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EVOLUTION IN THE CANARY ISLANDS III. TWO NEW *ARMINDA* (ORTHOPTERA; ACRIDIDAE; CATANTOPINAE) FROM THE CANARY ISLANDS, WITH NOTES ON THE *ARMINDA BRUNNERI* COMPLEX ON TENERIFE

BY CHRISTINA M. HOLZAPFEL

INTRODUCTION

THE ORTHOPTERA of the Canary Islands are well known, owing to the work of Chopard (1946), Willemse (1936, 1949, 1950), and others. Among the 43 species of Acridoidea reported to occur in the islands, seven are wingless endemic species. In the present paper, two additional wingless species are described, the taxonomic status of the Tenerifean Armindas is discussed, and the relationship between insular endemism and winglessness is reviewed briefly.

ACKNOWLEDGMENTS

Special thanks go to the late Dr. Kornelius Lems for his preliminary thoughts on the evolution of this genus in the Canary Islands, to Dr. Irving J. Cantrall for assistance in interpretation of morphological characteristics, and to Dr. Theodore H. Hubbell and Dr. Cantrall for criticizing the manuscript of this study. Dr. David R. Ragge of the British Museum (Natural History), Sñr. Vicenta Llorente of the Instituto Español de Entomologia, and Dr. Fer Willemse, Netherlands, were of invaluable assistance in their generous loans of series of *Arminda* specimens. Dr. K. K. Günther most generously gave of his time in searching for type material. This work was supported in part by a grant from the National Science Foundation, GB 6230, to N. G. Hairston, The University of Michigan, for research in Systematic and Evolutionary Biology. Field work in the Canary Islands was carried out in collaboration with Dr. Lems, principal investigator under grant GB 3876 from the National Science Foundation, and with support from the John Simon Guggenheim Memorial Foundation.

DIAGNOSIS

Specimens of *Arminda* from Gomera (*A. latifrons*) and Hierro (*A. hierröensis)* could not be procured for comparison with the new species, *fuerteventurae* and *lancerottensis*. According to Johnston (1956), the types of *latifrons* and *hierröensis* are housed in the Berlin Museum. However, correspondence with Dr. K. K. Günther indicated that the types could not be found, either at that institution or at the Polish Academy in Warsaw.

It is most unlikely that *fuerteventurae* or *lancerottensis* can be conspecific with either *latifrons* or *hierröensis*. The species of *Arminda* show much endemism. Only two cases have been reported in which a single species has been found on more than one island, *burri* on Gran Canaria and Tenerife, and *brunneri* on Tenerife and La Palma. In both instances, these distributions are based on the collection of a single specimen on the second island, and in both cases the islands are adjacent (Fig. 5) and are separated by less than 75 km. On the other hand, Hierro is the westernmost island in the Canaries, and Fuerteventura and Lanzarote are the easternmost. The island pairs are separated by the two large islands of Tenerife and La Palma, and by 250 km. distance. None of the four species under consideration is known from these two "central" islands.

The evidence for lack of conspecificity between *latifrons, hierröensis, fuerteventurae,* and *lancerottensis* is supported further by the size relationships of the females. Females of the two new species represent the smallest *Arminda* known, while the same sex in *hierröensis* and *latifrons* is decidedly larger (Table 1). The single female of *latifrons* described from Gomera is one of the larger specimens known for the genus.

Comparison of the species here described was made with *Arminda burri* Uvarov 1935, rather than with the genotype, *A. brunneri* Krauss 1892, because the published description of the latter is vague. Since *fuerteventurae* and *lancerottensis* can be distinguished morphologically one from the other only on the basis of shape of the male cercus and dorsal valves of the aedeagus, they were compared simultaneously. Fourteen ♂♂ and 21 ♀♀ of *fuerteventurae* and 24 ♂♂ and 9 ♀♀ of *lancerottensis* were compared with 10 ♂♂ and 17 ♀♀ of *burri*.

Compared with *A. burri,* these species (1) are much smaller in size

TABLE 1

SIZE RANGE OF ARMINDA DETERMINED FROM LITERATURE AND MUSEUM SPECIMENS

(In mm.)

