Anatomical description of a sample of *Scalenostoma subulatum* collected in Trindade Island, at middle Atlantic Ocean, as base for future revaluation of a wide-ranged species (Caenogastropoda, Eulimidae)

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ABSTRACT. Specimens identified as *Scalenostoma subulatum* were collected in Trindade Island, a remote Brazilian oceanic island at middle Atlantic Ocean. As the species is supposedly circumtropical, worldwide, as long as it is poorly known, a deep description of this sample is here performed, in order to allow further comparison with specimens from other distant geographic regions and oceans; since it is possible that several, similar-shelled species exist. The anatomical analysis of the samples revealed that this population is dioic, with intermediate level of simplification for parasitism. It lacks radular apparatus, intestine and anus, but has a well-developed acrembolic proboscis, long and narrow esophagus which ends branching into digestive gland. The remaining systems have expected characters for a caenogastropod, but the genital male ducts, pallial oviduct and nerve ring are relatively simple. The foot has three distinct regions, with a large and single anterior pedal gland opening at propodium tip.

INTRODUCTION

The eulimid *Scalenostoma subulatum* (Broderip in Sowerby, 1832: 61) is an extraordinary wide-ranged species. Samples identified as *S. subulatum* has been collected from Florida, USA, to Espírito Santo, Brazil, as well as in the Indo-Pacific region, as Australia, Philippines, Hawaii, etc., being mostly considered as circumtropical (Warmke & Abbott, 1961; Warén, 1980; Vokes & Vokes, 1983; Rios, 2009; Rosenberg, 2011). Additionally, a set of at least 16 nominal synonyms have been presented by the literature, as follows (in alphabetical order, with type locality in parenthesis): *Stylifer abbreviata* Mörch, 1875 (St. Thomas); *St. attenuata* Sowerby, 1878 (St. Thomas); *Melanella bibsae* Usticke, 1959 (St. Croix); *St. bulbiformis* Sowerby, 1878 (St. Thomas); *St. corallina* Petit, 1841 (Mauritius Is.); *St. cumingiana* Sowerby, 1878 (unknown); *St. deformis* Pease, 1867 (unknown); *St. exaratus* A. Adams, 1855 (Philippines); *St. fastigiata* Sowerby, 1878 (unknown); *St. deformis hawaiensis* Pilsbry, 1921 (Hawaii); *St. pyramidalis* Reeve, 1859 (not stated); *St. remotissimus* Pilsbry, 1921 (Hawaii); *St. solida* Sowerby, 1878 (unknown); *St. speciosus* H. Adams, 1869 (Mauritius); *St. subangulatus* A. Adams, 1855 (West Indies); *St. thomasiae* Sowerby, 1878 (St. Thomas); *St. variciferus* Hedley, 1899 (Funafuti). The species was described in the genus *Stylifer* Broderip 1832 (*St.*), and has as type locality *Indis Occidentalibus*, i.e., West Indies.

All this taxonomical and geographical information is only based on shells, as nothing beyond it is known. The shell, on the other hand, is somewhat malleable, possessing regional differences which have been interpreted as variations. Then the questions arise: Are actually all these samples of a single species? Is it possible that similar shelled species can be more restricted in their distribution, and we have not been able to separate them at present level of knowledge? With this scenario in mind, samples recently collected in Trindade Island, a Brazilian oceanic island located approximately at middle south Atlantic Ocean, have been identified as *Scalenostoma subulatum*. The main goal of this study is to perform an anatomical description of these specimens, in order to forthcoming compare with samples from other regions.

For this reason, no complete taxonomical treatment is giving herein, mainly in regard to the synonyms. They are maintained on standby up to more samples, mainly topotypes, being available.

MATERIAL AND METHODS

A complete list of examined specimens is given after description. They are fixed in 70% ethanol and dissected in ordinary techniques, with the specimens immersed in the fixative under stereo-microscope. For the specimen's extractions, a hole in the penultimate whorl was done, and the soft parts were extracted from it. All dissection steps were digitally photographed; all drawing were done with the aid of a camera lucida.

