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New data on slugs and semi-slugs from Cyrenaica (north-eastern Libya) (Parmacellidae, Limacidae, Agriolimacidae, Veronicellidae)

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ABSTRACT The following work provides an original contribution to the knowledge of Libya's slugs (Parmacellidae, Limacidae, Agriolimacidae, Veronicellidae). It is based on the morphological and anatomical investigations of some populations of slugs collected in Cyrenaica. An analysis of the existing bibliography on this topic is carried out and geonemic and biological data on the studied slugs are provided. We report for the first time *Eleutherocaulis striatus* (Simroth, 1896) (Veronicellidae) from North Africa, and *Ambigolimax valentianus* (A. Ferussac, 1822) (Limacidae) from Libya.

KEY WORDS Slugs; semi-slugs; North Africa; morphology; distribution.

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INTRODUCTION

In recent decades, also due to long periods of war and political instability, there have not been many studies on the Libyan malacofauna and, especially, on slugs.

Two native slugs are known from Libya, *Deroceras barceum* (Gambetta, 1924) and *Parmacella festae* Gambetta, 1924, the first is an endemic species to northern Cyrenaica (Altena, 1962; Wiktor, 2000) and the second to northern Cyrenaica and northern Egypt (Gambetta, 1925; Wiktor, 1983). Recently, Nair et al. (1996) have published a contribution to the knowledge of some slugs of Libya.

Between October 2018 and January 2019, despite many difficulties, one of us (A.A.) managed to collect several samples of land molluscs in some localities of Cyrenaica (north-eastern Libya). The morphological, anatomical study and bibliographic, biological and geonemic data of the slugs sampled in these researches (Parmacellidae, Limacidae, Agriolimacidae, Veronicellidae) are provided below in this work.

MATERIAL AND METHODS

All specimens were collected by eye-sight on the ground and under rocks. The specimens were investigated with regards to size, external morphology and genitalia's morphology. In order to study and illustrate genitalia, the specimens were fixed in 75% ethanol. Reproductive apparatus were extracted by means of scalpel, scissors and needles and they were studied and observed under a stereomicroscope (Leica MZ 7.5). Photographs were taken with a digital camera. The maximum lenght and width of the molluscs together with the shell and some parts of the genitalia were measured (in

millimeters) by a digital gauge. In the anatomical description, proximal denotes the part which is closest to the gonad and distal the part which is closest to the gonopore. The proximal female genitalia, sometimes indicated in the plates, are not described because they are not very informative.

Taxonomical references are based on MolluscaBase (2021) and other cited papers.

Voucher specimens used for this study were stored in the following Museums and private collections: CBL = Department of Zoology collection, University of Benghazi, Libya; CL = Liberto Fabio collection, Cefalù (Italy); CS = Sparacio Ignazio collection, Palermo (Italy); MSNG = Museo Civico di Storia Naturale di Genova "G. Doria" (Italy).

ACRONYMS. AA = Accessory atrial appendices; AG = albumen gland; AN = anus; BC = bursa copulatrix; DBC = duct of the bursa copulatrix; E = epiphallus; FGP = female genital pore; G = penial papilla; GA = genital atrium; HD = hermaphrodite duct; O = ovotestis; OV = ovispermiduct; P = penis; PA = penial appendix; PC = penial crest; PPG = papilla of the penial gland; PR = penial retractor muscle; PST = prostate; PV = perivaginal gland; T = tubules of the penial gland ; V = vagina; VD = vas deferens.

D max: shell maximum diameter; D min: shell minimum diameter; ex/x: specimen/s; L: mollusks length; W: mollusks width.

RESULTS

Systematics

Phylum MOLLUSCA Cuvier, 1795
Classis GASTROPODA Cuvier, 1795
Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo STYLOMMATOPHORA A. Schmidt, 1855
Superfamilia PARMACELLOIDEA P. Fischer, 1856 (1855)
Familia PARMACELLIDAE P. Fischer, 1856 (1855)
Genus *Parmacella* Cuvier, 1805
Subgenus *Parmacella* Cuvier, 1805

