Bonn. zool. Beitr.	Bd. 43	H. 2	S. 339—348	Bonn, Juli 1992

Octochaetid earthworms of the Canary Islands

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Abstract. The study of 379 specimens of *Dichogaster* collected at different times of the year has enabled the author to identify two species, *D. affinis* and *D. bolaui* (new recordings for the Canary Islands), as well as to extend their known area of distribution northwardly in the Macaronesia. Both species form part of the modern Canarian fauna, and they are considered to have been introduced accidentally by man from North Africa and the tropical regions of America. All references in literature to the presence of *D. oraedivitis* in the geographical area of the Canaries are refuted. Furthermore the morphology of *D. affinis* and *D. bolaui* is discussed, with some differences detected in the clitellum, penial setae, genital markings, seminal vesicles, as well as in the number of lateral hearts. The aforementioned species lives in highly altered biotopes of the thermo-Canarian zone, where *D. affinis* has managed to spread to a greater extent, with an altitudinal distribution from 4 to 500 m. The preference of *D. affinis* for alkaline soils containing more than 3 % organic matter is indicated by preliminary autoecological data.

Key words. Earthworms, Octochaetidae, Canaries.

Introduction

The presence of populations of *Dichogaster* in the zoogeographically most interesting Macaronesian area is a clear indication of their ability to colonize new geographical zones in spite of the substantial differences between the climate of such zones and those of America and Africa, where, according to literature, the genus is well represented (Cernosvitov 1938; Cognetti 1908; Csuzdi & Zicsi 1989; Michaelsen 1897, 1914; Omodeo 1958, 1973; Righi et al. 1978).

This genus had been cited only for the Cape Verde Islands (Cognetti 1908) and more recently for the Canaries (Talavera & Bacallado 1983) where it was little-known and had not come to the attention of researchers from abroad. Three basic goals have been pursued in the present paper. First, to provide a comprehensive set of data on insular distribution and ecology of those species which succeeded in establishing themselves in the Canarian Archipelago. Our second goal was to collect more information on the variability and morphological differences (with a view to analyzing them in the "Discussion"). Thirdly, to cast some light on misidentifications of certain Canarian specimens in the literature, improperly attributed to *D. oraedivitis*.

Material and methods

The material examined was collected from 1977 onwards in Tenerife, subsequently in La Gomera, Gran Canaria, Fuerteventura, and also Lanzarote (Fig. 1); the islands of La Palma and El Hierro were unsuccessfully sampled. The sites visited are listed in table I, together with their respective geographic coordinates of 1 x 1 km (UTM), altitude in metres (m), type of habitat and date of collection.

For collecting the specimens two methods were used: formalin spilling over 0.5 m^2 squares and digging with a geologist's hammer, with the latter proving to be the more effective, given the volcanic nature of Canarian soils. Diagnosis of the species studied was carried out using

50 mature specimens which had been preserved beforehand. The soil analysis techniques used to measure water pH, carbon (C), organic matter (OM) and nitrogen (N) are those described by Talavera (1987). The material studied is lodged in the Department of Animal Biology of the University of La Laguna.

This paper was partially supported by project IX/1989 of the University of La Laguna.

Table 1: Collecting sites.

