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Biogeographical Isolation and Bioacoustics: the Juan Fernandez Firecrown, *Sephanoides fernandensis* (Aves: Trochilidae) (King, 1831), of Robinson Crusoe Island, Chile

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Abstract. Three types of vocalisation of the endemic Juan Fernandez Firecrown, *Sephanoides fernandensis* (King, 1831), are described: courtship song, warning whistle, and territorial call. The first sonagrams of this hummingbird species are presented. Territorial vocalisations are most commonly uttered and are important to localise individuals on Robinson Crusoe Island, Chile. Although in the bioacoustic analysis significant differences between the three vocalisations are identified, they have one general character in common: audibility over a relative long distance. In this point these vocalisations also differ from those of its closest continental ally, the Green-backed Firecrown *S. sephaniodes*, and may represent an adaptation to the harsh island conditions and oceanic winds.

Keywords. Vocalisation, song, call, *Sephanoides fernandensis*, island adaptation.

1. INTRODUCTION

The endemic Juan Fernández Firecrown, *Sephanoides fernandensis* (King, 1831), is biogeographically the most isolated species of all hummingbirds (Aves: Trochilidae), being limited to only one small island in the South-east Pacific Ocean (Isla Robinson Crusoe: 47.11 km^2, 915 m high, 567 km distant to the mainland at 33°30'S & 78°50'W). The species has been separated from its mainland ancestors for some 600,000 years (ROY et al. 1998). Males and females show the most significant sexual dimorphism and dichromatism of all investigated Trochilidae (COLWELL 1989), and also seem to differ from each other in various ecological aspects. However, little is known about the ecology of this island endemic in detail, except that it is in threat of extinction and therefore classified as "critically endangered" (ROY et al. 1999; BIRDLIFE INTERNATIONAL 2004). This partly may be due to anthropogenic habitat destruction, competition, and predation by introduced mammals (BUSSE 1970; HAHN & RÖMER 2002). Its vocalisations are still undescribed (cf. JARAMILLO 2003). However, a successful conservation management requires basic information on aut-ecology. Attempts to reliably estimate the population size (BROOKE 1987; MEZA 1989; STILES 1987; STONE et al. 1989; HAHN 1998) require the knowledge of its vocalisations. This is especially important as its closest mainland relative, the Green-backed Firecrown *Sephanoides sephaniodes* (Lesson & Garnot, 1827), reached Robinson Crusoe between 1574 and 1830 (cf. AUDOUIN 1830) and now competes with it for food sources. Presenting the first data of the Juan Fernández Firecrown's bioacoustics, I aim to add more scientific information of this endemic and to provide basic material that may help future researchers and managers to acoustically identify individuals in the field.

On the basis of four field campaigns from 1992 to 2002, three main types of vocalisation have been identified: courtship song, warning whistle, and territorial song/call. The courtship song is a purring series of syllables, uttered without pause at comparatively low-pitched frequency levels (around 4–5 kHz) and high temporal rates, slightly falling and rising in pitch. It was recognised from the male, which was slowly flying behind the female and following her from a distance of about 50 cm. The warning call is a short and very high-pitched (8 kHz and more) whistle, which is uttered by both sexes. It may be heard during intra- and inter-specific conflicts with other (humming)birds or in case of the presence of potential predators (e.g., cats, rats, humans). This whistle is difficult to distinguish from Green-backed Firecrown vocalisations in the first instance. Most characteristic and most commonly uttered are territorial song and calls. Male Juan Fernandez Firecrowns are much more abundant than females on the island and, regarding to their larger size and physical dominance, are much more territorial. Thus, most such songs / calls which a listener may hear in the field come from males (Fig. 1), but females utter them too.