		A. brunneri Krauss 1892	*A. hierröensis* Enderlein 1930	*A. latifrons* Enderlein 1930	*A. burri* Uvarov 1935	*A. fuerteventurae* new species	*A. lancerottensis* new species
Body length (Head to end of	♂	10.8–12.5	10.0–10.5	———	16.0–16.5	9.6–10.8	9.8–10.3
hind femur)	♀	14.5–19.0	14.3–16.3	18.5	21.0–24.0	12.1–14.8	13.0–13.8
Length of	♂	2.2– 2.6	———	———	2.8– 3.5	1.6– 1.9	1.7– 1.8
pronotum	♀	2.8– 3.9	———	———	4.0– 5.0	3.0– 3.1	2.8– 2.9
Length of	♂	6.3– 7.7	———	———	8.3– 9.5	5.0– 5.8	5.2– 5.4
hind femur	♀	7.3–10.5	———	———	11.4–12.3	6.8– 7.5	7.3– 7.5

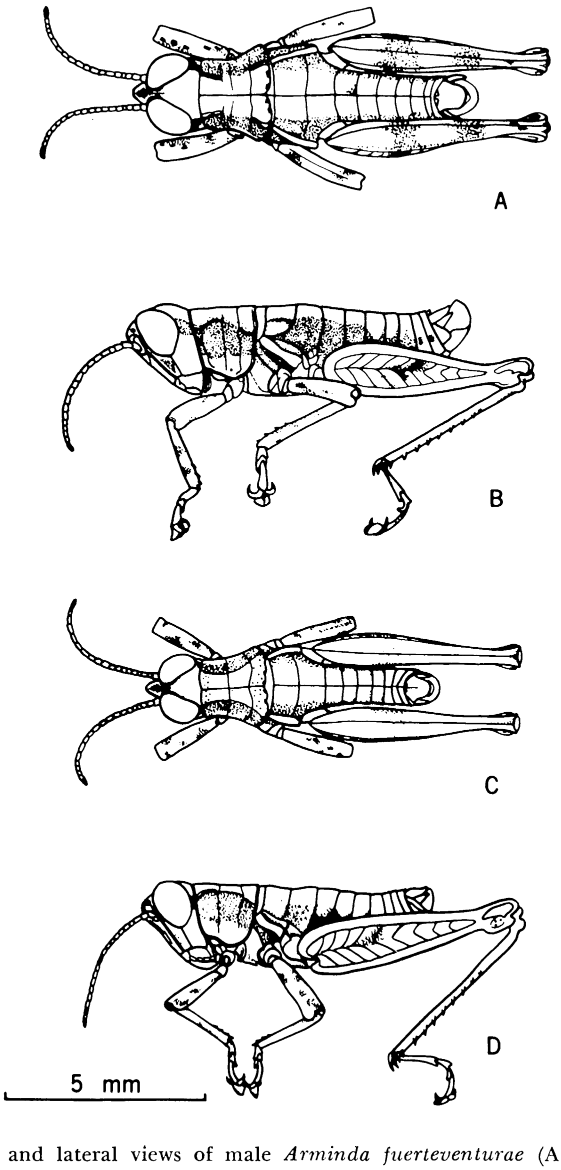

FIG. 1. Dorsal and lateral views of male *Arminda fuerteventurae* (A,B) and male *A. lancerottensis* (C,D).

(Table 1); (2) have the caudal margin of the pronotum of both males and females scalloped instead of straight (Fig. 1, A and C; Fig. 2, A and C); (3) usually have a dark pigment band between the fifth and sixth chevrons of the hind femur rather than pigment dispersed throughout most of the chevron area; (4) have the supra-anal plate of both males and females about as long as wide and rounded (Fig. 3, A and D; Fig. 4, B and E), rather than .6–.7 as wide as long and narrowing into a dull point; (5) have the cerci of the male as long as the supra-anal plate (Fig. 3, A and D) rather than extending beyond the terminus of the plate; (6) the subgenital plate of the female is without teeth in ventral view (Fig. 4, C and F), rather than having a single tooth on each side of the egg guide; (7) the dorsal lobes of the aedeagus are without membranous extensions (Compare Fig. 3, B, E, and H).

