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Vexillata liomyos n. sp. (Nemata: Ornithostrongylidae) from *Liomys pictus* (Rodentia: Heteromyidae) from Mexico, with Comments on the Synlophe of *Vexillata armandae*

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VEXILLATA LIOMYOS N. SP. (NEMATA: ORNITHOSTRONGYLIDAE) FROM *LIOMYS PICTUS* (RODENTIA: HETEROMYIDAE) FROM MEXICO, WITH COMMENTS ON THE SYNLOPHE OF *VEXILLATA ARMANDAE*

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ABSTRACT: Individuals of a new species of *Vexillata* were collected from the small intestines of *Liomys pictus* from the Estación de Biología Chamela, in Jalisco State, Mexico. The new species shows an array of characters that allow us to recognize it as a member of *Vexillata*; however, it can be distinguished from other species of the genus in that males possess an asymmetrical caudal bursa, females possess a characteristic cuticular inflation at the level of the ovijector, and both sexes possess a synlophe with 9 ridges at the midbody. Additional detail of the synlophe of *Vexillata armandae* Gardner et al., 1994 from *Chaetodipus hispidus* in New Mexico shows that both sexes have 12 cuticular ridges just posterior to the cephalic inflation, and in the posterior region of the body, females have 9 ridges of equal size while males possess 11 equal-sized ridges. In both sexes, the carene disappears at the posterior end of the body.

Rodents included in the Geomyoidea originated in the New World and have a distribution restricted primarily to the Nearctic and northern Neotropical regions (Thenius, 1972; Kurtén and Anderson, 1980); however, the Tuza or Giant Pocket Gopher *Orthogeomys dariensis* (Goldman, 1912) (Geomyidae) and 3 species of *Heteromys* Desmarest (Forest Spiny Pocket Mice: Heteromyidae) occur in northern Colombia and Venezuela, respectively (Eisenberg, 1989). In South America, pocket gophers are restricted in distribution to the mountainous regions of extreme northern Colombia; however, the limits of the geographic range of this species are, at present, undefined (Eisenberg, 1989). Species of *Orthogeomys* Merriam were evidently restricted from moving further south into South America by extensive river drainage barriers running east–west. Geomyoids are relatively recent immigrants into the southern continent, having crossed into South America from the north after the emergence of the Panamanian land bridge beginning as early as 2.5 million yr ago (Marshall and Sempere, 1993).

Some data are available on the parasites of geomyoid rodents from the southern Nearctic and northern Neotropical regions; however, most of the available information concerns the trichostrongyloid nematode fauna of only *Heteromys* (see Durette-Desset, 1971; Yoyotte-Vado, 1972; Denke, 1977; Guerrero, 1984; Gardner et al., 1994).

At the present time, 9 species of *Vexillata* (Durette-Desset, 1970) have been described from Nearctic and Neotropical rodents. Typically occurring as parasites in the small intestines of rodents of the superfamily Geomyoidea (Hall, 1916; Travassos, 1937; Caballero and Cerecero, 1943; Caballero, 1958; Durette-Desset, 1971, 1978; Yoyotte-Vado, 1972; Denke, 1977; Guerrero, 1984; Gardner et al., 1994), these nematodes have recently been found to occur in Nearctic muroid rodents, *Peromyscus* (cf. *difficilis*), from the state of Hidalgo, Mexico (Falcón-Ordaz and Sanabria, 1997). In light of this recent finding in the transition zone between the Neotropics and the Nearctic regions, we examined more closely other geomyoid and muroid rodents from throughout Mexico for the presence of *Vexillata*.

Four of the 9 known species of *Vexillata* occur in Mexico, including *Vexillata vexillata* (Hall, 1916) that Durette-Desset (1970) reported from *Liomys pictus* (Thomas) in Chiapas State (Caballero, 1958), and *Liomys irroratus* (Gray) and *Peromyscus difficilis* (J. A. Allen) from Hidalgo State (Falcón-Ordaz and Sanabria, 1997), *Vexillata dessetae* Denke, 1977, and *Vexillata legallae* Denke, 1977 as parasites of *Heteromys desmarestianus* (Gray) (syn. *Heteromys lepturus*) from Veracruz State (Denke, 1977), and *Vexillata convoluta* (Caballero and Cerecero, 1943) from *Pappogeomys merriami* (Thomas) from Michoacán state in central Mexico.

