THE LIMACIDAE OF THE CANARY ISLANDS

by

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(34th Contribution to the Knowledge of the Fauna of the Canary Islands edited by Dr. D. L. Uyttenboogaart, continued by Dr. C. O. van Regteren Altena [1]))

CONTENTS

INTRODUCTION

In the spring of 1947 I was so fortunate as to join for some 9 weeks the Danish Zoological Expedition to the Canary Islands. During my stay I collected materials for the Rijksmuseum van Natuurlijke Historie at Leiden, paying special attention to the land- and freshwater Mollusca. This paper contains the first results of the examination of the Mollusca collected.

My Danish friends Dr. Gunnar Thorson and Dr. Helge Volsøe generously put at my disposal the non-marine Mollusca they collected during their stay in the Canaries. When the material has been worked up, duplicates will be deposited in the Zoological Museum at Copenhagen.

I am indebted to several persons who helped me in various ways in the investigations here published. Prof. Dr. N. Hj. Odhner (Stockholm) very kindly put at my disposal a MS list of all the Mollusca of the Canary Islands and their distribution, which he had compiled for private use. Mr. Hugh Watson (Cambridge) never failed to help me by examining or lending specimens, and in detailed letters gave me the benefit of his great experience. During my stay in Paris in March 1950 Dr. G. Ranson and Dr. A. Franc put at my disposal for examination the Canarian slugs present in the Muséum National d'Histoire Naturelle, and I am indebted to Dr. L. Forcart (Natur-

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historisches Museum, Basel), Dr. Gordon K. MacMillan (Carnegie Museum, Pittsburgh), Dr. W. J. Rees (British Museum (Natural History), London), and Dr. A. Zilch (Natur-Museum "Senckenberg", Frankfurt am Main) for sending specimens on loan. Mr. H. E. Quick (Reading) was so kind as to correct the English typescript. To these persons, and to many others who helped in some way or other, but who have not been mentioned here, I wish to express my gratitude for their kind cooperation.

From the published data it would appear that an essential difference exists between the limacid fauna of the eastern Canary Islands (Lanzarote and Fuerteventura) on one hand, and that of the central and western islands (Gran Canaria, Tenerife, Gomera, La Palma, and Hierro) on the other. From the eastern islands representatives of the genus *Parmacella* only have been recorded, whereas the species from the central and western islands belong to the genera *Milax, Limax,* and *Deroceras.* It appeared, however, when examining Limacidae belonging to the Museums in Paris and Frankfurt am Main, that the genus *Parmacella* also occurs in Gran Canaria, and that *Limax flavus* is also found in Fuerteventura. Consequently the difference, though certainly great, is not so essential as it would seem to be at first.

Since Wollaston's time no new material of *Parmacella* seems to have been collected in the Canaries, except three empty shells from Gran Canaria recorded on p. 5 of this paper. As long as no well preserved spirit specimens are at hand, it is impossible to revise the Canarian forms of *Parmacella,* which Mousson (1872, p. 8 seq.) assigned to three endemic species on account of the characters of the shell only. Simroth (1898, p. 135) on the other hand expressed as his opinion, that all the described forms of *Parmacella* occurring from the Caucasus to the Canaries are but one species, *P. olivieri* Cuvier, 1804. Although this view has not generally been accepted, and Hesse (1926, p. 116) lists several species of *Parmacella* (*Parmacella*) from the Mediterranean region, a revision of the Canarian forms of *Parmacella* is required to judge their systematic value and affinities.

Apart of the discovery of *Limax flavus* L. in the culture zone near Betancuria, Fuerteventura, by C. R. Boettger in June 1913 (one specimen in the Senckenberg Museum) there are no new records of Limacidae from the eastern Canary Islands. This is the reason why in the next section the Limacidae of the central and western islands only are dealt with.

During my stay in the Canaries I collected Mollusca in Gran Canaria, Tenerife, and La Palma; slugs were found in the two latter islands only. A list of the localities visited has recently been published (v. R. Altena, 1949). All the measurements and colour descriptions in the next section are taken

from preserved specimens. The slugs I collected were stretched by immersion in water during some 12 hours before fixation in 65 per cent. alcohol.

SYSTEMATIC SURVEY OF THE LIMACIDAE OF THE CENTRAL AND WESTERN CANARY ISLANDS

1. **Parmacella** spec.

Previous records. The genus has not previously been recorded from the Western Canary Islands [1]).

Material examined belonging to other Museums. Gran Canaria: Lomo del Capon, Verneau leg.: 3 empty shells (Paris Museum).

As pointed out in the introduction a revision of the Canarian forms of *Parmacella* based on the examination of the anatomy is required to judge the value of the species hitherto described. It is doubtful whether species identifications based on shell characters only can be trustworthy. This first record of the genus from the archipelago outside the eastern islands is, however, of biogeographical interest.

2. **Milax (Milax) gagates** (Draparnaud, 1801)

Limax carenata d'Orbigny, 1836-1842, p. 47 (1839).
Limax carinata d'Orbigny, 1836-1842, pl. 3 fig. 4-8 (1842); Gray, 1854, p. 9.
Limax polyptielus Bourguignat, 1859, p. 143.
Lallemantia polyptiela Mabille, 1868, p. 144; 1884, p. 218.
Limax polyptielus Mousson, 1872, p. 6; Wollaston, 1878, p. 308.
Milax Gaimardi Mabille, 1883, p. 51; 1884, p. 216; Heynemann, 1906, p. 15.
Milax Verneaui Mabille, 1883, p. 51; 1884, p. 215.
Amalia gagates Heynemann, 1885, p. 291; Simroth, 1886, p. 322; Krause, 1894, p. 32; 1895, p. 22, pl. 1 fig. 1 (spermatophore); Kraepelin, 1895, p. 9; Heynemann, 1906, p. 74; May, 1912, p. 232; Simroth, 1912, p. 97, 98, 109.
[*Amalia gagates* var.] *raymondiana* Simroth, 1888, p. 69.
Amalia gagates var. *Raymondiana* Simroth, 1891, p. (295), 421, pl. 11 fig. 2, pl. 18 map 6.
Amalia gagates var. *carinata* Cockerell, 1891, p. 335.
Amalia marginata Collinge, 1894, p. 70, fig. on p. 71 (genitalia).
Amalia parryi Collinge, 1895, p. 7.
Amalia verneaui Mabille, 1898, p. 95.
Milax gaimardi Heynemann, 1906, p. 15.
[*Milax*] *verneaui* Heynemann, 1906, p. 15.
[*Amalia*] *parraji* Heynemann, 1906, p. 16, 17.
Milax gagates Hoffmann, 1928, p. 221, 222, 224; Odhner, 1932, p. 69; Fischer-Piette, 1946, p. 255.

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1) Dumont d'Urville (1830, p. 44), when describing the descent from the Pico de Teyde of some members of the Astrolabe Expedition, writes: "et M. Quoy découvrit des Parmacelles". As the genus *Parmacella* is, however, not mentioned by Quoy & Gaimard in their report on the zoology of this expedition, the record may be based on a wrong preliminary identification, and should be disregarded.

Amalia canaria Torres Mínguez, 1928a, p. 77; 1928b, p. 118.
Amalia Santosi Torres Mínguez, 1928b, p. 117, fig. on p. 118.

Previous records. Gran Canaria: no exact locality (Mousson; Simroth, 1886); in the upper part of El Monte, near San Mateo (Wollaston); Las Lagunetas; barranco de la Angostura; S. Pedro in the valley of Agaete (Odhner). — Tenerife: near Santa Cruz (d'Orbigny; Mabille, 1884; Collinge 1894); no exact locality (Mabille, 1883; Hoffmann); Agua Mansa (Heynemann); Puerto Orotava; Erica Region above Santa Cruz (Krause, 1894); Orotava (Collinge, 1894); Guimar (Kraepelin, 1895); Las Mercedes (Mabille, 1898); La Laguna; Vilaflor (Hoffmann). — Gomera: valle Hermigua; Cumbre del Carbonero; Eremita de las Nieves; Agulo; above Agulo (May, 1912). — La Palma: Santa Cruz (Torres Mínguez, 1928b).

Own material. Tenerife: barranco between La Laguna and Bufadero, 2 III 1947, G. Thorson leg.: 1; barranco Andura, or Andola, S of Realejo Alto, 17 III 1947: 9; barranco Ruiz, W of Realejo, 1 IV 1947: 1; on the side of an irrigation gutter, some 100 m above Arafo, 13 IV 1947: 2.

Material examined belonging to other Museums. Gran Canaria: no exact locality, Reiss & Fritsch leg., ex coll. Koch: 2; no exact locality, ex coll. Koch: 2 (Senckenberg Museum). — Tenerife: no exact locality, Quoy & Gaimard leg., 1829: 2; no exact locality, Verneau leg.: 3; no exact locality: 2; Santa Cruz, Verneau leg.: 2; "Badejoz, Guimor" (recte: barranco Badajoz near Guimar), Verneau leg.: 7; Las Mercedes, Buchet leg.: 4 (Paris Museum); Tacoronte, E. Appenhagen leg.: 3; Orotava, Noll leg., ex coll. Koch: 3; Orotava, ex coll. Koch: 1; Agua Mansa, Grenacher & Noll leg., ex coll. Heynemann: 19 (Senckenberg Museum). — La Palma: Argual, VII 1913, C. R. Boettger leg.: 1 (Senckenberg Museum).

The species was collected for the first time in Gran Canaria by Wollaston in 1858 or 1859; in Tenerife by d'Orbigny in 1826. W. May was the first to find it in Gomera in December 1907, and C. R. Boettger in La Palma in July 1913.

Like Simroth, Hoffmann, and Odhner I could find no difference from *Milax gagates* in the anatomy of my specimens.