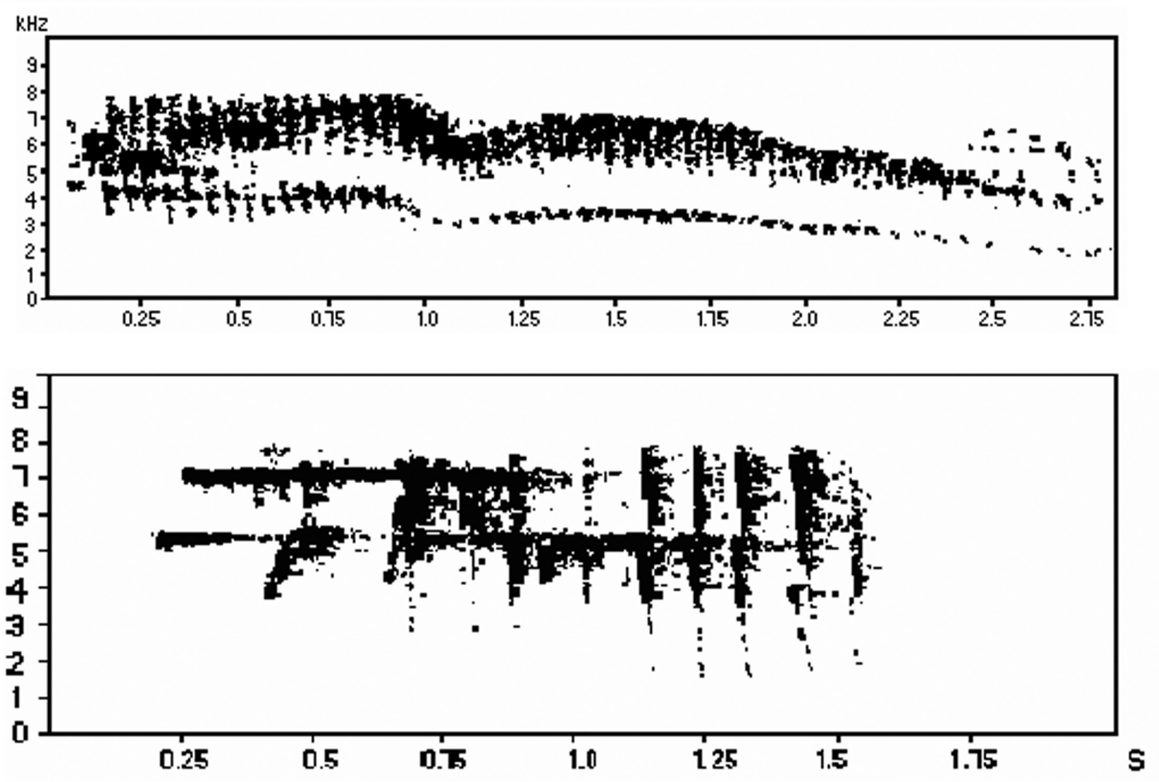

Fig. 1. Territorial vocalisations of the Juan Fernandez Firecrown *Sephanoides fernandensis* (KING, 1831) on Robinson Crusoe Island. Above: Sequence of the song uttered by a male in its territory. Below: call uttered by a male in its territory. The call may be uttered solely or loosely attached initially/finally to the song. Tape recordings were carried out with a DAT-Recorder (Sony; Type HD-S100) with external microphone and wind shield. Illustration bases on the program AVISOFT-SONAGRAPH PRO; program levels are: N=256, F=100, O=75, KHZ=16.

The sequence (Fig. 1, above) is composed of about 50 syllables. Every syllable is built up by one higher and one lower element. The temporal rate of syllables stays very stable throughout the whole sequence (1 syllable per 0.05 sec.). However, frequency range and amplitude of syllables vary during the song, clearly falling towards the end of the sequence. The song generally is very variable: it may continue for longer time durations than shown in Figure 1, repeatedly showing a wave-like structure of slightly falling and rising in pitch. The song reaches extremely high frequency levels. Therefore this firecrown belongs to the few bird species that have voices surpassing the mark of 8 kHz. BERGMANN & HELB (1982) state that this is normally the case with very small birds of low weight. This corresponds to the weight of *Sephanoides fernandensis* (♂ = 10.9 g; ♀ = 7.4 g according to MEZA 1989). The call (Fig. 1, below) is illustrated separately from the song in this case. Although it may be attached to the latter in some cases, it represents an independent feature. It is characterised by two horizontal elements of two frequency ranges (lower element on 5-5.5 and higher on 6.8-7.3 kHz). These elements function as connective structures throughout most of the call, although they end before the last vertical element. The vertical elements cover wide frequency ranges from at least 3.5 up to 8 kHz, without being split up in a higher and a lower part. At the end of the call (1.1 to 1.5 on the time scale) four elements form a unit. The temporal rating of the vertical elements in the call is slower than that of the song, about half of the speed with one element being uttered per 0.1 seconds. The lower temporal rate leads to a more defined structure of single elements and the overall unit than in the song.

The illustrated vocalisations probably have the function of marking the territory and warning competitors not to enter the area of flower agglomerations, as concluded from observations at flowering *Dendroseris* and *Eucalyptus* plants (pres. obs. in 1994 & 2001). Probably the described vocalisations can also have the function of signalising presence to potential partners. The structure of elements, and the pauses between them, turned out to be different in song and call. This is an indication that their functions may differ, even if sometimes uttered one after another. However, yet such functional differences have not been