Specimens of *Vexillata* collected from the small intestines of *L. pictus* in Jalisco state, Mexico, are reported in the present study. These individual nematodes could not be allocated to any previously known species of *Vexillata* and are described herein as a new species. Additional detail on the structure of the synlophe of *Vexillata armandae*, a parasite of *Chaetodipus hispidus* Baird, collected in New Mexico, is also described.

MATERIALS AND METHODS

Nematodes of *Vexillata* were collected in May and June 1993 and July 1994 at the Estación de Biología Chamela, a field station run by the Institute of Biology of the National Autonomous University of Mexico. The station is located in coastal Jalisco southwest of Guadalajara, between latitudes 19°22′–19°39′N and longitudes 104°56′ and 105°10′W. The vegetation of this region is dominated by tropical deciduous–dry forest interspersed with tropical semideciduous forest (Davis et al., 1997) (Fig. 1). Twenty-five specimens of *L. pictus* were collected and deposited in the voucher collection at the Estación de Biología Chamela. After capture in Sherman live traps, rodents were killed, and dissected. Nematodes were recovered by opening the small intestines with small blunt-nosed scissors and searching the mucosal side with a binocular dissecting microscope at approximately 5–15×. Nematodes recovered were placed in 8.5% saline, fixed in hot 70% ethanol, and stored in 70% ethanol. Specimens were cleared for study with lactophenol.

For examination of the synlophe, cross sections were made following Durette-Desset (1985) at anterior, middle, and posterior parts of the body. Because of the condition of these specimens, accurate drawings of the pattern of distribution of longitudinal ridges in regions of the body where ridges originated or disappeared was not possible. The following description is based on 14 male and 7 female nematodes. In *Vexillata*, individuals of all species possess, at about midbody, a left-lateral expansion of the cuticle termed the carene. CNHE refers to the Colección Nacional de Helmintos, National University of Mexico, Mexico City; HWML refers to the Harold W. Manter Laboratory of Parasitology, University of Nebraska, Lincoln. Drawings were made with a Wild microscope equipped with a drawing tube. Measurements were made using a Zeiss Ultraphot microscope and digital measuring soft-

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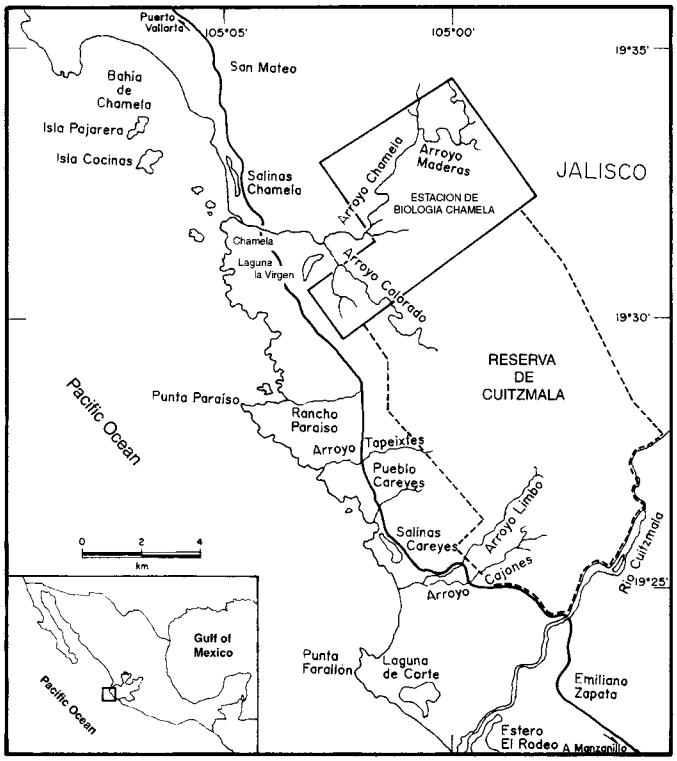
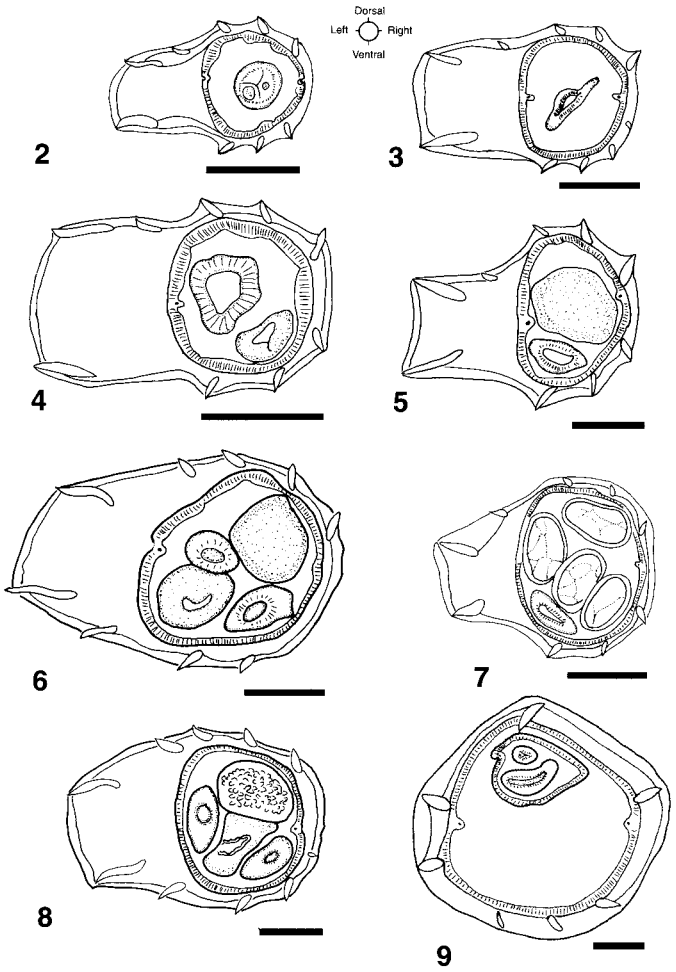