Arminda fuerteventurae new species

Male: small, total body length 9.6–10.8 mm.(Table 1). General coloration golden-tan, darkly pigmented along the sides of the pronotum and abdomen, the hind femur usually with a distinct band near the fifth and sixth chevrons. Antennae filiform, 20-segmented, about as long as the head and pronotum together, the terminal three segments modified into a concave, possibly sensory structure. Frons right-angled in lateral view, the frontal ridge narrow, as wide as the antennal scape, slightly protruding forward above the frontal ocellus, forming a rounded right angle with the fastigium of the vertex (Fig. 1, B); the latter with a longitudinal depression in most cases (Fig. 1, A). Interocular distance as wide as the basal segment of the antenna. Eyes large, strongly convex, extending above the head in lateral view, oval, the long diameter slightly greater than the gena below the eye. Antennal crescent complete, ivory white, half the width of the basal segment of the antenna. Ocelli large. Pronotum subcylindrical, smooth; metazona gently flaring, the posterior margin scalloped, the indentations marked by black spots. Median carina of the pronotum crossed by at least one sulcus. Lateral carinae regular, lightly callous, interrupted by three prominent sulci. Prozona three times as long as the metazona. Elytra, wings and tympana absent. Caudal femur slender, more than twice as long as the pronotum (Table 1). Hind tibia with nine external spines, including the external apical spine, distributed evenly along the distal two-thirds of the tibia. Male supra-anal plate about as wide as long, rounded terminally; cercus acutely conical, incurved, as long as the supra-anal plate. Dorsal lobes of the aedeagus broadly acuminate (Fig. 3, B), horse-

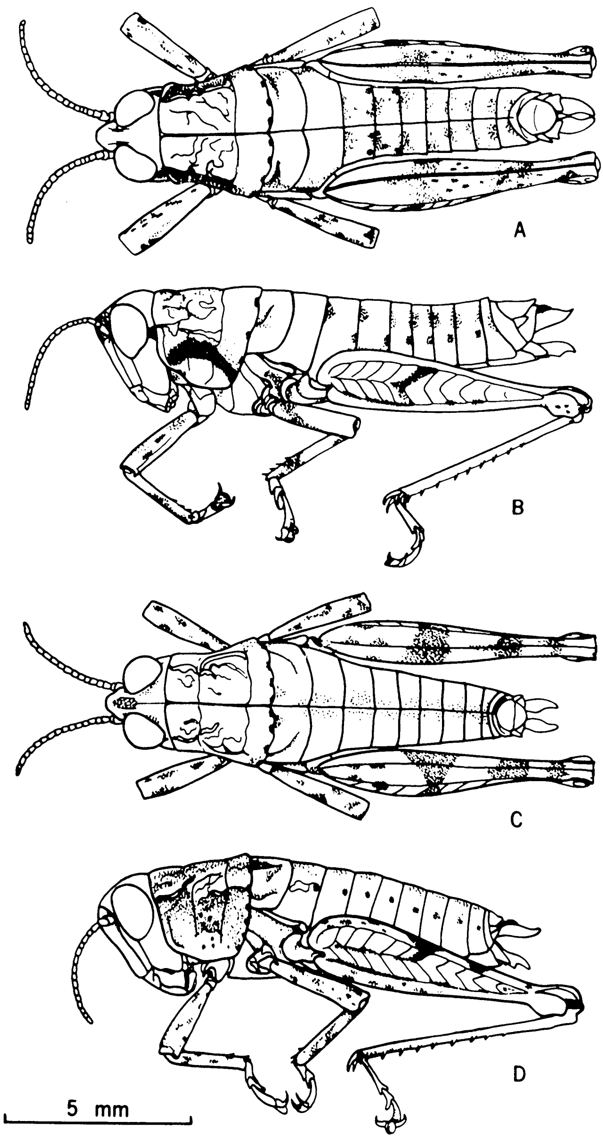

FIG. 2. Dorsal and lateral views of female *Arminda fuerteventurae* (A,B) and female *A. lancerottensis* (C,D).

shoe-shaped in cross section (Fig. 3, C). Epiphallus bridged, the ancorae bending back, away from the lophi, rounded at the tips; lophi smooth, lobiform (Fig. 3, G).

Female: The female of this species differs from the male in a number of characters. Size larger than that of the male (Table 1); body color usually uniform, ranging from golden-tan to red-brown, only occasionally with a pigment band on the sides of the pronotum. Pronotum distinctly sculptured with a pattern of anastomosing depressions; lateral carinae irregular, callous, divergent. Prozona about twice as long as the metazona. First abdominal segment with a pair of bilateral, dorsal concavities (Fig. 2, A). Female cercus triangular, often with slightly convex sides; dorsal angle of the upper ovipositor valve broadly obtuse, approximately 150°; eighth sternite with a shallow notch, more than 100° (Fig. 4, A). Subgenital plate in ventral view smooth, terminally cuspidate, without teeth (Fig. 4, C).