Sites	UTM (1 x 1 km	Alt (m)	Vegetation	Date
TENERIFE:				
1. Candelaria	CS6537	10	Ornamental plant	8. 11. 1977
2. Santa María del Mar	CS7244	180	Deforested	26. 2. 1977
3. Barranco Balayo	CS8655	20	Avocado trees	8. 4. 1978
4. La Laguna	CS7152	560	Deforested	3. 3. 1980
				7. 11. 1981
5. Las Galletas	CS3701	100	Tomatoes	3. 3. 1982
6. San Isidro	CS4607	280	Ornamental plants	3. 3. 1982
7. El Médano	CS4802	15	Greenhouse	5. 9. 1982
8. Jardín Botánico	CS4943	100	Greenhouse	4. 7. 1983
9. Fañabé	CS3009	180	Banana groves	20. 7. 1985
10. Puerto de Santiago	CS2024	80	Avocado trees	21. 7. 1985
11. Alcalá	CS2120	60	Avocado trees	14. 9. 1987
12. Sta. Cruz Tenerife	CS7549	50	Deforested	25. 10. 1987
13. Güimar	CS6431	100	Banana groves	20. 11. 1987
14. Los Silos	CS2138	110	Banana groves	15. 7. 1988
15. Bco. San Andrés	CS8353	20	Avocado trees	6. 12. 1988
16. Bajamar	CS6859	40	Banana groves	10. 12. 1989
GOMERA:				
17. Playa de Santiago	BS8403	160	Avocado trees	16. 7. 1985
18. Laguna de Santiago	BS8402	40	Banana groves	16. 7. 1985
GRAN CANARIA:				
19. Lomo del Galeón	DR3471	100	Avocado trees	14. 8. 1981
20. Bco. de las Vacas	DR5485	200	Papaya trees	14. 8. 1982
21. El Tablero	DR3972	100	Tomatoes	16. 8. 1982
22. Embalse Ayagaures	DR4080	400	Ornamental plants	18. 8. 1982
23. Presa Chamoriscán	DR3877	300	Avocado trees	18. 8. 1982
24. Puerto de Mogán	DR2577	40	Avocado trees	17. 8. 1983
25. La Aldea	DR2296	160	Banana groves	17. 8. 1983
26. Bco. de la Aldea	DR2795	300	Yam	17. 8. 1983
27. Tasarte	DR2598	500	Canebrake	17. 8. 1983
28. Las Palmas	DS5812	4	Ornamental plants	21. 8. 1985
LANZAROTE:				
29. Parque del Reducto	FT4004	4	Ornamental plants	19. 12. 1984
30. San Bartolomé	FT3508	260	Ornamental plants	21. 12. 1984
FUERTEVENTURA:				
31. Gran Tarajal	ES9520	40	Ornamental plants	13. 12. 1984
32. Puerto del Rosario	FS1152	10	Ornamental plants	15. 12. 1984

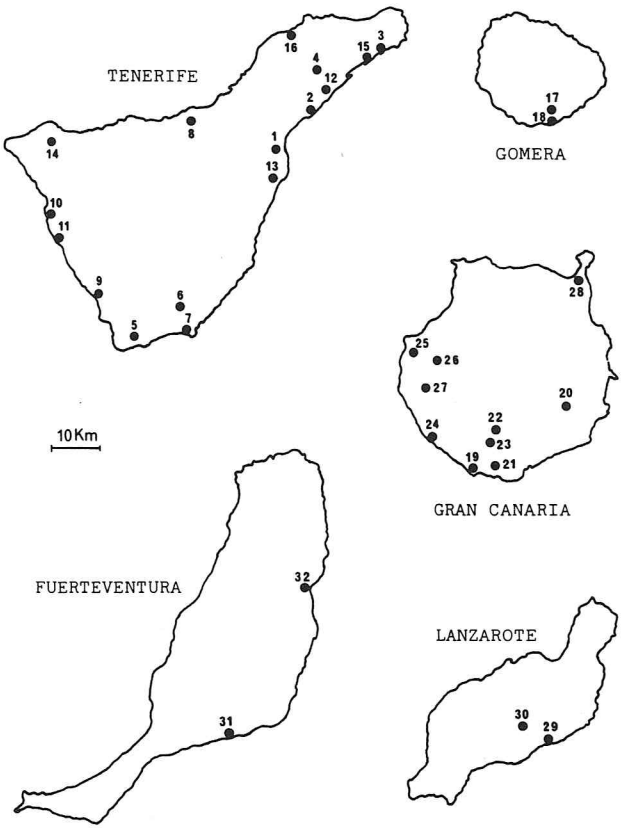

Fig. 1: The islands of Tenerife, La Gomera, Gran Canaria, Lanzarote, and Fuerteventura showing sites mentioned in table I.