FIGURE 1. Map showing location of the Estación de Biología Chamela in the region of coastal Jalisco state, southwest of Guadalajara (between latitude 19°22′–19°39′N and longitude 104°56′ and 105°10′W). The vegetation in the region is dominated by tropical deciduous–dry forest interspersed with tropical semideciduous forest.



FIGURES 2–9. Synlophe structure of both male and female *Vexillata liomyos* n. sp. Orientation on the page is given by the compass at the center-top of the page. All scale bars represent 5 μm. **2.** Cross section of a male at the level of the esophagus. **3.** Cross section of a female just posterior to the level of the esophagus. **4.** Cross section of a male at midbody. **5.** Cross section of a female at midbody. **6.** Cross section of a male at the level of the proximate part of the spicules. **7.** Cross section of a female at the level of the uterus at about ¾ body length. **8.** Cross section of a male just anterior to the cloaca. **9.** Cross section of a female at the level of the ovijector showing cuticular expansion.

ware (Jandel Sigma Scan Pro). Measurements are given in micrometers (μm) unless otherwise indicated. For each character, sample size is provided (n), followed by range then mean and standard deviation in parentheses.

DESCRIPTION

Vexillata liomyos n. sp.

(Figs. 2–21)

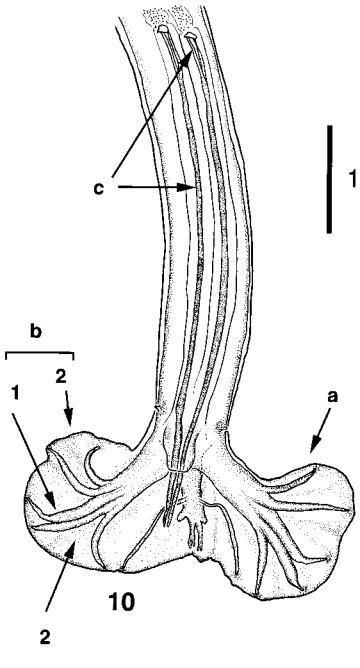
General: Nematodes of medium body size, coiled loosely, with well-developed carene. Females larger than males. Males with well-developed and slightly asymmetrical copulatory bursa. Females with a cuticular inflation at the level of the ovijector, straight tail, and body hooked anteriad just posterior to vulva.

