

A REVIEW OF SLUGS AND SEMI-SLUGS OF TUNISIA (TESTACELLIDAE, MILACIDAE AND LIMACIDAE)

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Abstract The aim of this work is to provide a first comprehensive survey of slugs and semi-slugs of Tunisia. The work is based on a critical analysis of the literature and on anatomical investigations of new material collected in 2005–2007. As such seven species are discussed (*Testacella fischeriana*, *Milax gagates*, *M. nigricans*, *M. gasulli*, *Lehmannia melitensis*, *L. marginata* and *Limacus flavus*). Both *Milax gagates* (Bourguignat 1801) and *Milax gasulli* Altena 1974 are confirmed for Tunisia and a detailed description is provided for them. *Milax nigricans* (Philippi 1836), *Limacus flavus* (Linnaeus 1758) and *Lehmannia melitensis* (Lesson and Pollonera 1882) are reported for the first time for Tunisia.

The taxonomic status of *Agriolimax* (*Malacolimax*) *kervillei* Germain 1907, and of the Tunisian species of *Testacella* are also discussed.

Key words Slugs, Testacellidae, Milacidae, Limacidae, Tunisia

INTRODUCTION

The terrestrial Gastropoda of Tunisia, particularly slugs, are still poorly known. Only limited data are found in the literature and even a simple checklist is not available with most current knowledge based on very few papers. These include: Bourguignat (1864a and 1868) who recorded *Milax gagates* from north-western Tunisia; Germain (1908) who signalled *Testacella bisulcata*, *Milax gagates* and *Agriolimax* (*Malacolimax*) *kervillei* from the Khroumerie region; Letourneux & Bourguignat (1887) who reported *Milax gagates* from Cap Roux, Tunis and Djebel Abdallah; Altena (1974) who recorded *Milax gasulli* from Zaghouan and Ktari; and Rezig (1976) who confirmed the occurrence of *Milax gagates* and *Testacella bisulcata* in northern Tunisia. Among these, *Agriolimax* (*Malacolimax*) *kervillei* and *Milax gasulli* were introduced as new species with Tunisian type localities. The descriptions provided by the above workers for some recorded species, particularly *Milax gagates* and *Milax gasulli*, are so poorly characterized that their occurrence in Tunisia is questionable. All the above references concern northern Tunisia, and no data on the general distribution of slugs within the Tunisian area can be found in the literature.

The present paper, therefore, provides a first comprehensive survey of the slugs of Tunisia. It is

based on both a literature search and on anatomical investigation of recently collected material. All taxa listed by earlier authors are dealt with, morphological and anatomical descriptions of all currently accepted species are given and some taxonomic problems are discussed. A revised key to genus and species is given.

MATERIAL AND METHODS

Specimens were collected by hand during field studies conducted in Tunisia between 2005 and 2007. Forty-one stations belonging to several bioclimatic areas (humid, sub-humid, semi arid and arid) and distributed from the northern to southern Tunisia, were prospected (Fig. 29).

Living slugs were drowned in water for 36 to 48 hours and then fixed in 75% ethanol. Animals were dissected under a stereomicroscope using thin, pointed, watchmaker's tweezers. Anatomical details were drawn using a Wild camera lucida.

Vouchers of *Milax gasulli*, *Milax nigricans* and *Milax gagates* are stored in Wrocław National Museum and vouchers of *Testacella fischeriana*, *Lehmannia melitensis*, *Lehmannia marginata* and *Limacus flavus* in the Faculty of Sciences of Tunis UR, Biodiversity and Populations Biology.

Geographic coordinates of the sampling stations were recorded using GPS and the map of geographical distribution (Fig. 29) completed using Compe GPS logiciel.

RESULTS

Family Testacellidae
Genus *Testacella* Draparnaud 1801*Testacella fischeriana* Bourguignat 1861
Figs 1–4

Material examined Beja 24 April 2005 (3); Ichkeul National Park 4 March 2007 (1); Djebel Ammar 11 February 2007 (4); Tabarka 29 March 2007 (2); Bni Mtir 17 February 2007 (10); Sejnene 26 January 2007 (2); Ain Draham 11 May 2007 (2). A new record for Tunisia.

Description Body (Fig. 1) medium-sized (20 to 40 mm), leaf-like, ventrally flattened and dorsally convex; dorsum with parallel dorso-lateral grooves running from in front of shell to behind tentacles; more or less distinct short dark band situated between the grooves; small, narrow, transverse grooves branching from dorso-lateral grooves; sole undivided, pale yellow in colour; mantle small with margins extending slightly beyond shell. Shell (Fig. 2) dextral, situated at posterior end of body, small, near-circular in shape, flattened with a depressed apex, orange yellowish to brownish in colour; with irregular growth lines.

Genitalia (Figs 3–4) characterized by: pale ootestis; thin and convoluted hermaphrodite duct; well developed albumen gland; ovispermiduct with externally differentiated female portion and prostatic portion; long free oviduct wide proximally; bursa copulatrix duct slightly longer than free oviduct + vagina length, ending in oval bursa copulatrix; vagina long and slender ending in very short genital atrium; vas deferens long, proximally slender and distally slightly wider; penis long, distal portion clearly wider; middle part of penis and distal part of vas deferens together enveloped by a muscular sheath; proximal part of penis more slender ending with well developed penial retractor muscle; penial appendix protrudes from proximal penis relatively close to retractor muscle.

Geographic range Described from Algeria (Bourguignat, 1861) and not subsequently recorded elsewhere.

Habitat and distribution It has been found in north and north-western Tunisia under calcareous rocks, in open habitats of various kinds including grasslands and Mediterranean maquis.