Although new species of *Milax* have been described from the Canary Islands by several authors, there is no evidence that more than one species of the genus occurs in the Canaries. The descriptions mostly lack any particulars of the anatomy, and the external characters given are insufficient to separate the "species" from *Milax gagates*.

I was able to examine the types of *Milax gaimardi* Mabille and *Milax verneaui* Mabille in Paris, and found their external characters as well as their anatomy to agree with *Milax gagates*. The 2 syntypes of *Milax gai-*

mardi were collected by Quoy & Gaimard in Tenerife, but not mentioned in their report on the zoology of the Astrolabe. Examination of the authentic specimens in Paris revealed that Mabille was right in considering the specimens recorded by Quoy & Gaimard (1832, p. 145) from Ascension as *Limax ascensionis* to be conspecific with those from Tenerife: they equally belong to *Milax gagates*.

The genitalia of *Amalia parryi* were described and figured by Collinge (1894); they do not agree in detail with typical genitalia of *Milax gagates*. Mr. Watson was so kind as to make inquiries after the type of *parryi*. At least part of the Collinge collection is preserved in the University Museum of Zoology at Cambridge, and it appeared that 3 specimens of *Milax* from the Canaries could be found there. They are from Santa Cruz, and labelled "*Amalia gagates* Drap.", without any indication of the collector's name or the date of collecting. According to Mr. Watson's letter these specimens proved to belong in fact to *Milax gagates*. As none of these slugs had been dissected, the specimen figured by Collinge is not among them, but it may be that they belong to the original lot, and that Collinge afterwards changed his opinion as to the identification.

However this may be, the evidence presented by Collinge's note is too uncertain to prove the occurrence of a second species of *Milax* at Santa Cruz. Mr. Watson in his letter suggests that possibly *parryi* has been established on a specimen of *Milax gagates* with slightly abnormal genitalia. When comparing Collinge's figure of the genitalia of *M. parryi* (Collinge, 1894, fig. on p. 71, s.n. *Amalia marginata*) with Watson's figure of the anterior part of the genitalia of *M. gagates* (Phillips & Watson, 1930, pl. 2 fig. 16) it appears that the two differ as to the shape of the atrium genitale, the receptaculum seminis, the penis, and the epiphallus. In several specimens from Tenerife, however, I found the shape of the epiphallus to agree rather well with that figured by Collinge; presumably it changes considerably during the sexual cycle. I never saw the series of "faintly coloured rings" encircling this organ in Collinge's specimen, but no great importance should be attached to that character. The receptaculum seminis is somewhat variable in the specimens I examined, but never so long as figured by Collinge. Often I found it more or less pyriform, though always much stouter than in *M. sowerbii* (Férussac). Probably some of the deviations in Collinge's figure may be attributed to its crudeness.

Variation. Simroth (1891, p. 295) originally thought that the Canarian form of this species belongs to a colour variety described from Algeria as *Limax Raymondianus* by Bourguignat. We now know, however, that the colour of *Milax gagates* in the Canaries generally varies from greyish with

lighter sides to almost wholly black, although differently coloured specimens occasionally occur. Specimens of a reddish, burnt sienna hue, as Simroth recorded already in 1886, certainly are an exception. Mabille (1884) mentions a brown specimen, which I saw in Paris. Among the Museum specimens examined I also found lighter ones, of a cream yellow colour. A similar variation in colour has been recorded from other countries, and there is not the slightest indication that the specimens from the Canaries would belong to a separate subspecies. In 1912 Simroth records the lighter specimens from higher up in the mountains of Gomera.

Habitat. The species is mostly met with in humid places, under stones, sometimes near irrigation gutters or pipes (d'Orbigny, v. R. Altena). Adult specimens are more resistant to desiccation than young ones; they even may enter houses (Torres Mínguez, 1928b). *Milax gagates* occurs high up in the mountains: Gran Canaria, Las Lagunetas (1200 m); Tenerife, Vilaflor (1400 m); Gomera, Eremita de las Nieves (1300 m).

Biology. The actual length of specimens is difficult to judge when they are preserved, as they contract much more on fixation than Limacinae, even when they have been stretched by immersion in water during some 12 hours before fixation. Nevertheless it is certain that sexual maturity can be reached long before the animal is full grown. In Paris I examined an alcohol specimen 22 mm long (Tenerife, Quoy & Gaimard leg.) which had been fixed during copulation. Simroth records small specimens with fully developed genitalia, and a large one which was still immature, from Gomera. In the spring of 1947 I collected young and semi-adult specimens of various sizes in Tenerife, and a full grown one was found by Mr. Thorson. Other dated records are, however, too scarce to decide whether reproduction occurs throughout the year, and what is the age normally reached by the species in the Canary Islands.

3. **Limax (Limacus) flavus** Linnaeus, 1758

Limax Canariensis d'Orbigny, 1836-1842, p. 47 (1839), pl. 3 fig. 1-3 (1842); Gray, 1854, p. 9; Bourguignat, 1859, p. 142; ? Mabille, 1884, p. 213.

Limax canariensis Mousson, 1872, p. 6; 1878, p. 308.

Limax variegatus Heynemann, 1885, p. 290; Krause, 1894, p. 31; 1895, p. 21; Heynemann, 1906, p. 74.

Limax flavus Cockerell, 1893, p. 173, 198 (no. 44 r); Hoffmann, 1928, p. 221, 223; Fischer-Piette, 1946, p. 255.

Previous records. Gran Canaria: no exact locality (d'Orbigny); ? Las Palmas (Mabille). — Tenerife: no exact locality (d'Orbigny; Krause, 1894; Hoffmann); ? Santa Cruz (Mabille); Orotava (Heynemann); barranco de

Castro near Orotava; S side of the island (Krause); La Laguna; Puerto Orotava (Hoffmann).

Own material. Tenerife: garden of the University of La Laguna, 9 V 1947: 1.

Material examined belonging to other Museums. No exact locality: 1; Tenerife: Tacoronte, E, Appenhagen leg.: 1; Orotava, among the debris of the historical dragon tree, IX 1871, Grenacher & Noll leg.: 1, and ? 2 juv.; environment of Orotava, 1913, C. R. Boettger leg.: 10; Vilaflor, III 1913, C. R. Boettger leg.: 2 (Senckenberg Museum).

The first specimens on both islands were collected by Webb & Berthelot between 1820 and 1830.

Though there is no doubt that the description of *Limax canariensis* d'Orbigny refers to *Limax flavus* L., the former name has also been used to indicate Canarian specimens of other species, viz., by Mabille (see under *Limax poirieri,* p. 10 and *Deroceras reticulatum,* p. 17), and Smith (see under *Deroceras reticulatum,* p. 17).

I failed to find the specimens recorded by Mabille from Las Palmas and Santa Cruz. As two samples labelled "*Limax canariensis*" by that author proved not to belong to *Limax flavus,* Mabille's records from Las Palmas and Santa Cruz are referred with doubt to this species.

Variation. The specimens of this species I examined belong to the typical form.

Habitat. Of all the slugs of the Canaries this one would seem to be the most bound to human settlements. It occurs high up in the mountains in Tenerife, viz., at Vilaflor (1400 m).

Biology. One of the Orotava specimens collected in September is sexually mature, those from Vilaflor collected in March are nearly mature, and my 24 mm long specimen taken at La Laguna in May shows the glandular tissues of the genitalia not yet fully developed. These data are insufficient to judge about the life cycle of the species in the Canaries.

4. **Limax (Lehmannia) poirieri** Mabille, 1883

Limax poirieri Mabille, 1883, p. 52; 1884, p. 214.
[*Limax arborum*] var. *valentianus* Simroth, 1888, p. 69.
Limax arborum var. *valentianus* Simroth, 1891 p. 281, 421, pl. 11 fig. 5; 5a; Krause, 1894, p. 31; 1895, p. 21; Kraepelin, 1895, p. 9.
Limax arborum valentianus Simroth, 1891, p. 280 note.
Limax arborum forma *typica* Krause, 1894, p. 31; 1895, p. 21.
? Limax maximus Collinge & Partridge, 1899, p. 38; Heynemann, 1906, p. 74.
Limax marginatus Collinge & Partridge, 1899, p. 38; Heynemann, 1906, p. 74.
[*Limax arborum*] *valentianus* Heynemann, 1906, p. 50.
Limax arborum May, 1912, p. 232; Simroth, 1912, p. 98, 105.

Lehmannia marginata Hoffmann, 1928, p. 221, 222, 223; Odhner, 1932, p. 69; Fischer-Piette, 1946, p. 255.

Previous records. Canary Islands: no exact locality (Simroth, 1891). — Gran Canaria: no exact locality (Mabille); ? Galdar (Collinge & Partridge); Valsequillo (Odhner). — Tenerife: Puerto Orotava (Krause; Hoffmann; Odhner); Orotava (Kraepelin; Collinge & Partridge; Odhner); Guimar (Kraepelin); no exact locality; Vaposas in the valley of Orotava (Hoffmann); Orotava-Buenavista; Agua Mansa (Odhner). — Gomera: Valle Hermoso (May, 1912).

Own material. Tenerife: park at Santa Cruz, 7 III 1947: 1; barranco near hotel Pino de Oro, Santa Cruz, 8 III 1947: 10; between Puerto Orotava and La Paz, 10 III 1947: 9; La Paz, 12 III 1947: 8; roadside near Botanical Garden of Orotava, 14 III 1947: 1; barranco Andura or Andola, S of Realejo Alto, 17 III 1947: 10; playa of El Ancon, 19 III 1947: 1; barranco near Tacoronte, 20 III 1947: 1; barranco W of Icod el Alto, 25 III 1947: 1; barranco Ruiz, W of Realejo, 1 IV 1947: 1; barranco W of Realejo, 2 IV 1947: 4; garden of hotel Taoro, Puerto Orotava, 4 IV 1947: 17; Icod de los Vinos, 5 IV 1947: 4; roadside near Guimar, 10 IV 1947: 4; garden of the University of La Laguna, 9 V 1947: 2.

