.7		331.0
<i>Cercomacra tyrannina</i>	17	150	195.8	24.5	11.00		17.6	45.0	7.0	2.5			112.4	17.5		1910.6
<i>Hylophylax naevoides</i>	16.5	75	97.9	12.2	2.00		3.2	16.3	2.6	2.5			40.9	6.4		674.3
<i>Myrmeciza immaculata</i>	44.5	225	293.6	36.7	1.50		2.4	4.1	0.6	2.5			10.2	1.6		454.7
<i>Myrmeciza exul</i>	23	175	228.4	28.5	7.00		11.2	24.5	3.8	2.5			61.3	9.6		1410.0
<i>Myrmeciza berlepschi</i>	28	175	228.4	28.5	3.50		5.6	12.3	1.9	2.5			30.7	4.8		858.2
<i>Gymnophylus leucopsis</i>	34	80	104.4	13.1	1.25		2.0	9.6	1.5	2.5			23.9	3.7		814.2
<i>Phaenostictus melanani</i>	[51]	[125]	[163.1]	[20.4]												
FORMICARIIDAE (2)																
<i>Formicarius nigricapillus</i>	57	200	261.0	32.6	2.50		4.0	7.7	1.2	2.5			19.2	3.0		1092.0
<i>Hylozeus perspicillatus</i>	42	200	261.0	32.6	0.25		0.4	0.8	0.1	2.5			1.9	0.3		80.5
TYRANNIDAE (41)																
<i>Phyllomyias griseiceps</i>	7	80	104.4	13.1												
<i>Zimmerius chrysops</i>	8.5	90	117.5	14.7	3.00		4.8	20.4	3.2	2.5			51.1	8.0		434.2
<i>Ornithion brunneicapillus</i>	7	125	163.1	20.4	1.00		1.6	4.9	0.8	2.5			12.3	1.9		85.8
<i>Campotoma obsolotum</i>	8	70	91.4	11.4												
<i>Tyrannulus elatus</i>	7	80	104.4	13.1	2.50		4.0	19.2	3.0	2.5			47.9	7.5		335.2
<i>Myiopogon cinereus</i>	10.5	100	130.5	16.3	1.00		1.6	6.1	1.0	2.5			15.3	2.4		160.9
<i>Myiopogon viridicatus</i>	13.5	125		15.6												
<i>Mionectes olivaceus</i>	14.5	40	52.2	6.5												
<i>Mionectes olivaceus</i>	10.5	50	65.3	8.2												
<i>Leptopogon superciliosus</i>	12.5	60	78.3	9.8	1.25		2.0	12.8	2.0	2.5			31.9	5.0		399.1
<i>Myiornis atricapillus</i>	5.5	110	143.6	17.9	2.50		4.0	13.9	2.2	2.5			34.8	5.4		191.6
<i>Lophortyx pileatus</i>	7.5	110	143.6	17.9		5.0	8.0	27.9	4.3	2.5			69.7	10.9		522.5
<i>Troglodytes nigricapillus</i>	6.5	100	130.5	16.3	1.00		1.6	6.1	1.0	2.5			15.3	2.4		99.6

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup> trans.	Units/ <sup>i</sup> trans. area	Ind. <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<i>Todirostrum cinereum</i>	6.5	90	117.5	14.7	3.50		5.6	23.8	3.7	2.5				59.6	9.3	387.4
<i>Rhynchoyulus pacificus</i>	26	75	97.9	12.2	0.50		0.8	4.1	0.6	2.5				10.2	1.6	265.6
<i>Tolmomyia flavotinctus</i>	14.5	110	143.6	17.9	3.00		4.8	16.7	2.6	2.5				41.8	6.5	606.1
<i>Platyrinchus cornutus</i>	9.5	40	52.2	6.5	1.25		2.0	19.2	3.0	2.5				47.9	7.5	455.0
<i>Tenotricicus erythrurus</i>	7	55		6.9							2.0		3.2	29.1	4.5	203.6
<i>Myiobius atricaudus</i>	10	20		2.5							3.0		4.8	120.0	18.7	1200.0
<i>Myiobius sulphureipennis</i>	11.5	20		2.5												
<i>Myiophobus fasciatus</i>	10	80	104.4	13.1	1.00		1.6	7.7	1.2	2.5				19.2	3.0	191.6
<i>Contopus cooperi</i>	32	120		15.0								0.75	1.2	6.0	0.9	78.0
<i>Empidonax virens</i>	13	100		12.5												
<i>Colonia colona</i>	16	110	143.6	17.9												
<i>Attila spadiceus</i>	39	225	293.6	36.7	1.50		2.4	4.1	0.6	2.5				10.2	1.6	398.5
<i>Rhytipterna holerythra</i>	[38.5]	[150]	[195.8]	[24.5]												
<i>Sirystes albigriseus</i>	[33]	[140]	[182.7]	[22.8]												
<i>Myiarchus tuberculifer</i>	20	100	130.5	16.3												
<i>Megarynchus pitangua</i>	74	125	163.1	20.4	0.25		0.4	1.2	0.2	2.5				3.1	0.5	226.8
<i>Myiozetetes cayanensis</i>	25.5	125	163.1	20.4	1.50		2.4	7.4	1.1	2.5				18.4	2.9	469.0
<i>Myiozetetes granadensis</i>	26.5	125	163.1	20.4	1.50		2.4	7.4	1.1	2.5				18.4	2.9	487.4
<i>Conopias albonotatus</i>	24.5	175	228.4	28.5	0.75		1.2	2.6	0.4	2.5				6.6	1.0	160.9
<i>Myiodynastes maculatus</i>	[46]	[120]		[15.0]												
<i>Legatus leucophaeus</i>	24.5	200	261.0	32.6	3.50		5.6	10.7	1.7	2.5				26.8	4.2	657.1
<i>Tyrannus melancholicus</i>	37.5	110	143.6	17.9	0.50		0.8	2.8	0.4	2.5				7.0	1.1	261.2
<i>Tyrannus nitigularis</i>	37	100		12.5								0.50	0.8	4.0	0.6	148.0
<i>Pachyrhamphus cinnamomeus</i>	22	75	97.9	12.2	3.50		5.6	28.6	4.5	2.5				71.5	11.2	1573.4
<i>Pachyrhamphus albigriseus</i>	[17.5]	[100]		[12.5]												
<i>Platyparis homochrous</i>	33.5	40		5.0												
<i>Tityra semifasciata</i>	79	80	104.4	13.1												
<i>Tityra inquisitor</i>	43	80	104.4	13.1												
COTINGIDAE (4)																
<i>Lipaugus unirufus</i>	[82]	[250]	[326.3]	[40.8]												
<i>Cotinga nattererii</i>	60	40		5.0												
<i>Carpodectes hopkei</i>	[110]	[40]		[5.0]												
<i>Querula purpurata</i>	106	150	195.8	24.5	0.50		0.8	2.0	0.3	5.0				10.2	1.6	1083.0
TYRIDAE (7)																
<i>Pipra mentalis</i>	14.5	100		12.5							1.0		1.6	8.0	1.2	116.0
<i>Lepidobatrix coronata</i>	9	55	71.8	9.0		3.0	4.8	33.4	5.2	2.5				83.6	13.0	752.4
<i>Manacus manacus</i>	17.5	70	91.4	11.4		15.0	24.0	131.4	20.5	2.5				328.4	51.2	5747.1
<i>Machaeropterus deliciosus</i>	13.5	90		11.3												
<i>Chloropipo holoholona</i>	16	20		2.5												
<i>Schiffornis turdina</i>	[31]	[175]	[228.4]	[28.5]												
<i>Sapayoa aenigma</i>	20.5	60	78.3	9.8	1.50		2.4	15.3	2.4	2.5				38.3	6.0	785.4

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<b>VIREONIDAE (3)</b>															
<i>Vireo olivaceus</i>	16.5	40		5.0											
<i>Hylophilus decuratus</i>	9	130	169.7	21.2	4.50		7.2	21.2	3.3	2.5			53.1	8.3	477.5
<i>Hylophilus ochraceiceps</i>	12	120	156.6	19.6	1.00		1.6	5.1	0.8	2.5			12.8	2.0	153.3
<b>TURDIDAE (2)</b>															
<i>Catharus ustulatus</i>	29	100		12.5											
<i>Turdus daguae</i>	52	155	202.3	25.3	1.25		2.0	4.9	0.8	2.5			12.4	1.9	642.7
<b>HIRUNINIDAE (8)</b>															
<i>Progne chalybea</i>	43	75		9.4											
<i>Progne subis</i>	[49.5]	[75]		[9.4]											
<i>Tachycineta bicolor</i>	[20]	[60]		[7.5]											
<i>Nochelidon tibialis</i>	10.5	50		6.3											
<i>Stelgidopteryx ruficollis</i>	13.5	75		9.4								1.75	2.8	28.0	4.4
<i>Riparia riparia</i>	14.5	50		6.3								1.75	2.8	18.7	2.9
<i>Hirundo rustica</i>	16	60		7.5											
<i>Petrochelidon pyrrhonota</i>	21.5	50		6.3											
<b>TROGLODYTIDAE (8)</b>															
<i>Campylorhynchus zonatus</i>	34.5	120	156.6	19.6	0.25		0.4	1.3	0.2	5.0			6.4	1.0	220.8
<i>Odonotornis brantickii</i>	[9.5]	[100]		[16.3]											
<i>Thryothorus nigricapillus</i>	21	200	261.0	32.6	5.50		8.8	16.9	2.6	2.5			42.1	6.6	885.1
<i>Thryothorus lucopogon</i>	16.5	175	228.4	28.5	3.00		4.8	10.5	1.6	2.5			26.3	4.1	433.5
<i>Troglodytes aedon</i>	10.5	125	163.1	20.4	0.25		0.4	1.2	0.2	2.5			3.1	0.5	32.2
<i>Henricornia leucosticta</i>	16	185	241.4	30.2	1.75		2.8	5.8	0.9	2.5			14.5	2.3	232.0
<i>Cypothorus phaeocephalus</i>	24.5	80		10.0											
<i>Microcerculus marginatus</i>	19	200	261.0	32.6	2.50		4.0	7.7	1.2	2.5			19.2	3.0	364.0
<b>POLIOPTILIDAE (3)</b>															
<i>Microbatas cinereiventris</i>	11.5	120	156.6	19.6	1.50		2.4	7.7	1.2	2.5			19.2	3.0	220.3
<i>Polioptila plumbea</i>	6	80	104.4	13.1	2.00		3.2	15.3	2.4	2.5			38.3	6.0	229.9
<i>Polioptila schizacegula</i>	6	80	104.4	13.1											
<b>PARULIDAE (8)</b>															
<i>Dendroica striata</i>	13	40		5.0											
<i>Dendroica fusca</i>	9.5	40		5.0											
<i>Seiurus noveboracensis</i>	18	20		2.5											
<i>Geothlypis semiflava</i>	15.5	125	163.1	20.4	1.00		1.6	4.9	0.8	2.5			12.3	1.9	190.0
<i>Geothlypis auricularis</i>	10	100	130.5	16.3											
<i>Opornis philadelphica</i>	12.5	20		2.5											
<i>Opornis agilis</i>	15	20		2.5											
<i>Basiluterus filicauda</i>	13.5	175	228.4	28.5	1.50		2.4	5.3	0.8	2.5			13.1	2.0	177.3
<b>THRAUPIDAE (27)</b>															
<i>Coereba flaveola</i>	9.5	45	58.7	7.3	5.50		8.8	74.9	11.7	2.5			187.3	29.2	1779.5
<i>Cyanerpes caeruleus</i>	12	40	52.2	6.5	1.25		2.0	19.2	3.0	2.5			47.9	7.5	574.7
<i>Cyanerpes cyaneus</i>	14	45	58.7	7.3	1.25		2.0	17.0	2.7	2.5			42.6	6.6	596.0

APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind. <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
<i>Chlorophanes spiza</i>	19	50	65.3	8.2	0.50		0.8	6.1	1.0	2.5				15.3	2.4	291.2
<i>Dacnis cayana</i>	13	30	39.2	4.9	0.50		0.8	10.2	1.6	2.5				25.5	4.0	332.1
<i>Dacnis greggia</i>	13.5	30	39.2	4.9	1.00		1.6	20.4	3.2	2.5				51.1	8.0	689.7
<i>Dacnis venusta</i>	16	30		3.8												
<i>Dacnis berlepschi</i>	13.5	50	65.3	8.2	1.00		1.6	12.3	1.9	2.5				30.7	4.8	413.8
<i>Erythrolipis salmoni</i>	[12]	[65]	[84.8]	[10.6]												
<i>Euphonia lanitirostris</i>	14.5	90	117.5	14.7	1.00		1.6	6.8	1.1	2.5				17.0	2.7	246.9
<i>Euphonia xanthogaster</i>	13	90	117.5	14.7	4.50		7.2	30.7	4.8	2.5				76.6	12.0	996.2
<i>Euphonia minima</i>	10	50	65.3	8.2			1.6									
<i>Euphonia fulviterisa</i>	11	90	117.5	14.7	1.00		1.6	6.8	1.1	2.5				17.0	2.7	187.3
<i>Tangara palmeri</i>	32.5	100	130.5	16.3												
<i>Tangara cyanicollis</i>	17	60	78.3	9.8	1.00		1.6	10.2	1.6	2.5				25.5	4.0	434.2
<i>Tangara larvata</i>	16	75	97.9	12.2	1.00		1.6	8.2	1.3	2.5				20.4	3.2	326.9
<i>Tangara johannae</i>	21	50	65.3	8.2	0.75		1.2	9.2	1.4	2.5				23.0	3.6	482.8
<i>Tangara lavinia</i>	17.5	60	78.3	9.8	1.25		2.0	12.8	2.0	2.5				31.9	5.0	558.7
<i>Thraupis episcopus</i>	33.5	75	97.9	12.2	2.50		4.0	20.4	3.2	2.5				51.1	8.0	1711.4
<i>Thraupis palmarum</i>	32.5	75	97.9	12.2	2.00		3.2	16.3	2.6	2.5				40.9	6.4	1328.2
<i>Ramphocelus icteronotus</i>	33.5	85		10.6								18.33	29.3	172.5	26.9	5780.4
<i>Piranga rubra</i>	30	85		10.6								0.25	0.4	2.4	0.4	70.6
<i>Chlorothraupis olivacea</i>	39.5	220	287.1	35.9	2.25		3.6	6.3	1.0	2.5				15.7	2.4	619.1
<i>Mitrospingus cassinii</i>	39.5	80	104.4	13.1	1.00		1.6	7.7	1.2	5.0				38.3	6.0	1513.4
<i>Tachyphonus luctuosus</i>	13	90		11.3												
<i>Tachyphonus delatrii</i>	19	100		12.5												
<i>Helminthophila xanthopygia</i>	38	135	176.2	22.0	0.50		0.8	2.3	0.4	2.5				160.0	25.0	3040.0
CARDINALIDAE (4)														5.7	0.9	215.7
<i>Salator maximus</i>	47	150	195.8	24.5	6.00		9.6	24.5	3.8	2.5				61.3	9.6	2881.2
<i>Salator atripennis</i>	56.5	180	234.9	29.4	1.50		2.4	5.1	0.8	2.5				12.8	2.0	721.6
<i>Salator grossus</i>	49	225	293.6	36.7	1.75		2.8	4.8	0.7	2.5				11.9	1.9	584.1
<i>Phreucticus ludovicianus</i>	[44.5]	[100]		[12.5]												
EMBERIZIDAE (10)																
<i>Rhodospingus cruentus</i>	[10.5]	[70]		[8.8]												
<i>Volatinia jacarina</i>	9.5	60		7.5												
<i>Tiaris obscurus</i>	10.5	80	104.4	13.1												
<i>Oryzoborus angolensis</i>	12	80	104.4	13.1	1.00		1.6	7.7	1.2	2.5				19.2	3.0	229.9
<i>Sporophila corvina</i>	10.5	65	84.8	10.6	2.00		3.2	18.9	2.9	2.5				47.2	7.4	495.1
<i>Sporophila luctuosa</i>	[12.5]	[70]		[8.8]												
<i>Sporophila nigricollis</i>	8	70	91.4	11.4	1.00		1.6	8.8	1.4	2.5				21.9	3.4	175.2
<i>Sporophila telasco</i>	8.5	30		3.8												
<i>Arremon aurantirostris</i>	26	60	78.3	9.8	3.00		4.8	30.7	4.8	2.5				76.6	12.0	1992.3
<i>Arremonops contrivaris</i>	40	160	208.8	26.1												