MATERIAL EXAMINED.—Holotype: ♂. Betancuria, Fuerteventura, 350 meters, May 3, 1964, K. M. Guichard. Paratypes: 6 ♂♂, 8 ♀♀, same data; 7 ♂♂, 10 ♀♀, Above Ampuyenta, Fuerteventura, about 500 meters, April 24, 1964, K. M. Guichard; 3 ♀♀, 1 km. south of Antigua, Fuerteventura, 254 meters, May 3, 1966, C. M. Holzapfel. The type specimen and 11 ♂♂ and 16 ♀♀ are in the British Museum (Natural History); 2 ♂♂ and 5 ♀♀ paratypes are housed in the Museum of Zoology of the University of Michigan.

Arminda lancerottensis new species

Male: Differs from *A. fuerteventurae* in that (1) the cerci are straight rather than incurved (Fig. 3, D), (2) the aedeagus lobes are laterally truncate rather than broadly acuminate (Fig. 3, E), and are J-shaped rather than horseshoe-shaped in cross-section (Fig. 3, F).

Female: Females of the two species cannot be distinguished on the basis of any morphological characteristics studied. Females of both species are illustrated to indicate range in variation of characters (number of spines on the fore tibia, sculpturing of the lower ovipositor valves, callosity of the ovipositor valves, etc.)

MATERIAL EXAMINED.—Holotype: ♂. Haria, Lanzarote, at about 600 meters elevation, May 19, 1964, K. M. Guichard. 32 paratypes were collected by Guichard in the following areas: Haria, Lanzarote, same data, 23 ♂♂ and 7 ♀♀. Tahiche, Lanzarote at about 50 meters elevation on May 23, 1964, 2 ♀♀. 21 ♂♂ and 5 ♀♀ paratypes are housed in the BMNH. 2 ♂♂ and 2 ♀♀ paratypes are located in the UMMZ.

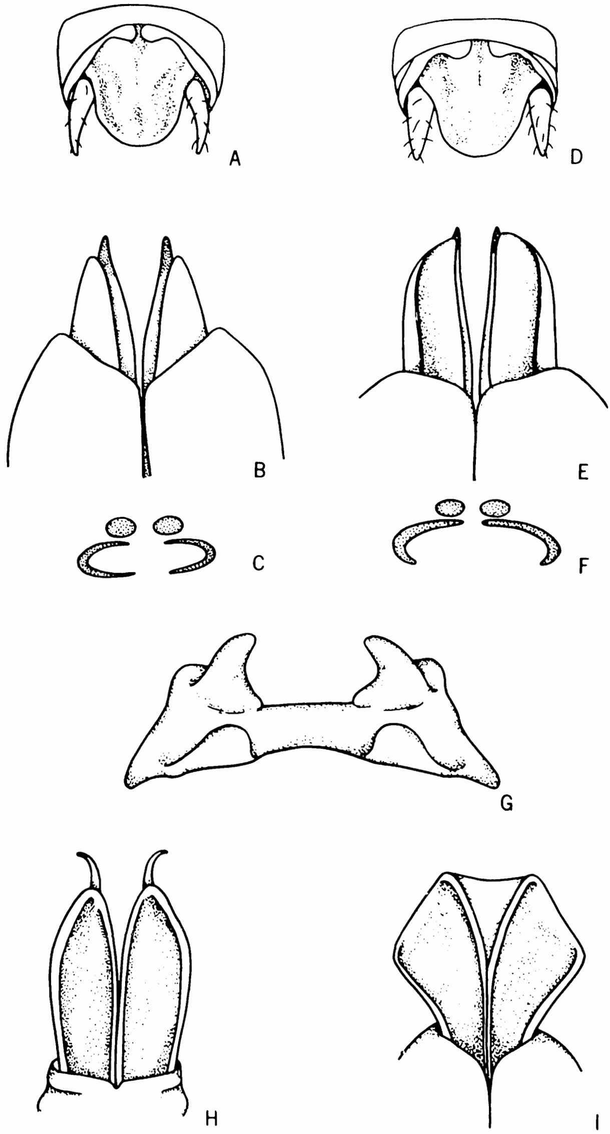

FIG. 3. Dorsal view of the supra-anal plate and cerci of male *A. fuerteventurae* (A) and male *A. lancerottensis* (D). Ventral view and cross-section of the dorsal lobes of the aedeagus of *A. fuerteventurae* (B,C) and *A. lancerottensis* (E,F). Epiphallus of *A. fuerteventurae* (G). Ventral view of the dorsal lobes of the aedeagus of *A. burri* (H), and *A. brunneri* (I).