Material examined belonging to other Museums. Gran Canaria: no exact locality, Ripoche leg.: 14, the syntypes of *Limax poirieri* (Paris Museum). — Tenerife: "Realijo" (recte Realejo), Verneau leg.: 4 (Paris Museum); Tacoronte, E. Appenhagen leg.: 8; environment of Orotava, 1913, C. R. Boettger leg.: 10 (Senckenberg Museum); valley of Orotava, 14 II 1895, H. G. Stehlin leg.: 19 (Basel Museum).

The species was first collected in Gran Canaria in or before 1881 by Ripoche, in Tenerife in 1877 or 1878 by doctor Verneau, and in Gomera in February 1908 by W. May.

Collinge & Partridge's record of *Limax maximus* from Gran Canaria and Tenerife, which was based on young specimens, probably refers to the present species. Mr. F. R. Parrington, director of the University Museum of Zoology at Cambridge, kindly informs me that the recorded specimens are not to be found in the Collinge collection in his Museum.

The specimens from Realejo in the Paris Museum were labelled "*Limax canariensis*, d'Orb." by Mabille.

This species was identified with *Limax (Lehmannia) marginatus* O. F. Müller, 1774 (= *arborum* Bouchard-Chantereaux, 1838) by most previous workers on Limacidae from the Canaries. A close examination of my large series of specimens, and of those in other collections, convinced me, however, that they are certainly specifically distinct. The main character by

which they can be distinguished from *L. marginatus* is the presence of long sharp cusps on the teeth of the radula, instead of the peculiar blunt cusps which are so characteristic of *L. marginatus*. Though the radula of the Canarian species varies to some extent, the figures of some teeth (fig. 1) may show that this organ is unmistakably distinct from that of *L. marginatus*.

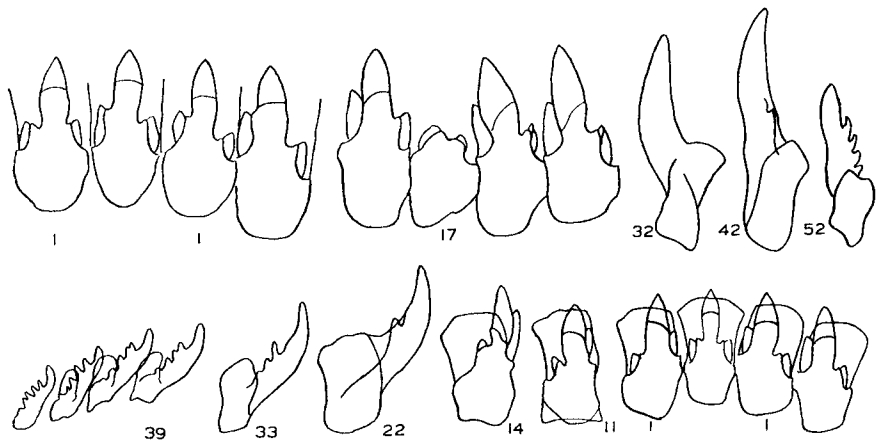

Fig. 1. Teeth of the radula of *Limax poirieri* Mabille from Tenerife. Upper row: adult specimen in which the teeth of the 17th longitudinal row are abnormal. Lower row: half grown specimen.

In my specimens I find the following formulae for the radulae of a half grown (1), and an adult (2) specimen:

(1): $\frac{27}{2\text{-}6} + \frac{15}{3} + \frac{1}{3} + \frac{15}{3} + \frac{27}{2\text{-}6} \times \pm 120$

(2): $\frac{22}{1\text{-}4} + \frac{30}{3} + \frac{1}{3} + \frac{30}{3} + \frac{22}{1\text{-}4} \times 118$

This agrees fairly well with the description of the radula of specimens from Tenerife by Krause (1895, p. 21), who found 109 longitudinal, and 112 transversal rows of teeth. He too observed that the cusps are longer and more pointed than in *L. marginatus*, and that the laterals are three cuspid.

The alimentary canal has virtually the same shape as in *L. marginatus*; a long intestinal coecum is present.

The genital organs offer other characters for distinguishing this species from *L. marginatus*. The penial appendix is not tapering to a point, but cylindrical with a blunt termination, and generally larger than in *L. marginatus* (fig. 2). When the penis is opened it appears that the papilla occurring in the penis of *L. marginatus* is lacking in *L. poirieri*. Instead of the muscular folds of the former species a sharply angled crest protrudes from the inner

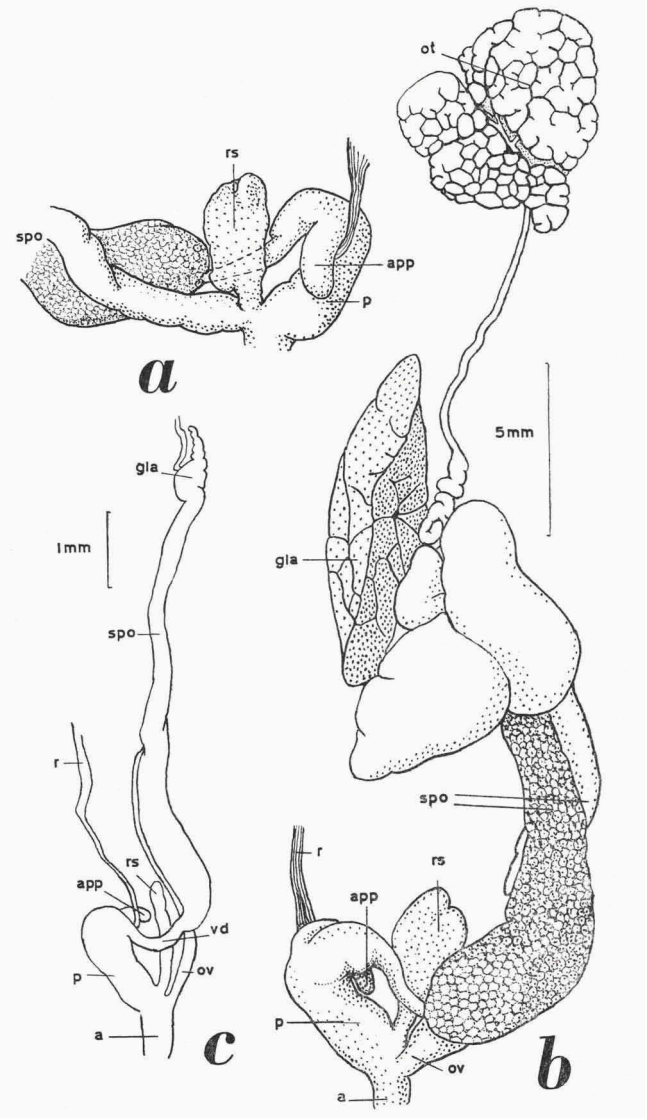

Fig. 2. Genitalia of *Limax poirieri* Mabille from Tenerife, a, b, adult specimen; c, half grown specimen. Abbreviations: a, atrium genitale; app, penial appendix; gla, glandula albuminalis; ot, ovotestis; ov, oviduct; p. penis; r, retractor penis; rs, receptaculum seminis; spo, spermoviduct; vd, vas deferens.

wall of the penis in *L. poirieri* (fig. 3). The receptaculum seminis never has the pyriform shape which we usually meet in *L. marginatus*.

Using the terms of Ridgway (1912) the colour of my specimens may be described as generally pale olive buff, passing to vinaceous buff in darker specimens. In one specimen from La Paz the mantle is sayal brown. Simroth (1891, pl. 11 fig. 5, 5a) figured two red-brown specimens from the Canaries, but I suspect this darker colour to be due to bad preservation.

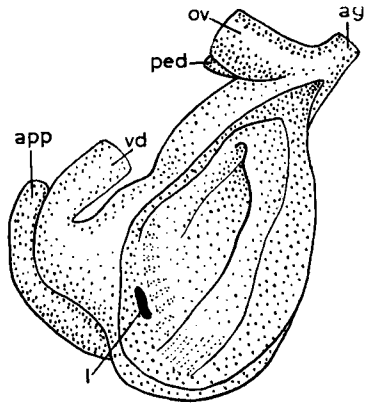

Fig. 3. Penis of *Limax poirieri* Mabille, opened. Abbreviations. l, entrance to lumen of penial appendix; ped, pedicle of the receptaculum seminis; the others as in fig. 2.

I saw some ill-preserved museum specimens in which the colour had become darker, sometimes only in places which had obviously been pinched.

There are two lateral and a medial dark longitudinal band on the mantle, and two lateral bands on the back, rather close to the medial line. Laterally from these small diffuse patches of dark pigment may occur (fig. 4). In general there is a tendency for this dark pattern to become obsolete with growing age, but sometimes the bands are already poorly developed in young or half grown specimens.

There is no doubt that this is the species described by Mabille as *Limax poirieri,* although that author did not examine the anatomy.

On account of the external characters Canarian specimens of this species have been recorded as "*L. arborum* var. *valentianus* by some authors. Although it seems very likely indeed that *L. poirieri* is a synonym of *L. valentianus* Férussac, even a careful examination of all the available evidence could not remove the doubt whether these names indicate two closely allied species or are to be considered synonyms.

The original description of *Limax valentianus* by Férussac (in Férussac & Deshayes, 1819-1851, vol. 2, p. 96ε, 1823) runs as follows:

"Rufus, flavo variegatus; clypeo dorsoque fasciis nigris duobus donatus.