Results

Dichogaster affinis (Michaelsen, 1890)

Benhamia affinis Michaelsen, 1890
Dichogaster affinis: Michaelsen, 1900

Description (Fig. 2): Length 16—31 mm, mean 25.3 mm. Segment number 72—124, mean 96. Two female pores between setae "ab" in segment 14; in most cases they are surrounded by an elliptic papilla. Genital markings occasionally lacking and where present are ventromedian in intersegmental furrows 7/8/9/10, 7/8/9/10/11, or seldom in 7/8/9, 8/9/10/11. Clitellum annular located over segments 13—20 (62 % of specimens studied), 13—¼21, 21 (31 % of specimens), and 12—20 (the remaining 7 % of specimens). Two gizzards in segments 6 and 7 respectively; the posterior one extends over segment 8 whereas the anterior presents an edge-shaped muscle fold projecting forward. Spermathecae, two pairs in segments 8 and 9, with a fine pen-

duncle containing a diverticle which widens towards the end to form a minute bladder. Curve-ended penial setae and various sharp denticles alternatively placed.

Collecting sites. — 1: 4 exx (2 adult). 3: 5 exx (4 adult). 5: 9 exx. 6: 6 exx. 7: 1 ex (adult). 8: 4 exx (3 adult). 9: 1 ex (adult). 10: 1 ex (adult). 11: 3 exx (adult). 13: 2 exx. 14: 6 exx (2 adult). 15: 2 exx. 16: 2 exx. 17: 1 ex. 18: 1 ex. 19: 1 ex (adult). 20: 7 exx (5 adult). 21: 23 exx (4 adult). 22: 53 exx (11 adult). 23: 21 exx (3 adult). 24: 36 exx (10 adult). 25: 26 exx (12 adult). 26: 3 exx (1 adult). 27: 2 exx (1 adult). 28: 3 exx. 29: 8 exx (1 adult). 30: 6 exx (1 adult). 31: 2 exx. 32: 9 exx (2 adult).

Ecology and distribution: *D. affinis* is an anthropochorous species which lives at depths of between 1 and 4 cm, mainly in sunny biotopes which receive periodic amounts of water and organic manure. The species shows a clear preference for avocado and banana groves, where the main cores of the population in the islands appear to be centred. It is also frequent in gardens or parks containing exotic plants, and to a lesser extent in greenhouses, tomato crops on the south-southeast side of Tenerife and Gran Canaria, as well as in some habitats — ñame (edible tuberose root of the Yam family) and sugar cane plantations — where human alteration is less common and where the environmental conditions are different. Therefore, the ecological tolerance of *affinis* is evident.

This species fits the characteristics proposed by Bouché (1972) and Lee (1985) for epigeic earthworms; however, the stomach contents of the specimens collected in Parque del Reducto (island of Lanzarote) contained soil with amorphous organic matter, which is more in keeping with the behaviour of endogeic polihumic species. It often forms small populations occupying habitats where no other eartworms are present although it is capable of coexisting with other species, *Amynthas morrisi* (Beddard, 1892), *Pithemera bicincta* (Perrier, 1875), and seldom *A. rosea bimastoides* (Cognetti, 1901). Table I shows that *D. affinis*' preferred habitat is alkaline soils (pH >7) containing amounts of organic matter in excess of 3 % (except for Playa de Santiago). The C/N ratio, which ranges from 4,33 to 19,70 %, reveals that this species has managed to adapt to oxygenated soils, and also to soils with a lower oxygen content (C/N >13).

The introduction of *D. affinis* in the Canaries is quite recent, as shown by its specific insular distribution. It was presumably transported by man in flowerpots and/or the soil of plants imported from America and, to a lesser extent, from Africa; cultivation of some of these plants for commercial purposes commenced in the 19th century (banana and tomatoes), while others such as avocado are more recent, and papaya trees have been imported by immigrants from Venezuela and Cuba over the last few decades.

The finding of this species constitutes a new recording both for the Canary Islands and for Macaronesia. It is wide-spread throughout Gran Canaria, reaching zones as high as 500 m (Tasarte), which leads one to venture the hypothesis that this was the island to receive the first foreign specimens. The presence of *affinis* in La Gomera, Lanzarote and Fuerteventura is merely a token one, with a distribution limited to a few habitats situated at altitudes of 4 and 260 m; however, in Tenerife it is better represented, and is distributed throughout the entire thermo-Canarian zone on the south and south-east sides, which afford an ideal infrastructure for avocado and papaya growing.

Table 2: Mean ($\bar{x}$) and standard deviation (σ) values of the edaphic factors corresponding to 10 soil samples where *D. affinis* lived.