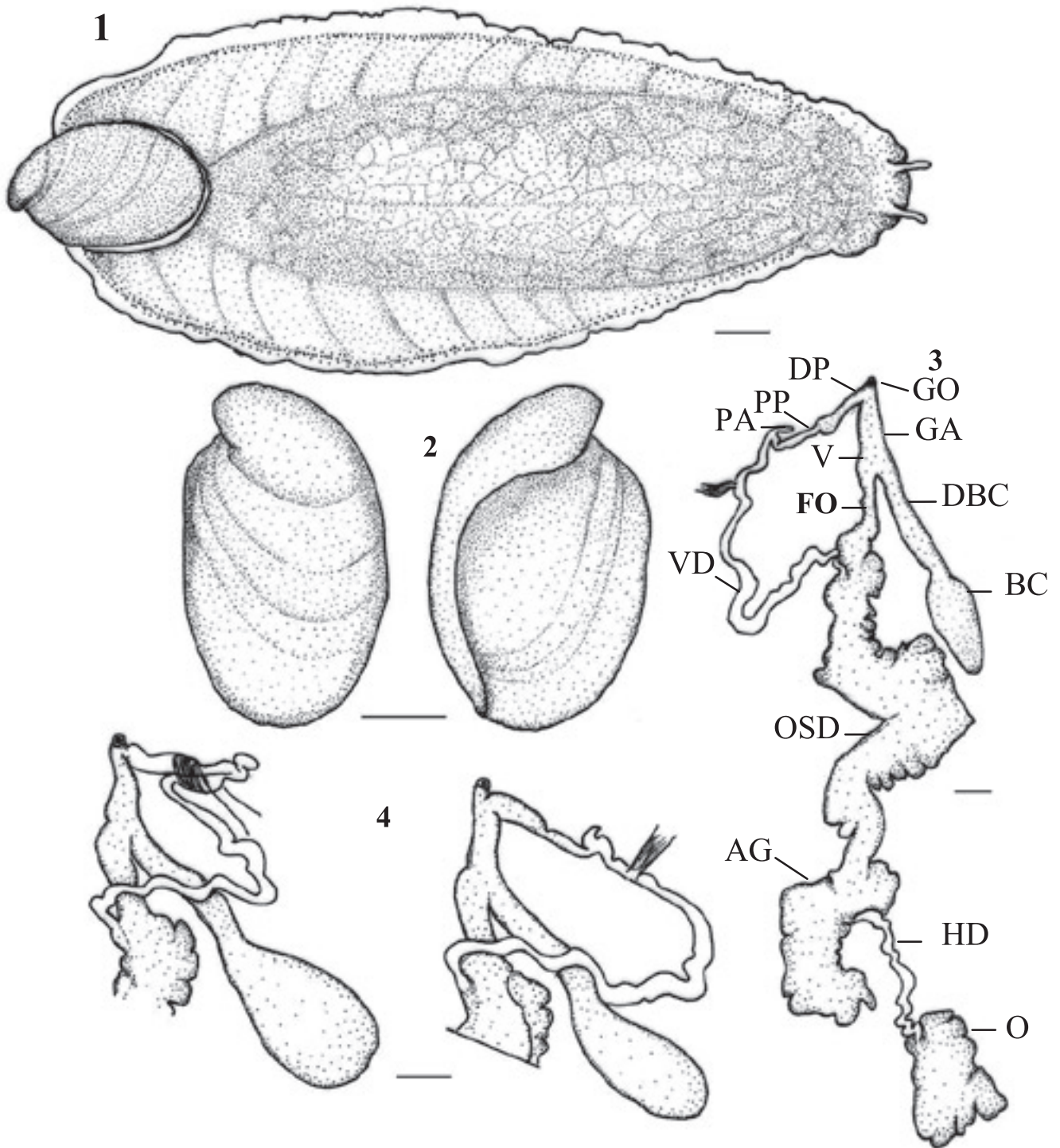
Comparisons Germain's (1908) report of *Testacella bisulcata* (Risso 1829) from Tunisia was later (erroneously) confirmed by Ktari and Rezig (1976). Two species of *Testacella* were described by Bourguignat (1861) from Algeria: *Testacella fischeriana* Bourguignat 1861 and *Testacella bron-deli* Bourguignat 1861. An anatomical study by Guisti *et al.* (1995), on the basis of some alcohol-preserved specimens collected by Prof. A. Riedel from the type locality of the two species described by Bourguignat, showed that both corresponded to *Testacella fischeriana* Bourguignat 1861. Moreover, a comparison between this species and the Tunisian species called *Testacella bisulcata* by Ktari and Rezig (1976) indicated that they correspond to a single species (Guisti *et al.*, 1995). Our study of recently collected material from Tunisia agrees with the hypothesis of Guisti *et al.* that the Tunisian *Testacella* has genitalia which to *T. fischeriana*, with only some minor differences: the bursa copulatrix duct is greater than twice the free oviduct length; the vagina is longer than described by Bourguignat and more slender.

Family Milacidae Ellis 1926
Genus *Milax* Gray 1855*Milax gagates* (Draparnaud 1801)
Figs 5–9

Milax gagates Bourguignat 1864a: 302.
Amalia (Pirainea) gagates Germain 1908: 135.
Milax (Lallemantia) gagates Ktari and Rezig 1976: 36.

Material examined Tinja 31 March 2005 (2); Djebel Ammar 11 February 2007 (5); Bni Mtir 17 February 2007 (2); Zaghuan (Jouf) 27 February 2007 (3); Ichkeul National Park 4 March 2007 (5); Zriba 28 March 2007 (5); Ain Errahma 8 April 2007 (2); Ain Draham 11 May 2007 (3); Bir Bouregba 30 January 2007 (2).

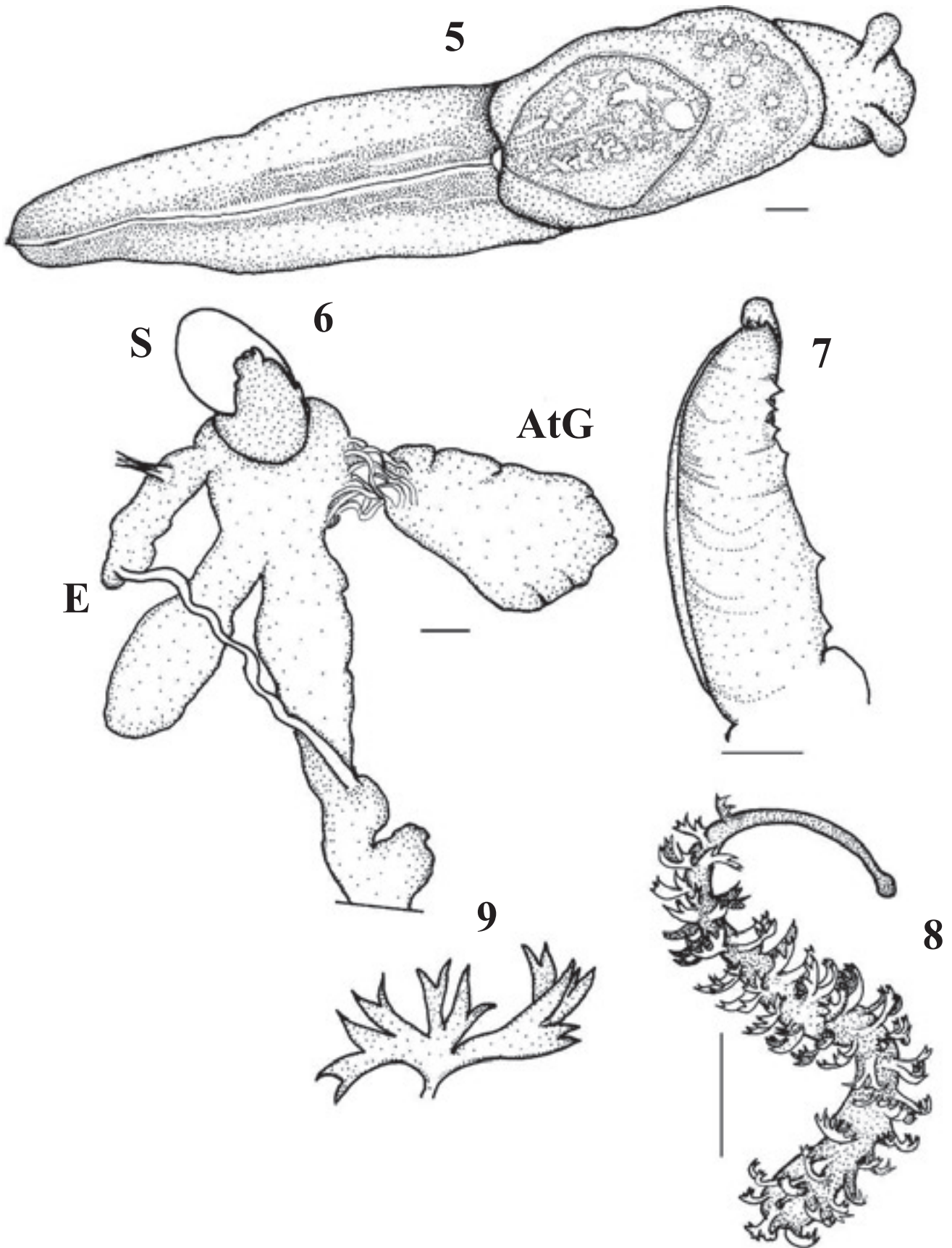
Description Medium-sized slug (Fig. 5), body length 35 to 50 mm; mantle length 10 to 20 mm; body dark grey to yellow in colour; mantle sometimes ornamented with lighter spots; skin sculpture weak. Genitalia (Figs 6–7) characterized by penis slightly shorter than epiphallus; the extreme part of penis is rounded; vas deferens length more than twice length of penis + epiphallus, arising