Habit. Nous avons reçu cette espèce dans la liqueur, ce qui ne permet pas d'en faire la description ni la figure d'une manière bien exacte. Elle se trouve à Valence, en Espagne, dans les jardins."

This description is supplemented by a figure (Férussac, op. cit., Atlas, pl. VIII A fig. 5, 6) of an "Animal demi-contracté, vu en dessus et de coté", which shows a slug with which *L. poirieri* agrees rather well, although the latter has the longitudinal bands on the back somewhat narrower. The colour

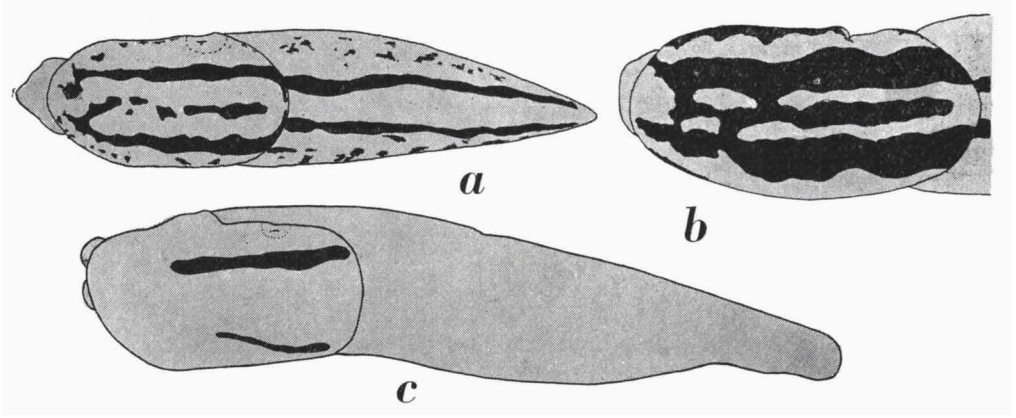

Fig. 4. Diagrams showing the variation of the pigment pattern in half-grown *Limax poirieri* Mabille from Tenerife. The pigmented areas are black in the diagrams irrespective of the varying intensity of pigmentation in the specimens. a, common form; b, variety with broad bands in the mantle; c, variety with obsolete pigment pattern.

as described by Férussac seems to be darker than in *L. poirieri,* but as set forth above, this may be due to bad preservation.

In Paris I was able to examine two specimens labelled *Limax valentianus* from Férussac's collection. They may be the types, but this cannot be proved. Their colour is light brown passing to grey on the sides. The dark longitudinal bands on the mantle and back are hardly visible and narrow. If one supposes that Férussac's figure was made after one of these two specimens, this figure shows the animal about $1^1/_3$ times enlarged, and the dark pigment must have vanished almost wholly during the specimen's stay in spirit of more than 125 years. There is nothing against these presumptions. One of these specimens was dissected and the penial appendix appeared to be rather long and recurved, cylindrical with a blunt end. Contrary to what was seen in mature specimens from Tenerife the vas deferens was swollen at its distal end, so that there is a constriction at the point where the retractor is inserted, viz., between the base of the penial appendix and the

swollen part of the vas deferens on one side, and the penis on the other. The same was seen in a specimen belonging to a second lot of two from Valencia in the Paris Museum. I nevertheless think that these specimens from Valencia are conspecific with *L. poirieri,* and that the difference noted in the genital organs is connected with the sexual development of the specimens.

Pollonera (1887a, p. [2], pl. 1 fig. 1-4; 1887b, p. [2], pl. 3 fig. 4) was the first to describe the anatomy of a slug (from Barcelona) which he thought to be *L. valentianus,* and wrongly classed with *Agriolimax* [= *Deroceras*]. The penial appendix as described and figured by Pollonera has the shape of a stalked globule, and is therefore different from that of *L. poirieri.* Simroth (1887, p. 166) on the other hand examined the anatomy of one of Pollonera's specimens and found the penial appendix to have the shape of a recurved flagellum-like projection [1]) with a blunt termination [2]). In Simroth's opinion Pollonera mistook the folded appendix for a stalked globule. Mr. Watson, however, was so kind as to send me on loan a specimen of *"Limax* cf. *valentianus"* from N. Spain showing the penial appendix distinctly swollen at its distal end. In this slug the longitudinal bands on the back are somewhat wider than in the specimens assigned to *L. poirieri.*

It may therefore be that a second, closely related species occurs in Spain, in which the longitudinal bands on the back are wider, and the penial appendix is a stalked globule. If these characters would prove to be always correlated, the specimen figured by Férussac must belong to this second species, which consequently would be the true *L. valentianus* Férussac. In that case some slight difference which Mr. Watson noted to exist between the radula of his Spanish specimen and some radulae of *L. poirieri* might prove to have the value of a specific character too. The radular teeth figured by Pollonera (1887a, pl. 1 fig. 4) from what he thought to be *L. valentianus* roughly agree with those of the two Spanish forms, but Pollonera apparently overlooked the tiny endocusps of the laterals.

The examination of more material from Spain, where the two forms must live side by side at Barcelona and Valencia, can only solve the question whether they are distinct species or not.

The distribution of *"Limax arborum"* (= *marginatus*) has been compiled by Oekland (1925, p. 67). Part of the records certainly refer to *Limax valentianus* and *Limax poirieri.* The true *Limax marginatus* apparently is essentially an inhabitant of the temperate zone. In Europe it is lacking in Southern Italy and the Iberian Peninsula. I was able to examine correctly

1) Simroth, 1887. p. 166: "einen zusammengelegten flagellumartigen Anhang".
2) Simroth, 1891, p. 280: "unverjüngt geschlossen".

identified specimens from Northern Italy belonging to the Senckenberg Museum, whereas a young specimen from Palermo going under the same name and belonging to the same collection has radular teeth with long pointed cusps, and consequently belongs to another species. The genitalia have not yet developed enough to enable an identification of this species. The records from Spain are those dealt with above, and refer to *Limax valentianus* and *L. poirieri*. Simroth(1891, p. 281) recorded specimens from Monchique (province of Algarve, Portugal) with the same shape of the penial appendix as in the specimen he examined from Barcelona; they are consequently *L. poirieri*.

From the description and figures in Pilsbry's recent monograph it appears that *L. poirieri* occurs in California and Missouri (Pilsbry, 1948, p. 530-532, fig. 285, 286). The examination of the radula of a specimen from Torbay, Newfoundland, belonging to the Carnegie Museum revealed that the records from Newfoundland (Brooks & Brooks, 1940, p. 59) refer to the true *L. marginatus*. While the pattern of distribution of *L. poirieri* in North America shows that the species was introduced, *L. marginatus* apparently is a native species in Newfoundland.

Limax poirieri was recorded (as *L. valentianus*) from greenhouses at Swansea by Quick (1949, p. 24), and Dr. A. D. J. Meeuse, that keen collector of the fauna of glasshouses, presented our Museum with a mature specimen of this species which he found in a hothouse in Belfast Botanical Gardens on November, 26, 1948. These records and those from North America show that *L. poirieri* is a species liable to be transported by man. All records of *L. marginatus* from tropical and subtropical countries should therefore be checked.

Variation. The variation in colour, pigment pattern, and other characters has sufficiently been dealt with above.

Habitat. My specimens were all found on the ground, mostly under stones, pieces of wood, etc., sometimes creeping in wet places.

Biology. The length of the 74 specimens I collected from March 7 to May 9 ranges from 6-42 mm, and the genitalia even of the larger ones are still hardly developed (fig. 2c). Odhner collected in March and April too, and reports the length of his largest specimen to be 34 mm. Krause (1895, p. 21), whose brother started collecting earlier in the season, i.e., in the beginning of February, records a mature specimen from Puerto Orotava.

The specimens collected by Stehlin in the valley of Orotava on February 14, 1895, and belonging to the Basel Museum, distinctly belong to two age classes: 15 specimens have a length of 25-35 mm, and those dissected show the genitals fully developed, whereas 4 others are young and

measure 8-13 mm. For comparison with the sizes recorded by Odhner and myself these measurements should be multiplied by some factor (which I estimate to be about 1½), because the specimens apparently had not been stretched before fixation.

As during the dry summer season the growth of these slugs probably is very slow, it may be concluded from these data that propagation in *L. poirieri* in Tenerife takes place in winter, and that the adults die after a life of little more than 12 months. The biology, therefore, provides another difference from *L. marginatus*, in which species the individuals normally live 2½-3 years.

5. **Deroceras reticulatum** (O. F. Müller)

Limax canariensis Smith, 1884, p. 276; Mabille, 1898, p. 95.
Agriolimax agrestis Heynemann, 1885, p. 291; Simroth, 1891, pl. 18 map 5; Krause, 1894, p. 31; 1895, p. 21; Collinge & Partridge, 1899, p. 38; Heynemann, 1906, p. 10, 74; Hoffmann, 1928, p. 221, 224; Fischer-Piette, 1946, p. 255.
?*Agriolimax Drymonius* Simroth, 1886, p. 319; 1891, p. 288, pl. 18 map 5; Krause, 1894, p. 32; 1895, p. 21; Simroth, 1912, p. 108.
[*Agriolimax*] *agrestis-reticulatus* Simroth, 1886, p. 319.
[*Agriolimax agrestis*] *reticulatus* Simroth, 1891, p. 282.
?*Agriolimax simrothi* Cockerell, 1893, p. 176, 202 (no. 131).
?[*Agriolimax*] *simrothi* Heynemann, 1906, p. 8, 13.
?*Agriolimax agrestis* var. *simrothi* Hoffmann, 1928, p. 223, 224.
Agriolimax reticulatus Odhner, 1932, p. 69.