Parmacella (Parmacella) festae Gambetta, 1924

Parmacella sp. - Haimann, 1882: 619, Bengasi
Parmacella sp. - Martens, 1883: 147, Cyrenaika, Bengazi
Parmacella sp. - Martens 1885: 188, Cyrenaika, Bengazi
Parmacella sp. - Haimann 1885: 258, Cyrenaica
Parmacella sp. - Cornalia in Haimann 1886: 207, Bengasi
Parmacella sp. - Kobelt 1898: 362, In der Umgebung von Benghazi in der Cyrenaika
Parmacella sp. - Sturany 1908: 310, Bengasi
Parmacella cfr. *deshayesi* - Ghigi 1923: 249–250, Cirene, fontana di Apollo; Uadi Derna
Parmacella sp. - Colosi 1923: 9, Cirenaica
Parmacella festae - Gambetta, 1924: 9-20, Figs. 2–5 (anat.), Merg, Uadi el Cuf, Chersa, Derna, Uadi Derna, Sidi Garbaa.
Parmacella festae - Gambetta, 1925: 560 (Map), Cirenaica
Parmacella festae - Gambetta, 1929: 248–249, Figs. 1–2, Porto Bardia
Parmacella festae - Ghigi, 1929: 523–526, Pl. 8, Figs. 1–5, Cirene
Parmacella festae - Hesse, 1934: 108, Derna, Merg; Porto Bardia
Parmacella alexandrina - Hesse, 1934: 102, 108, Derna, Bengasi
Parmacella olivieri - Forcart, 1959: 39–41, Fig. 2 (anat.), Derna
Parmacella (Parmacella) festae - Wiktor 1983: 82–91, Figs. 10–18 (anat.), Libya: Viananze, Sidi-Mahius (= Sidi Mahyus); Benghazi; Barce ca. 14 km from Tobruk; Egypt: Burg-el-Arab, Marit
Parmacella (Parmacella) festae - Alonso et al. 1986: 141–145, Figs. 10–12 (anat.)
Tandonia rustica - Nair et al., 1996: 251–256, Benghazi, 32°05'N, 20°16'E, 32 m; Albayda, 32°45'N, 21°45'E, 600 m; Shahhat, 32°49'N, 21°51'E, 625 m
Parmacella (Parmacella) festae - Martinez-Orti & Borreda, 2012: 11, 16, Libya and Egypt
Parmacella (Parmacella) festae - Martinez-Orti & Borreda, 2013: 66

MATERIAL EXAMINED. Cyrenaica, Bengasi, Benina, 32°04'12.6"N 20°16'27.9"E, 137 m, leg. A. Abusneina, 1.II.2019, 3 exx (CBL), idem 12 exx (CL L280–294), idem 5 exx (CS 5455/5), idem 2 exx MSNG.

DESCRIPTION. The examined specimens of *P. festae* are characterized by a shell with protoconch covered with minute pits arranged regularly in spi-

ral rows; aperture without denticles or folds but a deep triangular pit is present on the extemal ridge between the protoconch and spatula (Figs. 1–5); the genitals are characterized by an epiphallus long four times the length of the penis, two accessory atrial appendices, one of them generally longer and slightly bent, the other straight; genital atrium and distal penis with internal walls crossed by longitudinal folds; proximal penis with a cylindrical or cylindro-conical penial papilla, covered with very small tubercles; inner walls of the proximal penis and epiphalus covered with papillae and those of the vagina and perivaginal gland covered by larger papillae (Figs. 6–10).

Distribution and Biology. It is widespread in northern Cyrenaica from the surroundings of Benghazi to Porto Bardia. Wiktor (1983) also reports it from Egypt in Burg-el-Arab.

The specimens examined in this paper were sampled in semi-natural open fields in the surroundings of Benina.

Remarks. *Parmacella* was one of the first molluscs to be reported in Cyrenaica (Haiman, 1882; Martens, 1883), however, only in 1924 it was described by the Italian malacologist Gambetta as a new species, with the name *P. festae*. We describe the internal structure of the genitalia, for the first time.

Martínez–Ortí & Borredà (2012) revised the systematics of the family Parmacellidae ascribing *P. festae* with *P. olivieri* to the subgenus *Parmacella* s. str. This subgenus is characterized by an extended atrial entrance, running from the genital opening to the insertion of the atrial appendices; the lack of intra-atrial stimulators; and the presence of two atrial accessory appendices of very similar size.