Figures 1–4 *Testacella fischeriana* (specimens from Sidi Thebet): external appearance (1); details of shell (2); genitalia (3); distal genitalia (4). Scale bar = 1 mm. AG albumen gland, BC bursa copulatrix, DBC duct of bursa copulatrix, DP distal penis, FO free oviduct, GA genital atrium, GO genital orifice, HD hermaphrodite duct, O ovotestis, OSD ovispermiduct, PA penial appendix, PP proximal penis, PR penial retractor muscle, V vagina, VD vas deferens.

laterally from proximal extremity of epiphallus; free oviduct very long, vagina very short; bursa copulatrix oval; bursa copulatrix duct short slender in the posterior part and slightly

widened at the entrance in genital atrium; large genital atrium containing a thin and tape-shaped stimulator which is twisted, gradually narrowing towards its end and with a series of small



Figures 5–9 *Milax gagates* (specimens from Sidi Thebet): external appearance (5); distal genitalia (6); stimulator (7); spermatophore (8), posterior part of spermatophore (9). Scale bar = 1 mm. AtG atrial gland, E epiphallus, S stimulator.

papillae, more or less evidently situated along the edge, the remaining surface smooth; spermatophore elongate and narrow anteriorly and cylindrical posteriorly, the anterior part smooth with rounded extremity, the medium and posterior part all covered with multiple branched spines on all sides (Figs 8–9).

Geographic range Native in southern and western Europe, north-west Africa and the Canary Islands.

Habitat and distribution in Tunisia This species was recorded from shady microhabitats under damp stones in the northern part of Tunisia.

Comparison and remarks Based on external appearance this species can be difficult to distinguish from its congeners *M. nigricans* and *M. gasulli*. Anatomically, the smooth genital stimulator, occasionally with low papillae along the edge (Martin & Angulo, 1986), is diagnostic.

Milax nigricans (Philippi 1836)
Figs 10–12

Material examined Djebel Ammar 19 January 2005 (3); Djebel el Jouza 3 February 2005 (7); El Feïja National Parc 3 March 2005 (3); Tinja 31 March 2005 (2); Beja 24 April 2005 (4); Nefza 2 September 2005 (4); La Galite 24 September 2005 (2); Ghar el Melh 11 October 2005 (2); Tunis 15 October 2005 (9); Cheninni oasis 15 March 2006; Djebel Mansour 18 March 2006 (4); Mateur 2 April 2006 (3); Ichkeul National Parc 5 May 2006 (4); Cap Zebib 13 May 2006 (3); Kef 3 June 2006 (2); Sejnene. 26.I.07 (1); Ennahli Parc 1 February 2007 (2); Bni Mtir 18 February 2007 (12); Tabarka 29 March 2007 (2); Aïn Errahma 8 April 2007 (2); Aïn Draham 11 May 2007 (3); Tozeur oasis 16 May 2007 (3); Dghoumes oasis 18 May 2007 (3).

Description Body length 50 to 70 mm; mantle length about 20 mm (Fig. 10), black to greyish or sometimes greenish in colour (populations of Bni Mtir and Aïn Draham); keel prominent; mantle more or less granulated with a horseshoe-shaped groove. Genitalia (Figs 11–12) characterized by a cylindrical epiphallus slightly shorter than penis; vas deferens longer than penis and epiphallus, arising from the proximal extremity of epiphallus; vagina and bursa copulatrix duct

short; bursa copulatrix short and oval in shape; penis and vagina open into a wide genital atrium to which a mass of atrial accessory glands are attached via slender ducts; stimulator conical, situated inside atrial cavity and with acuminate to rounded papillae randomly distributed on the inner side; spermatophore not figured but elongate and conical at its anterior end.

Geographic range Mediterranean-Atlantic area north to southern Britain and Holland (Castillejo, 1998).

Habitat and distribution in Tunisia This species was found at many stations across the country, especially cultivated fields and gardens but also typical Mediterranean habitats.

Comparisons The *Milax* genus includes several morphologically similar species. Anatomical study is necessary to differentiate them, the main diagnostic criteria being the shape of the stimulator, the disposition of the papillae and the shape of the spermatophore.