## APPENDIX 18A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass (g)	Ave. <sup>b</sup> DTD (m)	Eff. <sup>c</sup> DTD (m)	Eff. <sup>d</sup> DA (ha)	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density (g/km <sup>2</sup> )
ICTERIDAE (6)																
<i>Cacicus microhynchus</i>	64.5	225		28.1								3.00	4.8	10.7	1.7	688.0
<i>Amblycercus holosericeus</i>	64	200	261.0	32.6	1.00		1.6	3.1	0.5	2.5				7.7	1.2	490.4
<i>Zarhynchus wagleri</i>	163.5	125		15.6												
<i>Molothrus bonariensis</i>	49.5	90		11.3								2.25	3.6	20.0	3.1	990.0
<i>Molothrus oryzivorus</i>	190.5	110		13.8								0.25	0.4	1.8	0.3	346.4
<i>Dolichonyx oryzivorus</i>	42	20		2.5												
SUM	26 463.0	29 040			240.25	23.0					6.0	110.33		5309.0	828.2	193 387.7
No. of bird species (MTW/total)	162/231	162/231			126	3					3	30				162
Average	163.4	179.3														36.4



## APPENDIX 18B

MTW-study: within-habitat abundance, population density, and available area per territory of the bird community in the transect area of MNT1. In contrast to Appendix 18a, the population data presented here refer exclusively to those portions of the transect area that actually contained the appropriate habitat for each species, in order to gain a better impression of the abundance and population density the species may reach in comparable homogeneous habitat. For species that occupied rather broad ecological niches, and therefore were present in the entire transect area, the population data are the same as in the previous appendix. The detection threshold distances, within-habitat length, and effective detection areas within habitat are shown for all 268 bird species recorded between Aug. 1995 and Mar. 1998 within 100 m of the transects MNT1 and MNT2 (cf. Appendix 12a). For species recorded only in the transect area of MNT2, the values are stated in '[...]' brackets. Population data are shown exclusively for the 162 species recorded in the MTW study of MNT1 between Feb. and Nov. 1997. It is likely that such high population densities as calculated here for some species may be reached only locally in ideal habitat. The results may not be representative for other areas of Playa de Oro, even where similar habitat is present (e.g., continuous *terra firme* forest). Furthermore, the total number of territories or individuals recorded was often small and, in some cases, the 'within-habitat detection area' was very small in relation to the expected territory size of the species. In other words, the results have to be regarded as preliminary and should be interpreted with caution. Whenever I assumed that the within-habitat abundance or population density were considerably overestimated due to methodological biases or small sample size, the results are written in italics. Abbreviations used and explanations: (a) average detection threshold distance (Ave. DTD); see Appendix 18a; (b) effective detection threshold distance (Eff. DTD); see Appendix 18a; (c) within-habitat transect length (WiHabit TraLen); estimated length of the portion of the transect that actually contained appropriate habitat for the species; the total length of transect MNT1 was 625 m; (d) effective detection area within habitat (Eff. DA WiHabit): the area effectively surveyed within the habitat of each species in the complete MTW study, calculated as the product of twice the effective DTD (or the 'average DTD' for species that could not be analyzed in units of territories or displaying males) and the within-habitat transect length; the product was divided by 10 000 in order to obtain the result in 'hectares'; (e) number of territories (No. terr.); see Appendix 18a; (f) number of displaying males (No. displ. MM); see Appendix 18a; (g) units per kilometer transect within habitat (Units/km WiHabit): number of territories or displaying males per kilometer transect within the habitat of the species; (h) units per km<sup>2</sup> within habitat (Units/km<sup>2</sup> WiHabit): number of territories or displaying males per square kilometer within the habitat of the species; (i) individuals per unit (Ind./unit); see Appendix 18a; (j) maximum number of individuals (Max. no. ind.); see Appendix 18a; (k) average number of individuals (Ave. no. ind.); see Appendix 18a; (l) number of individuals per km transect within habitat (No. ind./km WiHabit): the number of individuals per kilometer transect within the habitat of the species, either the maximum or average number of individuals, depending on the species or bird group (cf. Appendix 18a); (m) number of individuals per km<sup>2</sup> within habitat (No. ind./km<sup>2</sup> WiHabit): absolute population density within an area of one square kilometer within the habitat of the species; (n) available area per territory (Available area/terr.); in general, this area is the sum of the size of the home ranges, which include the territories, and the size of the unoccupied portion of the detection area within the habitat; for species that occupied 100% of the detection area within the habitat, this area is a reasonably good estimate for the mean territory size; for species that occupied less than 100% of the detection area within the habitat, the territory size may be considerably smaller than indicated here. See p. 110-115, Estimation of population densities on the basis of transect-mapping data, for further details on the methodology used for the calculation of the population data and p. 164-166, How real are the modeled community data based on transect mapping?, on identified biases.

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WiHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / <sup>g</sup> km WiHab	Units / <sup>h</sup> km <sup>2</sup> WiHab	Ind. / <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / <sup>l</sup> km WiHab	No. ind. / <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area / terr. [ha]
TINAMIDAE (3)														
<i>Tinamus major</i>	[400]	[522.0]	[375]	[39.2]										
<i>Crypturellus berlepschi</i>	200	261.0	375	19.6	0.50		1.3	2.6	2.5				6.4	39.2
<i>Crypturellus soui</i>	275	358.9	625	44.9	5.00		8.0	11.1	2.5				27.9	9.0
ARDEIDAE (1)														
<i>Bucorides striata</i>	40		100	0.8										
CATHARTIDAE (3)														
<i>Syrnemonphus papa</i>	200		625	25.0										
<i>Conogyne atratus</i>			[625]	[25.0]										
<i>Cathartes aura</i>	200		625	25.0							2.75	4.4	11.0	
ACCIPITRIDAE (12)														
<i>Pandion haliaetus</i>	200		625	25.0										
<i>Lepidodon cayanensis</i>	[400]	[522.0]	[625]	[65.3]										
<i>Elanoides forficatus</i>	175		625	21.9										
<i>Ictinia plumbea</i>	175		625	21.9										
<i>Accipiter superciliosus</i>	[100]	[130.5]	[375]	[9.8]										
<i>Accipiter bicolor</i>	[325]	[424.1]	[375]	[31.8]										
<i>Leucopternis plumbeus</i>	[375]	[489.4]	[375]	[36.7]										
<i>Leucopternis semiplumbeus</i>	[325]	[424.1]	[525]	[44.5]										
<i>Leucopternis princeps</i>	400		625	50.0										
<i>Buco magnirostris</i>	300	391.5	500	39.2	1.00		2.0	2.6	2.5				6.4	39.2
<i>Buco brachyurus</i>	225		625	28.1										
<i>Spizartus tyrannus</i>	500	652.5	625	81.6										
FALCONIDAE (5)														
<i>Micrastur ruficollis</i>	[225]	[293.6]	[375]	[22.0]										
<i>Micrastur semitorquatus</i>	[400]	[522.0]	[375]	[39.2]										
<i>Herpessobates cacinians</i>	450	587.3	625	73.4	0.25		0.4	0.3	2.5				0.9	293.6
<i>Falco rufigularis</i>	[200]	[261.0]	[625]	[32.6]										
<i>Falco peregrinus</i>	[200]		[625]	[25.0]										
CRACIDAE (2)														
<i>Oriallis erythroptera</i>	250		625	31.3										
<i>Penelope purpurascens</i>	250		375	18.8										
ODONTOPHORIDAE (2)														
<i>Odonophorus erythrops</i>	325	424.1	375	31.8	2.25		6.0	7.1	4.0				28.3	14.1
<i>Rhynchortyx cinctus</i>	275	358.9	375	26.9	3.25		8.7	12.1	2.5				30.2	8.3
RALLIDAE (3)														
<i>Latenallus ibigularis</i>	150	195.8	250	9.8	4.00		16.0	40.9	2.5				102.2	2.4
<i>Anatalafennus concolor</i>	200	261.0	450	23.5	2.00		4.4	8.5	2.5				21.3	11.7
<i>Neorex colombiana</i>	20	26.1	250	1.3										
SCOLOPACIDAE (1)														
<i>Actitis macularia</i>	60		100	1.2										
COULMIDAE (7)														
<i>Punaenaena spectosa</i>	125	163.1	625	20.4	2.50		4.0	12.3	2.5				30.7	8.2

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / <sup>g</sup> km WtHab	Units / <sup>h</sup> km <sup>2</sup> WtHab	Ind. / <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / <sup>l</sup> km WtHab	No. ind. / <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area / terr. [ha]
<i>Paragöena subvinnacea</i>	250	326.3	625	40.8	3.00		4.8	7.4	2.5				18.4	13.6
<i>Paragöena goodoni</i>	200	261.0	625	32.6	3.00		4.8	9.2	2.5				23.0	10.9
<i>Clarinis pretiosa</i>	225		250	11.3										
<i>Lepotilla pallida</i>	450	195.8	450	17.6	8.50		18.9	48.2	2.5				120.6	2.1
<i>Geotrygon veraguensis</i>	25	32.6	375	2.4	1.00		2.7	40.9	2.5				102.2	2.4
<i>Geotrygon montana</i>	125	163.1	375	12.2										
PSITTACIDAE (6)														
<i>Ana ambigua</i>	400		625	50.0										
<i>Touit dilectissimus</i>	275		625	34.4										
<i>Pionopsitta pulchra</i>	225		625	28.1							3.50	5.6	12.4	
<i>Pionus menstruus</i>	300		625	37.5							4.50	7.2	12.0	
<i>Pionus chalcopterus</i>	300		625	37.5							2.50	4.0	6.7	
<i>Amazona formosa</i>	450		625	56.3							1.25	2.0	2.2	
CUCULIDAE (6)														
<i>Piaya cayana</i>	110	143.6	625	17.9	2.00		3.2	11.1	2.5				27.9	9.0
<i>Piaya minuta</i>	60	78.3	450	7.0	1.00		2.2	14.2	2.5				35.5	7.0
<i>Crotophaga ani</i>	90		250	4.5										
<i>Crotophaga sulcirostris</i>	[90]		[250]	[4.5]										
<i>Tapera naevia</i>	250	326.3	250	16.3										
<i>Neomorphus radiololus</i>	[125]	[163.1]	[225]	[7.3]										
STRIGIDAE (4)														
<i>Megascops centralis</i>	[125]	[163.1]	[375]	[12.2]										
<i>Glaucidium griseiceps</i>	[250]	[326.3]	[375]	[24.5]										
<i>Pulsatrix perspicillata</i>	[300]	[391.5]	[375]	[29.4]										
<i>Strix virgata</i>	225	293.6	525	30.8	0.50		1.0	1.6	2.5				4.1	61.7
NYCTIBIDAE (1)														
<i>Nyctibius griseus</i>	200	261.0	625	32.6	0.50		0.8	1.5	2.5				3.8	65.3
CAPRIMULGIDAE (2)														
<i>Nyctidromus albigollis</i>	225	293.6	250	14.7	1.25		5.0	8.5	2.5				21.3	11.7
<i>Nyctiphypus rosenbergi</i>	200	261.0	375	19.6	1.50		4.0	7.7	2.5				19.2	13.1
APOIDAE (6)														
<i>Streptoprocne zonaris</i>	150		625	18.8							2.75	4.4	14.7	
<i>Cypseloides rutilus</i>	[125]		[625]	[15.6]										
<i>Chaetura pelagica</i>	75		625	9.4							7.25	11.6	77.3	
<i>Chaetura spinicaudus</i>	50	62.5	625	6.3							10.25	16.4	164.0	
<i>Chaetura cinereiventris</i>	[75]		[625]	[9.4]										
<i>Panoptilia ayenensis</i>	60		625	7.5							0.75	1.2	10.0	
TROCHILIDAE (15)														
<i>Glaucois aeneus</i>	55		400	4.4							0.25	0.6	5.7	
<i>Threnetes ruckeri</i>	60		625	7.5							9.25	14.8	123.3	
<i>Phaethornis yaruqui</i>	85		625	10.6							3.75	6.0	35.3	
<i>Phaethornis siriguairis</i>	35		625	4.4							1.00	1.6	22.9	
<i>Eunoere aquila</i>	55		625	6.9										