Sites	pH	% C	% OM	% N	C/N
Jardín Botánico (8)	7.0	1.30	2.24	0.30	4.33
Alcalá (11)	7.3	2.37	4.10	0.24	9.87
Güimar (13)	7.6	2.55	4.44	0.21	12.14
Los Silos (14)	7.5	7.31	12.60	0.41	17.82
Bco. San Andrés (15)	7.9	3.60	6.20	0.27	13.33
Bajamar (16)	7.0	2.43	4.20	0.35	6.94
Playa Santiago (17)	8.1	1.72	2.97	0.13	13.23
Laguna de Santiago (18)	7.4	2.54	4.38	0.27	9.40
Lomo de Galeón (19)	7.6	3.35	5.76	0.17	19.70
Puerto de Mogán (24)	7.9	2.20	3.70	0.20	11.00
	$\bar{x}$ 7.5	**2.93**	**5.04**	**0.23**	**12.57**
	σ 0.3	**1.67**	**2.89**	**8.41**	**4.62**

Dichogaster bolaui (Michaelsen, 1891)

Benhamia bolavi Michaelsen, 1891
Dichogaster bolaui: Michaelsen, 1900

Description (Fig. 3): Length 53—76 mm, mean 62 mm. Segment number 107—136, mean 125. A single female pore surrounded by a thin ventromedian papilla located on the "aa" setal line of segment 14. Genital markings not present, appearing is only one specimen between setae "ab" in segment 19. Clitellum annular in 13, 14—19, presenting two deep parallel ventral furrows along segments ½17—½19. Lateral hearts in 8—12 or 9—12, which are larger in the latter three. Two pairs of plurilobulated seminal vesicles in segments 11 and 12. Asymmetric prostates, the anterior pair takes up segments 17 and 18, while the posterior pair is confined to 19. Single spermathecae, two pairs in segments 8 and 9, with a thick peduncle featuring a diverticle which widens distally in the shape of an acorn.

Collecting sites. — 2: 6 exx (3 adult). 4: 121 exx (5 adult). 12: 4 exx.

Ecology and distribution: The species *bolaui* has been found only on the eastern side of Tenerife (a new record for the Canaries, and a second for Macaronesia) and in view of the difficulty involved in reliably defining an altitude distribution range, we will limit ourselves here to indicating that it was collected in two urban areas situated at heights of 180 and 560 m, respectively. Its presence in very old parts of the metropolitan area of Santa Cruz—La Laguna indicates a longer period of colonization than that of *D. affinis*, and is doubtless a result of farming and shipping activities which commenced in the XVI century.

It is an endogeic species whose living quarters can be found near sewage drains and close to the cesspools in the yards of old houses in the metropolitan area. It has not succeeded in colonizing other types of habitats, such as tropical cultures, perhaps due to the strong selective pressure it has to withstand from other species living off similar resources. It seems, therefore, that the process of dispersal of *D. bolaui* is currently at a standstill and is even decreasing due to the constant and progressive

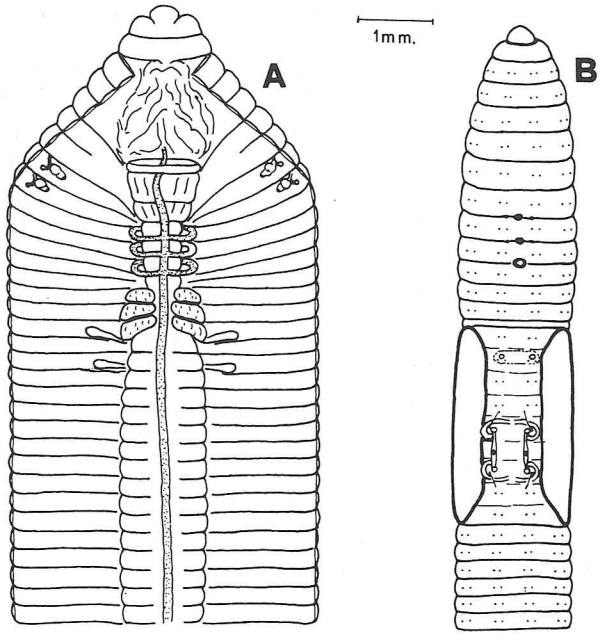

Fig. 2: *Dichogaster affinis*. A = General dissection of the anterior region; B = External morphology (lateral view).

transformation of the urban environment in which it lives. The large number of immature specimens collected during the months of October, November and February is a possible indication that the sexual maturity of *bolaui* takes place in the spring. However it was not possible to prove this due to the difficulty we encountered in gaining access to the urban refuges where they usually live. With regard to the immature specimens, it is worth noting that their collection took place when they surfaced after prolonged periods of rainfall.