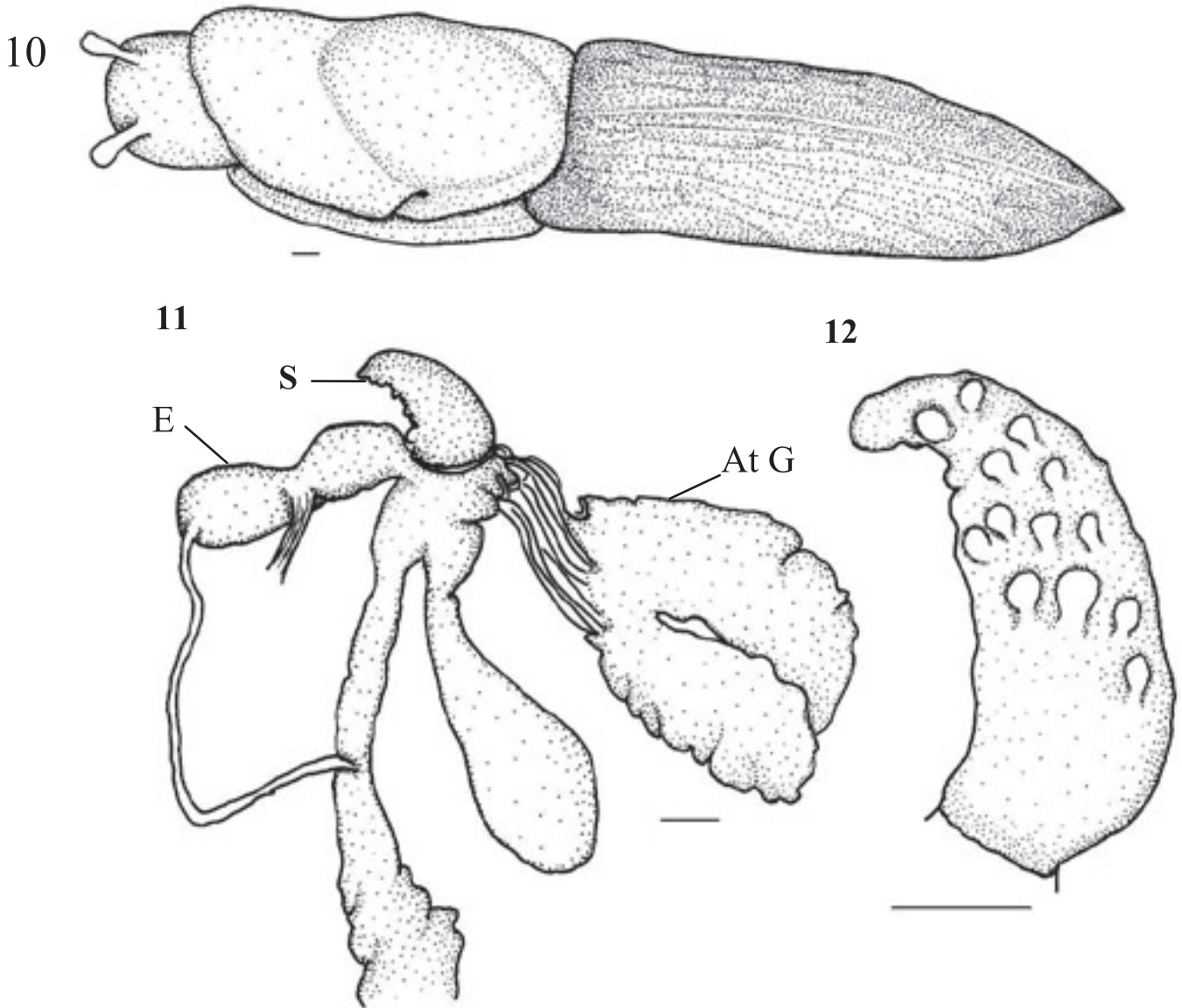
Milax gasulli Altena 1974
Figs 13–17

Milax gasulli Altena, 1974: 103, figs. 1–3.

Material examined Zaghouan 27 February 2007 (1); Lebna dam 2 February 2007; Aïn Errahma 8 April 2007 (3).

Description Body length 60 to 70 mm; mantle length 11 to 13 mm (Fig. 13), black to grey in colour, with yellowish spots that are lighter on the mantle; mantle grey and superficially granulated; skin sculpture weak.

Genitalia (Figs 14–17) characterized by expanded penis evidently shorter than epiphallus; vas deferens very thin connecting apically to the epiphallus; vagina very short; circular bursa copulatrix with very short and wide duct which with the vagina is surrounded by a thin sheath which Altena (1974) called the vaginal gland; small genital atrium with which large atrial accessory glands communicate via multiple ducts; stimulator elongate and cylindrical with a conical, pointed and recurved apex, arising from the genital atrium, and with a line of conical and pointed papillae in two rows along the



Figures 10–12 *Milax nigricans* (specimens from Sejnene): external appearance (10); distal genitalia (11); stimulator (12). Scale bar = 1 mm. AtG atrial gland, E epiphallus, S stimulator.

inner side; spermatophore not figured – cylindrical, short and covered with hooks according to Wiktor (1987).

Geographic range No records registered outside Tunisia.

Habitat Recorded from north-eastern Tunisia in a natural and humid microhabitat on clayey soil with a calcareous substratum.