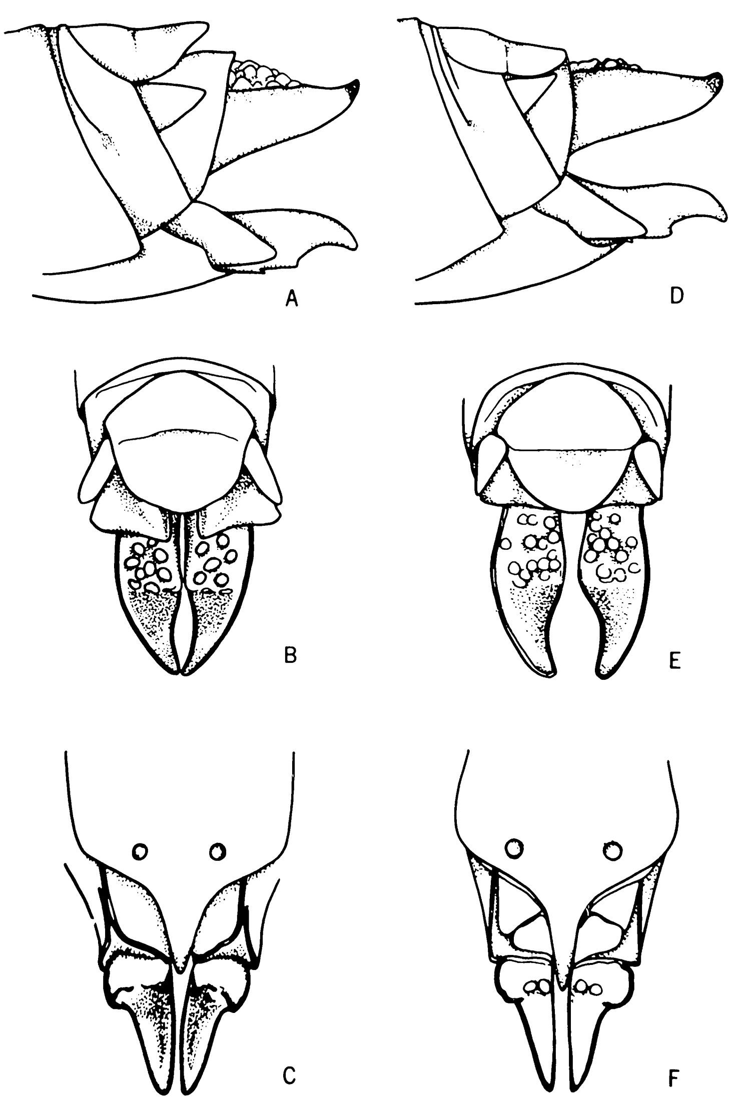

FIG. 4. Lateral view of the external genital complex, dorsal view of the supra-anal plate and ventral view of the subgenital plate of female *A. fuerteventurae* (A,B,C) and *A. lancerottensis* (D,E,F).

DISTRIBUTION AND ECOLOGY

Arminda is represented on all of the Canary Islands (Fig. 5), and occurs predominately below 1000 meters elevation. On Lanzarote and Fuerteventura the genus has not been found above 600 meters. *A. lancerottensis* is known from only two localities along the major north-south road on Lanzarote, separated by 13 km. distance. All localities of *fuerteventurae* lie within a small 5 km. diameter nucleus between 254 and 500 meters elevation, in the center of Fuerteventura. It is certain that both of these species have wider distributions than indicated since both islands are poorly known faunistically and in associated floristic elements.

At least in Antigua, Fuerteventura where *Arminda fuerteventurae* was collected, the species is found in open, rocky fields characterized by sparse, semi-desert vegetation. The dominant woody shrubs of the area are the common tobacco weed, *Nicotiana glauca* Graham, and *Launaea spinosa* (L) Hook f. *Mesembryanthemum nodiflorum* L., *Lotus lancerottensis* Webb, *Sisymbrium erysimoides* Desf., *Plantago sericea* Benth. (non. Kit. nec Bolle) and *Chenopodium album* L. predominate at ground level. Adults were collected on March 3 at this site, and K. M. Guichard has collected adult Armindas as late as May in adjacent localities.