Previous records. Gran Canaria: San Pedro in the valley of Agaete; barranco de la Angostura; Las Lagunetas (Odhner). — Tenerife: no exact locality (Simroth; Hoffmann); Agua Mansa (Heynemann; Odhner); Puerto Orotava (Krause); Santa Cruz (Collinge & Patridge); Orotava (Collinge & Partridge; Odhner); La Laguna; Vilaflor (Hoffmann).

Own material. Tenerife: roadside near Botanical Garden of Orotava, 12 III 1947: 11 (among which a specimen of the var. *nigra* (Morelet, 1845)); Santa Catilina above Orotava, 13 III 1947: 3; Botanical Garden of Orotava, 14 III 1947: 1; Agua Garcia, 15 III 1947: 1: barranco W of the village of Puerto Orotava, 16 III 1947: 11; barranco Andura or Andola, S of Realejo, 17 III 1947: 7; barranco near Tacoronte, 20 III 1947: 2; barranco Ruiz, W of Realejo, 1 IV 1947: 4; barranco W of Realejo, 2 IV 1947: 2; University garden at La Laguna, 9 V 1947: 2 + ? 1.

Material examined belonging to other Museums. Tenerife: no exact locality, [II 1873], Challenger collection: 2 (British Museum); Las Mercedes, Buchet leg.: 6 (Paris Museum); Tacoronte, E. Appenhagen leg.: several; Orotava, Koch collection: 2 + ? 1, the type of *Agriolimax simrothi* Cockerell; Orotava, XI 1913, C. R. Boettger leg.: 5; Agua Mansa, 1871, Grenacher & Noll leg.: many (Senckenberg Museum).

The species was collected for the first time in Gran Canaria by Odhner, III-IV 1930; in Tenerife by Noll & Grenacher in 1871.

All my own specimens were dissected, and no *D. agreste* (Linnaeus, 1758) proved to occur among them. In all my specimens the penial stimulator is normally developed, even in the young ones it could always be found. One specimen from the University garden of La Laguna is referred with doubt to this species. Its colour is lighter than of all the other specimens, and the genitalia are wholly abnormal. I found a poorly developed ovotestis in front of the intestinal coecum. The only trace of a copulatory organ is a small conical papilla at the inner side of the genital pore. No spermoviduct could be traced. As one expects the genitalia of any *Deroceras* of that size (19 mm) to be more developed, I consider it to be a pathological specimen.

"*Agriolimax Drymonius*" (= *simrothi*) was established on a specimen without penial stimulator, but agreeing in all other essential details with the present species. A second specimen was recorded by Krause. I had an opportunity of examining the type, but its preservation appeared to be too bad to allow of a reexamination of the anatomy. If we follow Hoffmann and Odhner, and consider it an abnormal *Deroceras reticulatum,* it remains unexplained why twice such an abnormal specimen was found in Tenerife. As far as I know specimens with this deficiency were never recorded from other localities.

Variation. Light specimens of a pale buff colour occur side by side with specimens in which the dark reticulate pattern is well developed. One specimen from a roadside near the Botanical Garden of Orotava has the mantle, back and sides black without any trace of the reticulate pattern left. The black colour is in strong contrast with the white foot sole in this specimen, and at first sight I thought I had found a young *Limax maximus* Linnaeus var. *nigra* Dumont & Mortillet. Dissection, however, showed its identity with *Deroceras reticulatum* var. *nigra* (Morelet). An almost equally dark specimen was found in the sample from Tacoronte in the Senckenberg Museum.

Habitat. The species was found in humid places, near wells and irrigation gutters, or under stones in drier places. It ascends to 1200 m in Gran Canaria (Las Lagunetas), and to 1400 m in Tenerife (Vilaflor).

Biology. Young specimens of various sizes were found together with the adults. So it appears that reproduction of this species in the Canaries is not bound to a special season. This agrees with what is known about its reproduction elsewhere. It cannot be deduced from the data at hand whether reproduction is interrupted during the dry summer season or not.

6. **Deroceras laeve** (O. F. Müller, 1774)

Agriolimax laevis May, 1912, p. 232; Simroth, 1912, p. 97, 98, 107; Hoffmann, 1928, p. 224; Fischer-Piette, 1946, p. 255.
Deroceras laeve Boettger, 1932, p. 254.

Previous records. Canary Islands: everywhere (Boettger). — Gomera: valle Hermigua; above Agulo; valle Gran Rey (May).

Own material. Tenerife: above Arafo, 13 IV 1947: 1.

This species was first collected in Gomera by W. May in December 1907, in Tenerife by the author in April 1947.

Even if we admit that Boettger must have meant "wherever suitable conditions are found", his observation that this species occurs "everywhere" in the Canary Islands is not in accordance with the experience of other collectors. Unfortunately most of his material was lost during the war (Boettger in lit.), and no *D. laeve* were among his Canarian slugs in the Senckenberg Museum. It seems possible that in La Palma *Deroceras* cf. *caruanae*, and in Gran Canaria and Tenerife perhaps even young *D. reticulatum* were mistaken for this species.

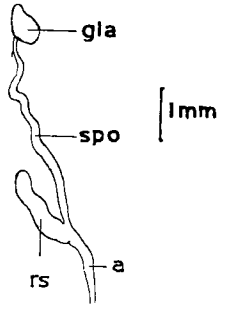

Fig. 5. Anterior part of the genitalia of *Deroceras laeve* (O. F. Müll.) from Arafo, Tenerife. Abbreviations as in fig. 2.

The specimens recorded by May and Simroth are middle and small sized, and aphallic. The same is the case is in my specimen, which has a length of 12 mm (cf. fig. 5).

Variation. The colour of May's specimens was mouse-grey to black, that of mine is light buff (Ridgway, 1912), with the back somewhat, the mantle conspicuously darker by diffuse black pigment. There is no evidence of other than aphallic specimens occurring in the Canaries.

Habitat. The specimens recorded from Gomera were collected in humid places (bank of a rivulet, edge of a gutter). The specimen from Arafo was found at the edge of an irrigation gutter. In Gomera *D. laeve* ascends to about 400 m, the locality in Tenerife is at about 600 m.

Biology. W. May collected his specimens from December to February;

among some 160 specimens there were no adults. My specimen of April is also not adult. As the dry summer is an unfavourable season for slugs, it seems most likely that reproduction of *D. laeve* occurs in autumn in the Canaries.

7. **Deroceras** cf. **caruanae** (Pollonera, 1891)

There are no previous records of this species in the Canary Islands.

Own material. La Palma: Barranco Dolores between Santa Cruz and the carretera, 21 IV 1947: 7; between La Galga and El Cubo, 23 IV 1947: 1; Los Tilos, 24 IV 1947: 3; in the laurel woods of the barranco Aduares, 25 IV 1947: 7.

The above mentioned specimens differ from the original description and figure of this species by Pollonera (1891, p. 3, fig. 2) in the following respects: (1) they are smaller, viz., up to 20 mm; (2) the colour is pinkish to yellowish buff, more or less darkened on the mantle and back by diffuse black spots, but without any trace of a black keel; (3) the receptaculum seminis has a narrow oblong shape.

I was struck by the conformity of the genitalia of my specimens with those figured by Pilsbry (1948, fig. 298) from American specimens identified as *D. caruanae*. As it appears from Pilsbry's text that Mr. Hugh Watson examined specimens of this American slug as well as British specimens which are certainly conspecific, I sent some of my specimens to Mr. Watson for examination. In his opinion the slugs from La Palma certainly belong to the same species as those from SW England and California. Mr. Watson was so kind as to present some specimens of this species collected in Cornwall and Devon to our Museum, and after a careful examination of these I am convinced that Mr. Watson's identification is right.

The English specimens are but a trifle larger than those from La Palma. Their skin is somewhat less pigmented, but they give the impression of being darker, as darkly pigmented connective tissue shines through the skin. This subcutaneous connective tissue is of a lighter hue in my Canarian slugs, but that is the only difference worth mentioning I can find. According to Pilsbry (1948, p. 559) the same difference is found between Californian and English specimens, and his presumption that it is due to climatic influences is corroborated by this new find of specimens with lighter connective tissue in a warmer climate.

Pilsbry (1948, p. 560) pointed out that a comparison with specimens from the type locality of Pollonera's species, the island of Malta, is necessary to be sure of the identification.

Variation. As has been stated above, my specimens vary as to the amount of diffuse dark pigment found in the mantle and back.

Habitat. *Deroceras* cf. *carunae* was found in humid places in some barranco's at the E coast of La Palma.

Biology. My specimens have a length of 10-20 mm, but from field notes it appears that between La Galga and El Cubo I met also with specimens smaller than 10 mm which I did not collect. The larger specimens show the genitalia fully developed, and the receptaculum contains a mass of sperm in some of them. From these data is appears that propagation of the species in La Palma is not restricted to one season, and can take place in spring. From the data at hand it cannot be concluded whether Canarian *Deroceras* cf. *caruanae* reach the size of 28-32 mm given by Pilsbry (1948, p. 557) for Californian specimens, or not.

BIOGEOGRAPHICAL NOTES ON THE LIMACIDAE OF THE CANARY ISLANDS

1. Table showing the distribution of Limacidae in the Canary Islands.
2. The distribution of Limacidae in Tenerife.

Of all the Canary Islands Tenerife presents the greatest diversity as to the environment of animal life. This diversity is due to the central position

species \ island	Lanzarote	Fuerte-ventura	Gran Canaria	Tenerife	Gomera	La Palma	Hierro
Parmacella sp.	+	+	+	—	—	—	—
Milax gagates	—	—	+	+	+	+	—
Limax flavus	—	+	+	+	—	—	—
Limax poirieri	—	—	+	+	+	—	—
Deroceras reticulatum	—	—	+	+	—	—	—
Deroceras laeve	—	—	—	+	+	—	—
Deroceras cf. *caruanae*	—	—	—	—	—	+	—

of the island in the archipelago, and to the great height of the Pico de Teyde and surrounding mountains. It most clearly appears from the different types of vegetation, which have been studied by botanists since Humboldt visited the island in June 1799 (cf. Humboldt, 1814). The most exact and elaborate description of the distribution of vegetation over the island has been given by Salter (1918). A rough impression of this distribution is provided by

a sketch map published by Knoche (1923, p. 112), which map is here reproduced with some slight modifications (fig. 6).