Familia LIMACIDAE Lamarck, 1801
Subfamilia LIMACINAE Lamarck, 1801
Genus *Limacus* Lehmann, 1864

Limacus flavus (Linnaeus, 1758)

Lymax deshayesii - Haimann 1882: 619, Bengasi
Lymax deshayesii - Cornalia in Haimann 1886: 207, Bengasi

Distribution. Holomediterranean.

Remarks. The genus *Limacus* was reported by Haiman at the end of 1800 (sub *Limax deschayesii*) from Benghazi but subsequently it was no longer reported, and we did not find it in our samples. Its original distribution area is not precisely known, it is probably the south-eastern Europe, nowadays *L. flavus* has been introduced worldwide.

In North Africa, *L. flavus* has been reported from Morocco (Pallary, 1922), Algeria (Bourguignat, 1861; Haimann, 1885), Tunisia (Abbes et al., 2010) and Egypt (Azzam, 2003; Ali & Robinson, 2020).

Familia AGRIOLIMACIDAE H. Wagner, 1935
Subfamilia AGRIOLIMACINAE H. Wagner, 1935
Genus *Deroceras* Rafinesque, 1820
Subgenus *Deroceras* Rafinesque, 1820

Deroceras (Deroceras) barceum (Gambetta, 1924)

Agriolimax barceus - Gambetta, 1924: 7–9, Fig. 1 (anat.), Parte orientale della Cirenaica: Sidi Garbaa, Derna, altopiano di El Fetejà
Agriolimax barceus - Gambetta, 1925: 560 (Map), Cirenaica
Agriolimax barceus - Hesse, 1934: 108, Derna, Sidi Garbaa, El Fefjà
Deroceras barceum - Altena, 1962: 53–56, Fig. 2 (map.), Fig. 3 (genit.), plateau de El Fetejà (recte El Ftaajah); col oriental au dessus de Derna; Derna; Sidi Garbaa; Ain Mara à l'ouest de Derna; Wadi en Nsuria; Cyrène au pied de l'escarpement; Sidi Fanag près de Messa; Wadi El Kuf, près du pont; Wadi Sudan, premier affluent du Wadi El Kuf; wadi entre W. El Gattara et W. Tuega; troisième wadi au sud du col à l'est de Barce; col de Tocra; Wadi Zaza à l'est de Driana; Wadi Chresci à l'est de Driana; Wadi Fej; petit wadi près du col entre Benina et Er Regima; Haua Hamed
Deroceras barceum - Rähle, 1984: 45, Libyen
Malacolimax tenellus - Nair et al., 1996: 251–256, Alabyar, 32°11'N 20°36'E, 280 m; Shahhat, 32°49'N, 21°51'E, 625 m, Darnah 32°47'N 22°34 26'E, 120 m
Deroceras (Deroceras) barceum - Wiktor 2000: 385, 390–391, 406–408, 413–414, 429–430, 580–582, Figs. 127–134, Cyrenaika; Wadi Sudan, Hamed, Sidi Faliay near Messa.

Material examined. Cyrenaica, Benghazi,

Alhwari, 32°03’08.3”N 20°06’30.9”E, leg. A. Abusneina, 8.XI.2018, 1 ex juven. (CL L150).

DESCRIPTION. The specimen examined here is sub-adult; length: 11 mm, width: 2.8 mm, mantel: 5 mm. It has a uniform cream color, only on the mantel there are darker spots irregularly aggregated, sole cream color.

DISTRIBUTION AND BIOLOGY. Endemic species of northern Cyrenaica, widespread from the surroundings of Benghazi up to Derna.

The *Deroceras* specimen was sampled together with 35 specimens of an allochthonous Veronicellidae (see below).

REMARKS. The genital morphology of *D. barceum* is well-known thanks to the works of Gambetta (1924), Altena (1962) and Wiktor (2000).

Genus *Ambigolimax* Pollonera, 1887

Ambigolimax valentianus (A. Ferussac, 1822)

Tandonia sowerbyi - Nair et al. 1996: 251-256, Alabyar, 32°11’N 20°36’E, 280 m

MATERIAL EXAMINED. Cyrenaica, Benghazi, Shebna, 32°07’19.6”N 20°08’22.2”E, 20 m, leg. A. Abusneina, 11.XI.2018, 4 exx (CL L73–76), idem 2 exx (CS 5456/2), idem 1 ex MSNG.