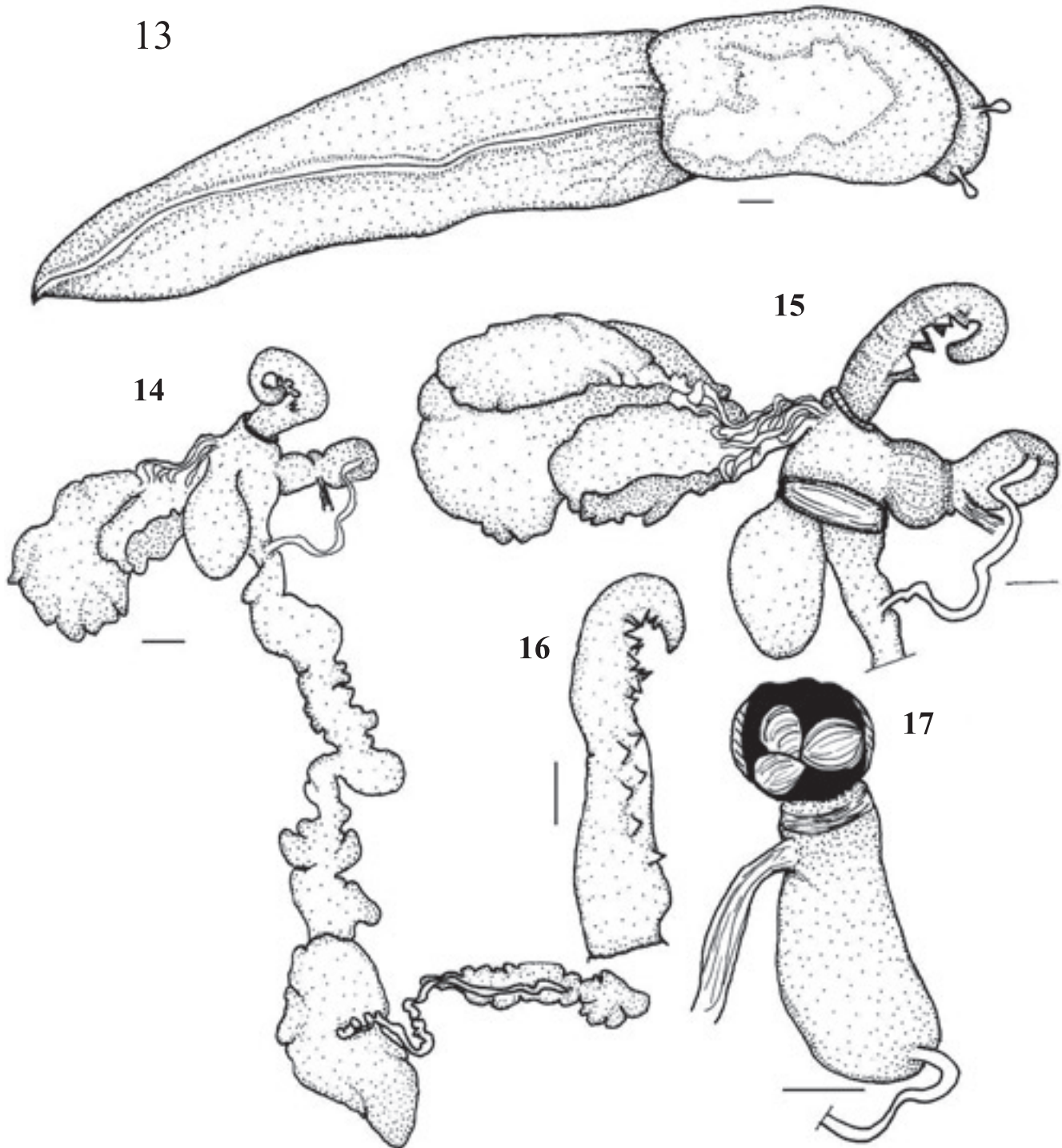
Comparisons On the basis of material obtained in Tunisia, this species is distinguishable from *Milax nigricans* and *M. gagates* by its smaller size, its lighter colour and the mantle spots. Internally,

the diagnostic characters of *M. gasulli* are the thin and slender stimulator with its double row of pointed papillae and the size and the shape of the spermatophore (not figured).

Family Limacidae Rafinesque 1815
Genus *Lehmannia* Heynemann 1862

Lehmannia marginata (O.F. Müller 1774)
Figs 18–20

Material examined Bni Mtir 17 February 2007 (4); Feija National Parc 3 March 2005 (2); Tinja 31 March 2005 (3); Monastir 2 April 2005 (1); Tunis 15 October 2005 (13); Ennahli Parc 1 February



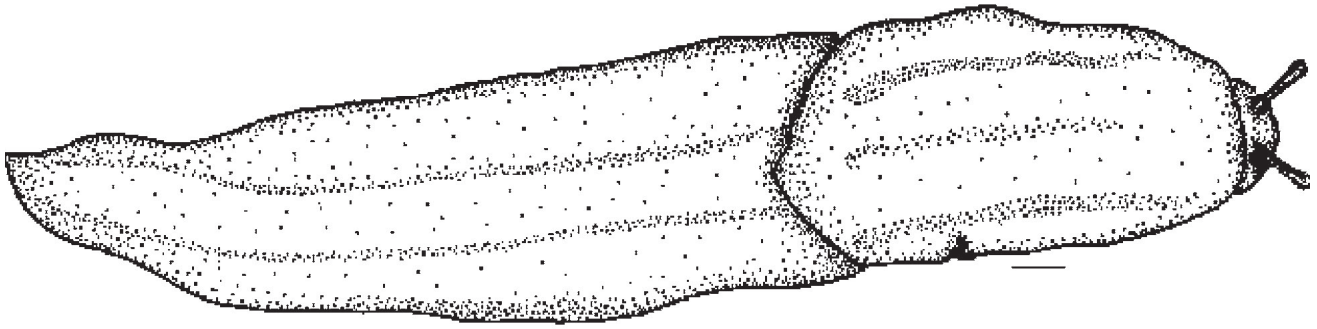
Figures 13–17 *Milax gasulli* (specimens from Zaghouan): external appearance (13), genitalia (14), distal genitalia (15), stimulator (16), inner part of the distal penis (17). Scale bar = 1 mm.

2007 (2); Zaghouan 27 February 2007 (9); Zembra 2 June 2007 (15); Aïn Errahma 8 April 2007 (2); Aïn Draham 11 May 2007 (3).

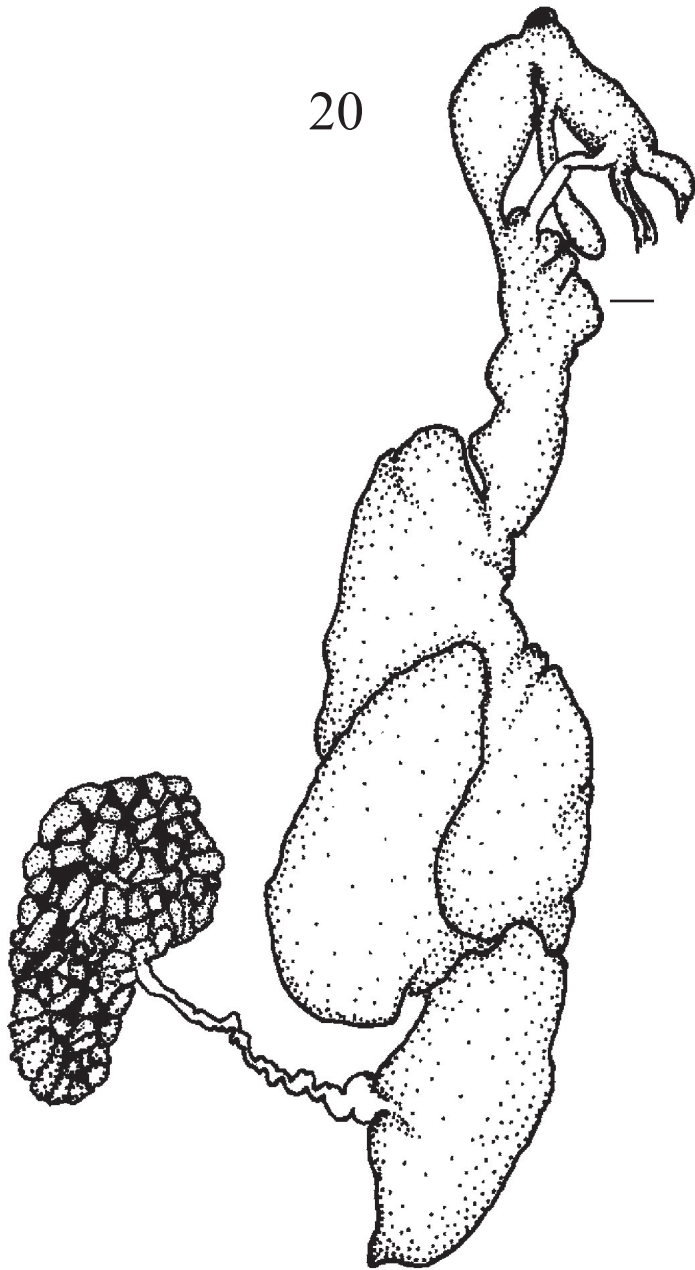
Description Body (Fig.18) medium-sized (50 to 60 mm fully extended), elongate with a short

keel at the tail; colouration pale grey to yellow-grey; two darker bands situated symmetrically either side of the median line; three parallel dark lines on mantle, the central one more or less indistinct and interrupted with centre of mantle often darker. Shell (Fig. 19) whitish transparent