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DIT	Eff. <sup>b</sup> DIT	Eff. <sup>b</sup> DIT	WtLen	Eff. DA <sup>d</sup> WtHab	No. <sup>e</sup> terr.	No. <sup>f</sup> displ.	Units/ <sup>g</sup> km	Units/ <sup>h</sup> WtHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km	WtHab	No. ind./ <sup>m</sup> km <sup>2</sup>	Available <sup>n</sup> area/terr. [ha]
<i>Androdon aequatorialis</i>	100			375	7.5							0.50	1.3		6.7	
<i>Florisuga mellivora</i>	60			625	7.5							0.25	0.4		3.3	
<i>Popelatria conversi</i>	30			625	3.8							0.25	0.4		6.7	
<i>Thalania fainyi</i>	50			625	6.3											
<i>Damophila julie</i>	35			450	3.2							0.25	0.6		7.9	
<i>Anazilia tzacatl</i>	60			250	3.0							2.50	10.0		83.3	
<i>Anazilia amabilis</i>	40			625	5.0											
<i>Anazilia rosenbergi</i>	55			625	6.9							5.75	9.2		83.6	
<i>Chalybura urochrysa</i>	45			375	3.4											
<i>Heliothyrx barroti</i>	40			625	5.0							2.25	3.6		45.0	
TROGONIDAE (3)																
<i>Trogon compus</i>	225	293.6		375	22.0	0.50		1.3	2.3	2.5					5.7	44.0
<i>Trogon chinurus</i>	200	261.0		625	32.6	2.50		4.0	7.7	2.5					19.2	13.1
<i>Trogon rufus</i>	200	261.0		525	27.4											
ALCEDINIDAE (4)																
<i>Megasceryle torquata</i>	150	195.8		150	5.9											
<i>Chlomeryle americana</i>	60	78.3		250	3.9											
<i>Chlomeryle inda</i>	60	78.3		375	5.9											
<i>Chlomeryle seneca</i>	[30]	[39.2]		[375]	[2.9]											
MOMOTIDAE (2)																
<i>Electron platyrhynchos</i>	250	326.3		375	24.5	0.50		1.3	2.0	2.5					5.1	48.9
<i>Barphibengus nairii</i>	250	326.3		525	34.3	1.50		2.9	4.4	2.5					10.9	22.8
GAULULIDAE (1)																
<i>Galbula ruficauda</i>	175	228.4		500	22.8	2.25		4.5	9.9	2.5					24.6	10.2
BUCCONIDAE (3)																
<i>Nyctalus nadius</i>	175	228.4		625	28.5	1.00		1.6	3.5	2.5					8.8	28.5
<i>Malacoptila panamensis</i>	40	52.2		625	6.5	2.00		3.2	30.7	2.5					76.6	3.3
<i>Micromonacha lanceolata</i>	[75]	[97.9]		[375]	[7.3]											
CAPITONIDAE (1)																
<i>Capito squamatus</i>	60	78.3		625	9.8	1.00		1.6	10.2	3.5					35.8	9.8
RAMPHASTIDAE (3)																
<i>Peroglossus sanguineus</i>	175	228.4		625	28.5	1.00		1.6	3.5	4.0					14.0	28.5
<i>Ramphastos brevis</i>	325	424.1		625	53.0	0.50		0.8	0.9	3.5					3.3	106.0
<i>Ramphastos swainsonii</i>	450	587.3		625	73.4	1.00		1.6	1.4	3.5					4.8	73.4
PICIDAE (8)																
<i>Picus olivaceus</i>	35	45.7		400	3.7	1.25		3.1	34.2	2.5					85.5	2.9
<i>Piculus litae</i>	100	130.5		625	16.3											
<i>Celex loritatus</i>	225	293.6		625	36.7	0.50		0.8	1.4	2.5					3.4	73.4
<i>Dryocopus lineatus</i>	250	326.3		500	32.6	1.00		2.0	3.1	2.5					7.7	32.6
<i>Melanerpes pucherani</i>	175	228.4		500	22.8	2.00		4.0	8.8	2.5					21.9	11.4
<i>Veniliornis kirikii</i>	125	163.1		625	20.4	1.00		1.6	4.9	2.5					12.3	20.4
<i>Veniliornis callonotus</i>	125	163.1		500	16.3	1.00		2.0	6.1	2.5					15.3	16.3
<i>Campephilus gonzalezensis</i>	225	293.6		525	30.8											

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	Eff. <sup>b</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / <sup>g</sup> km WiHab	Units / <sup>h</sup> km <sup>2</sup> WiHab	Ind. / <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / <sup>l</sup> km WiHab	No. ind. / <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area / terr. [ha]
<b>FURNARIIDAE (5)</b>														
<i>Synallaxis brachyura</i>	60	78.3	400	6.3	7.00		17.5	111.7	2.5				279.4	0.9
<i>Hylocistes virgatus</i>	200	261.0	475	24.8	1.50		3.2	6.0	2.5				15.1	16.5
<i>Automolus rubiginosus</i>	125	163.1	625	20.4	2.00		3.2	9.8	2.5				24.5	10.2
<i>Xenops minutus</i>	75	97.9	625	12.2	2.00		3.2	16.3	2.5				40.9	6.1
<i>Sclerurus mexicanus</i>	[200]	[261.0]	[225]	[11.7]										
<b>DENDROCOLAPTIDAE (8)</b>														
<i>Dendrocincla fuliginosa</i>	150	195.8	625	24.5	1.00		1.6	4.1	2.5				10.2	24.5
<i>Glyphorynchus spirurus</i>	60	78.3	475	7.4	2.50		5.3	33.6	2.5				84.0	3.0
<i>Dendrocolaptes sanctithomae</i>	125	163.1	375	12.2	0.50		1.3	4.1	2.5				10.2	24.5
<i>Xiphorhynchus leucyrmus</i>	175	228.4	625	28.5	2.00		3.2	7.0	2.5				17.5	14.3
<i>Xiphorhynchus erythrogynus</i>	100	130.5	625	16.3	0.75		1.2	4.6	2.5				11.5	21.8
<i>Lepidocolaptes sylvetti</i>	125	163.1	250	8.2	0.25		1.0	3.1	2.5				7.7	32.6
<i>Campylorhynchus trochiloides</i>	150	195.8	500	19.6	1.00		2.0	5.1	2.5				12.8	19.6
<i>Campylorhynchus pusillus</i>	[125]	[163.1]	[375]	[12.2]										
<b>THAMNOPHILIDAE (18)</b>														
<i>Cymbidulinius lineatus</i>	110	143.6	625	17.9	1.00		1.6	5.6	2.5				13.9	17.9
<i>Tanaba major</i>	200	261.0	400	20.9	1.75		4.4	8.4	2.5				21.0	11.9
<i>Thamnophtila atrinucha</i>	110	143.6	625	17.9	2.00		3.2	11.1	2.5				27.9	9.0
<i>Thamnistes andabatus</i>	75	97.9	375	7.3										
<i>Dysithamnus puncticeps</i>	125	163.1	225	7.3	0.50		2.2	6.8	2.5				17.0	14.7
<i>Myrmotherula ignota</i>	100	130.5	475	12.4	1.00		2.1	8.1	2.5				20.2	12.4
<i>Myrmotherula pacifica</i>	100	130.5	250	6.5	4.00		16.0	61.3	2.5				153.3	1.6
<i>Myrmotherula fulviventris</i>	60	78.3	375	5.9	2.00		5.3	34.1	2.5				85.1	2.9
<i>Myrmotherula axillaris</i>	100	130.5	375	9.8	2.50		6.7	25.5	2.5				63.9	3.9
<i>Myrmotherula schisticolor</i>	60		375	4.5										
<i>Microtopus quixensis</i>	125	163.1	475	15.5	3.00		6.3	19.4	2.5				48.4	5.2
<i>Cercomacra tyrannina</i>	150	195.8	450	17.6	11.00		24.4	62.4	2.5				156.1	1.6
<i>Hylophylax naevoides</i>	75	97.9	475	9.3	2.00		4.2	21.5	2.5				53.8	4.6
<i>Myrmeciza immaculata</i>	225	293.6	475	27.9	1.50		3.2	5.4	2.5				13.4	18.6
<i>Myrmeciza exsul</i>	175	228.4	475	21.7	7.00		14.7	32.3	2.5				80.7	3.1
<i>Myrmeciza berlepschi</i>	175	228.4	625	28.5	3.50		5.6	12.3	2.5				30.7	8.2
<i>Gymnophaps leucopsis</i>	80	104.4	475	9.9	1.25		2.6	12.6	2.5				31.5	7.9
<i>Phoenicircus melanotus</i>	[125]	[163.1]	[225]	[7.3]										
<b>FORMICARIIDAE (3)</b>														
<i>Formicarius nigricapillus</i>	200	261.0	475	24.8	2.50		5.3	10.1	2.5				25.2	9.9
<i>Hylophyes perspicillatus</i>	200	261.0	225	11.7	0.25		1.1	2.1	2.5				5.3	47.0
<b>TYRANNIDAE (41)</b>														
<i>Phylloscopus griseiceps</i>	80	104.4	250	5.2										
<i>Zimmerius chlorops</i>	90	117.5	625	14.7	3.00		4.8	20.4	2.5				51.1	4.9
<i>Ornithion brunneicapillus</i>	125	163.1	475	15.5	1.00		2.1	6.5	2.5				16.1	15.5
<i>Campostoma obsoletum</i>	70	91.4	250	4.6										
<i>Tyrannulus elatus</i>	80	104.4	400	8.4	2.50		6.3	29.9	2.5				74.8	3.3

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> WiHab TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ km WiHab	Units/ km <sup>2</sup> WiHab	Ind./ <sup>1</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>1</sup> km WiHab	No. ind./ <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area/terr. [ha]
<i>Myopagis caniceps</i>	100	130.5	475	12.4	1.00		2.1	8.1	2.5				20.2	12.4
<i>Myopaga viridicada</i>	125		625	15.6										
<i>Mionectes oliuacens</i>	40	52.2	475	5.0										
<i>Mionectes oleagineus</i>	50	65.3	625	8.2										
<i>Lepidopogon sapercillarlis</i>	60	78.3	375	5.9	1.25		3.3	21.3	2.5				53.2	4.7
<i>Myiomis atricapillus</i>	110	143.6	625	17.9	2.50		4.0	13.9	2.5				34.8	7.2
<i>Lophoricus pilatus</i>	110	143.6	450	12.9		5.0	11.1	38.7	2.5				96.8	
<i>Tadlostrotrum nigriceps</i>	100	130.5	475	12.4	1.00		2.1	8.1	2.5				20.2	12.4
<i>Tadlostrotrum cinereum</i>	90	117.5	250	5.9	3.50		14.0	59.6	2.5				149.0	1.7
<i>Rhynchochrycus pacificus</i>	75	97.9	375	7.3	0.50		1.3	6.8	2.5				17.0	14.7
<i>Tahinomys flaviventris</i>	110	143.6	625	17.9	3.00		4.8	16.7	2.5				41.8	6.0
<i>Platyrinchus cornutus</i>	40	52.2	375	3.9	1.25		3.3	31.9	2.5				79.8	3.1
<i>Terenotriccus erythrurus</i>	55		375	4.1						2.0		5.3	48.5	
<i>Myiobius atricaudus</i>	20		250	1.0						3.0		12.0	300.0	
<i>Myobius sulphureipennis</i>	20		375	1.5									47.9	5.2
<i>Myiophobus fasciatus</i>	80	104.4	625	5.2	1.00		4.0	19.2	2.5				6.0	
<i>Contopus cooperi</i>	120		250	15.0										
<i>Empidonax virescens</i>	100		625	12.5										
<i>Colonia tolonis</i>	110	143.6	625	17.9			2.4	4.1	2.5		0.75	1.2	10.2	24.5
<i>Attila spadiceus</i>	225	293.6	625	36.7	1.50									
<i>Rhytiperna holerythra</i>	[150]	[195.8]	[375]	[14.7]										
<i>Syrtes albobrunneus</i>	[140]	[182.7]	[475]	[17.4]										
<i>Myiarchus tuberculifer</i>	100	130.5	450	11.7										
<i>Megarynchus pitangua</i>	125	163.1	250	8.2	0.25		1.0	3.1	2.5				7.7	32.6
<i>Myiozetetes cayanensis</i>	125	163.1	400	13.1	1.50		3.8	11.5	2.5				28.7	8.7
<i>Myiozetetes grandisensis</i>	125	163.1	400	13.1	1.50		3.8	11.5	2.5				28.7	8.7
<i>Conopias albionitatus</i>	175	228.4	375	17.1	0.75		2.0	4.4	2.5				10.9	22.8
<i>Myiodynastes maculatus</i>	[120]		[625]	[15.0]										
<i>Legatus leucophaeus</i>	200	261.0	625	32.6	3.50		5.6	10.7	2.5				26.8	9.3
<i>Tyrannus melancholicus</i>	110	143.6	250	7.2	0.50		2.0	7.0	2.5		0.50	2.0	17.4	14.4
<i>Tyrannus niveigularis</i>	100		250	5.0									10.0	
<i>Pachyanphus cinnamomeus</i>	75	97.9	625	12.2	3.50		5.6	28.6	2.5				71.5	3.5
<i>Pachyanphus albobrunneus</i>	[100]		[375]	[7.5]										
<i>Platyparis homochrous</i>	40		625	5.0										
<i>Tityra semifasciata</i>	80	104.4	625	13.1										
<i>Tityra inquisitor</i>	80	104.4	625	13.1										
COTTINGIDAE (4)														
<i>Lipaugus uirrifufus</i>	[250]	[326.3]	[225]	[14.7]										
<i>Cotinga nattererii</i>	40		625	5.0										
<i>Carpodectes hopkei</i>	[40]		[375]	[3.0]										
<i>Querula purpurata</i>	150	195.8	525	20.6	0.50		1.0	2.4	5.0				12.2	41.1
PIPIDAE (7)														
<i>Tityra mentalis</i>	100		375	7.5						1.0		2.7	13.3	

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / <sup>g</sup> km WtHab	Units / <sup>h</sup> km <sup>2</sup> WtHab	Ind. / <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / <sup>l</sup> km WtHab	No. ind. / <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area / terr. [ha]
<i>Lepidobatrax coronata</i>	55	71.8	375	5.4		3.0	8.0	55.7	2.5				139.3	
<i>Manacus manacus</i>	70	91.4	625	11.4		15.0	24.0	131.4	2.5				328.4	
<i>Machaeropterus deliciosus</i>	90		375	6.8										
<i>Chloropipo bolochlora</i>	20		225	0.9										
<i>Schiffornis turdina</i>	[175]	[228.4]	[375]	[17.1]										
<i>Sapayoa atinqua</i>	60	78.3	375	5.9	1.50		4.0	25.5	2.5				63.9	3.9
VIREONIDAE (3)														
<i>Vireo olivaceus</i>	40		625	5.0										
<i>Hylophilus decurtatus</i>	130	169.7	625	21.2	4.50		7.2	21.2	2.5				53.1	4.7
<i>Hylophilus ochraceiceps</i>	120	156.6	375	11.7	1.00		2.7	8.5	2.5				21.3	11.7
TURDIDAE (2)														
<i>Catharus ustulatus</i>	100		625	12.5										
<i>Turdus daguae</i>	155	202.3	375	15.2	1.25		3.3	8.2	2.5				20.6	12.1
HIRUNINIDAE (8)														
<i>Progne chalybea</i>	75		250	3.8										
<i>Progne subis</i>	[75]		[625]	[9.4]										
<i>Tachycineta bicolor</i>	[60]		[625]	[7.5]										
<i>Neochelidon tibialis</i>	50		625	6.3										
<i>Stelgidopteryx ruficollis</i>	75		250	3.8							1.75	2.8	28.0	
<i>Riparia riparia</i>	50		625	6.3							1.75	7.0	46.7	
<i>Hirundo rustica</i>	60		625	7.5										
<i>Petrochelidon pyrrhonota</i>	50		625	6.3										
TROGLODYTIDAE (8)														
<i>Campylorhynchus zonatus</i>	120	156.6	250	7.8	0.25		1.0	3.2	5.0				16.0	31.3
<i>Odonorhynchus brunickii</i>	[100]	[130.5]	[375]	[9.8]										
<i>Thryothorus nigricapillus</i>	200	261.0	500	26.1	5.50		11.0	21.1	2.5				52.7	4.7
<i>Thryothorus lucasogoni</i>	175	228.4	475	21.7	3.00		6.3	13.8	2.5				34.6	7.2
<i>Troglodytes aedon</i>	125	163.1	100	3.3	0.25		2.5	7.7	2.5				19.2	13.1
<i>Henicorhina leucosticta</i>	185	241.4	375	18.1	1.75		4.7	9.7	2.5				24.2	10.3
<i>Cyporhynchus phaeocephalus</i>	80		375	6.0										
<i>Microcerulus marginatus</i>	200	261.0	375	19.6	2.50		6.7	12.8	2.5				31.9	7.8
POLIOPTILIDAE (3)														
<i>Microbates cinereiventris</i>	120	156.6	375	11.7	1.50		4.0	12.8	2.5				31.9	7.8
<i>Polioptila plumbea</i>	80	104.4	400	8.4	2.00		5.0	23.9	2.5				59.9	4.2
<i>Polioptila schistaceigula</i>	80	104.4	375	7.8										
PARULIDAE (8)														
<i>Dendroica striata</i>	40		625	5.0										
<i>Dendroica fusca</i>	40		625	5.0										
<i>Seiurus noveboracensis</i>	20		250	1.0										
<i>Geothlypis semiflava</i>	125	163.1	250	8.2	1.00		4.0	12.3	2.5				30.7	8.2
<i>Geothlypis auricularis</i>	100	130.5	250	5.0										
<i>Oporornis phalaenoptilus</i>	20		250	1.0										
<i>Oporornis agilis</i>	20		250	1.0										

## APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WiHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km	Units/ <sup>h</sup> km <sup>2</sup> WiHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km <sup>2</sup> WiHab	No. ind./ <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area/terr. [ha]
<i>Basileuterus fulvicauda</i>	175	228.4	625	28.5	1.50		2.4	5.3	2.5			13.1		19.0
TIRAPUDIDAE (27)														
<i>Coreba flaveola</i>	45	58.7	625	7.3	5.50		8.8	74.9	2.5			187.3		1.3
<i>Cyanerpes caeruleus</i>	40	52.2	375	3.9	1.25		3.3	31.9	2.5			79.8		3.1
<i>Cyanerpes cyaneus</i>	45	58.7	400	4.7	1.25		3.1	26.6	2.5			66.5		3.8
<i>Chlorophanes spiza</i>	50	65.3	625	8.2	0.50		0.8	6.1	2.5			15.3		16.3
<i>Dacnis cayana</i>	30	39.2	375	2.9	0.50		1.3	17.0	2.5			42.6		5.9
<i>Dacnis egregia</i>	30	39.2	450	3.5	1.00		2.2	28.4	2.5			71.0		3.5
<i>Dacnis venusta</i>	30		625	3.8										
<i>Dacnis berlepschi</i>	50	65.3	625	8.2	1.00		1.6	12.3	2.5			30.7		8.2
<i>Erythrolipis salmoni</i>	[65]	[84.8]	[375]	[6.4]										
<i>Euphonia lanirostris</i>	90	117.5	250	5.9	1.00		4.0	17.0	2.5			42.6		5.9
<i>Euphonia xanthogaster</i>	90	117.5	625	14.7	4.50		7.2	30.7	2.5			76.6		3.3
<i>Euphonia miniata</i>	50	65.3	625	8.2										
<i>Euphonia fulvica</i>	90	117.5	525	12.3	1.00		1.9	8.1	2.5			20.3		12.3
<i>Tangara palmeri</i>	100	130.5	375	9.8										
<i>Tangara cyanicollis</i>	60	78.3	450	7.0	1.00		2.2	14.2	2.5			35.5		7.0
<i>Tangara larvata</i>	75	97.9	450	8.8	1.00		2.2	11.4	2.5			28.4		8.8
<i>Tangara johannae</i>	50	65.3	375	4.9	0.75		2.0	15.3	2.5			38.3		6.5
<i>Tangara larinia</i>	60	78.3	625	9.8	1.25		2.0	12.8	2.5			31.9		7.8
<i>Thraupis episcopus</i>	75	97.9	450	8.8	2.50		5.6	28.4	2.5			71.0		3.5
<i>Thraupis palmarum</i>	75	97.9	450	8.8	2.00		4.4	22.7	2.5			56.8		4.4
<i>Ramphocelus icteronotus</i>	85		450	7.7							18.33	40.7	239.7	
<i>Pinanga rubra</i>	85		250	4.3							0.25	1.0	5.9	
<i>Chlorothraupis olivacea</i>	220	287.1	475	27.3	2.25		4.7	8.2	2.5			20.6		12.1
<i>Mitrospingus cassinii</i>	80	104.4	625	13.1	1.00		1.6	7.7	5.0			38.3		13.1
<i>Tachyphonus luctuosus</i>	90		375	6.8										
<i>Tachyphonus delatrii</i>	100		475	9.5										
<i>Heerospingus xanthopygius</i>	135	176.2	375	13.2	0.50		1.3	3.8	2.5			210.5		26.4
CARDINALIDAE (4)														
<i>Salator maximus</i>	150	195.8	550	21.5	6.00		10.9	27.9	2.5			69.7		3.6
<i>Salator atripennis</i>	180	234.9	400	18.8	1.50		3.8	8.0	2.5			20.0		12.5
<i>Salator grossus</i>	225	293.6	525	30.8	1.75		3.3	5.7	2.5			14.2		17.6
<i>Phenicticus ludovicianus</i>	[100]		[625]	[12.5]										
EMBERIZIDAE (10)														
<i>Rhodospingus cruentus</i>	[70]		[250]	[3.5]										
<i>Volatinia jacarina</i>	60		250	3.0										
<i>Tiaris obscura</i>	80	104.4	250	5.2										
<i>Oryzoborus argolis</i>	80	104.4	250	5.2	1.00		4.0	19.2	2.5			47.9		5.2
<i>Sporophila corvina</i>	65	84.8	250	4.2	2.00		8.0	47.2	2.5			117.9		2.1
<i>Sporophila luctuosa</i>	[70]		[250]	[3.5]										
<i>Sporophila nigricollis</i>	70	91.4	250	4.6	1.00		4.0	21.9	2.5			54.7		4.6
<i>Sporophila telasco</i>	30		250	1.5										



APPENDIX 18B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km WtHab	Units/ <sup>h</sup> km <sup>2</sup> WtHab	Ind./ <sup>i</sup> unit WtHab	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km WtHab	No. ind./ <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Arrenomera aurantirostris</i>	60	78.3	450	7.0	3.00		6.7	42.6	2.5				106.4	2.3
<i>Arrenomera contritoris</i>	160	208.8	250	10.4										
ICTERIDAE (6)														
<i>Cacicus microphrynchus</i>	225		625	28.1							3.00	4.8	10.7	
<i>Amblycercus holosericeus</i>	200	261.0	625	32.6	1.00		1.6	3.1	2.5				7.7	32.6
<i>Zarhynchus uugleri</i>	125		625	15.6										
<i>Molothrus bonariensis</i>	90		400	7.2							2.25	5.6	31.3	
<i>Molothrus oryzivorus</i>	110		450	9.9							0.25	0.6	2.5	
<i>Dolichonyx oryzivorus</i>	20		250	1.0										

## APPENDIX 19A

MTW-study: detection threshold distance, abundance, population density, and biomass of the bird community in the transect area of MNT2. The detection threshold distances and effective detection areas are shown for all 268 bird species recorded between Aug. 1995 and Mar. 1998 within 100 m of the transects MNT1 and MNT2 (see Appendix 12b for details). For species recorded only in the transect area of MNT1, the values are stated in [...] brackets. The population data are shown exclusively for the 144 species recorded in the MTW study of MNT2 between Mar. and Nov. 1997. The results may not be representative for other areas of Playa de Oro, even where similar habitat is present (e.g., continuous *terra firme* forest), and should be regarded as preliminary. Whenever I assumed that abundance, population density, and biomass density were considerably overestimated due to methodological biases or small sample size, the results are written in italics. Abbreviations used and explanations: (a) body mass; see Appendix 18a; (b) average detection threshold distance (Ave. DTD); see Appendix 18a; (c) effective detection threshold distance (Eff. DTD); the effective DTD for MNT2 was obtained by adding 30.9 % to the value of the average DTD; see p. 113 for details; (d) effective detection area (Eff. DA); the area effectively surveyed for each species in the complete MTW study, calculated as the product of twice the effective DTD (or the 'average DTD' for species that could not be analyzed in units of territories or displaying males) and the transect length (here 550 m); the product was divided by 10 000 in order to obtain the result in 'hectares'; (e) number of territories (No. terr.); see Appendix 18a; (f) number of displaying males (No. displ. MM); see Appendix 18a; (g) units per kilometer transect (Units/km trans.); see Appendix 18a; (h) units per km<sup>2</sup> (Units/km<sup>2</sup>); see Appendix 18a; (i) units per transect area (Units/trans. area); the transect area of MNT2 was 14.1 ha and is shown in Figure 8; cf. Appendix 18a; (j) individuals per unit (Ind./unit); see Appendix 18a; (k) maximum number of individuals (Max. no. ind.); see Appendix 18a; (l) average number of individuals (Ave. no. ind.); see Appendix 18a; (m) number of individuals per km transect (No. ind./km); see Appendix 18a; (n) number of individuals per km<sup>2</sup> (No. ind./km<sup>2</sup>); see Appendix 18a; (o) number of individuals per transect area (No. ind./trans. area); see Appendix 18a; (p) biomass density; see Appendix 18a. See p. 110-115, Estimation of population densities on the basis of transect-mapping data, for further details on the methodology used for the calculation of the population data and p. 164-166, How real area the modeled community data based on transect mapping?, on identified biases.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<b>TINAMIDAE (3)</b>																
<i>Tinamus major</i>	1052	400	523.6	57.6	1.50		2.7	2.6	0.4	2.5	2.5			6.5	0.9	6849.4
<i>Crypturellus berlepschi</i>	523	200	261.8	28.8	1.00		1.8	3.5	0.5	2.5	2.5			8.7	1.2	4540.2
<i>Crypturellus soui</i>	217	275	360.0	39.6	2.50		4.5	6.3	0.9	2.5	2.5			15.8	2.2	3425.1
<b>ARDEIDAE (1)</b>																
<i>Buorides striata</i>	[212]	[40]		[4.4]												
<b>CATHARTIDAE (3)</b>																
<i>Sarcocornophus papa</i>	3375	150		16.5												
<i>Conceps aratus</i>	2081	150		16.5												
<i>Cathartes aura</i>	1467	150		16.5												
<b>ACCIPITRIDAE (12)</b>																
<i>Pandion haliaetus</i>	1486	150		16.5												
<i>Lepodon cayanensis</i>	484	400	523.6	57.6	0.50		0.9	0.9	0.1	2.5				2.2	0.3	1050.4
<i>Elanoides forficatus</i>	442	175		19.3												
<i>Ictinia plumbea</i>	247	175		19.3												
<i>Accipiter superciliosus</i>	98	100	130.9	14.4												

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]		
<i>Acipiter bicolor</i>	341	325	425.4	46.8	0.25		0.5	0.5	0.1	2.5			1.2	0.2	557.9		
<i>Leucopternis plumbeus</i>	482	375	490.9	54.0													
<i>Leucopternis semiplumbens</i>	288	325	425.4	46.8													
<i>Leucopternis princeps</i>	1000	400		44.0													
<i>Buco magisteris</i>	269	300	392.7	43.2													
<i>Buco brachyurus</i>	495	225		24.8													
<i>Spizaetus tyrannus</i>	[1035]	[500]	[654.5]	[72.0]													
FALCONIDAE (5)																	
<i>Microtus ruficollis</i>	179	225	294.5	32.4													
<i>Microtus semitorquatus</i>	702	400	523.6	57.6	0.25		0.5	0.4	0.1	2.5			1.1	0.2	761.8		
<i>Herpotheres cachimans</i>	668	450	589.1	64.8	0.25		0.5	0.4	0.1	2.5			1.0	0.1	644.3		
<i>Falco ruficularis</i>	166	200	261.8	28.8													
<i>Falco peregrinus</i>	782	200		22.0													
CRACIDAE (2)																	
<i>Ortalis erythroptera</i>	[632]	[250]		[27.5]	0.25		0.5	0.9	0.1	2.5			2.3	0.3	4681.8		
<i>Penelope purpurascens</i>	2060	250		27.5													
ODONTOPHORIDAE (2)																	
<i>Odontophorus erythrops</i>	280	325	425.4	46.8	3.50		6.4	7.5	1.1	4.0			29.9	4.2	8376.7		
<i>Rhynchortyx cinctus</i>	158	275	360.0	39.6	2.00		3.6	5.1	0.7	2.5			12.6	1.8	1995.1		
RALLIDAE (3)																	
<i>Lanius albigularis</i>	47	150	196.4	21.6	1.00		1.8	4.6	0.7	2.5			11.6	1.6	544.0		
<i>Amazilia luciae</i>	133	200	261.8	28.8	4.00		7.3	13.9	2.0	2.5			34.7	4.9	4618.4		
<i>Neotrex colombiana</i>	[73]	[20]	[26.2]	[2.9]													
SCOLOPACIDAE (1)																	
<i>Actitis macularia</i>	40	60		6.6													
COLUMBIDAE (7)																	
<i>Pataigenus spectosa</i>	244	125	163.6	18.0	0.50		0.9	2.8	0.4	2.5			6.9	1.0	1694.6		
<i>Pataigenus subvirens</i>	172	250	327.3	36.0	2.00		3.6	5.6	0.8	2.5			13.9	2.0	2389.1		
<i>Pataigenus godsoni</i>	134	200	261.8	28.8	3.50		6.4	12.2	1.7	2.5			30.4	4.3	4071.5		
<i>Clarus pretiosa</i>	[67]	[225]		[24.8]													
<i>Lepotila pallida</i>	157	150	196.4	21.6	6.00		10.9	27.8	3.9	2.5			69.4	9.8	10 903.5		
<i>Georgyon tenuigenis</i>	152	25	32.7	3.6	1.25		2.3	34.7	4.9	2.5			86.8	12.2	13 195.4		
<i>Georgyon montana</i>	117	125	163.6	18.0													
PSITTACIDAE (6)																	
<i>Ana ambigua</i>	1348	400		44.0									0.50	0.9	1.1	1531.8	
<i>Touit dilectissimus</i>	[65]	[275]		[30.3]													
<i>Pionopsitta pulchra</i>	150	225	24.8	24.8									7.25	13.2	29.3	4.1	4393.9
<i>Pionus menstruus</i>	247	300		33.0									2.25	4.1	6.8	1.0	1684.1
<i>Pionus chalcopterus</i>	210	300		33.0									6.00	10.9	18.2	2.6	3818.2
<i>Amazona farinosa</i>	610	450		49.5									3.00	5.5	6.1	0.9	3697.0
CUCULIDAE (6)																	
<i>Piaya cayana</i>	108	110	144.0	15.8													
<i>Piaya minuta</i>	35	60	78.5	8.6	1.00		1.8	11.6	1.6	2.5			28.9	4.1			1012.8