DESCRIPTION. The examined specimens have the typical characters of the species: short, clavate penis with a cylindrical flattened appendix placed laterally on the proximal penis and an S-shaped crest inside the penis (Figs. 13–15). The external colur pattern of the mollusk is the most common for the species: light brown background color with three darker bands on the mantle of which the central one is indistinct, and other two bands on the back.

DISTRIBUTION AND BIOLOGY. *Ambigolimax valentianus* (Férussac, 1823) was originally described based on specimens from Valencia (Spain), but currently, it has been introduced through a great part of the temperate regions by human action (Sparacio et al., 2018).

REMARKS. In North Africa, *A. valentianus* was reported by Wiktor (1983) from Algeria and by Borredà & Martínez-Ortí (2017) from Algeria and Morocco. It is a new species from Libya.

Ordo SYSTELLOMMATOPHORA Pilsbry, 1948
Superfamilia VERONICELLIDEA Gray, 1840
Familia VERONICELLIDAE Gray, 1840
Genus *Eleutherocaulis* Simroth, 1913

Eleutherocaulis striatus (Simroth, 1896)

MATERIAL EXAMINED. Cyrenaica, Bodzera, Kuwayfiyah, 32°11’41”N 20°09’10”E, 6 m, leg. A. Abusneina, 29.X.2018, 9 exx CL L26-34. Cyrenaica, Sidi Khalifah, 32°14’26”N, 20.11’09”E, 4 m, leg. A. Abusneina, 11.XI.2018, 4 exx CBL, idem 16 exx, CL L53–72. Cyrenaica, Benghazi, Alhwari, 32°03’08.3”N 20°06’30.9”E, leg. A. Abusneina, 8.XI.2018, 4 exx (CBL), idem 22 exx (CL L114–139), idem, 5 exx (CS 5457/5), idem 5 exx (MSNG).

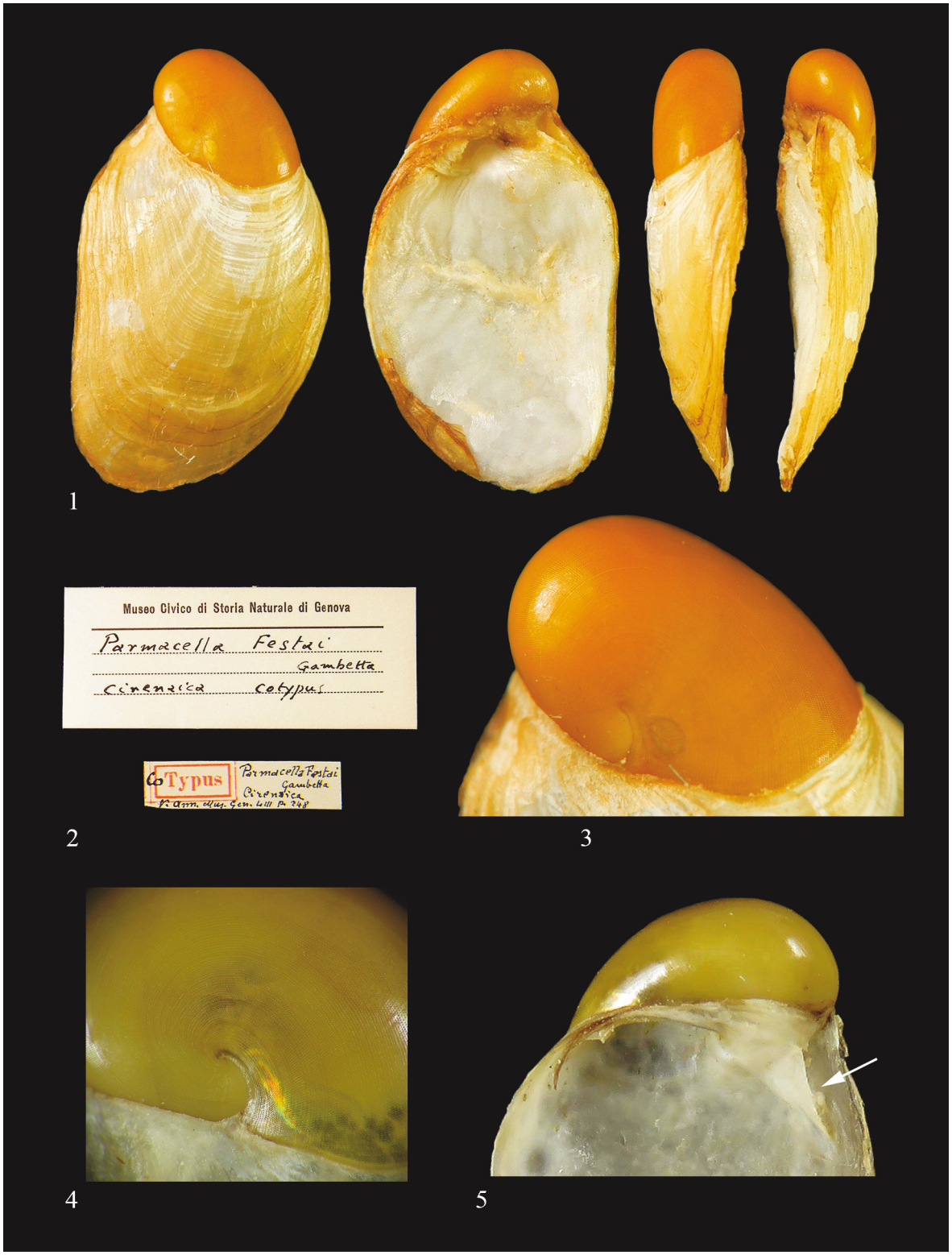
DESCRIPTION. The specimens show the typical characters of the genus *Eleutherocaulis*: spherical anus, open submedianly; female genital pore open in the posterior half of the hyponotum (Figs. 16, 17), anterior intestinal loop not covered by digestive gland and tubules of the penial gland directly attached to the papilla. The examination of the genitals allowed the attribution to *E. striatus*. This species is characterized by a penial gland with numerous tubules attached directly to a conical papilla and a penis with cylindrical, elongated penial papilla, with a swelling on the apex (Figs. 18–20) (Forcart, 1953; Gomes, 2007).