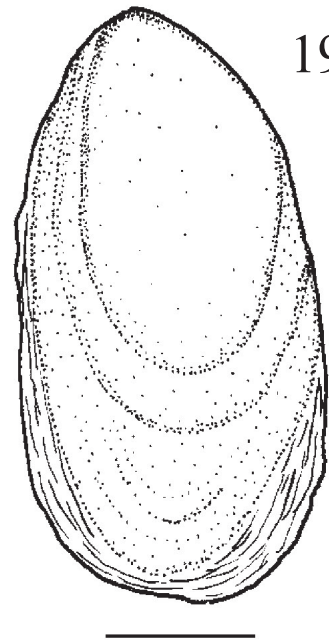
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Figures 18–20 *Lehmannia marginata* (specimens from Zaghouan): external appearance (18); shell (19); genitalia (20). Scale bar = 1 mm.

and iridescent, oval and thin, 3.9×2.42 mm in one example. Genitalia (Fig. 20) characterized by short vas deferens arising from the blunt apex of penis; at opposite side short conical appendix protrudes; penis cylindrical; vagina absent; bursa copulatrix oval in shape with a short duct (Quick, 1960; Wiktor, 1983; Nobre, 1930); ovotestis well developed.

Geographic range Central and western Europe. Not previously reported in Northern Africa.

Habitat Found in northern Tunisia with one station in the central part of the east coast and in Zembra oasis. Common at these sites on damp, clayey to calcareous soil under rocks.

Remarks *Agriolimax* (*Malacolimax*) *kervillei*, was introduced as a new species from Tunisia (Germain, 1907). It includes two varieties: var *fulva* Germain 1908 and var *picturata* Germain 1908. These were described as approaching *Lehmannia nyctelia* (Bourguignat 1861) but distinguished by having brown (rather than black) and single (rather than double) lateral bands, and with tentacles and mantle of a different form, as well as being a larger animals (Germain, 1908). Wiktor (1983) also considered *A. kervillei* to be a synonym of *Lehmannia nyctelia*. However, on the basis of the discovery of *L. marginata* in Tunisia it appears just as likely that *Agriolimax* (*Malacolimax*) *kervillei* is a synonym of *Lehmannia marginata*. It is not possible to eliminate entirely the possibility that *Lehmannia nyctelia* also occurs so further studies are needed to clarify the position.

Lehmannia melitensis (Lesson and Pollonera
1882)
Figs 21–25

Material examined Zaghouan, 17 February 2007 (4).

Description Body (Fig. 21) small (length: 20 to 30 mm; mantle length 9 to 10 mm), pale yellow to orange in colour without lateral bands; keel short and at the tail; shell (Fig. 22) well developed, thick, oval in shape and with nucleus laterally situated at posterior vertex. Genitalia (Figs 23–25) characterized by: very short vas

deferens entering tip of the penis laterally; penial retractor muscle ending near to the vas deferens; penial appendix longer than penis, arising from the opposite side of penis side by side with vas deferens; vagina absent; bursa copulatrix duct arising from distal; free oviduct as long as bursa copulatrix; ovotestis well developed (Lesson & Pollonera, 1882).

Geographic range Previously known from the Maltese Islands, Sicily and the Aeolian Islands (Giusti *et al.*, 1995).

Habitat Found at a single station in north-eastern Tunisia, in a wet natural habitat under calcareous rocks.

Comparison This species is reported here for the first time from Tunisia. In external morphology *Lehmannia melitensis* and *L. marginata* appear distinct. Internally they show similarities and may require further research to define reliable differences.

Genus *Limacus* Lehmann 1864

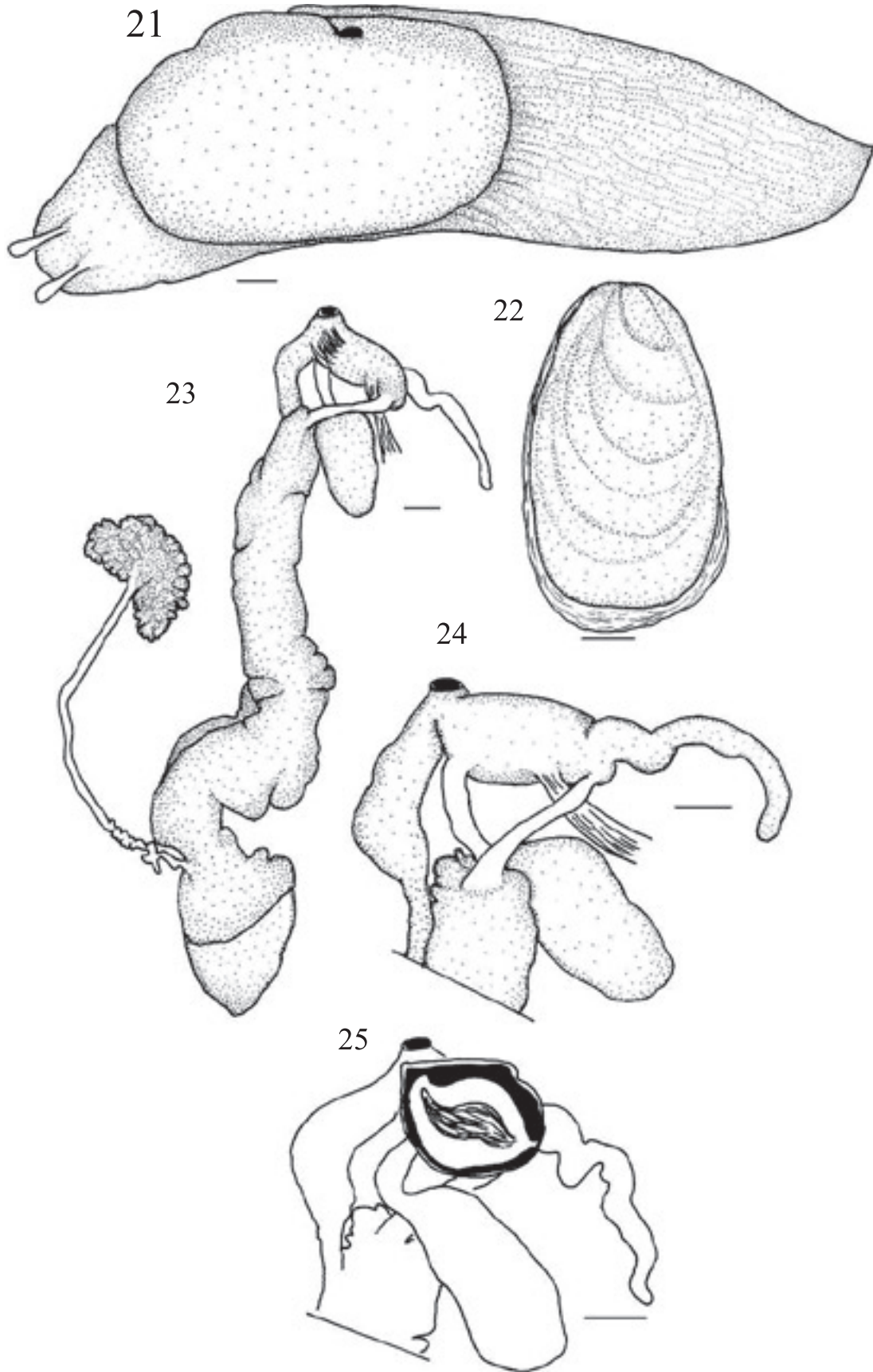
Limacus flavus (Linnaeus 1758)
Figs 26–28