THE *ARMINDA BRUNNERI-STRIATIFRONS-APPENHAGENI* COMPLEX ON TENERIFE

During the preparation of descriptions of the new *Arminda* species considered in this paper, a comparison with specimens considered to be the genotype, *A. brunneri* Krauss from Tenerife, was made. Over 100 specimens of *Arminda* from Tenerife were at hand, representing the ranges of material housed in the British Museum (Natural History), the Instituto Español de Entomologia, and the private Willemse Collection in Holland; only a few of these specimens had been identified. No morphological differences could be found between material received under the names *A. brunneri* and *A. striatifrons*. This observation resulted in a study of the distribution and variation of *Arminda* on Tenerife, the largest and most varied of the Canary Islands.

A. brunneri was described in 1892 by Krauss on the basis of one female collected at San Andrés on the northeastern coast of Tenerife. In 1929, Enderlein described two new species of *Arminda*, one (*appenhageni*) also from San Andrés, and the other (*striatifrons*) from Guajonge, a few kilometers away. The two localities from which these

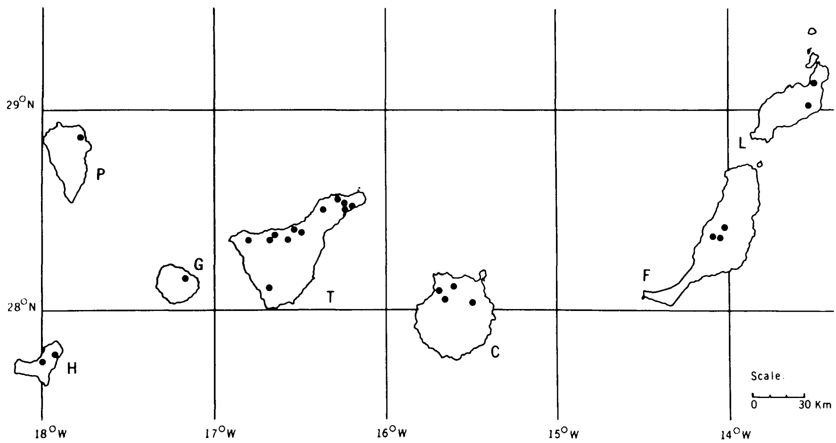

FIG. 5. Known distribution of *Arminda* on the Canary Islands. Island codes and known species west to east: H. = Hierro, *A. hierroensis;* P = La Palma; *A. brunneri;* G = Gomera, *A. latifrons;* T = Tenerife, *A. brunneri, A. burri;* C = Gran Canaria, *A. burri;* F = Fuerteventura, *A. fuerteventurae;* L = Lanzarote, *A. lancerottensis.*

three species were described lie within 16 km. of each other in the Anaga Peninsula on the northernmost corner of the island. Furthermore, all three holotypes are females, which in many grasshopper taxa are notoriously variable and more difficult than males to distinguish. No diagnoses were included in the description of Enderlein's species; the characters noted were general body coloration, interocular distance, shape of the lower ovipositor valves and morphology of the flagellum of the antenna.

The 109 specimens of *Arminda* from Tenerife were sorted into localities and arranged in east-west order. Few specimens were available from the far northwest portion of the island. Size, details of external morphology and internal male genitalia were studied in specimens from each area. The following relationships were observed:

1) The Tenerifean Armindas have a wide distribution, ranging the entire 78 km. distance east to west along the north coast of the island (Fig. 5). One female from the peculiar Barranco del Infierno on the southwest coast of the island suggests a wider distribution on this less populous coast than is indicated by collection data.

2) Specmens from all localities are within the same size range, based on hind femur and pronotum measurements (Fig. 6).

3) The morphology of the dorsal lobe of the aedeagus showed essentially no variation among localities. All specimens studied closely resemble the example from San Andrés, the type locality of *brunneri* and *appenhageni* (Fig. 3, I). One male from La Vega on the northwest coast of Tenerife is of doubtful status; it is morphologically indistinguishable from *burri,* known only from Gran Canaria.

4) Features of the external male genitalia vary from locality to locality. For example, the supra-anal plate varies in shape from nearly square to slightly elongate, both in series from a single locality and throughout the range represented. Cerci are straight and slightly longer than the supra-anal plate in all cases observed.