DISTRIBUTION AND BIOLOGY. It is widespread in Central Africa: Sudan, Congo, Tanzania, Zimbabwe.

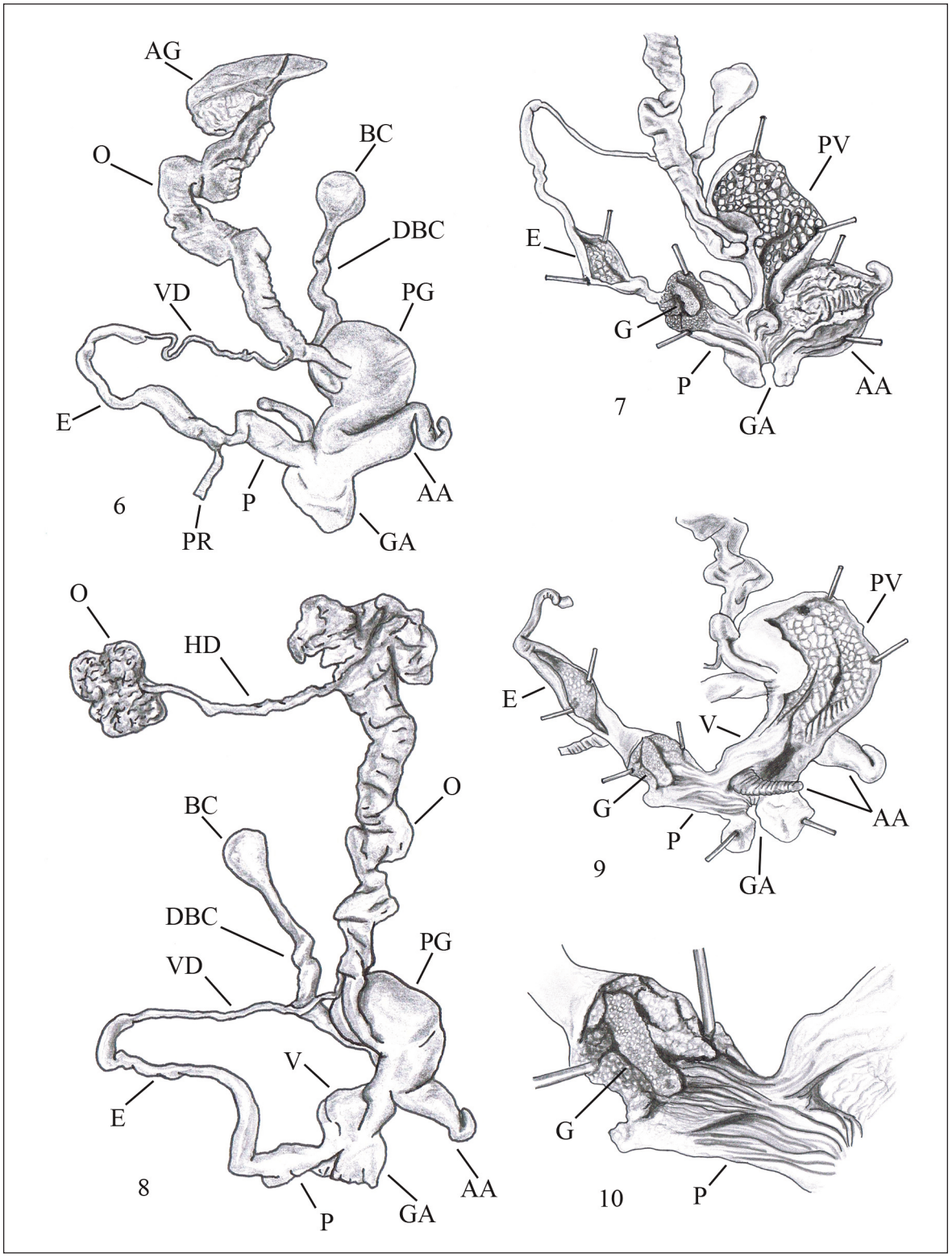
Eleutherocaulis striatus was sampled in gardens and orchards. This species seems to have been well acclimatized in the three localities where collected (Bodzera, Sidi Khalifah and Alhwari).