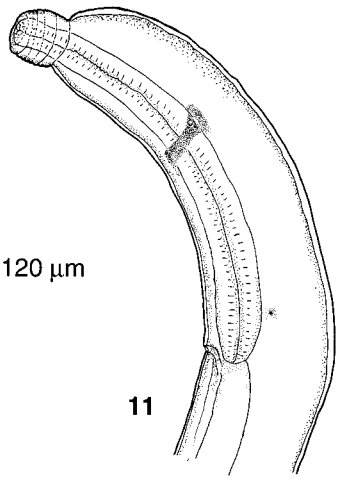
Synlophe: Ridges in both sexes arising just posterior to the cephalic inflation; 2 lateral-left ridges robust and extending to form a well-developed carene. Both males and females possess 9 cuticular ridges in the middle of the body, with 5 dorsal and 4 ventral. In anterior region, females with 10 ridges, 5 dorsal and 5 ventral (Fig. 3). In the posterior region, males with 10 ridges, 5 dorsal and 5 ventral (Fig. 8), and females with 7 ridges at the level of the ovijector, with 3 dorsal and 4 ventral (Fig. 9). No carene was observed at the level of the ovijector.

Male: Length n = 14, 3.85–8.55 mm, 6.62 mm (1.74 mm). Maximum diameter n = 14, 82–203, 140 (39.2). Cephalic inflation length n = 13, 23–73, 41 (12.8) long by 34–77, 46 (12) wide. Distance from anterior end to nerve ring n = 1, 223; to excretory pore n = 5, 252–374, 306 (47.2), and to deirids, n = 6, 196–350, 289 (59.2). Esophagus length n = 7, 303–393, 348 (31) by n = 6, 24–35, 28 (4) wide at base. Spicules equal in length n = 14, 481–837, 704 (142.3), alate and simple in structure. Gubernaculum well developed and cuticularized, located dorsal to spicules, length n = 10, 23–97, 52 (21.8) by n = 10, 19–34, 24 (5.5) wide in the middle. Genital cone length n = 5, 19–33, 25 (7).

Arrangement of rays of bursa typical of nematodes of the genus *Vexillata,* 2–1–2 identical in both bursal lobes with a lateral pair, a mediolateral ray, and a posterolateral pair (Fig. 10). Rays of left lobe similar in size. Externodorsal rays long and very slender. Dorsal ray with 2 short asymmetrical branches arising from main trunk starting just posterior of the middle of the dorsal ray with each branch ending in a single blunt terminus. Dorsal ray splitting into 2 symmetrical branches, each branch splitting into a fork with the terminal portions of unequal lengths and internal ray of each pair always shorter than external ray. Beneath the dorsal ray is observed a thin velum that originates at the terminus of the genital cone and ends at the border of the dorsal lobe. The bursa is slightly asymmetrical with the right lobe being rounded in form and slightly smaller than the left lobe. The left lobe is slightly larger.

Female (Figs. 11, 12): Monodelphic. Length n = 7, 7.70–15.10 mm, 10.31 mm (2.88). Maximum diameter n = 7, 60–194, 127 (40.7). Cephalic inflation length n = 6, 19–478, 166 (216.1) by n = 6, 13–48, 31 (11.8) wide. Distance from anterior extremity to excretory pore n = 4, 335–491, 401 (69.6) and to deirids n = 4, 335–447, 381 (48). Esophagus length n = 5, 409–525, 468 (47.5) by n = 5, 27–47, 35 (8) wide near base. Width of body at vestibule n = 7, 102–209, 159 (35). Vulva to tip of tail n = 7, 135–182, 159 (18) to anus n = 7, 29–64, 46 (11.5).