5) Females from single localities cannot be distinguished from those from other localities. Range of variation in body shape, coloration, features of the external genitalia, etc. exhibit more variation than in males. For example, general body shape of females varies from a stocky and robust form to slender, both in a given locality and over the range of localities. Relative body proportions of males, on the other hand, are very constant. Enderlein (1929) used the angulation of the dorsal ovipositor valve to distinguish between the holotypes of *brunneri* and *appenhageni.* His illustration of this valve resembles a typical lower ovipositor valve of *Arminda,* rotated 180° (i.e. with the ventral surface up). This type of structure was not seen in any of the 60 female specimens studied from all localities, including the type locality of *A. brunneri* and *A. appenhageni.* It is suggested that Enderlein's drawing of the upcurved toothless lower valve is either reversed or represents an unusually worn structure.

On the basis of study of morphology of material at hand, the ambiguity in the descriptions of Enderlein's female holotypes and the overlap in type localities, it is concluded that *Arminda* on Tenerife represents one widely dispersed taxon, the females of which are quite variable, both within a single collection area and over the whole extent of the range, and the males of which are conservative and constant. Hence, *Arminda appenhageni* Enderlein 1929 and *Arminda striatifrons* Enderlein 1929 are here considered to be synonyms of *Arminda brunneri* Krauss 1892.

THE WINGLESS CONDITION AND INSULAR ENDEMISM

The notion that the wingless condition in insects is related to windi-

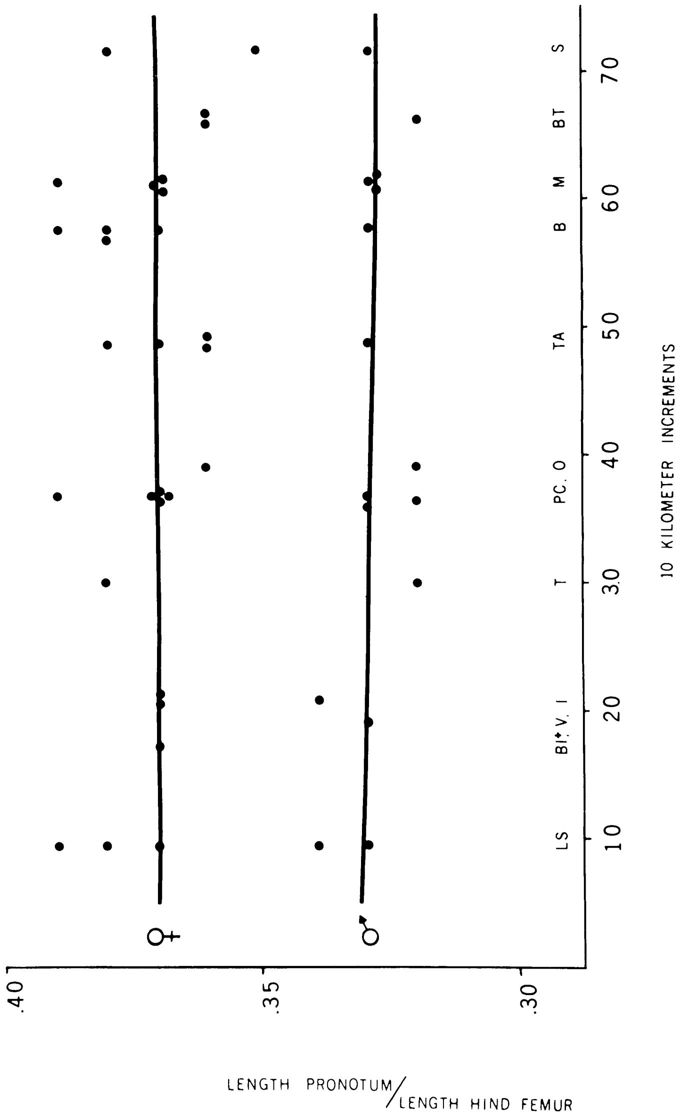

FIG. 6. Variation in relative size of *Arminda* on Tenerife. Specific collection sites are arranged in west to east order. Sites except for BI+ are located on the north coast. LS = Los Silos; BI+ = Barranco del Infierno; V = La Vega; I = Icod; T = Tigaiga; PC = Puerto de la Cruz; O = Orotava; Ta = Tacoronte; B = Bajamar; M = Mercedes; BT = Barranco Tahodio; S = San Andrés. Coefficients of correlation: ♂ = 0.35, ♀ = 0.02.

ness and other features of oceanic islands and mountain tops has been maintained since the days of Darwin (1859). On the basis of the distribution and ratio of winged to apterous Acridoidea in the Canaries and on the "source" continent, Africa, this relationship is reinterpreted.