REMARKS. Most Veronicellidae species occur in restricted geographical areas, within their own biogeographical region. However, *Eleutherocaulis altae* (Férussac, 1821), *Sarasinula plebeia* (Fischer, 1868) and *Veronicella cubensis* (Pfeiffer, 1840) are widespread in several regions of the world, probably through human activities (Gomes, 2007). This is the first record of *E. striatu*s outside central Africa.

Recently, two other Veronicellids have been reported from Egypt: Ali (2017) reports *E. stuhlmanni* (Simroth, 1895) from El Zamalek, Cairo and Ali & Robinson (2020) *E. altae* (Férussac, 1822) from Abo Rawash, El Saliba district; no diagnostic data are provided for a reliable classification of the two species.



Figures 1–3. *Parmacella (Parmacella) festae* Gambetta, 1924, Syntype, Libya, Cyrenaica (MSNG). Fig. 1: shell D max: 11.5 mm, D min: 6.5 mm; Fig. 2: labels; Fig. 3: microsculpture of the protoconch. Figures 4, 5: *P. festae*, Libya, Cyrenaica, Benina (CL 281), shell D max: 11.5 mm, D min: 6.5 mm; Fig. 4: microsculpture of the protoconch; Fig. 5: deep triangular pit on the extemal ridge between the protoconch and limacella.



Figures 6, 7. *Parmacella festae*, Lybia, Cyrenaica, Benina (CL 280). Fig. 6: genitalia, Fig. 7: internal structures of the distal genitalia. Figures 8, 9. *P. festae*, Lybia, Cyrenaica, Benina (CL 281). Fig. 8: genitalia, Fig. 9: internal structures of the distal genitalia.