Material examined Tunis 1 November 2006 (8); Zaghouan 16 December 2006 (2).

Description Body (Fig. 26) large (80 to up to 120 mm extended); grey in colour with pale dusky dorsum and obscure paler mottling on mantle; keel short and near the tail.

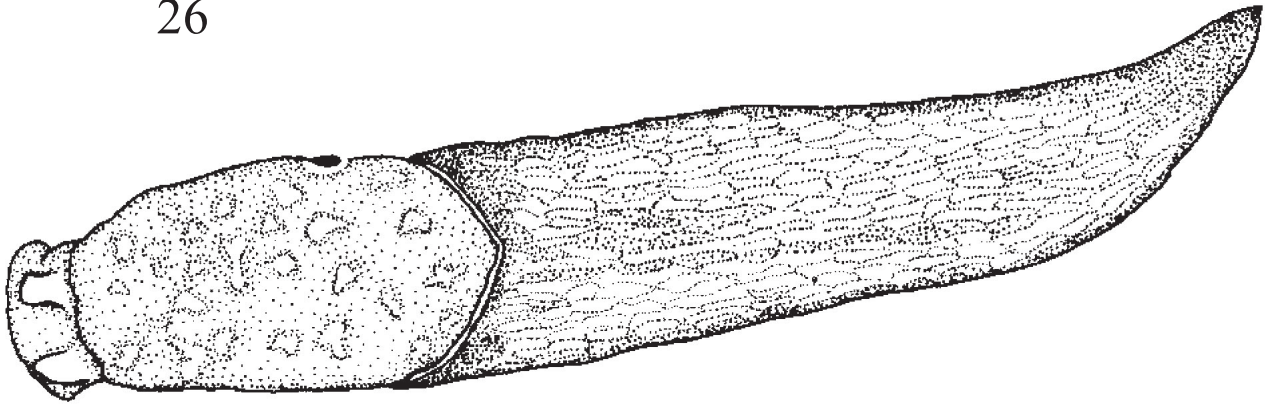
Genitalia (Fig. 27) characterized by: cylindrical penis, usually twisted on itself, measuring about 1/6 body length; penial retractor muscle ending at tip of proximal penis, side by side with vas deferens (Castillejo, 1998; Wiktor, 1989); true vagina present; bursa copulatrix duct arises from the vagina side by side with the free oviduct (not from the distal penis) (Giusti, 1973; Giusti *et al.*, 1995). Interior of proximal penis has series (4/6) of longitudinal, wavy, pleats; distal penis with an only one large fold (Fig. 28).

Geographic range Known from Algeria (Bourguignat, 1864b), most Mediterranean countries and western and northern Europe (Wiktor, 2001).

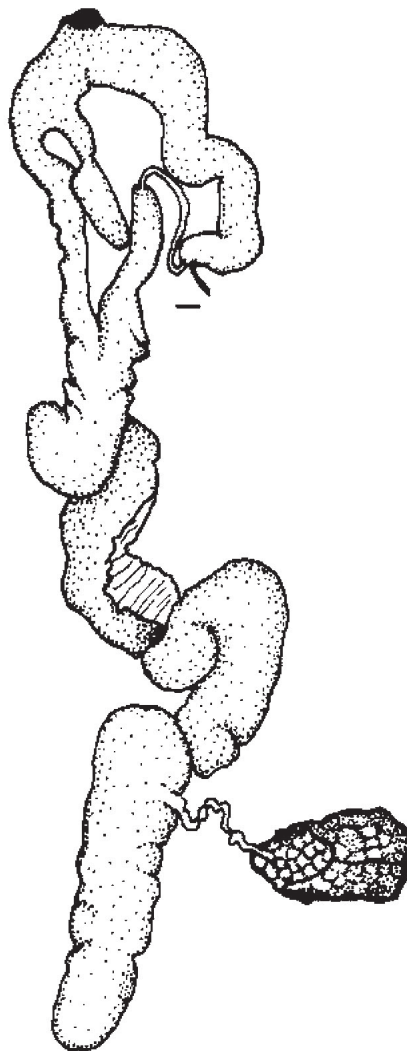


Figures 21–25 *Lehmannia melitensis* (specimens from Zaghouan): external appearance (21); shell (22), genitalia (23); distal genitalia (24); internal structure of penis (25). Scale bar = 1 mm.

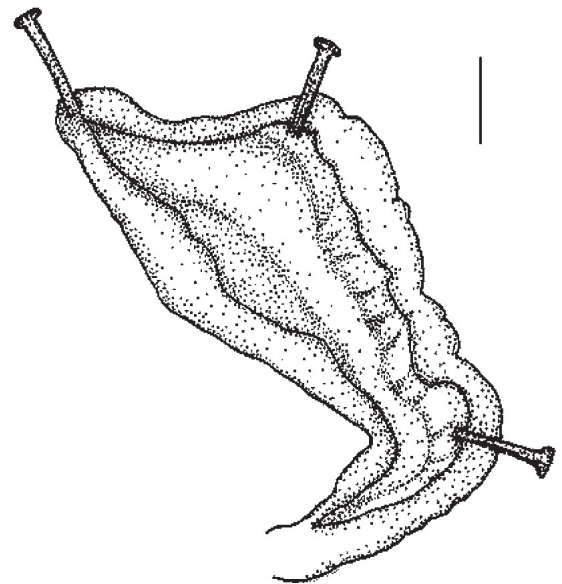
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28



Figures 26–28 *Limacus flavus* (specimens from Tunis): external appearance (26); genitalia (27); internal structure of penis (28). Scale bar = 1 mm.