Discussion

According to Jamieson (1974) the genus *Dichogaster* includes more than 100 species, a figure increased to 200 by Gates (1982), which is very striking and at the same time causes one to wonder whether the creating of new species during the 1970s was really so notable. The present author considers that a thorough revision of the above-mentioned genus is needed in order to avoid it being used as a permanent refuge for those species for which sufficient evidence has not been given, such as *D. cheranganiensis* Cernosvitov, 1938; *D. kakulimana* Michaelsen, 1914; *D. navana* Michaelsen, 1938; *D. badajos* Righi et al., 1978. The original descriptions of these were based on one specimen alone and the possibility of carrying out a more thorough taxonomic comparative study was ruled out. Clearly, a careful analysis of the range of specific mor-

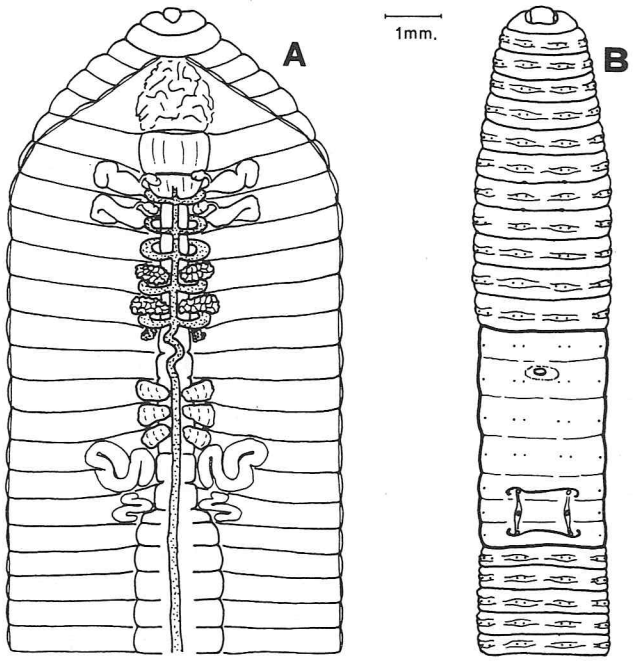

Fig. 3: *Dichogaster bolaui*. A = General dissection of the anterior region; B = External morphology (lateral view).

phological variability could help correct past mistakes or help avoid arbitrary identifications of new taxa. There must be no recurrence of previous cases such as those of *D. rugosa* (Eisen, 1896), *D. sinuosus* (Stephenson, 1931), *D. b. decanephre* (Michaelsen, 1908), *D. b. octonephra* (Rosa, 1855) and *D. b. palmicola* (Michaelsen, 1908), the validity of which has already been legitimately questioned.

A comparison between our description of *D. bolaui* and those found in the literature consulted reveals a number of differences. Michaelsen (1891), Omodeo (1955, 1963) and Pickford (1938) describe the position of the clitellum as being between segments 13—20, whereas in the Canarian specimens it is in 13, 14—19, a finding more consistent with Gates (1972), Michaelsen (1900) and Sims & Gerard (1985). Moreover our specimens have a greater number of segments, they are bigger (53—76 mm) and feature two pairs of seminal vesicles in segments 11 and 12 (the same number is indicated by Gates 1972 and Pickford 1938) as compared to the single pair described by Cognetti (1905), Michaelsen (1900) and Omodeo (1955); the number of lateral hearts (up to 5 pairs) is also greater, although it is not advisable to view this as a significant difference, since the two first pairs are extremely thin and may even be absent. At this point it should be noted that among the specimens examined were those collected in Santa María del Mar, which were erroneously assigned to *D.*

oraedivitis (Talavera et al. 1980; Talavera & Bacallado 1983). Hence, we eliminate them from the faunistic catalogue of the Canaries.