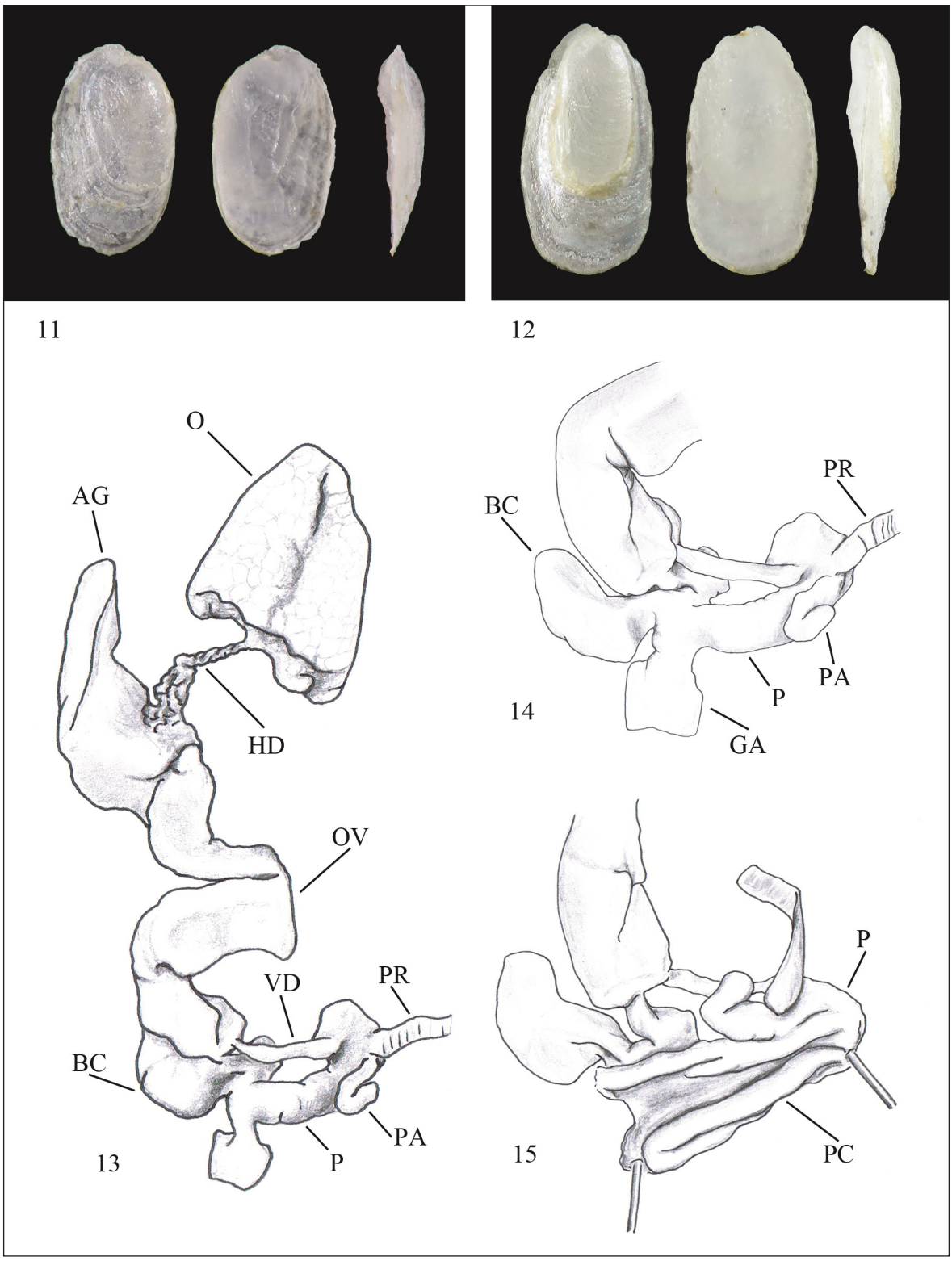
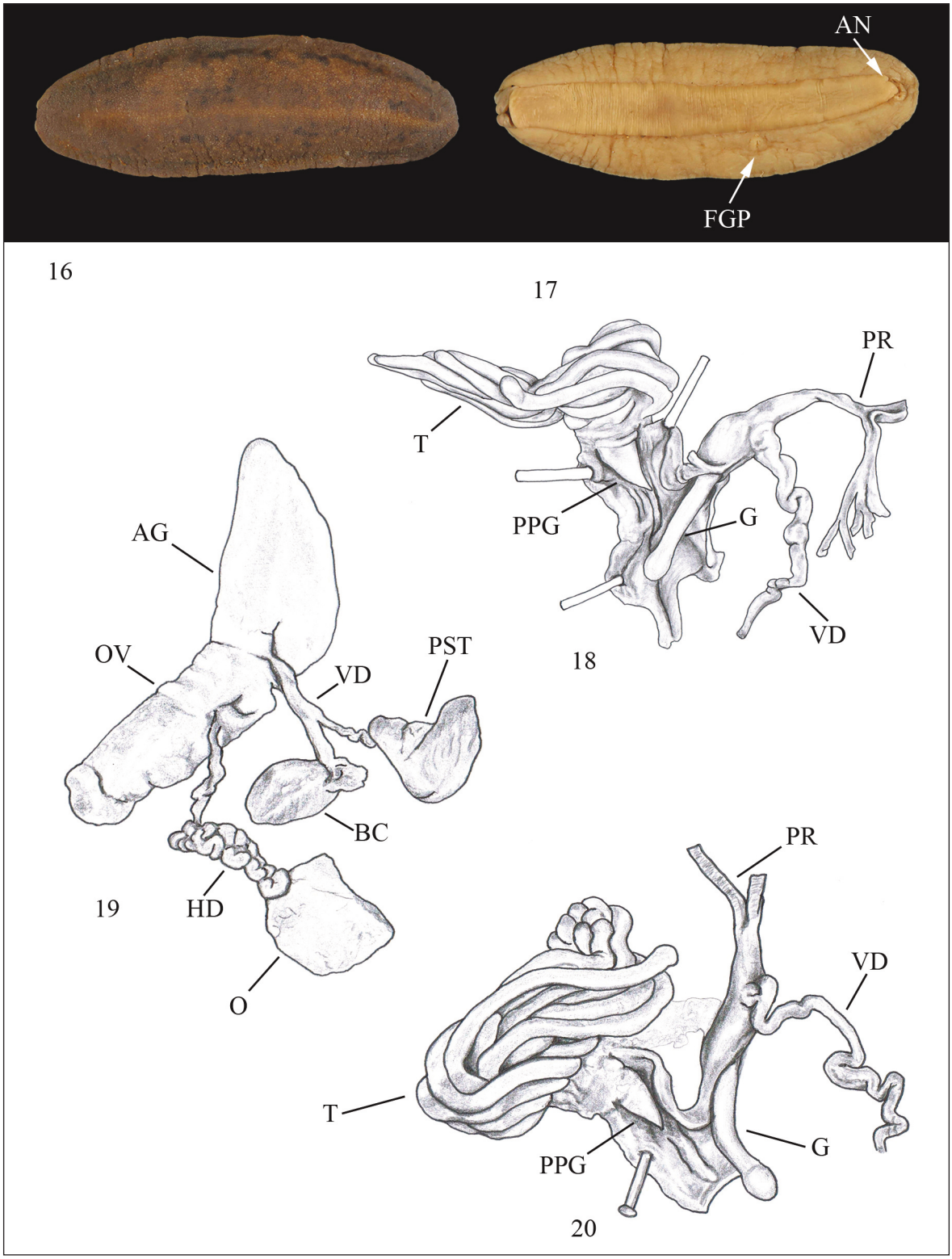