Habitat Only recorded from north-eastern Tunisia and clearly synanthropic as it occurs in gardens and disturbed habitats.

FIELD KEY TO TUNISIAN SLUGS

1. Slug with a small, external, and posteriorly placed shell.....*Testacella fischeriana*
 Slug lacking an external shell.....2
2. Medium or large in size, keel extending along the whole back behind the mantle; body black to grey, unicolourous or spotted3
 Slug medium or large, but keel short and limited to the area near the tail.....5
3. Body large and dark, epidermis appearing rough; stimulator large with acuminate to rounded papillae on the inner side; spermatophore elongate, conical anteriorly
*Milax nigricans*
 Body smaller and paler, epidermis appearing relatively smooth; stimulator smaller, conical to flattened.....4
4. Stimulator narrow, elongate and recurved at apex, with a double row of pointed papillae or spines on the inner side; spermatophore short, cylindrical and covered with hooks*M. gasulli*
 Stimulator broader, shorter and smoother and with low or no papillae; spermatophore elongate, narrow anteriorly and cylindrical posteriorly, anterior part smooth*M. gagates*
5. Medium-sized, pale yellowish-grey to yellow-brown, dorsum without pale spots on a darker ground; body translucent, moderately convex.....6
 Large, ground colour brownish-grey with many irregular yellow spots, particularly on the mantle; body strongly convex
*Limacus flavus*
6. Ground colour greyish, dorsum with 2 lateral dark bands continuing onto the mantle
*Lehmannia marginata*
 Slug yellow-brownish and lacking lateral bands*L. melitensis*

DISCUSSION

Previous studies on the Tunisian malacofauna recorded 4 species of slugs (*Testacella bisulcata*, *Milax gagates*, *Milax gasulli* and *Agriolimax*

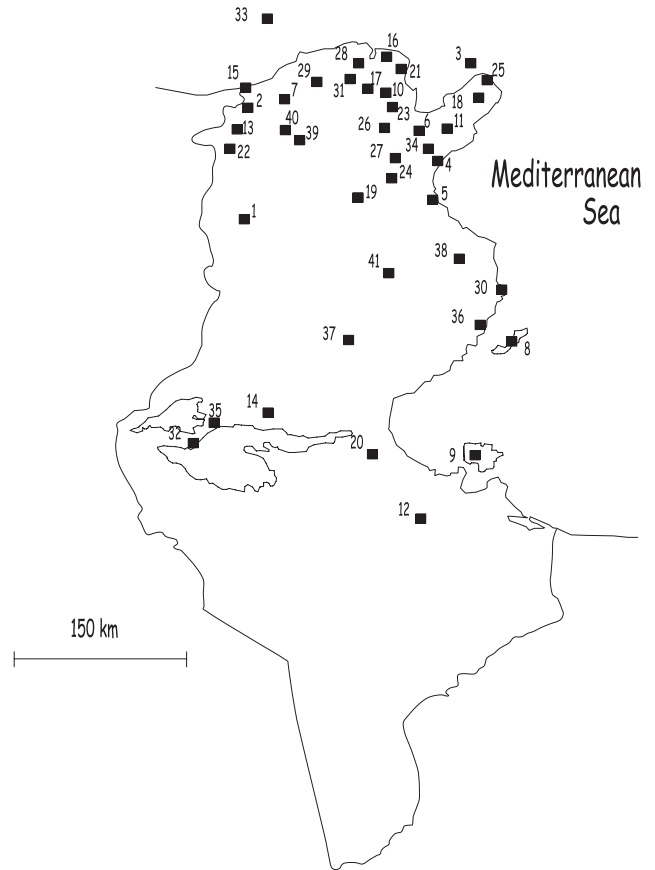


Figure 29 Map showing the location of sampling sites in Tunisia: 1: El Kef; 2: Aïn Draham; 3: Zembra isle; 4: Bouficha; 5: Aïn Errahma; 6: Djebel Resas; 7: Nefza; 8: Kerkennah isles; 9: Djerba isle; 10: Parc ennahli; 11: Barrage Lebna; 12: Medenine; 13: Beni Mtir; 14: Dghoumes oasis; 15: Tabarka; 16: Cap zebib; 17: Sidi Thebet; 18: Dar chichou; 19: Djebel Mansour; 20: Chenini oasis; 21: Ghar el Melh; 22: Fija National Park; 23: Tunis (Ibn khldoun); 24: Jouf; 25: Hawaria; 26: Oudhna; 27: Bir Bouregba; 28: Ichkeul National Park; 29: Matmata; 30: Monastir; 31: Mateur; 32: Tozeur oasis; 33: La Galite island; 34: Zaghouan; 35: Degueche oasis; 36: Sfa1; 37: Bouhedma National Park; 38: Kondaar; 39: Djebel El jouza; 40: Beja; 41: Sbukha.

(*Malacolimax kervillei*) of which *Testacella bisulcata* was probably a misidentification of *Testacella fischeriana*, and *Agriolimax (Malacrolimax) kervillei* placed in the wrong genus, probably corresponding to a *Lehmannia*.

Several species are here added to the fauna of Tunisia (*Milax nigricans*, *Lehmannia melitensis* and *Limacus flavus*) and an identification key to distinguish species is presented.

Most slug species appear to have restricted distributions. *Testacella fischeriana* was found only in areas with subhumid to humid climate. *Milax gagates* was found only in northern Tunisia where

the climate varies from semi-arid (in the east), to humid (in the west). *Milax nigricans* is the most widespread species, recorded in more than half of the sampling sites and appears able to tolerate the aridity prevailing inland, even in oases. *Milax gasulli*, *Lehmannia melitensis* and *Limacus flavus* were only recorded in north-eastern Tunisia. Finally *Lehmannia marginata* occurs in northern Tunisia and may be able to tolerate the semi-arid climate of shoreline habitats.

We note that the genera *Parmacella* found in Egypt (Pallary, 1909) and Algeria (Bourguignat, 1864b), and the various *Deroceas* recorded from southern Italy and Sicily, have not yet been recorded from Tunisia. Consequently, more field work is justified to determine the full distribution and complement of slugs in this area.

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