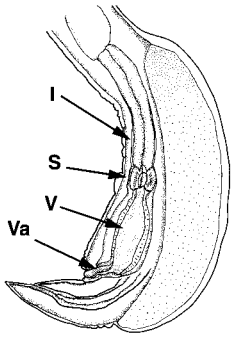
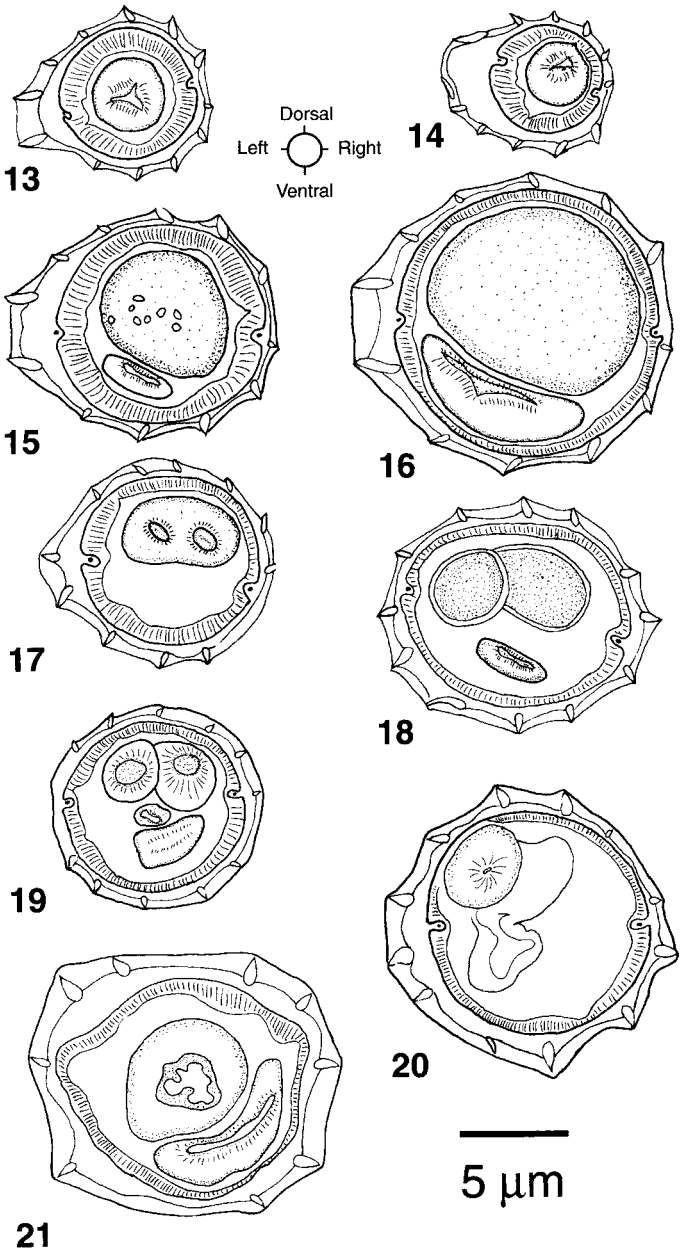


FIGURE 10. Drawing of the posterior end of a male of *Vexillata liomyos* showing the slightly asymmetrical copulatory bursa (**a**), the 2–1–2 arrangement of the bursal rays (**b**), the characteristic dorsal ray (**c**), and the setaceous spicules.

FIGURE 11. *Vexillata liomyos* n. sp. showing the anterior end of a male with cuticular inflation, nerve ring, and cephalic inflation. Note the position of the excretory pore and deirids (cervical papillae) at the level of the esophageal intestinal junction.

FIGURE 12. Drawing of the posterior end of a female of *Vexillata liomyos* showing the cuticular inflation and ovijector consisting of the infundibulum (I), sphincter (S), vestibule (V), and vagina (Va).



FIGURES 13–21. Synlophe drawings of *Vexillata armandae* Gardner et al., 1994, all representing cross sections. Orientation on the page is given by the compass at the center-top of the page. **13.** Anterior end (esophageal region) of male. **14.** Anterior end (esophageal region) of female. **15.** Midbody of male. **16.** Midbody of female. **17.** Posterior ¼ of body of male through the proximal parts of the spicules. **18.** Posterior ¼ of body of female through the uterus showing 2 eggs. **19.** Posterior end of male just anterior to the cloaca showing spicules. **20.** Posterior end of female in region of the infundibulum. **21.** Posterior end of female, just anterior to the vulva at the level of the vestibule.

Tail length n = 7, 56–185, 132 (39.4). Vagina vera length n = 7, 9–49, 30 (12.4); vestibule length n = 7, 94–127, 106 (11.8); sphincter length n = 7, 25–39, 30 (6.9), and length of infundibulum n = 7, 117–166, 139 (14.5). Approximately 60 eggs observed, egg length 50–74, 62 (5.1) long by 19–43, 37 (4.9) wide. Vulva located just anterior to ventral bend of tail.