Figure 11. Shell of *Deroceras (Deroceras) barceum*, Libya, Cyrenaica, Benghazi, Alhwari, D max: 2.8 mm, D min: 1.6 mm. Figures 12–15: *Ambigolimax valentianus*, Libya, Cyrenaica, Benghazi, Shebna (CL 73); Fig. 12: shell, D max: 5.7 mm, D min: 2.9 mm; Fig. 13: genitalia; Fig. 14: distal genitalia; Fig. 15: internal structure of the penis.



Figures 16–19. *Eleutherocaulis striatus*, Libya, Cyrenaica, Benghazi, Alhwari (CL 115). Fig. 16: mollusk in dorsal view, L: 36 mm, W: 12 mm. Fig. 17: mollusk in ventral view. Fig. 18: male genitalia: penial gland with its papilla and penis with penial papilla. Fig. 19: female genitalia. Figure 20: *L. striatus*, Libya, Cyrenaica, Benghazi, Sidi Khalifah (CL 53), male genitalia: penial gland with its papilla and penis with penial papilla.

CONCLUSIONS

In this paper, we summarise the current knowledge about slugs and semy-slugs of Cyrenaica, which could be helpful in further research on this group.

The presence of only two native species, *P. festae* and *D. barceum*, is confirmed while two alien species, *A. valentianus* e *E. striatus*, have been discovered. The first one has a remarkable predisposition to synanthropization which allowed it to spread over a vast area of the Mediterranean and in other temperate areas of the world. *Eleutherocaulis striatus* is reported here for the first time, outside its biogeographical area of origin, but it seems to have become well acclimatized with large populations around Benghazi.

The presence of the genera *Limacus* and *Milax* Gray, 1855 in Libya (Nair et al., 1996: *Milax gagates?*) needs confirmation through anatomical or molecular studies.

Future research will be essential to improve knowledge on these land snails and to monitor the spread of the alien species and their impact on native species and on the environment.

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