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<i>Crotophaga ani</i>	105	90		9.9												
<i>Crotophaga sulcirostris</i>	82	90		9.9												
<i>Tapera naenia</i>	[52]	[250]	[327.3]	[36.0]												
<i>Neomorphus radiolatus</i>	340	125	163.6	18.0												
STRIGIDAE (4)																
<i>Megascops centralis</i>	105	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			13.9	2.0		1458.4
<i>Glauclidium griseiceps</i>	51	250	327.3	36.0												
<i>Pulsarius perspicillatus</i>	873	300	392.7	43.2	0.50		0.9	1.2	0.2	2.5			2.9	0.4		2526.2
<i>Strix virgata</i>	[250]	[225]	[294.5]	[32.4]												
NYCTIBIDAE (1)																
<i>Nyctibius griseus</i>	[185]	[200]	[261.8]	[28.8]												
CAPRIMULGIDAE (2)																
<i>Nyctidromus albigallus</i>	53	225	294.5	32.4	1.00		1.8	3.1	0.4	2.5			7.7	1.1		409.0
<i>Nyctiphrynus rosenbergi</i>	52	200	261.8	28.8	1.50		2.7	5.2	0.7	2.5			13.0	1.8		677.1
APODIDAE (6)																
<i>Streptoprocne zonaris</i>	98	150		16.5							1.50	2.7	9.1	1.3		890.9
<i>Cypseloides nylus</i>	21	125		13.8												
<i>Chaetura pelagica</i>	24	75		8.3												
<i>Chaetura spinicaudus</i>	15	50		5.5							1.00	1.8	18.2	2.6		272.7
<i>Chaetura cinereiventris</i>	14	75		8.3												
<i>Panyptila cayennensis</i>	21	60		6.6												
TROCHILIDAE (15)																
<i>Glaucois aeneus</i>	5	55		6.1							0.25	0.5	4.1	0.6		20.7
<i>Threnetes ruckeri</i>	6.5	60		6.6							9.00	16.4	136.4	19.2		886.4
<i>Phaethornis yaruqui</i>	6	85		9.4							6.00	10.9	64.2	9.0		385.0
<i>Phaethornis virgularis</i>	2.5	35		3.9							0.75	1.4	19.5	2.7		48.7
<i>Euxoetes aquila</i>	11	55		6.1							2.00	3.6	33.1	4.7		363.6
<i>Androdon aequatorialis</i>	7.5	100		11.0							0.75	1.4	6.8	1.0		51.1
<i>Florisuga mellinora</i>	7.5	60		6.6												
<i>Popelataria conversii</i>	3	30		3.3												
<i>Thalurania fannyi</i>	4.5	50		5.5												
<i>Damophila julie</i>	3	35		3.9												
<i>Amazilia tzacatl</i>	5	60		6.6												
<i>Amazilia amabilis</i>	[4.5]	[40]		[4.4]												
<i>Amazilia rosenbergi</i>	4	55		6.1							7.25	13.2	119.8	16.9		479.3
<i>Chalybura urodryas</i>	7	45		5.0							1.25	2.3	25.3	3.6		176.8
<i>Heliodoxa barroti</i>	5	40		4.4							0.25	0.5	5.7	0.8		28.4
TROGONIDAE (3)																
<i>Trogon comopus</i>	104	225	294.5	32.4	2.25		4.1	6.9	1.0	2.5			17.4	2.4		1805.7
<i>Trogon chinamensis</i>	88	200	261.8	28.8	2.50		4.5	8.7	1.2	2.5			21.7	3.1		1909.9
<i>Trogon rufus</i>	58	200	261.8	28.8												
ALCEDINIDAE (4)																
<i>Megascops tonquata</i>	317	150	196.4	21.6	0.25		0.5	1.2	0.2	2.5			2.9	0.4		917.3

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<i>Chloroceryle americana</i>	37.5	60	78.5	8.6											
<i>Chloroceryle inda</i>	56.5	60	78.5	8.6											
<i>Chloroceryle aenea</i>	15	30	39.3	4.3											
<b>MONOTIDAE (2)</b>															
<i>Electron platyrhynchos</i>	76	250	327.3	36.0	3.25		5.9	9.0	1.3	2.5			22.6	3.2	1715.4
<i>Barphitenegus nartii</i>	142	250	327.3	36.0	1.75		3.2	4.9	0.7	2.5			12.2	1.7	1725.8
<b>GALBULIDAE (1)</b>															
<i>Galbula ruficauda</i>	26	175	229.1	25.2											
<b>BUCCONIDAE (3)</b>															
<i>Nystalus radiatus</i>	61	175	229.1	25.2											
<i>Malacoptila panamensis</i>	41	40	52.4	5.8	1.50		2.7	26.0	3.7	2.5			65.1	9.2	2669.5
<i>Micromonacha lanceolata</i>	19	75	98.2	10.8											
<b>CAPTIONIDAE (1)</b>															
<i>Capito squamatus</i>	58	60	78.5	8.6	1.00		1.8	11.6	1.6	3.5			40.5	5.7	2349.7
<b>RAMPHASTIDAE (3)</b>															
<i>Pteroglossus sanguineus</i>	250	175	229.1	25.2	1.00		1.8	4.0	0.6	4.0			15.9	2.2	3975.0
<i>Ramphastos brevis</i>	424	325	425.4	46.8	1.00		1.8	2.1	0.3	3.5			7.5	1.1	3171.2
<i>Ramphastos swainsonii</i>	622	450	589.1	64.8	1.00		1.8	1.5	0.2	3.5			5.4	0.8	3359.8
<b>PICIDAE (8)</b>															
<i>Picumnus olivaceus</i>	[12]	[35]	[45.8]	[5.0]	0.50		0.9	3.5	0.5	2.5			8.7	1.2	460.1
<i>Picus latre</i>	53	100	130.9	14.4	0.50		0.9	1.5	0.2	2.5			3.9	0.5	297.1
<i>Celexus loritatus</i>	77	225	294.5	32.4	0.50		0.9	1.4	0.2	2.5			3.5	0.5	638.9
<i>Dryocopus lineatus</i>	184	250	327.3	36.0	0.50		0.9	1.4	0.2	2.5			9.9	1.4	625.0
<i>Melanerpes formicivorus</i>	63	175	229.1	25.2	1.00		1.8	4.0	0.6	2.5			13.9	2.0	513.9
<i>Veniliornis kiriki</i>	37	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			3.9	0.5	933.7
<i>Veniliornis callonotus</i>	[27]	[125]	[163.6]	[18.0]											
<i>Campoplex gazaquensis</i>	242	225	294.5	32.4	0.50		0.9	1.5	0.2	2.5			3.9	0.5	933.7
<b>FURNARIIDAE (5)</b>															
<i>Synallaxis brachyura</i>	19	60	78.5	8.6	3.00		5.5	34.7	4.9	2.5			86.8	12.2	1649.4
<i>Hylocichla ustulata</i>	34	200	261.8	28.8	2.25		4.1	7.8	1.1	2.5			19.5	2.8	664.1
<i>Automolus rubiginosus</i>	44	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			13.9	2.0	611.2
<i>Xenops minutus</i>	12	75	98.2	10.8	2.00		3.6	18.5	2.6	2.5			46.3	6.5	555.6
<i>Sclerurus mexicanus</i>	25	200	261.8	28.8	0.25		0.5	0.9	0.1	2.5			2.2	0.3	54.3
<b>DENDROCOLAPTIDAE (8)</b>															
<i>Dendrocincla fuliginosa</i>	39	150	196.4	21.6	1.25		2.3	5.8	0.8	2.5			14.5	2.0	564.3
<i>Glycyborychus spirurus</i>	14	60	78.5	8.6	3.00		5.5	34.7	4.9	2.5			86.8	12.2	1215.4
<i>Dendrocolaptes sanctithomae</i>	68	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			13.9	2.0	944.5
<i>Xiphorhynchus lachrymosus</i>	56	175	229.1	25.2	2.00		3.6	7.9	1.1	2.5			19.8	2.8	1111.2
<i>Xiphorhynchus erythrogaster</i>	48	100	130.9	14.4	1.00		1.8	6.9	1.0	2.5			17.4	2.4	833.4
<i>Lepidocolaptes souleyetii</i>	[27.5]	[125]	[163.6]	[18.0]											
<i>Campylorhynchus trochilirostris</i>	42	150	196.4	21.6	0.50		0.9	2.8	0.4	2.5			6.9	1.0	277.8
<i>Campylorhynchus pusillus</i>	40	125	163.6	18.0											

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<b>THAMNOPHILIDAE (18)</b>															
<i>Cymbidillus lineatus</i>	35	110	144.0	15.8											
<i>Taraba major</i>	60	200	261.8	28.8											
<i>Thamophilus atrinucha</i>	23	110	144.0	15.8	2.00		3.6	12.6	1.8	2.5			31.6	4.5	726.1
<i>Thomistes anabatinus</i>	21	75	98.2	10.8	1.50		2.7	13.9	2.0	2.5			34.7	4.9	729.2
<i>Dryothamnus puncticeps</i>	17	125	163.6	18.0	1.50		2.7	8.3	1.2	2.5			20.8	2.9	354.2
<i>Myrmotherula ignea</i>	7	100	130.9	14.4	1.00		1.8	6.9	1.0	2.5			17.4	2.5	121.5
<i>Myrmotherula pacifica</i>	9.5	100	130.9	14.4	3.00		5.5	20.8	2.9	2.5			52.1	7.3	494.8
<i>Myrmotherula fulviventris</i>	10.5	60	78.5	8.6	2.50		4.5	28.9	4.1	2.5			72.3	10.2	759.6
<i>Myrmotherula exilis</i>	8.5	100	130.9	14.4	2.50		4.5	17.4	2.4	2.5			43.4	6.1	368.9
<i>Myrmotherula schisticolor</i>	[8.5]	[60]		[6.6]											
<i>Microtophis quixensis</i>	9	125	163.6	18.0	1.50		2.7	8.3	1.2	2.5			20.8	2.9	187.5
<i>Cercocarpia tyrannina</i>	17	150	196.4	21.6	7.00		12.7	32.4	4.6	2.5			81.0	11.4	1377.4
<i>Hylophylax naevioides</i>	16.5	75	98.2	10.8	2.50		4.5	23.1	3.3	2.5			57.9	8.2	954.9
<i>Myrmeciza immaculata</i>	44.5	225	294.5	32.4	1.50		2.7	4.6	0.7	2.5			11.6	1.6	515.1
<i>Myrmeciza exul</i>	23	175	229.1	25.2	8.00		14.5	31.7	4.5	2.5			79.4	11.2	1825.5
<i>Myrmeciza borlepsi</i>	28	175	229.1	25.2	3.25		5.9	12.9	1.8	2.5			32.2	4.5	902.8
<i>Gymnophis leucopsis</i>	34	80	104.7	11.5	2.25		4.1	19.5	2.8	2.5			48.8	6.9	1660.3
<i>Phenostictus melanani</i>	51	125	163.6	18.0	0.25		0.5	1.4	0.2	2.5			3.5	0.5	177.1
<b>FORMICARIIDAE (2)</b>															
<i>Formicarius nigricapillus</i>	57	200	261.8	28.8	4.00		7.3	13.9	2.0	2.5			34.7	4.9	1979.3
<i>Hylozeus perspicillatus</i>	42	200	261.8	28.8	3.50		6.4	12.2	1.7	2.5			30.4	4.3	1276.1
<b>TYRANNIDAE (41)</b>															
<i>Phyllomyia grisiceps</i>	[7]	[80]	[104.7]	[11.5]											
<i>Zimmerius chrysops</i>	8.5	90	117.8	13.0	2.25		4.1	17.4	2.4	2.5			43.4	6.1	368.9
<i>Ornithion brunneicapillus</i>	7	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			13.9	2.0	97.2
<i>Camptostoma obscurum</i>	[8]	[70]	[91.6]	[10.1]											
<i>Tyrannulus elatus</i>	[7]	[80]	[104.7]	[11.5]											
<i>Myiopagis caniceps</i>	10.5	100	130.9	14.4											
<i>Myiopagis viridicatus</i>	13.5	125		13.8											
<i>Myiozetetes olivaceus</i>	14.5	40	52.4	5.8		4.0	7.3	69.4	9.8	2.5			173.6	24.5	2517.5
<i>Myiozetetes olivaceus</i>	10.5	50	65.5	7.2											
<i>Leptopogon superciliosus</i>	12.5	60	78.5	8.6	1.25		2.3	14.5	2.0	2.5			36.2	5.1	452.1
<i>Myiornis atricapillus</i>	5.5	110	144.0	15.8	3.00		5.5	18.9	2.7	2.5			47.4	6.7	260.4
<i>Lophortyx pileatus</i>	7.5	110	144.0	15.8		2.0	3.6	12.6	1.8	2.5			31.6	4.5	236.8
<i>Todirostrum nigricops</i>	6.5	100	130.9	14.4	1.50		2.7	10.4	1.5	2.5			26.0	3.7	169.3
<i>Todirostrum cinereum</i>	6.5	90	117.8	13.0	1.75		3.2	13.5	1.9	2.5			33.8	4.8	219.4
<i>Rhynchocyclus pacificus</i>	26	75	98.2	10.8	1.00		1.8	9.3	1.3	2.5			23.1	2.5	601.9
<i>Tolmomyia flavinotus</i>	14.5	110	144.0	15.8	1.00		1.8	6.3	0.9	2.5			15.8	2.2	228.9
<i>Platyrinchus coronatus</i>	9.5	40	52.4	5.8	1.50		2.7	26.0	3.7	2.5			65.1	9.2	618.5
<i>Tenoriozetetes erythrus</i>	7	55		6.1							2.0	3.6	33.1	4.7	231.4
<i>Myiobius aricaudus</i>	10	20		2.2									1.8		
<i>Myiobius sulphureipigius</i>	11.5	20		2.2							1.0		45.5	6.4	522.7