It should be borne in mind that in this map the actual situation is highly simplified, as the zones indicated may be subdivided, and much overlapping of the different kinds of vegetation occurs. Some of the names of zones have been used in a more restricted sense by other authors.

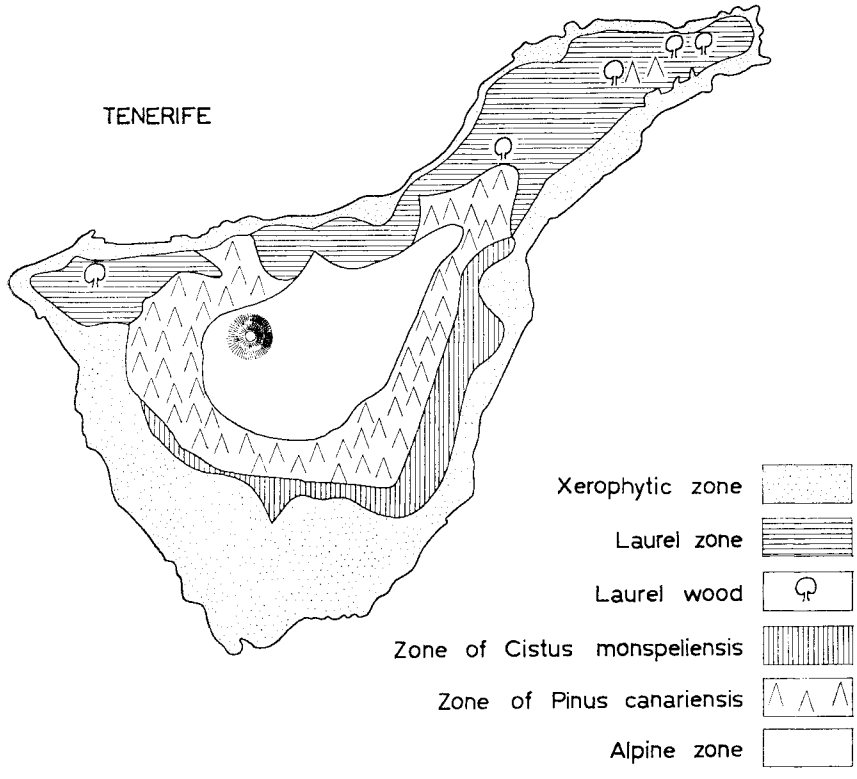

Fig. 6. The distribution of vegetation in Tenerife after Knoche (1923, map on p. 112, slightly modified).

In the first zone distinguished by Knoche the vegetation is of a xerophytic type. It is best developed in the S part of the island, which is situated in the rain shadow of the Pico and surrounding mountains, and consequently is very dry. Here the landscape is desert-like. In a narrow strip along the N and SE coasts the vegetation shows a similar habitus, which on the N coast, however, seems to be due to the wind being very salt rather than to drought.

The second, or laurel zone is for the greater part occupied by various

plantations, viz., of bananas, vine, tomatoes and oranges, and higher up in the mountains of wheat, potatoes and vegetables. Some remains of the laurel woods which originally must have covered an important part of this zone, are indicated in the map. With the next, or pine wood zone this zone contains the most humid parts of the island. Here the humidity supplied by the NE trade wind condenses on the vegetation, is subsequently absorbed by the soil, and where it meets with impermeable layers, eventually appears at the surface again in wells. Most of the water supplied by these wells is used by man for irrigation, but it may be assumed that the now irrigated lower parts of the island originally derived profit from this water in an unorganised and consequently more irregular way.

In the intermediate heights of the S side of the island clouds are formed during day time by a sea breeze which is the result of the local action of the sun (cf. Brown, 1927, p. e31). These clouds are considerably smaller in extent than those caused by the trade wind in the N part of island. Therefore the laurel zone is here replaced by a zone with a vegetation adapted to less humidity. Here the wild flora is characterised by *Cistus monspeliensis*, but at present this zone also is for the greater part occupied by plantations.

In the lower parts of the pine wood zone the vegetation is characterised by *Erica arborea*, in the upper part by woods of *Pinus canariensis*, which however, have considerably decreased in the last centuries. Above the upper limit of the pine wood zone, i.e., above about 2000 m, we find eventually a very dry climate with a great daily variation of temperature. In this alpine zone the vegetation is poor in species and dominated by some shrubby Leguminosae.

The recorded distribution of Limacidae in Tenerife is shown in fig. 7. The following is a list of the localities. When no height is indicated this is 200 m or less.

1. Buenavista; 2. Icod de los Vinos; 3. barranco Ruiz; barranco W of Realejo; barranco de Castro; 4. Icod el Alto, ± 500 m; 5. barranco S of Realejo Alto, ± 350 m; 6. Puerto Orotava; La Paz; 7. El Ancon; 8. botanical garden of Orotava, and surroundings; 9. Orotava, ± 350 m; 10. Santa Catilina, ± 450 m; 11. Agua Mansa, ± 1200 m; 12. Tacoronte, ± 500 m; barranco near Tacoronte, ± 400 m; 13. Agua Garcia, ± 700 m; 14. La Laguna, ± 550 m; 15. Las Mercedes, ± 650 m; 16. La Laguna-Bufadero, height ?; 17. Santa Cruz; 18. above Arafo, ± 600 m; 19. Guimar, ± 300 m; 20. Vilaflor, ± 1400 m; 21. Los Cristianos; 22. between Guimar and Socorro.

Some recorded localities could not be indicated on the map: S side of the island (*Limax flavus*), between Orotava and Buenavista (*Limax poirieri*),

Erica region above Santa Cruz (*Milax gagates*), because they are too vaguely described. Vaposas in the valley of Orotava (*Limax poirieri*) could not be found on the maps at my disposal.

The greater part of the localities in which Limacidae have been found in Tenerife are situated in the areas which are most frequently visited by col-

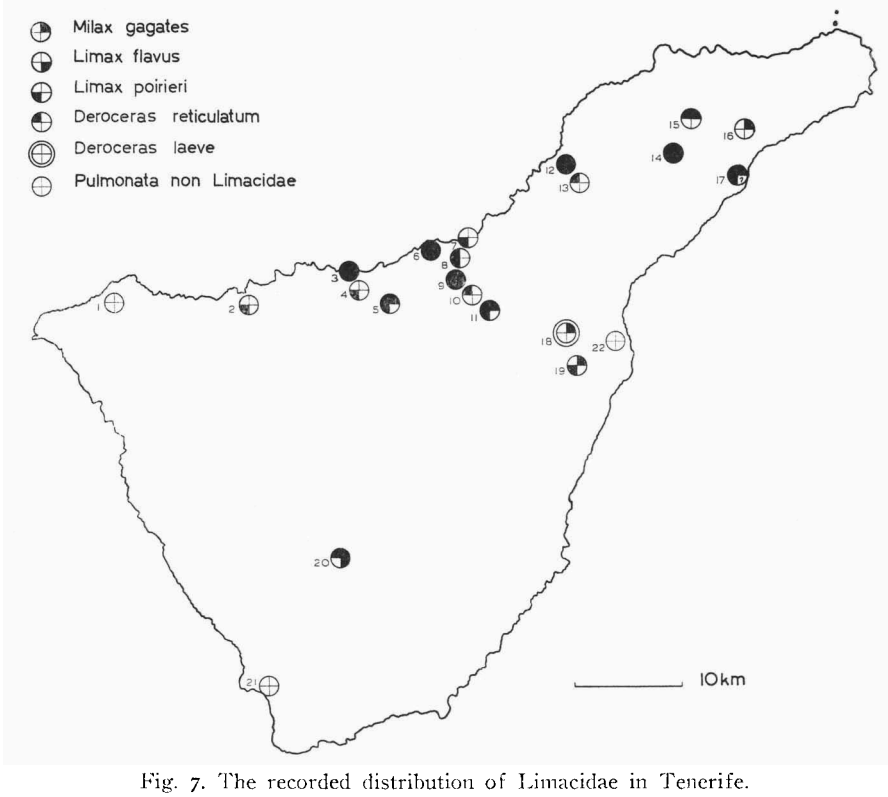

Fig. 7. The recorded distribution of Limacidae in Tenerife.

lectors, viz., the surroundings of Santa Cruz, Guimar, La Laguna, and the valley of Orotava. Therefore it may be asked if the map does not show the distribution of collectors rather than that of Limacidae. Although I am sure that many localities in which limacids occur could be added to this map, I think that nevertheless an approach to a correlation of the distribution of Limacidae with that of vegetation can be made. As exact data about the vegetation in each of the localities are lacking, this correlation cannot be more than a rough one. Therefore the comparison is not made with Salter's more detailed and exact description of the phytogeography of the island. Naturally the notion arrived at in this way should be checked by further investigations.

In the first place it appears that limacids are lacking in two large areas, viz., in the desert area of the xerophytic zone in the S part of the island, and in the alpine zone.