Taxonomic summary

Host: Liomys pictus (Thomas, 1893).

Prevalence: Ten of 25 infected (40%).

Type locality: Estación de Biología Chamela, Municipio de la Huerta, Jalisco State, Mexico. 19°22′–19°39′N, 104°02′–105°10′W.

Specimens deposited: Holotype, male: CNHE catalog number 3911. Allotype female: CNHE catalog number 3912. Paratypes, 5 males and 1 female: CNHE catalog numbers (including whole worms and cross sections): 3913–3914; 8 males and 5 females, in 1 vial of 70% ethanol, Harold W. Manter Laboratory of Parasitology catalog number HWML15711.

Etymology: This species was named after the host (*L. pictus*) from which it was collected; *liomyos* meaning ''of *liomys.*''

Diagnosis

Species of *Vexillata* are characterized by having a relatively symmetrical copulatory bursa, well-developed lateral lobes, bursal ray arrangement 2–1–2, with ray 6 separated from ray 5, synlophe with well-developed carene, and an axis of orientation of the frontal type (Durette-Desset, 1971).

Currently, species of the genus are separated in 2 groups following Durette-Desset (1971, 1978) and later confirmed by Denke (1977) and Guerrero (1984). Group A is characterized by having 12 ridges in the synlophe in the middle of the body, the dorsal ray being divided at the midpoint of its length. This group includes *V. vexillata, V. convoluta,*

V. dessetae, *V. legallae*, and *V. armandae* Gardner, Fong, Al-Banna, and Raymond, 1994. Members of group B possess 11 ridges in the synlophe in the middle of the body, and the dorsal ray is divided at the distal end. This group is composed of *Vexillata petteri* Durette-Desset, 1970; *Vexillata chabaudi* Yoyotte-Vado, 1972; *Vexillata tejerai* Guerrero, 1984, and *Vexillata scorzai* Guerrero, 1984 (see Durette-Desset, 1970; Yoyette-Vado, 1972; Guererro, 1984).

Vexillata liomyos n. sp. was assigned to *Vexillata* because it presents all diagnostic characters of the genus; however, it can be placed in a group most closely allied with *V. vexillata*, *V. dessetae*, and *V. armandae* because they all possess a copulatory bursa with a dorsal ray with 2 conspicuous lateral projections in the middle of the length of the ray. *Vexillata liomyos* n. sp. is easily distinguished from them and the other congeners by having a synlophe with 9 cuticular ridges in the middle of the body in both males and females, with a variable number in other regions of the body in both sexes, i.e., in the anterior part, only females possesses 10 ridges, but in the posterior part, males possess 10 and females 7 ridges. In addition, males of *V. liomyos* have a slightly asymmetrical bursa, and females show a characteristic cuticular inflation at the level of the ovijector.

Comments on the synlophe of *V. armandae*

Gardner et al. (1994) described *V. armandae* from *C. hispidus* collected in eastern New Mexico, but they only presented the structure of the synlophe at the middle level of the body. Lichtenfels (1977) and Lichtenfels and Pilitt (1983a, 1983b) proposed that the synlophe of trichostrongyloid nematodes should be studied by making cross sections at different levels through the body. In spite of this proposal, most descriptions of these nematodes still lack adequate detail. We agree with this proposal because we found a high degree of variability in the number of ridges among both males and females at different levels of the body in several species of trichostrongyloid nematodes (Falcón-Ordaz, 2000). The examination of additional material of *V. armandae* gave us a chance to reanalyze the structure of the synlophe in this species, and we present our findings below, adding to the description of the synlophe of Gardner et al. (1994).

The synlophe in the anterior and middle region of the body in both sexes of *V. armandae* presents 12 cuticular ridges starting just posterior to the cephalic inflation; 5 ridges ventral, 5 dorsal, and 2 forming the carene (Figs. 13–18). In the posterior region of the body, males possess 11 (Fig. 19) and females possess 9 cuticular and equally sized ridges (Fig. 21). In both sexes, the carene disappears at the posterior end of the body (Figs. 19–21).

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