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/g km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<i>Myiophobus fasciatus</i>	[10]	[80]	[104.7]	[11.5]												
<i>Contopus cooperi</i>	32	120		13.2												
<i>Empidonax virens</i>	13	100		11.0												
<i>Colonia colonus</i>	16	110	144.0	15.8	1.00		1.8	6.3	0.9	2.5			15.8		2.2	252.5
<i>Attila spadiceus</i>	[39]	[225]	[294.5]	[32.4]												
<i>Rhytiperna holerybna</i>	38.5	150	196.4	21.6	0.50		0.9	2.3	0.3	2.5			5.8		0.8	222.8
<i>Syrtes albigricus</i>	33	140	183.3	20.2												
<i>Myiarchus tuberculifer</i>	[20]	[100]	[130.9]	[14.4]												
<i>Megarynchus pitangua</i>	74	125	163.6	18.0	1.00		1.8	5.6	0.8	2.5			13.9		2.0	354.2
<i>Myiozetetes cayanensis</i>	25.5	125	163.6	18.0												
<i>Myiozetetes gaudensis</i>	26.5	125	163.6	18.0												
<i>Conopias albinotatus</i>	24.5	175	229.1	25.2	1.00		1.8	4.0	0.6	2.5			9.9		1.4	243.1
<i>Myiodynastes maculatus</i>	46	120		13.2												
<i>Legatus leucophaeus</i>	24.5	200	261.8	28.8	1.00		1.8	3.5	0.5	2.5			8.7		1.2	212.7
<i>Tyrannus melancholicus</i>	37.5	110	144.0	15.8												
<i>Tyrannus nigrigularis</i>	37	100		11.0												
<i>Pachyrhamphus cinnamomus</i>	22	75	98.2	10.8	2.00		3.6	18.5	2.6	2.5		0.25	0.5	2.3	0.3	84.1
<i>Pachyrhamphus albigricus</i>	17.5	100		11.0										46.3	6.5	1018.6
<i>Platyparis homodromus</i>	33.5	40		4.4												
<i>Tityra semifasciata</i>	79	80	104.7	11.5												
<i>Tityra inquisitor</i>	[43]	[80]	[104.7]	[11.5]												
COTTINGIDAE (4)																
<i>Lipaugus unirufus</i>	82	250	327.3	36.0												
<i>Cotinga nattererii</i>	[60]	[40]		[4.4]												
<i>Carpodacus hoppei</i>	110	40		4.4												
<i>Querula purpurata</i>	106	150	196.4	21.6	0.50		0.9	2.3	0.3	5.0			11.6		1.6	1226.9
PYRIDAE (7)																
<i>Pipra mentalis</i>	14.5	100	130.9	14.4			9.0	16.4	62.5	8.8	2.5		156.3		22.0	2265.8
<i>Lepidobrix coronata</i>	9	55	72.0	7.9			7.0	12.7	88.4	12.5	2.5		221.0		31.2	1988.8
<i>Manacus manacus</i>	17.5	70	91.6	10.1			7.0	12.7	69.4	9.8	2.5		173.6		24.5	3038.4
<i>Machaenopus deliciosus</i>	13.5	90		9.9												
<i>Chloropipo holochlora</i>	16	20		2.2												
<i>Schiffhorris turtina</i>	31	175	229.1	25.2												
<i>Sapayoa aetigna</i>	20.5	60	78.5	8.6	1.50		2.7	17.4	2.4	2.5			43.4		6.1	889.8
VIREONIDAE (3)																
<i>Vireo olivaceus</i>	16.5	40		4.4												
<i>Hylophilus decuratus</i>	9	130	170.2	18.7	3.00		5.5	16.0	2.3	2.5			40.1		5.6	360.6
<i>Hylophilus ochraceiceps</i>	12	120	157.1	17.3	1.00		1.8	5.8	0.8	2.5			14.5		2.0	173.6
TURDIDAE (2)																
<i>Catharus ustulatus</i>	29	100		11.0												
<i>Turdus daugueti</i>	52	155	202.9	22.3	1.50		2.7	6.7	0.9	2.5			16.8		2.4	873.7
HIRUNDINIDAE (8)																
<i>Progne chalybea</i>	43	75		8.3												

## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD [m]	Eff. <sup>c</sup> DTD [m]	Eff. <sup>d</sup> DA [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<i>Progne subis</i>	49.5	75		8.3												
<i>Tachycineta bicolor</i>	20	60		6.6												
<i>Neochelidon tibialis</i>	10.5	50		5.5												238.6
<i>Stelgidopteryx ruficollis</i>	13.5	75		8.3												122.7
<i>Riparia riparia</i>	14.5	50		5.5												
<i>Hirundo rustica</i>	16	60		6.6												
<i>Petrochelidon pyrrhonota</i>	21.5	50		5.5												
TROGLODYTIDAE (8)																
<i>Campylorhynchus zonatus</i>	[34.5]	[120]	[157.1]	[17.3]												
<i>Odonotrichia bruniifolia</i>	9.5	100	130.9	14.4												
<i>Thryothorus nigricapillus</i>	21	200	261.8	28.8	2.00		3.6	6.9	1.0	2.5				17.4	2.4	364.6
<i>Thryothorus leucopogon</i>	16.5	175	229.1	25.2	4.25		7.7	16.9	2.4	2.5				42.2	5.9	695.7
<i>Troglodytes aedon</i>	10.5	125	163.6	18.0												
<i>Henicorhina leucosticta</i>	16	185	242.2	26.6	1.50		2.7	5.6	0.8	2.5				14.1	2.0	225.2
<i>Cyborhynchus phaeocephalus</i>	[24.5]	[80]		[8.8]												
<i>Microcerculus nigrigularis</i>	19	200	261.8	28.8	4.50		8.2	15.6	2.2	2.5				39.1	5.5	742.2
POLIOPTILIDAE (3)																
<i>Microbatas cinereiventris</i>	11.5	120	157.1	17.3	4.25		7.7	24.6	3.5	2.5				61.5	8.7	707.2
<i>Polioptila plumbea</i>	[6]	[80]	[104.7]	[11.5]	1.50		2.7	13.0	1.8	2.5				32.6	4.6	195.3
<i>Polioptila schizacercula</i>	6	80	104.7	11.5												
PARULIDAE (8)																
<i>Dendroica striata</i>	[13]	[40]		[4.4]												
<i>Dendroica fusca</i>	[9.5]	[40]		[4.4]												
<i>Sciurus noveboracensis</i>	[18]	[20]		[2.2]												
<i>Geothlypis semiflava</i>	15.5	125	163.6	18.0												
<i>Geothlypis auricularis</i>	[10]	[100]	[130.9]	[14.4]												
<i>Oporornis philladelphica</i>	[12.5]	[20]		[2.2]												
<i>Oporornis agilis</i>	[15]	[20]		[2.2]												
<i>Basileuterus fulvicauda</i>	13.5	175	229.1	25.2	1.00		1.8	4.0	0.6	2.5				9.9	1.4	133.9
THRAUPIDAE (27)																
<i>Coereba flaveola</i>	9.5	45	58.9	6.5	1.00		1.8	15.4	2.2	2.5				38.6	5.4	366.5
<i>Cyanerpes caeruleus</i>	12	40	52.4	5.8												
<i>Cyanerpes cyaneus</i>	[14]	[45]	[58.9]	[6.5]												
<i>Chlorophanes spiza</i>	19	50	65.5	7.2												
<i>Dacnis cayana</i>	13	30	39.3	4.3												
<i>Dacnis egregia</i>	13.5	30	39.3	4.3												
<i>Dacnis venusta</i>	16	30		3.3												
<i>Dacnis berlepschi</i>	13.5	50	65.5	7.2	1.50		2.7	20.8	2.9	2.5				52.1	7.3	703.2
<i>Erythroblyptis salmوني</i>	12	65	85.1	9.4												
<i>Euphonia laniusis</i>	14.5	90	117.8	13.0												
<i>Euphonia xanthogaster</i>	13	90	117.8	13.0	4.00		7.3	30.9	4.4	2.5				77.2	10.9	1003.2
<i>Euphonia minuta</i>	10	50	65.5	7.2	1.00		1.8	13.9	2.0	2.5				34.7	4.9	347.2
<i>Euphonia fulvicauda</i>	11	90	117.8	13.0												



## APPENDIX 19A. Continued.

Family (no. of spp.) / species	Body <sup>a</sup> mass [g]	Ave. <sup>b</sup> DTD	Eff. <sup>c</sup> DTD	Eff. <sup>d</sup> DA	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km trans.	Units/ <sup>h</sup> km <sup>2</sup>	Units/ <sup>i</sup> trans. area	Ind./ <sup>j</sup> unit	Max. <sup>k</sup> no. ind.	Ave. <sup>l</sup> no. ind.	No. <sup>m</sup> ind./ km	No. <sup>n</sup> ind./ km <sup>2</sup>	No. ind./ <sup>o</sup> trans. area	Biomass <sup>p</sup> density [g/km <sup>2</sup> ]
<i>Tangara pulveri</i>	32.5	100	130.9	14.4	1.00		1.8	6.9	1.0	2.5			17.4	2.4		564.3
<i>Tangara cyanitollis</i>	[17]	[60]	[78.5]	[8.6]												
<i>Tangara larva</i>	16	75	98.2	10.8	1.00		1.8	9.3	1.3	2.5			23.1	3.3		370.4
<i>Tangara johannae</i>	21	50	65.5	7.2	1.00		1.8	13.9	2.0	2.5			34.7	4.9		729.2
<i>Tangara larinda</i>	17.5	60	78.5	8.6	1.00		1.8	11.6	1.6	2.5			28.9	4.1		506.4
<i>Thraupis episcopus</i>	33.5	75	98.2	10.8	1.00		1.8	9.3	1.3	2.5			23.1	3.3		775.5
<i>Thraupis palmarum</i>	32.5	75	98.2	10.8												
<i>Ramphocelus icteronotus</i>	33.5	85		9.4								14.00	25.5	149.7	21.1	5016.0
<i>Priniga rubra</i>	30	85		9.4								0.25	0.5	2.7	0.4	80.2
<i>Chlorothraupis olivacea</i>	39.5	220	288.0	31.7	2.75		5.0	8.7	1.2	2.5			21.7	3.1		857.3
<i>Mitrospingus castinii</i>	39.5	80	104.7	11.5	1.00		1.8	8.7	1.2	5.0			43.4	6.1		1714.5
<i>Tachyphonus luctuosus</i>	13	90		9.9												
<i>Tachyphonus delatrii</i>	19	100		11.0												
<i>Heeroppingus xanthopygius</i>	38	135	176.7	19.4	1.00		1.8	5.1	0.7	2.5			161.4	22.8		3065.9
CARDINALIDAE (4)													12.9	1.8		488.7
<i>Saltator maximus</i>	47	150	196.4	21.6	3.00		5.5	13.9	2.0	2.5			34.7	4.9		1632.1
<i>Saltator atripennis</i>	56.5	180	235.6	25.9	1.00		1.8	3.9	0.5	2.5			9.6	1.4		545.0
<i>Saltator grossus</i>	49	225	294.5	32.4	1.75		3.2	5.4	0.8	2.5			13.5	1.9		661.7
<i>Phaeucticus ludovicianus</i>	44.5	100		11.0												
EMBERIZIDAE (10)																
<i>Rhodospingus cruentus</i>	10.5	70		7.7												
<i>Volatinia jacarina</i>	9.5	60		6.6												
<i>Tiaris obscurus</i>	10.5	80	104.7	11.5												
<i>Oryzoborus angolensis</i>	12	80	104.7	11.5	1.00		1.8	8.7	1.2	2.5			21.7	3.1		260.4
<i>Sporophila corvina</i>	10.5	65	85.1	9.4	1.00		1.8	10.7	1.5	2.5			26.7	3.8		280.5
<i>Sporophila luctuosa</i>	12.5	70		7.7												
<i>Sporophila nigricollis</i>	8	70	91.6	10.1	1.00		1.8	9.9	1.4	2.5			24.8	3.5		198.4
<i>Sporophila telasco</i>	8.5	30		3.3												
<i>Arremon aurantivestris</i>	26	60	78.5	8.6	4.50		8.2	52.1	7.3	2.5			130.2	18.4		3385.7
<i>Arremonops contritoris</i>	[40]	[160]	[209.4]	[23.0]												
ICTERIDAE (6)																
<i>Cacicus microphylus</i>	64.5	225		24.8								12.75	23.2	51.5	7.3	3322.7
<i>Amphispicus holosericeus</i>	[64]	[200]	[261.8]	[28.8]												
<i>Zarbynchus uugleri</i>	163.5	125		13.8								0.25	0.5	1.8	0.3	297.3
<i>Molothrus bonariensis</i>	[49.5]	[90]		[9.9]												
<i>Molothrus oryzivorus</i>	190.5	110		12.1												
<i>Dolichonyx oryzivorus</i>	[42]	[20]		[2.2]												
SUM	32 056.5	30 930			197.5	29.0					3.0	96.5	4814.8	678.8		197 622.4
No. of species (MTW/total)	144/231				112	5					2	25				144
Average	222.6	214.8														41.0

## APPENDIX 19B

MTW-study: within-habitat abundance, population density, and available area per territory of the bird community in the transect area of MNT2. In contrast to Appendix 19A the population data presented here refer exclusively to those portions of the transect area that actually contained the appropriate habitat for the species, in order to gain a better impression of the abundance and population density the species may reach in comparable homogeneous habitat. For species that occupied rather broad ecological niches, and therefore were present in the entire transect area, the population data are the same as in the previous appendix. The detection threshold distances, within-habitat length, and effective detection areas within habitat are shown for all 268 bird species recorded between Aug. 1995 and Mar. 1998 within 100 m of the transects MNT1 and MNT2 (see Appendix 12b for details). For species recorded only in the transect area of MNT1, the values are stated in "[...]" brackets. Population data are shown exclusively for the 144 species recorded in the MTW study of MNT2 between Mar. and Nov. 1997. It is likely that such high population densities as calculated here for some species may be reached only locally in ideal habitat. The results may not be representative for other areas of Playa de Oro, even where similar habitat is present (e.g., continuous *terra firme* forest). Furthermore, the total number of territories or individuals recorded was often small and, in some cases, the 'within-habitat detection area' was very small in relation to the expected territory size of the species. In other words, the results have to be regarded as preliminary and should be interpreted with caution. Whenever I assumed that the within-habitat abundance or population density were considerably overestimated due to methodological biases or small sample size, the results are written in italics. Abbreviations used and explanations: (a) average detection threshold distance (Ave. DTD); see Appendix 18a; (b) effective detection threshold distance (Eff. DTD); see Appendix 18a; (c) within-habitat transect length (WiHab TraLen): estimated length of the portion of the transect that actually contained appropriate habitat for the species; the total length of transect MNT2 was 550 m; (d) effective detection area within habitat (Eff. DA WiHab): see Appendix 18b; (e) number of territories (No. terr.): see Appendix 18a; (f) number of displaying males (No. displ. MM): see Appendix 18a; (g) units per kilometer transect within habitat (Units/km WiHab): see Appendix 18b; (h) units per km<sup>2</sup> within habitat (Units/km<sup>2</sup> WiHab): see Appendix 18b; (i) individuals per unit (Ind./unit): see Appendix 18a; (j) maximum number of individuals (Max. no. ind.): see Appendix 18a; (k) average number of individuals (Ave. no. ind.): see Appendix 18a; (l) number of individuals per km transect within habitat (No. ind./km WiHab): see Appendix 18b; (m) number of individuals per km<sup>2</sup> within habitat (No. ind./km<sup>2</sup> WiHab): see Appendix 18b; (n) available area per territory (Available area/terr.): see Appendix 18b. See p. 110-115, Estimation of population densities on the basis of transect-mapping data, for further details on the methodology used for the calculation of the population data and p. 164-166, How real are the modeled community data based on transect mapping?, on identified biases.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WiHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units <sup>g</sup> km WiHab	Units <sup>h</sup> km <sup>2</sup> WiHab	Ind. <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. <sup>l</sup> km WiHab	No. ind. <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area/terr. [ha]
<b>TINAMIDAE (3)</b>														
<i>Tinamus major</i>	400	523.6	550	57.6	1.50		2.7	2.6	2.5				6.5	38.4
<i>Crypturellus berlepschi</i>	200	261.8	550	28.8	1.00		1.8	3.5	2.5				8.7	28.8
<i>Crypturellus soui</i>	275	360.0	550	39.6	2.50		4.5	6.3	2.5				15.8	15.8
<b>ARBIDEAE (1)</b>														
<i>Buarideia striata</i>	[40]		[75]	[0.6]										
<b>CATHARTIDAE (3)</b>														
<i>Sarcocampophus papa</i>	150		550	16.5										
<i>Coragyps atratus</i>	150		550	16.5										
<i>Cathartes aura</i>	150		550	16.5										
<b>ACCIPITRIDAE (12)</b>														
<i>Pandion haliaetus</i>	150		550	16.5							0.25	0.5	1.5	