In the desert area I collected during three days in the neighbourhood of Los Cristianos and found three species of Pulmonata, but no Limacidae. The area devoid of limacids in the S of the island is most likely to be crescent-shaped. To the NW it would seem to include even the surroundings of Buenavista, where both Odhner and I collected land Mollusca without meeting with limacids. To the NE at least the region between Guimar and Socorro, where I had the same experience, might belong to it.

The alpine zone was certainly visited by most collectors of mollusca in Tenerife, as the landscape inside the large caldeira ranks among the most interesting of the island. As far as I could ascertain, however, no mollusk was ever recorded from this zone.

Limax poirieri is the only species which I collected in some localities doubtlessly to be assigned to the xerophytic zone. Near El Ancon I found a specimen under stones quite near the beach, among a halophytic vegetation. In the immediate neighbourhood little stalactites of salt hanging from the roof of a small cave exposed to the sea wind showed how resistant this species must be to the influence of a salt atmosphere. At La Paz the same species occurs under stones on a slope where the well known *Euphorbia canariensis* grows; this locality is also directly exposed to the sea wind. Other habitats of Limacidae near Puerto Orotava probably do not belong to the xerophytic zone, nor is that the case with the localities in which I collected Limacidae at Santa Cruz.

Most of the localities from which Limacidae have been recorded are situated in the laurel zone on the N coast, and in the zone of *Cistus monspeliensis* on the SE coast. *Milax gagates*, *Limax poirieri*, and *Deroceras reticulatum* are common and seem to be spread all over these two regions, whereas *Limax flavus* occurs more locally. As far as can be deduced from the indications of the localities the latter species occurs mostly close to human habitations, in gardens, etc. The indication "barranco de Castro", however, would seem to refer to a true "wild" locality. *Deroceras laeve* is only known to occur at Arafo. As the laurel zone on the N coast seems to present the most adequate biotopes for this species, and no records from the island previous to 1947 exist, I consider *Deroceras laeve* to be recently introduced into Tenerife.

In the valley of Orotava the highest locality from which Limacidae are recorded is Agua Mansa, at 1200 m, still in the laurel wood zone. Apparently they only exceptionally enter the zone of the pine woods: *Milax gagates*

is recorded from the *Erica* region above Santa Cruz and from Vilaflor; *Limax flavus* and *Deroceras reticulatum* have also been found in the latter locality. Though I visited the pine wood zone in several places I never met with any limacids there myself.

Summarizing we can state that in Tenerife the laurel wood zone and the zone of *Cistus monspeliensis* present the most congenial conditions to Limacidae in general. *Limax poirieri* only enters the halophytic part of the xerophytic zone, and therefore seems to be the species most resistant to salt winds. *Milax gagates, Limax flavus,* and *Deroceras reticulatum* are the species spread to the greatest height; they locally enter the pine wood zone. Records of limacids from the two driest areas, viz., the desert area in the S, and the alpine zone, are lacking.

3. The distribution of Limacidae in the other Canary Islands.

As the distribution of Limacidae in the other islands has not yet been so closely investigated, and as I do not know these islands so well (Gran Canaria, La Palma), or not at all by personal experience, I must desist from a detailed discussion of this distribution. Some remarks only will be made.

The great difference between the limacid fauna of the eastern islands on one hand and the central and western ones on the other can satisfactorily be explained by the difference in ecological conditions between these groups. The eastern islands, Lanzarote and Fuerteventura, have a dry climate, and the landscape therefore is similar to that of the xerophytic zone of Tenerife. In the central and western islands, however, the climate grows more and more humid from E to W, especially in those parts of the islands which are exposed to the NE trade wind.

Almost all the Limacidae recorded from the eastern islands belong to the genus *Parmacella,* which has its main distribution in the deserts and semi-deserts of the Mediterranean region. The only other record (*Limax flavus*) is from the culture zone near Betancuria, Fuerteventura, where conditions may be improved through irrigation.

As far as could be ascertained [1]) the four species of Limacidae which Gran Canaria has in common with Tenerife all occur in those parts of the island which are exposed to the NE. Most of the localities seem to belong to the laurel wood zone (cf. Knoche, 1923, map on p. 185). *Parmacella* sp. is recorded from "Lomo del Capon" in this island, a locality which I have been unable to find on the maps at my disposal. It would fit well

1) As the locality "Las Palmas" for *Limax flavus* is dubious, no exact locality for this species in Gran Canaria is known.

into the notion arrived at in this paper, if this locality eventually should appear to belong to the extensive desert area on the S side of the island.

In Gomera most records of Limacidae are from the NE exposed parts of the island too. The valle Gran Rey at the W coast, where *Deroceras laeve* was found near the sea, is an exception not to be explained without an exact knowledge of the habitat. Just as in Tenerife the southern part of the island is covered by a desert area, from which no limacids have been recorded. It is remarkable that even the genus *Parmacella* seems to be lacking in the desert areas of these two islands.

Apart from the record of *Milax gagates* from Argual, the records of Limacidae from La Palma are from the barrancos of the E coast, which are situated in the laurel wood zone (cf. Knoche, 1923, map on p. 120). The part of the island exposed to the N, however, is unexplored as to the molluscan fauna. At the locality Argual, near the W coast at a height of about 300 m, the landscape is probably similar to that near Guimar in Tenerife. Though a xerophytic vegetation occurs locally, no true desert area can be distinguished in La Palma.

From the island of Hierro no Limacidae have been recorded.

4. Historical biogeography of the Limacidae of the Canary Islands.

The most fascinating problem presented by the fauna of the Canary Islands is its history. An explanation of the occurrence of the great number of endemic genera, species, and subspecies, and their affinity with members of the fauna of sometimes far remote parts of the world, has been sought by several authors.

It will be clear that the historical biogeography of the forms of *Parmacella* occurring in the archipelago cannot be discussed as long as no modern revision of these forms has established their identity and relations. Therefore *Milax gagates, Limax flavus, L. poirieri, Deroceras reticulatum, D. laeve,* and *D.* cf. *caruanae* only will concern us here. These species all occur elsewhere also, and, therefore, we must first try and answer the question whether they are native species in the Canaries or not.

Simroth (1912, p. 106, 108) was of opinion that the occurrence of *"Limax arborum"* and *"Agriolimax laevis"* in the Canaries is to be explained by his pendulation theory. Hoffmann (1929, p. 224) on the other hand thought that *"Agriolimax agrestis, A. laevis, Limax flavus* und *Milax gagates"* may be introduced species, whereas *"Lehmannia marginata"* only would be native and would have reached the archipelago over some land bridge.

In general the following arguments can be adduced for considering a species to be native in some area:

(1) the species occurs as a fossil in that area,

(2) it is represented by a subspecies restricted to that area,

(3) it was already found to be present by the first collectors,

(4) its pattern of distribution in the area is such as could be expected of a native species.

On the other hand (5) the fact that a species has been certainly introduced into parts of the world far remote from its original area of distribution points to its liability to transport by man, and should make us cautious in considering it a native species.

Ad (1). There are no records of fossil Limacidae from the Canaries.

Ad (2). Although several species of Limacidae have been described from the central and western Canary Islands, a thorough revision of the literature shows that there is insufficient evidence to consider them good species or even subspecies, and consequently they have all been treated as synonyms in the systematic part of this paper. It must be borne in mind, however, that the Canarian material of *Limax poirieri* and *Deroceras* cf. *caruanae* could be compared with only a very scanty material from other localities. It is, therefore, impossible to prove that the Canarian specimens of these two species do not belong to separate subspecies, but no indications of geographic variation were found.

The specimens of *Deroceras laeve* may belong to a form which is aphallic throughout life and propagates by means of selffertilisation only. Boettger (1932) showed how this "mutant", which he called *D. laeve sandwichiense* (Eydoux & Souleyet), has enabled the species to spread over islands and large parts of continents into which it had been introduced by man. As none of the specimens examined from the Canaries is adult, there is no proof that they do not ever develop male copulatory organs. In a form which propagates by selffertilisation introduced colonies will generally be the offspring of one individual and are likely to consist of uniform specimens. The fact that the only specimen of *D. laeve* from Tenerife is of a light buff colour, whereas the specimens from all the localities in Gomera are mouse-grey to black, may be an indication that they are of different stock.

Ad (3). I made a thorough study of the chronology of the visits of collectors of Limacidae to each of the islands, and of the first records of the species from each island. Mainly for this purpose the list of collectors appended to this paper was drawn up. In many cases it appeared that even common species were not collected by the first collector visiting an island. After all it seems, however, too hazardous to draw any conclusion about the introduction of species on such evidence.

This can be shown by an example. Wollaston and Lowe collected mollusca

in all the islands of the group, and Wollaston (1878, p. 308-313) records some Limacidae from his travels, but none from Gomera and La Palma. It would, however, be wrong to assert that consequently no Limacidae occurred in these two islands before about 1860, for Wollaston did not record any limacid from Tenerife, in which island certainly more than one species occurred already in 1797 [1]).

Ad (4). Though the distribution of the 6 species in the archipelago is not yet known in detail, it is worth while to consider what is known up to now for every species in turn.

Milax gagates occurs in Gran Canaria, Tenerife, Gomera, and La Palma. In Tenerife it is widely spread, and the records from Gran Canaria and Gomera do not give the impression that the species occurs so locally that it must have been recently introduced. In La Palma, however, it seems to be lacking in a great part of the laurel wood zone in which it is likely to find adequate conditions. The two localities from which it has been recorded are the main port Santa Cruz, and Argual situated close to Tazacorte, the second port of the island. Probably *Milax gagates* has been introduced rather recently into the island.

Limax flavus appears to occur in very few localities in Fuerteventura and Gran Canaria, and rather locally in Tenerife. As far as can be judged it occurs mainly in or near human settlements. I do not think there can exist any doubt about this species having been introduced into the Canaries.