The differences between *D. bolaui* and *D. affinis* are noticeable in terms of both morphology (Fig. 2) and habitat. The species *affinis* is smaller, it has two female pores in segment 14 and features 2 to 3 genital markings; this number is consistent with that of South-East Asian earthworms (Gates 1972)), but is greater than that indicated by Stephenson (1931); a wide margin of variability exists, therefore, with a taxonomic significance which should be taken into account. On the other hand, not all the specimens examined present genital markings, which were found in sexually mature specimens only and not always in the same position. The absence of seminal vesicles is also striking since the different descriptions consulted (except for that by Pickford 1938) include 2 to 3 pairs in segments 11, 12 or 10, 11, 12.

On the basis of the details included above, it can be said that the species studied alive in completely different man-modified habitats have not managed to colonize laurel and conifer forests which possess a wealth of faunistic elements (Talavera 1987). Thus, *D. bolaui* lives in the metropolitan area of Tenerife, but does not extend beyond this area, perhaps because of a poorer tolerance of environmental variability and/or the fact that it competes poorly with other endogeic species which are widely distributed throughout the island: *A. rosea bimastoides*; *A. trapezoides* (Dugès, 1828); *A. morrisi*; *M. dubius* (Fletcher, 1887). *D. affinis*, meanwhile, is better represented in specific areas of the thermo-Canarian zone in Tenerife, La Gomera and Gran Canaria, where temperatures are warm enough for it to survive in the shelter of the exotic plants imported by Canarian farmers and immigrants. Plants of this type abound in La Palma, and hence it is likely that hitherto undetected populations of *Dichogaster* exist on the island; the presence of this genus on El Hierro is less probable, since tropical cultures here are more recent and sporadic (having been introduced in the early 1970s). A preliminary review of the literature indicates that its distribution in the rest of the Macaronesian islands has not been fully established yet, and thus a comparative global analysis is ruled out for the moment. The finding of *D. bolaui* in the Cape Verde islands (Cognetti 1908), although of interest from a biogeographical standpoint, does not clarify whether it is wide-spread or not.

Little information is available concerning the edaphic factors of the soils where *Dichogaster* lives; due to insufficient study, Fragoso (1989) found *D. bolaui* in tropical forest soil (lithosols or rendzinas?) with a pH of 7.05 and organic matter content of 9,3 %; in our case it has been impossible to sample the soil, since most of the specimens were found in paved yards. The above values differ from those obtained for soils where *D. affinis* lives, mainly vertisols and sodium soils, with a higher water pH in most cases, and lower organic matter content (except for the sample collected in Los Silos, which contained 12.6 %). To sum up, the autoecological data presented here are virtually unknown and reveal that the species *affinis* is absent in acid soils in the Canary Islands, scarcely present in neutral soils, and appears to favour alkaline soils.

Zusammenfassung

Bei der Untersuchung von 379 Exemplaren von *Dichogaster*, die zu verschiedenen Jahreszeiten auf den Kanarischen Inseln gefangen worden sind, konnten zwei Arten identifiziert werden, *D. affinis* und *D. bolaui* (beide neu auf dem Archipel), womit sich ihr Verbreitungsgebiet in Makaronesien von Süden nach Norden ausgeweitet hat. Beide Arten gehören zur rezenten kanarischen Fauna, wobei man davon ausgeht, daß sie aus Nordafrika oder aus den tropischen Regionen Amerikas von Menschen zufällig eingeschleppt worden sind. Alle Angaben über das Vorhandensein von *D. oraedivitis* auf den Kanarischen Inseln werden als falsch betrachtet. Außerdem wird auch die Morphologie von *D. affinis* und *D. bolaui* beschrieben und diskutiert; insbesondere einige Verschiedenheiten in Clitellum, Penisborsten, Genitalpapillen und Samenbläschen sowie in der Anzahl der Herzbläschen. Beide Arten leben in den sehr stark gestörten Biotopen der wärmeren Unterstufe der Inseln, wo es *D. affinis* gelungen ist, sich im Bereich zwischen 4 und 500 m Höhe stark auszubreiten. Die autoökologischen Daten weisen vorläufig für *affinis* auf eine Vorliebe für alkalische Böden mit einem Gehalt von mehr als 3 % an organischen Stoffen hin.

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