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km WtHab	Units/ <sup>h</sup> km <sup>2</sup> WtHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km WtHab	No. ind./ <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Lepidodon cyanensis</i>	400	523.6	550	57.6	0.50		0.9	0.9	2.5			2.2		115.2
<i>Elanoides forficatus</i>	175		550	19.3										
<i>Ictinia plumbea</i>	175		550	19.3										
<i>Accipiter supersciliosus</i>	100	130.9	550	14.4										
<i>Accipiter bicolor</i>	325	425.4	550	46.8										
<i>Leucopternis plumbeus</i>	375	490.9	550	54.0	0.25		0.5	0.5	2.5			1.2		216.0
<i>Leucopternis semiplumbeus</i>	325	425.4	550	46.8										
<i>Leucopternis princeps</i>	400		550	44.0										
<i>Buteo magnirostris</i>	300	392.7	425	33.4										
<i>Buteo brachyurus</i>	225		550	24.8										
<i>Spizactus tyrannus</i>	[500]	[654.5]	[550]	[72.0]										
FALCONIDAE (5)														
<i>Microstur nigrifollis</i>	225	294.5	550	32.4									1.1	230.4
<i>Microstur semitorquatus</i>	400	523.6	550	57.6	0.25		0.5	0.4	2.5			1.0		259.2
<i>Hepataethers cacinmans</i>	450	589.1	550	64.8	0.25		0.5	0.4	2.5					
<i>Falco nigrigularis</i>	200	261.8	550	28.8										
<i>Falco peregrinus</i>	200		550	22.0										
CRACIDAE (2)														
<i>Ortalis erythroptera</i>	[250]		[550]	[27.5]										
<i>Penelope purpurascens</i>	250		550	27.5	0.25		0.5	0.9	2.5			2.3		110.0
ODONTOPHORIDAE (2)														
<i>Odonophorus erythrops</i>	325	425.4	550	46.8	3.50		6.4	7.5	4.0			29.9		13.4
<i>Rhynchortyx tinctus</i>	275	360.0	550	39.6	2.00		3.6	5.1	2.5			12.6		19.8
RALLIDAE (3)														
<i>Latenallus albigularis</i>	150	196.4	125	4.9	1.00		8.0	20.4	2.5			50.9		4.9
<i>Anatalimnias concolor</i>	200	261.8	275	14.4	4.00		14.5	27.8	2.5			69.4		3.6
<i>Neorex colombiana</i>	[20]	[26.2]	[125]	[0.7]										
SCOLOPACIDAE (1)														
<i>Actitis macularia</i>	60		100	1.2										
COLUMBIDAE (7)														
<i>Pangaea speciosa</i>	125	163.6	200	6.5	0.50		2.5	7.6	2.5			19.1		13.1
<i>Pangaea subvincta</i>	250	327.3	550	36.0	2.00		3.6	5.6	2.5			13.9		18.0
<i>Pangaea goodoni</i>	200	261.8	550	28.8	3.50		6.4	12.2	2.5			30.4		8.2
<i>Clarus pretiosa</i>	[225]		[150]	[6.8]										
<i>Lepotila pallida</i>	150	196.4	425	16.7	6.00		14.1	36.0	2.5			89.9		2.8
<i>Georgyon veraguensis</i>	25	32.7	425	2.8	1.25		2.9	44.9	2.5			112.3		2.2
<i>Georgyon montana</i>	125	163.6	425	13.9										
PSITTACIDAE (6)														
<i>Ana ambigua</i>	400		550	44.0						0.50	0.9		1.1	
<i>Touti dilectissimus</i>	[275]		[550]	[30.3]										
<i>Pionopsitta pulchra</i>	225		550	24.8						7.25	13.2		29.3	
<i>Pionus menstruus</i>	300		550	33.0						2.25	4.1		6.8	
<i>Pionus chalcopterus</i>	300		550	33.0						6.00	10.9		18.2	

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WiHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ km WiHab	Units/ km <sup>2</sup> WiHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km <sup>2</sup> WiHab	No. ind./ <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area/terr. [ha]
<i>Amazonia farnosa</i>	450		550	49.5							3.00	5.5	6.1	
CUCULIDAE (6)														
<i>Playa cayana</i>	110	144.0	550	15.8										
<i>Playa minuta</i>	60	78.5	150	2.4	1.00		6.7	42.4	2.5				106.1	2.4
<i>Crotophaga ani</i>	90		125	2.3										
<i>Crotophaga sulcirostris</i>	90		125	2.3										
<i>Tapera naevia</i>	[250]	[327.3]	[125]	[8.2]										
<i>Neomorphus nudiolus</i>	125	163.6	425	13.9										
STRIGIDAE (4)														
<i>Megascops centralis</i>	125	163.6	550	18.0	1.00		1.8	5.6	2.5				13.9	18.0
<i>Glucidium griseiceps</i>	250	327.3	425	27.8										
<i>Pulsatrix perspicillata</i>	300	392.7	550	43.2	0.50		0.9	1.2	2.5				2.9	86.4
<i>Strix virgata</i>	[225]	[294.5]	[550]	[32.4]										
NYCTIBIDAE (1)														
<i>Nyctibius griseus</i>	[200]	[261.8]	[550]	[28.8]										
CAPRIMULGIDAE (2)														
<i>Nyctidromus albigollis</i>	225	294.5	200	11.8	1.00		5.0	8.5	2.5				21.2	11.8
<i>Nyctiphrynus rosenbergi</i>	200	261.8	550	28.8	1.50		2.7	5.2	2.5				13.0	19.2
APODIDAE (6)														
<i>Streptoprocne zonaris</i>	150		550	16.5						1.50		2.7	9.1	
<i>Cypseloides nutilus</i>	125		550	13.8										
<i>Chaetura pelagica</i>	75		550	8.3										
<i>Chaetura spinicaudus</i>	50		550	5.5						1.00		1.8	18.2	
<i>Chaetura cinereiventris</i>	75		550	8.3										
<i>Panyptila cayennensis</i>	60		550	6.6										
TROCHILIDAE (15)														
<i>Glauis aeneus</i>	55		150	1.7						0.25		1.7	15.2	
<i>Threnetes ruckeri</i>	60		550	6.6						9.00		16.4	136.4	
<i>Phaethornis yaruqui</i>	85		550	9.4						6.00		10.9	64.2	
<i>Phaethornis sirigularis</i>	35		550	3.9						0.75		1.4	19.5	
<i>Eutoxeres aquila</i>	55		550	6.1						2.00		3.6	33.1	
<i>Androdon aequatorialis</i>	100		550	11.0						0.75		1.4	6.8	
<i>Florisuga mellivora</i>	60		550	6.6										
<i>Popelatria conversii</i>	30		550	3.3										
<i>Thalurania fannyi</i>	50		550	5.5										
<i>Damophila julie</i>	35		200	1.4										
<i>Amazilia tzacatl</i>	60		125	1.5										
<i>Amazilia amabilis</i>	[40]		[550]	[4.4]										
<i>Amazilia rosebergi</i>	55		550	6.1						7.25		13.2	119.8	
<i>Chalybura unchrysis</i>	45		450	4.1						1.25		2.8	30.9	
<i>Heliothryx barroti</i>	40		550	4.4						0.25		0.5	5.7	
TROGONIDAE (3)														
<i>Trogon comops</i>	225	294.5	550	32.4	2.25		4.1	6.9	2.5				17.4	14.4

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / g km WtHab	Units / h km <sup>2</sup> WtHab	Ind. / i unit WtHab	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / l km WtHab	No. ind. / m km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Trogon chionurus</i>	200	261.8	550	28.8	2.50		4.5	8.7	2.5				21.7	11.5
<i>Trogon rufus</i>	200	261.8	550	28.8										
ALCEDINIDAE (4)														
<i>Megasceryle torquata</i>	150	196.4	550	21.6	0.25		0.5	1.2	2.5				2.9	86.4
<i>Chlomeryle americana</i>	60	78.5	100	1.6										
<i>Chlomeryle inda</i>	60	78.5	550	8.6										
<i>Chlomeryle aenea</i>	30	39.3	550	4.3										
MOMOTIDAE (2)														
<i>Electron platyrhynchos</i>	250	327.3	550	36.0	3.25		5.9	9.0	2.5				22.6	11.1
<i>Batrachidergus martii</i>	250	327.3	550	36.0	1.75		3.2	4.9	2.5				12.2	20.6
GALBULIDAE (1)														
<i>Galbula ruficauda</i>	175	229.1	550	25.2										
BUCCONIDAE (3)														
<i>Nyctalus radiatus</i>	175	229.1	550	25.2										
<i>Malacoptila panamensis</i>	40	52.4	550	5.8	1.50		2.7	26.0	2.5				65.1	3.8
<i>Micromonacha lanceolata</i>	75	98.2	550	10.8										
CAPITONIDAE (1)														
<i>Capito squamatus</i>	60	78.5	550	8.6	1.00		1.8	11.6	3.5				40.5	8.6
RAMPHASTIDAE (3)														
<i>Peroglossus sanguineus</i>	175	229.1	550	25.2	1.00		1.8	4.0	4.0				15.9	25.2
<i>Ramphastos brevis</i>	325	425.4	550	46.8	1.00		1.8	2.1	3.5				7.5	46.8
<i>Ramphastos swainsonii</i>	450	589.1	550	64.8	1.00		1.8	1.5	3.5				5.4	64.8
PICIDAE (8)														
<i>Picumnus olivaceus</i>	[35]	[45.8]	[550]	[5.0]										
<i>Piculus litae</i>	100	130.9	550	14.4	0.50		0.9	3.5	2.5				8.7	28.8
<i>Celex loriscus</i>	225	294.5	550	32.4	0.50		0.9	1.5	2.5				3.9	64.8
<i>Dryocopus lineatus</i>	250	327.3	425	27.8	0.50		1.2	1.8	2.5				4.5	55.6
<i>Melanerpes formicivorus</i>	175	229.1	425	19.5	1.00		2.4	5.1	2.5				12.8	19.5
<i>Veniliornis kirikii</i>	125	163.6	550	18.0	1.00		1.8	5.6	2.5				13.9	18.0
<i>Veniliornis collaris</i>	[125]	[163.6]	[550]	[18.0]										
<i>Campoplex gaudens</i>	225	294.5	550	32.4	0.50		0.9	1.5	2.5				3.9	64.8
FURNARIIDAE (5)														
<i>Spiallax brachyura</i>	60	78.5	175	2.7	3.00		17.1	109.1	2.5				272.8	0.9
<i>Hylocichla ustulata</i>	200	261.8	550	28.8	2.25		4.1	7.8	2.5				19.5	12.8
<i>Automolus rubiginosus</i>	125	163.6	425	13.9	1.00		2.4	7.2	2.5				18.0	13.9
<i>Xenops minutus</i>	75	98.2	550	10.8	2.00		3.6	18.5	2.5				46.3	5.4
<i>Sclerurus mexicanus</i>	200	261.8	350	18.3	0.25		0.7	1.4	2.5				3.4	73.3
DENDROCOLAPTIDAE (8)														
<i>Dendrocincla fuliginosa</i>	150	196.4	550	21.6	1.25		2.3	5.8	2.5				14.5	17.3
<i>Glyptornis spinus</i>	60	78.5	500	7.9	3.00		6.0	38.2	2.5				95.5	2.6
<i>Dendrocolaptes sanctithomae</i>	125	163.6	550	18.0	1.00		1.8	5.6	2.5				13.9	18.0
<i>Xiphorhynchus lachrymans</i>	175	229.1	550	25.2	2.00		3.6	7.9	2.5				19.8	12.6
<i>Xiphorhynchus erythrogaster</i>	100	130.9	550	14.4	1.00		1.8	6.9	2.5				17.4	14.4

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / g km WtHab	Units / h km <sup>2</sup> WtHab	Ind. / i unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / l km <sup>2</sup> WtHab	No. ind. / m km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Lepidocolaptes souleyetii</i>	[125]	[163.6]	[125]	[4.1]										
<i>Campylorhynchus trochilrostris</i>	150	196.4	275	10.8										
<i>Campylorhynchus pusillus</i>	125	163.6	550	18.0	0.50		0.9	2.8	2.5			6.9		36.0
THAMNOPHILIDAE (18)														
<i>Cymbilanius lineatus</i>	110	144.0	425	12.2										
<i>Taraba major</i>	200	261.8	275	14.4										
<i>Thamnophilus atrinucha</i>	110	144.0	550	15.8	2.00		3.6	12.6	2.5			31.6		7.9
<i>Thamnites anabatius</i>	75	98.2	550	10.8	1.50		2.7	13.9	2.5			34.7		7.2
<i>Drythamnus puncticeps</i>	125	163.6	550	18.0	1.50		2.7	8.3	2.5			20.8		12.0
<i>Myiobothula ignea</i>	100	130.9	550	14.4	1.00		1.8	6.9	2.5			17.4		14.4
<i>Myiobothula pacifica</i>	100	130.9	150	3.9	3.00		20.0	76.4	2.5			191.0		1.3
<i>Myiobothula fulviventris</i>	60	78.5	450	7.1	2.50		5.6	35.4	2.5			88.4		2.8
<i>Myiobothula axillaris</i>	100	130.9	450	11.8	2.50		5.6	21.2	2.5			53.1		4.7
<i>Myiobothula schistolor</i>	[60]		[450]	5.4										
<i>Microtopias quixensis</i>	125	163.6	550	18.0	1.50		2.7	8.3	2.5			20.8		12.0
<i>Cercomacra tyrannina</i>	150	196.4	275	10.8	7.00		25.5	64.8	2.5			162.0		1.5
<i>Hylophylax naevioides</i>	75	98.2	550	10.8	2.50		4.5	23.1	2.5			57.9		4.3
<i>Myrmeciza immaculata</i>	225	294.5	550	32.4	1.50		2.7	4.6	2.5			11.6		21.6
<i>Myrmeciza exul</i>	175	229.1	550	25.2	8.00		14.5	31.7	2.5			79.4		3.1
<i>Myrmeciza borlepsi</i>	175	229.1	550	25.2	3.25		5.9	12.9	2.5			32.2		7.8
<i>Gymnotiphy leucopsis</i>	80	104.7	550	11.5	2.25		4.1	19.5	2.5			48.8		5.1
<i>Phoenicostictus melanani</i>	125	163.6	400	13.1	0.25		0.6	1.9	2.5			4.8		
FORMICARIIDAE (2)														
<i>Formicarius nigricapillus</i>	200	261.8	550	28.8	4.00		7.3	13.9	2.5			34.7		7.2
<i>Hylopeces perspicillatus</i>	200	261.8	550	28.8	3.50		6.4	12.2	2.5			30.4		8.2
TYRANNIDAE (41)														
<i>Phyllomyia griseiceps</i>	[80]	[104.7]	[125]	[2.6]										
<i>Zimmerius chrysops</i>	90	117.8	550	13.0	2.25		4.1	17.4	2.5			43.4		5.8
<i>Ornithion brunneicapillus</i>	125	163.6	550	18.0	1.00		1.8	5.6	2.5			13.9		18.0
<i>Campotoma obsolentum</i>	[70]	[91.6]	[125]	[2.3]										
<i>Tyrannulus edulis</i>	[80]	[104.7]	[125]	[2.6]										
<i>Myiopetes canticops</i>	100	130.9	550	14.4										
<i>Myiopetes viridicata</i>	125		550	13.8										
<i>Mionectes olivaceus</i>	40	52.4	550	5.8	4.0		7.3	69.4	2.5			173.6		
<i>Mionectes okeageus</i>	50	65.5	550	7.2										
<i>Leptopogon superciliosus</i>	60	78.5	475	7.5	1.25		2.6	16.8	2.5			41.9		6.0
<i>Myiornis atricapillus</i>	110	144.0	550	15.8	3.00		5.5	18.9	2.5			47.4		5.3
<i>Lophortyx pileatus</i>	110	144.0	275	7.9		2.0	7.3	25.3	2.5			63.1		
<i>Todirostrum nigriceps</i>	100	130.9	550	14.4	1.50		2.7	10.4	2.5			26.0		9.6
<i>Todirostrum cinereum</i>	90	117.8	125	2.9	1.75		14.0	59.4	2.5			148.5		1.7
<i>Rhyncocyclus pacificus</i>	75	98.2	475	9.3	1.00		2.1	10.7	2.5			26.8		9.3
<i>Tolmomyia flavinotus</i>	110	144.0	550	15.8	1.00		1.8	6.3	2.5			15.8		15.8
<i>Platyrinchus coronatus</i>	40	52.4	450	4.7	1.50		3.3	31.8	2.5			79.6		3.1