There is no reason to consider *Limax poirieri* a recently introduced species in Gran Canaria and Tenerife on account of its distribution, because in both islands it is widely spread. It is remarkable, however, that in Gomera but one specimen was found by May, although a great part of that island would seem to present suitable habitats. The unique locality in Gomera, Valle Hermoso, is situated near a little port. It seems likely, therefore, that *L. poirieri* is an introduced species in Gomera.

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1) The first who met with Limacidae in Tenerife were Ledru c.s. in 1796-1797. Ledru (1810, p. 186) states the following: "Limaces. Les mêmes qu'en Europe. Les plus communs sont la noire, la rouge, la cendrée et l'agreste. On trouve ces limaces dans les vignes, les jardins et dans la plaine de la Laguna." On account of this statement Férussac (in Férussac & Deshayes, 1819-1851, vol. 2, p. 63, 96δ, 96ε (1823)) records *"Arion empiricorum"*, *"Limax antiquorum"*, and *"Limax agrestis"* from Tenerife. It seems, however, impossible to know which species Ledru exactly meant, and it certainly would be too bold to infer that he was the first to observe *Milax gagates, Limax flavus, Limax valentianus,* and *Deroceras reticulatum* in Tenerife. We may only safely conclude from the paragraph cited above that as early as 1797 more than one species of limacids occurred in Tenerife. As the Spaniards had already conquered the island in the 15th century, and have introduced various plants ever since, this evidence does not oppose the possible view that the Limacidae of Tenerife are introduced by man.

No indications for considering *Deroceras reticulatum* an introduced species are given by the pattern of distribution of this species in Gran Canaria and Tenerife, the only islands of the archipelago from which it has been recorded.

It was already set forth above (p. 25) that the occurrence of *Deroceras laeve* in one locality only in Tenerife suggests a recent introduction of the species into this island. In Gomera on the contrary it is widely spread.

Deroceras cf. *caruanae* occurs in several barranco's on the W coast of La Palma. It would be very interesting to know whether it also lives in the barranco's on the N coast which probably would present similar habitats to the species.

The patterns of distribution provide arguments in favour of the view that *Milax gagates* is an introduced species in La Palma, *Limax flavus* in the three islands from which it has been recorded, *Limax poirieri* in Gomera, and *Deroceras laeve* in Tenerife. A possible assumption of the six species under consideration having been introduced into all the islands is, however, not invalidated by the fact that several of them have a wide distribution in one or more of the islands. The possibility of introduction by man has existed already for centuries, and at present human traffic in some of the islands is so intense that probably an introduced species can be spread all over the island in some decades.

Ad (5). Pilsbry (1948, p. 521 seq.) recently revised the N American Limacidae, and concluded that *Milax gagates, Limax flavus, "Limax marginatus"* (which I have shown to include *L. poirieri* on p. 16), *Deroceras reticulatum,* and *D.* cf. *caruanae* are introduced species in N America. *Milax gagates, Limax flavus,* and *Deroceras reticulatum* are moreover recorded as introduced species from several other extra-european localities. Although *Deroceras laeve* is native in N America, its occurrence in many tropical and subtropical countries is considered to be due to introduction by man. All the six species here dealt with are consequently liable to transport by man.

Of such species it is difficult to say what area they exactly occupied before their distribution began to be influenced by man. The original area of *Milax gagates* probably is a part of the Mediterranean region, while *Limax flavus* is thought to be native in the eastern part of that region. *Deroceras reticulatum* seems to be native in the temperate zone of Europe. The original area of distribution of *Limax poirieri* most probably includes the S coast of the Iberian peninsula. Though there are no records yet from Europe beyond this peninsula, it may be found to be distributed farther Eastward in the Mediterranean region. The data about the distribution of *Deroceras caruanae* are very scarce. The species was originally described from Malta.

D. cf. *caruanae* occurs in SW England, where it might even be a native species (Quick, 1949, p. 29).

The above considerations lead to the following conclusion: There is no evidence of any of the 6 species of Limacidae discussed being a native species in the Canary Islands. On the other hand the assumption that they were imported by man is corroborated by many facts, and would provide a satisfactory explanation of their occurrence. A better knowledge of the distribution of *Limax poirieri* and *Deroceras caruanae* is required to substantiate the supposition that they are introduced from Europe into the Canary Islands rather than otherwise.

ALPHABETICAL LIST OF THE PERSONS WHO COLLECTED OR OBSERVED LIMACIDAE IN THE CANARY ISLANDS

ANONYMUS 1. Tenerife, before 1887. Specimens described by Simroth (1886, p. 319) via Koch collection in the Senckenberg Museum, Frankfurt a. M.

ANONYMUS 2. Canary Islands, before 1889. Specimens described by Simroth (1891, p. 280) in the Senckenberg Museum, Frankfurt a. M. [1]).

ANONYMUS 3. Tenerife, before 1894. Specimen in Natural History Museum, Vienna, mentioned by Simroth in lit. (cf. Krause, 1894, p. 31).

E. APPENHAGEN. Tenerife: Tacoronte, before 1928. Specimens recorded without exact locality by Hoffmann (1928, p. 221), labelled "Tacoronte" in the Senckenberg Museum, Frankfurt a. M.

SABIN BERTHELOT. Canary Islands, 1820-VIII 1830, the last two years with Ph. B. Webb. See: PHILIP BARKER WEBB.

Dr. C. R. BOETTGER. Tenerife: several localities, 1913; Fuerteventura: Betancuria, VI 1913; La Palma: Argual, VII 1913. Material dealt with in this paper in the Senckenberg Museum, Frankfurt a. M.

Mr. BUCHET. Tenerife: Las Mercedes, before 1890. Material dealt with by Mabille (1898, p. 95) in the Muséum National d'Histoire Naturelle, Paris.

Naturalists of the Challenger Expedition. Tenerife, II 1873 (cf. Spry, 1884, p. 316). Material reported upon by Smith (1884, p. 276) in the British Museum (Natural History), London.

Dr. VON FRITSCH. Lanzarote, Fuerteventura, 1862 (cf. Mousson, 1872, p. 3). Material dealt with by Mousson (1872, p. 8-10). See also: Mr. REISS.

Dr. H. GRENACHER. Tenerife: Orotava, and Agua Mansa, 30 VIII-9 X 1871 (cf. Noll, 1872), with Dr. F. C. Noll. Specimens recorded by Heynemann (1885, p. 290, 291) partly via Koch collection in the Senckenberg Museum, Frankfurt a. M.

AUREL KRAUSE. Tenerife: several localities, II-medio IV 1893. Specimens described by Arthur Krause (1894; 1895, p. 21-22). Material in the Berlin Zoological Museum.

E. & K. KRAEPELIN. Tenerife: Orotava, and Guimar, III-IV 1894. Material identified by Prof. A. Krause of Berlin recorded by K. Kraepelin (1895, p. 9).

A. P. LEDRU c.s. Tenerife, 6 XI 1796-15 III 1797. Observations published by Ledru (1810, p. 186).

R. TH. LOWE, see: T. VERNON WOLLASTON.

Prof. W. MAY. Gomera: several localities, XI 1907-III 1908. Material reported upon by May (1912, p. 232), and Simroth (1912).

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1) These specimens were not among the samples from that Museum that I examined.

Dr. F. C. NOLL, see: Dr. H. GRENACHER.

Dr. NILS HJ. ODHNER. Gran Canaria: several localities, 18 III-2 IV 1930; Tenerife: several localities, 7 IV-20 IV 1930. Material reported upon by Odhner (1932, p. 69-70) in Naturhistoriska Riksmuseum, Stockholm.

A. D'ORBIGNY. Tenerife: Santa Cruz, during a six days stay in 1826 (cf. d'Orbigny, 1836-1842, p. 6 (1839)). Material described by d'Orbigny (o. c., p. 47-48).

G. S. PARRY. Tenerife: Santa Cruz, before 1896; Tenerife: Orotava, Santa Cruz, and Gran Canaria: Galdar, before 1896; Tenerife. Orotava, before 1900. The material was dealt with by Collinge (1894, 1895), and Collinge & Partridge (1899).

J. R. C. QUOY & J. P. GAIMARD. Tenerife, 14 VI-21 VI 1826 (cf. Dumont d'Urville, 1830, p. 27-51). Material dealt with by Mabille (1883, p. 51) in the Muséum National d'Histoire Naturelle, Paris.

Mr. REISS and Dr. VON FRITSCH. Gran Canaria, 1862. Material dealt with in this paper, via Koch collection in the Senckenberg Museum, Frankfurt a. M.

Mr. RIPOCHE. Gran Canaria, before 1882. Material described by Mabille (1883, p. 52; 1884, p. 214) in the Muséum National d'Histoire Naturelle, Paris.

ELIAS SANTOS ABREU. La Palma: Santa Cruz, before 1929. Specimens described by Torres Mínguez (1928b).

Dr. H. G. STEHLIN. Tenerife: several localities, 1895. Specimens recorded by Hoffmann (1928, p. 221) in Naturhistorisches Museum, Basel.

Dr. VERNEAU. Tenerife: several localities, 1877-1878. Material described by J. Mabille (1883, p. 51; 1884, p. 215) in Muséum National d'Histoire Naturelle, Paris.

PHILIP BARKER WEBB. Canary Islands, IX 1828-VIII 1830, with S. BERTHELOT (cf. Stearn, 1937, p. 61). Material reported upon by Webb & Berthelot (1833, p. 308-311), and d'Orbigny (1836-1842, p. 47-51 (1839)).

T. VERNON WOLLASTON. Lanzarote, Fuerteventura, and Gran Canaria, I-VII 1858, and II-VII 1859, with R. TH. LOWE. Material reported upon by Mousson (1872, p. 6-9), and Wollaston (1878, p. 308-313).

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