Of 1427 species of Acridoidea from the whole of continental Africa for which information on wing length is available, 631 species, or 44% of the species are either entirely wingless or have reduced wings, i.e. all cases in which the hind wings are shorter than the abdomen (Dirsh, 1965; Johnston, 1956, and secondary sources noted by these authors). In contrast only 9, or 21%, of the 43 species of Acridoidea in the Canaries are wingless; none have reduced wings. When only the subfamilies of Acridoidea represented on the Canaries are compared with the same subfamilies from continental Africa, the proportion of wingless and reduced-winged species remains higher on the continent, 33% compared with 21% (Table 2). Subfamilies with largely long-winged species in Africa (Acridinae, Truxalinae) are represented by long-winged species in the Canaries. *Dericorys,* the only long-winged genus of the Dericorythinae in Africa, is represented in the Canaries by the macropterous *Dericorys lobata.*

Hence, there are proportionally *fewer* wingless grasshoppers on the Canary Islands than on the African mainland. Furthermore, although the Canary Islands are rugged mountainous areas, *Arminda* tends to occur at low elevations, often inhabiting flat, open fields.

In view of the fact that the closest relatives of all of the wingless genera on the Canary Islands are also wingless or micropterous in continental Africa, it seems evident that the apterous condition of the Canarian taxa does not represent an adaptation to the insular environment.

The wingless condition does seem to be related to degree of endemism. All four of the wingless genera of Acridoidea present on the Canaries (the pamphagids, *Purpuraria* and *Acrostira,* and the catantopines, *Arminda* and *Chopardminda)* are endemic to the Canary Islands. On the other hand, none of the genera of winged grasshoppers are endemic, although eight of the species are. Moreover, all of the apterous species are established on single islands, while several of the winged endemic species have spread throughout the archipelago (for example, *Calliptamus plebius* (Walker)), or at least to several adjacent islands (*Omocestus simonyi* Krauss).

The Guichard collection from the British Museum (Natural History) contains one specimen of *A. burri,* previously known only from Gran Canaria, labelled from La Vega, Tenerife, and one specimen of *A.*

TABLE 2

COMPARATIVE WING LENGTH OF THE ACRIDOIDEA OF THE CANARY ISLANDS AND CONTINENTAL AFRICA

Family:	Canary Islands			Africa		
Subfamily:	No. genera	No. wing-less species	No. long-winged species	No. genera	No. reduced wing and wingless spp.	No. long-winged species
Pamphagidae						
Pamphaginae	2	2	0	10	60	0
Acrididae						104
Catantopinae	2	7	0	67	99	274
Acridinae	8	0	22	89	52	43
Calliptaminae	1	0	4	7	0	2
Dericorythinae	1	0	1	5	13	138
Truxalinae	5	0	5	49	26	47
Cyrtacanthacridinae	1	0	1	16	1	55
Pyrgomorphidae	1	0	1	40	78	
Totals	21	9	34	283	329	663
% Wingless Species		21%			33%	

brunneri, previously endemic to Tenerife, from San Andrés y Sauces, La Palma. Communication with this museum indicates that these data are correct.

SUMMARY

1. Two new wingless species of grasshoppers are described from the Canary Islands: *Arminda lancerottensis* from Lanzarote, and *A. fuerteventurae,* an endemic of Fuerteventura. These species are very closely related, the males differing from one another only in details of the genitalia.

2. *Arminda appenhageni* Enderlein and *A. striatifrons* Enderlein from Tenerife are indistinguishable from the genotype, *A. brunneri* Krauss, also from Tenerife, and are here synonymized with *A. brunneri.*

3. One the basis of comparison with 1427 species of Acridoidea from continental Africa for which data on wing length are available, it was found that a higher proportion of reduced-winged and wingless species occurs on the mainland than on the Canary Islands. Perhaps more importantly, the closest known relatives of the wingless genera on the Canary Islands are either wingless or micropterous on the "source" continent. Hence, at least among the Acridoidea of the Canary Islands, winglessness is not an adaptation to the insular environment.

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