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km WtHab	Units/ <sup>h</sup> km <sup>2</sup> WtHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km <sup>2</sup> WtHab	No. ind./ <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Tenorioicus erythrinus</i>	55		475	5.2						2.0		4.2	38.3	
<i>Myiobius aricaudus</i>	20		125	0.5										
<i>Myiobius sulphureipygus</i>	20		400	1.6						1.0		2.5	62.5	
<i>Myiophobus fasciatus</i>	[80]	[104.7]	[125]	[2.6]										
<i>Contopus cooperi</i>	120		550	13.2										
<i>Empidonax virecens</i>	100		550	11.0										
<i>Colonia colonus</i>	110	144.0	550	15.8	1.00		1.8	6.3	2.5				15.8	15.8
<i>Attila spadiceus</i>	[225]	[294.5]	[550]	[32.4]										
<i>Rhytipterna holerythra</i>	150	196.4	550	21.6	0.50		0.9	2.3	2.5				5.8	43.2
<i>Syrstes albigriseus</i>	140	183.3	550	20.2										
<i>Myiarchus tuberculifer</i>	[100]	[130.9]	[200]	[5.2]										
<i>Megarynchus pitangus</i>	125	163.6	200	6.5	1.00		5.0	15.3	2.5				38.2	6.5
<i>Myiozetetes cayanensis</i>	125	163.6	200	6.5										
<i>Myiozetetes granadensis</i>	125	163.6	200	6.5										
<i>Conopias albivittatus</i>	175	229.1	550	25.2	1.00		1.8	4.0	2.5				9.9	25.2
<i>Myiodynastes maculatus</i>	120		550	13.2										
<i>Legatus leucophotus</i>	200	261.8	550	28.8	1.00		1.8	3.5	2.5				8.7	28.8
<i>Tyrannus melancholicus</i>	110	144.0	200	5.8										
<i>Tyrannus niveigularis</i>	100		200	4.0							0.25	1.3	6.3	
<i>Pachyrhamphus cinnamomeus</i>	75	98.2	425	8.3	2.00		4.7	24.0	2.5				59.9	4.2
<i>Pachyrhamphus albigriseus</i>	100		550	11.0										
<i>Platysaris homochrous</i>	40		550	4.4										
<i>Tityra semifaciata</i>	80	104.7	550	11.5										
<i>Tityra inquisitor</i>	[80]	[104.7]	[550]	[11.5]										
COTINGIDAE (4)														
<i>Lipaugus uiriflorus</i>	250	327.3	400	26.2										
<i>Cotinga nattererii</i>	[40]		[550]	[4.4]										
<i>Carpodectes hopkei</i>	40		550	4.4										
<i>Querula purpurata</i>	150	196.4	550	21.6	0.50		0.9	2.3	5.0				11.6	43.2
PIRIDAE (7)														
<i>Pipra mentalis</i>	100	130.9	450	11.8		9.0	20.0	76.4	2.5				191.0	
<i>Lepidoblasis coronata</i>	55	72.0	450	6.5		7.0	15.6	108.0	2.5				270.1	
<i>Manacus manacus</i>	70	91.6	275	5.0		7.0	25.5	138.9	2.5				347.2	
<i>Machaeroperus deliciosus</i>	90		550	9.9										
<i>Chloropipo holochlora</i>	20		400	1.6										
<i>Schiffornis tuelina</i>	175	229.1	400	18.3										
<i>Sapayoa aenigma</i>	60	78.5	400	6.3	1.50		3.8	23.9	2.5				59.7	4.2
VIREONIDAE (3)														
<i>Vireo olivaceus</i>	40		550	4.4										
<i>Hylophilus decuratus</i>	130	170.2	550	18.7	3.00		5.5	16.0	2.5				40.1	6.2
<i>Hylophilus ochraceiceps</i>	120	157.1	400	12.6	1.00		2.5	8.0	2.5				19.9	12.6
TURDIDAE (2)														
<i>Catherus ustulatus</i>	100		550	11.0										

## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WiHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WiHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units/ <sup>g</sup> km WiHab	Units/ <sup>h</sup> km <sup>2</sup> WiHab	Ind./ <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind./ <sup>l</sup> km WiHab	No. ind./ <sup>m</sup> km <sup>2</sup> WiHab	Available <sup>n</sup> area/terr. [ha]
<b>HIRUNINIDAE (8)</b>	155	202.9	550	22.3	1.50		2.7	6.7	2.5				16.8	14.9
<i>Progne chalybea</i>	75		125	1.9										
<i>Progne subis</i>	75		550	8.3										
<i>Tachycineta bicolor</i>	60		550	6.6										
<i>Neochelidon tibialis</i>	50		550	5.5							1.25	2.3	22.7	
<i>Stelgidopteryx ruficollis</i>	75		150	2.3							0.75	5.0	33.3	
<i>Riparia riparia</i>	50		550	5.5										
<i>Hirundo rustica</i>	60		550	6.6										
<i>Petrochelidon pyrrhonota</i>	50		550	5.5										
<b>TROGLODYTIDAE (8)</b>														
<i>Camptylorhynchus zonatus</i>	[120]	[157.1]	[550]	[17.3]										
<i>Odontorhynchus brunickii</i>	100	130.9	550	14.4										
<i>Thryothorus nigricapillus</i>	200	261.8	200	10.5	2.00		10.0	19.1	2.5				47.7	5.2
<i>Thryothorus leucopogon</i>	175	229.1	550	25.2	4.25		7.7	16.9	2.5				42.2	5.9
<i>Troglodytes aedon</i>	125	163.6	125	4.1										
<i>Henicorhina leucosticta</i>	185	242.2	450	21.8	1.50		3.3	6.9	2.5				17.2	14.5
<i>Cyborhynchus phaeocephalus</i>	[80]		[450]	[7.2]										
<i>Microcerulus marginatus</i>	200	261.8	550	28.8	4.50		8.2	15.6	2.5				39.1	6.4
<b>POLOPTILIDAE (3)</b>														
<i>Microbatas cinereiventris</i>	120	157.1	550	17.3	4.25		7.7	24.6	2.5				61.5	4.1
<i>Polioptila plumbea</i>	[80]	[104.7]	[150]	[3.1]										
<i>Polioptila schiacterigula</i>	80	104.7	550	11.5	1.50		2.7	13.0	2.5				32.6	7.7
<b>PARULIDAE (8)</b>														
<i>Dendroica striata</i>	[40]		[550]	[4.4]										
<i>Dendroica fusca</i>	[40]		[550]	[4.4]										
<i>Sciurus noveboracensis</i>	[20]		[150]	[0.6]										
<i>Geothlypis semiflava</i>	125	163.6	125	4.1										
<i>Geothlypis auricularis</i>	[100]	[130.9]	[125]	[2.5]										
<i>Oporornis phalaenoptera</i>	[20]		[125]	[0.5]										
<i>Oporornis agilis</i>	[20]		[125]	[0.5]										
<i>Basileuterus fulvicauda</i>	175	229.1	550	25.2	1.00		1.8	4.0	2.5				9.9	25.2
<b>THRUPIDAE (27)</b>														
<i>Correba flavola</i>	45	58.9	550	6.5	1.00		1.8	15.4	2.5				38.6	6.5
<i>Cyanerpes caeruleus</i>	40	52.4	550	5.8										
<i>Cyanerpes cyaneus</i>	[45]	[58.9]	[125]	[1.5]										
<i>Chlorophanes spiza</i>	50	65.5	550	7.2										
<i>Dacnis cayana</i>	30	39.3	550	4.3										
<i>Dacnis egregia</i>	30	39.3	550	4.3										
<i>Dacnis venusta</i>	30		550	3.3										
<i>Dacnis berlepschi</i>	50	65.5	550	7.2	1.50		2.7	20.8	2.5				52.1	4.8
<i>Erythrolipis salmoni</i>	65	85.1	550	9.4										
<i>Euphonia lanirostris</i>	90	117.8	200	4.7										



## APPENDIX 19B. Continued.

Family (no. of spp.) / species	Ave. <sup>a</sup> DTD [m]	Eff. <sup>b</sup> DTD [m]	WtHab <sup>c</sup> TraLen [m]	Eff. DA <sup>d</sup> WtHab [ha]	No. <sup>e</sup> terr.	No. <sup>f</sup> displ. MM	Units / <sup>g</sup> km WtHab	Units / <sup>h</sup> km <sup>2</sup> WtHab	Ind. / <sup>i</sup> unit	Max. <sup>j</sup> no. ind.	Ave. <sup>k</sup> no. ind.	No. ind. / <sup>l</sup> km <sup>2</sup> WtHab	No. ind. / <sup>m</sup> km <sup>2</sup> WtHab	Available <sup>n</sup> area/terr. [ha]
<i>Euphonia xanthogaster</i>	90	117.8	550	13.0	4.00		7.3	30.9	2.5			77.2	77.2	3.2
<i>Euphonia miniata</i>	50	65.5	550	7.2	1.00		1.8	13.9	2.5			34.7	34.7	7.2
<i>Euphonia fulvicrisa</i>	90	117.8	550	13.0										
<i>Tangara palmeri</i>	100	130.9	550	14.4	1.00		1.8	6.9	2.5			17.4	17.4	14.4
<i>Tangara cyathollis</i>	[60]	[78.5]	[425]	[6.7]										
<i>Tangara larvata</i>	75	98.2	425	8.3	1.00		2.4	12.0	2.5			30.0	30.0	8.3
<i>Tangara johannae</i>	50	65.5	550	7.2	1.00		1.8	13.9	2.5			34.7	34.7	7.2
<i>Tangara larinia</i>	60	78.5	550	8.6	1.00		1.8	11.6	2.5			28.9	28.9	8.6
<i>Thraupis episcopus</i>	75	98.2	425	8.3	1.00		2.4	12.0	2.5			30.0	30.0	8.3
<i>Thraupis palmarum</i>	75	98.2	425	8.3										
<i>Ramphocelus icteronotus</i>	85		300	5.1						14.00	46.7	274.5	274.5	
<i>Piranga rubra</i>	85		150	2.6						0.25	1.7	9.8	9.8	
<i>Chlorothraupis olivacea</i>	220	288.0	550	31.7	2.75		5.0	8.7	2.5			21.7	21.7	11.5
<i>Mitrospingus cassinii</i>	80	104.7	550	11.5	1.00		1.8	8.7	5.0			43.4	43.4	11.5
<i>Tachyphonus luctuosus</i>	90		550	9.9										
<i>Tachyphonus delatrii</i>	100		550	11.0						17.75	32.3	161.4	161.4	
<i>Heterospingus xanthopygius</i>	135	176.7	550	19.4	1.00		1.8	5.1	2.5			12.9	12.9	19.4
CARDINALIDAE (4)														
<i>Salpator maximus</i>	150	196.4	425	16.7	3.00		7.1	18.0	2.5			44.9	44.9	5.6
<i>Salpator atripennis</i>	180	235.6	250	11.8	1.00		4.0	8.5	2.5			21.2	21.2	11.8
<i>Salpator grossus</i>	225	294.5	550	32.4	1.75		3.2	5.4	2.5			13.5	13.5	18.5
<i>Phenictus ludovicianus</i>	100		450	9.0										
EMBERIZIDAE (10)														
<i>Rhodospingus cruentus</i>	70		125	1.8										
<i>Volatinia jacarina</i>	60		125	1.5										
<i>Tiaris obscurus</i>	80	104.7	125	2.6										
<i>Oryzoborus angolensis</i>	80	104.7	250	5.2	1.00		4.0	19.1	2.5			47.7	47.7	5.2
<i>Sporophila corvina</i>	65	85.1	125	2.1	1.00		8.0	47.0	2.5			117.5	117.5	2.1
<i>Sporophila luctuosa</i>	70		125	1.8										
<i>Sporophila nigricollis</i>	70	91.6	125	2.3	1.00		8.0	43.7	2.5			109.1	109.1	2.3
<i>Sporophila telasco</i>	30		125	0.8										
<i>Arremon aurantifrons</i>	60	78.5	425	6.7	4.50		10.6	67.4	2.5			168.5	168.5	1.5
<i>Arremonops contrastis</i>	[160]	[209.4]	[125]	[5.2]										
ICTERIDAE (6)														
<i>Cacicus microphrynus</i>	225		550	24.8						12.75	23.2	51.5	51.5	
<i>Amblycercus holboellii</i>	[200]	[261.8]	[425]	[22.3]										
<i>Zarhynchus uugleri</i>	125		550	13.8						0.25	0.5	1.8	1.8	
<i>Molothrus bonariensis</i>	[90]		[125]	[2.3]										
<i>Molothrus oryzivorus</i>	110		275	6.1										
<i>Dolichonyx oryzivorus</i>	[20]		[125]	[0.5]										