Abbreviations in the figures: **ap**, female aperture; **au**, auricle; **ce**, cerebral and pleural ganglia; **cg**, capsule gland; **cm**, columellar muscle; **cv**, ctenidial vein; **dg**, digestive gland; **di**, diaphragmatic septum;

eg, esophageal gland**es**, esophagus; **ey**, eye; **ft**, foot (mesopodium); **gi** gill; **he**, haemocoel; **hg**, hypobranchial gland; **ki**, kidney solid tissue; **mb**, mantle border; **ne**, nephrostome; **nr**, nerve ring; **op**, opercular pad; **os**, osphradium; **ov**, pallial oviduct; **pb**, proboscis; **pc**, pericardium; **pd**, penis groove; **pe**, penis; **pg**, pedal gland and its aperture; **pn**, pedal ganglion; **pp**, penis terminal papilla; **pr**, propodium; **py**, pallial cavity; **rm**, retractor muscle of proboscis; **ry**, rhynchostome; **sb**, subesophageal ganglion; **st**, gastric region; **su**, supraesophageal ganglion; **sv**, seminal vesicle; **sy** statocyst; **te** cephalic tentacle; **tg**, integument; **ts**, testis; **vd**, pallial vas deferens; **ve**, ventricle; **vg**, opened (groove) pallial vas deferens.
Institutional abbreviation: **MZSP**, Museu de Zoologia da Universidade de São Paulo.

SYSTEMATICS

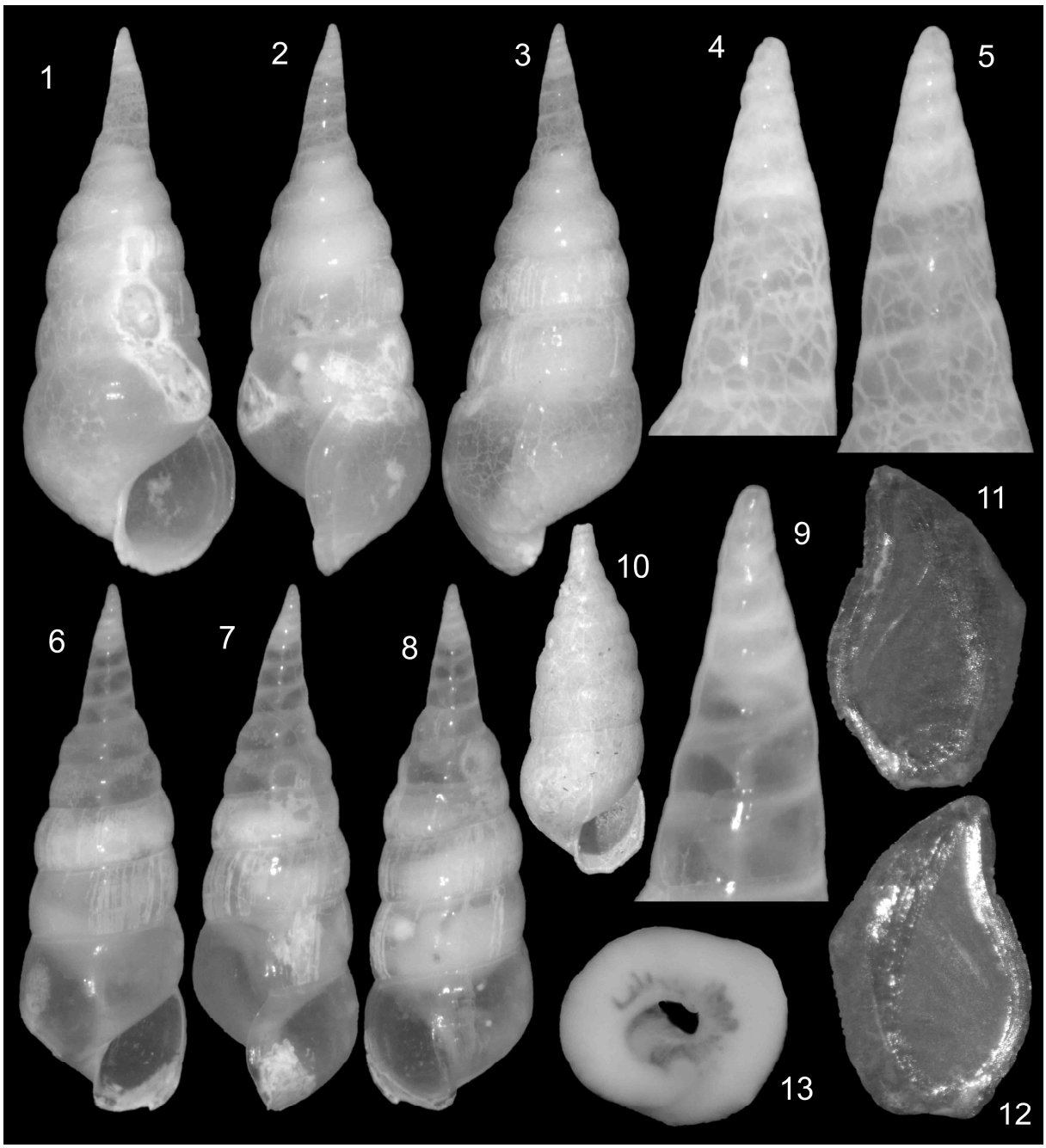
Scalenostoma subulatum (Broderip, 1832)
Figs 1-25

Synonymy: in analysis.