cleared up. Both territorial vocalisation types of *S. fernandensis* are similar in being piercing and loud. They should be identifiable on basis of the presented sonagrams, even by persons not familiar with this species. The field observations showed song/call audibility over a relatively long distance. This may be an evolutionary adaptation of the Juan Fernandez Firecrown to the harsh island conditions and counteract the generally reduced audibility through strong oceanic winds (cf. HAHN & MATTES 2000). Mechanisms behind this may be the wide frequency range of both song and call. The quick repetition of well defined elements additionally contributes to an intensive sounding, heard even over long distances. Field comparisons of audibility to its nearest relative, the Green-backed Firecrown (COLWELL 1989; ROY et al. 1998), showed larger distances for endemic Juan Fernandez Firecrowns. Green-backed generally seem to use higher frequencies and temporal ratings (cf. EGLI 2002) but a less extended frequency range, and therefore are not heard as far as Juan Fernandez Firecrowns. In turn, the invasive Green-backed fly more and longer distances than Juan Fernandez Firecrowns, and thus compensate this vocal disadvantage through their higher mobility.

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MERZ, B. (ed.) 2006. Phylogeny, Taxonomy, and Biology of Tephritoid flies (Diptera, Tephritoidea). Proceedings of the 3rd Tephritoid Taxonomist's Meeting, Geneva, 19-24. July 2004. Instrumenta Biodiversitatis **7**, 274 pp. ISBN 2-88139-012-9. Price CHF 100.00.

This interesting soft-cover book contains the Proceedings of the 3rd Tephritoid Taxonomist's (sic) Meeting and is the second published volume from this series of conferences. The results of the first and second meetings held in 1998 and 2000, respectively, have also been published (ALUJA & NORRBOM 1999; FREIDBERG 2006). For the third conference the theme was expanded to include researchers working with other families of the superfamily Tephritoidea. In the present proceedings there are 11 articles by 18 authors from eight different countries. Four families, as well as the tephritid subfamily Tachiniscinae, are examined, contributing to the taxonomy and phylogeny (8 articles), biology (1 article), faunistics (1 article) and morphology (1 article) of the Tephritoidea. As stated in its introduction, this volume reflects the high productivity of tephritid workers, the international cooperation among many different laboratories and covers taxa from all biogeographic regions of the world. This well bound book is published by the Muséum d'histoire naturelle, Genève, on glossy paper with excellent black and white line drawings, including many superb habitus illustrations and photographs.

The first contribution revises the eastern Asian and Papuan species of *Herina* of the Ulidiidae (E.P. Kameneva), with the description of 10 new species and the first species-level key from this region. The second paper proposes a classification of the bizarre head structures (appendages, tubercles, stalks, antlers, etc.) that occur in the acalyptrate Diptera (A.E. Whittington), with special emphasis on the extreme head morphology of the Plastotephritinae (Platystomatidae). In the subsequent contribution, the European fossil specimens from the families Pallopteridae, Ulidiidae and Tephritidae are reviewed (G. Gentilini, V.A. Korneyev & E.P. Kameneva), with the description of a new genus and two new species. The next paper revises the genera and species of the Tachiniscinae, treated here as a subfamily of Tephritidae (V.A. Korneyev & A.L. Norrbom). Two new genera and two new species are described; a key to genera and a cladistic analysis are included in this thorough study. The remaining contributions deal exclusively with the more typical tephritids. The fifth article analyses the phylogeny of the subtribe Pelmatopina, an odd group of stalk-eyed tephritids (X.-I. Chen & X.-J. Wang). In a contribution toward resolving the classification of the Dacini, 10 subgenera and 67 species groups of *Dacus* are proposed (D.L. Hancock & R.A.I. Drew), based on an analysis of 32 morphological characters and includes 14 new generic synonymies and a key to subgenera. The following article describes the 3rd instar larva and biology of one of the most enigmatic Palaearctic tephritids, *Malica caraganae* (S.V. & V.A. Korneyev). The eighth contribution describes three new species of *Gymnocarena* (A.L. Norrbom), extending the distribution of this New World genus to Costa Rica. The next article describes a new Afrotropical genus and three new species of the Schistopterini (I. Zonstein & A. Freidberg). The book finishes with two articles on the island faunas of Tephritidae. In the first article, a checklist of 16 species from the Madeiran archipelago is presented (J.T. Smit), including host plant records, ecology and island records. The second article analyses the phylogeny of the Hawaiian tephritids based on mtDNA (J.M. Brown, M. Todd-Thompson, A. McCord, A. O'Brien & B. O'Fallon) and postulates that the 25 endemic species are the result of a single colonization event.

In summary, this book is a stimulating collection of articles covering a large aspect of the Tephritoidea. It has been very carefully edited and the illustrations are all of high quality. This book is not only essential for all tephritoid taxonomists', but will appeal to workers in all aspects of fruit fly research and in the fields of morphology, sexual selection, evolution, biogeography and ecology. The next tephritid taxonomist's meeting is planned for 2008 and I look forward to the subsequent proceedings volume and the excellent reputation that has been developed from the previous two books.

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