Description

Shell (Figs. 1-10) About 12 mm; outline somewhat turriform; width ~31-38% of total length. Color pure white, translucent; surface smooth, glossy. Outline clearly having two regions, superior region, including first 8-9 whorls, clearly slender; inferior region clearly wider, transition marked by slightly abrupt change of shell growth, as sudden increase of profile of whorls (Figs. 1-3, 6-10); superior (narrow) shell portion with width= ~40% of length, second (wide) portion with width ~60% of length. Protoconch of 1.5-2 whorls (Figs. 4, 5, 9), elongated, smooth; suture shallow; tip rounded; length ~160 µm, occupying ~3% of shell length and ~8% of shell width; limit with teleoconch unclear. Sculpture wanting, except for growth lines scantly seen as orthocline undulations (Figs. 6-7); surface glossy, smooth, shining. Profile of first 8-9 whorls almost planar to weakly convex, suture shallow (Figs. 4, 5, 9); remaining 4-5 whorls similar to preceding whorls, except for larger and more convex profile (Figs. 1-3, 6-8, 10); axis of first 8-9 whorls straight (Fig. 10), weakly arched (Figs. 1-2) or weakly sigmoid (Fig. 7). Axis of last 4-5 whorls straight; size of 4-5 last whorls augmenting gradually and uniformly (Figs. 1-3), somewhat same-sized (Fig. 10) or with some preceding whorl larger than next whorl (Figs. 6-7). Aperture elliptical (Figs. 1, 6, 10), width ~70% of length; outer lip orthocline, uniformly rounded, lacking notches (Figs. 2, 7), middle region widest; siphonal notch wide. Inner lip convex, its superior half weakly convex to straight, disposing ~45° with longitudinal shell axis; inferior half slightly concave, almost vertical positioned.
Head-foot (Figs. 14-18) Of almost 2 whorls, color pale cream. Head simple, barely convex, occupying ~80% of head-foot width. Each cephalic tentacle ~twice longer than wide, weakly dorso-ventrally flattened; tip rounded; located close from each other and to median line (Figs. 16, 18, 21). Propodium extending ~1/4 whorl anterior to head, somewhat cylindrical; anterior end planar, arched, with narrow pedal gland aperture in median-anterior region of anterior end (Figs. 15, 17: pg). Pedal gland large, located in anterior region of haemocoel, penetrating into pedal musculature in antero-dorsal region, gradually narrowing up to aperture (Fig. 15: pg). Mesopodium (Figs. 15-17: ft) weakly larger than propodium, simple, sole planar. Opercular pad somewhat thick, subterminal (Figs. 15, 16: op). Columellar muscle shorter than 1 whorl, stubby, located in mid-way between foot and posterior end of haemocoel (Figs. 14-16: cm). Haemocoel ~3-times longer than wide (Fig. 18), posterior region protruding beyond posterior insertion in columellar muscle because of long proboscis (Figs. 14, 15); proboscis and esophagus zigzagging inside longitudinal axis of haemocoel; nerve ring located in anterior region, close to head (Fig. 18: nr). Males with small penis originating just posterior to right tentacle (Fig. 14).
Operculum (Figs. 11, 12) Oval, horny, pale beige, translucent; occupying entire aperture. Superior end pointed, weakly curved inwards; inferior end rounded. Edges flexiclaudent. Outer surface opaque, nucleus terminal, located in inferior end; growth lines as undulations, disposed mostly parallel to inner margin. Inner surface glossy; scar oval, its superior region sharp pointed, its inferior region circular, occupying ~80% of entire surface.
Mantle organs (Figs 19, 20) Mantle border simple, relatively thick; no appendices or siphon. Cavity of 1.5 whorls. Osphradium ridge-like, with ~1/5 cavity length, ~10 times longer than wide; located at short distance from edge; anterior and posterior end rounded and similar sized. Gill elliptical, weakly curved (concavity left); anterior end bluntly pointed, posterior

Figures 1-13. *Scalenostoma subulatum* from Trindade Is., Brazil, general features
1. Specimen 108341♀, whole apertural view, female (specimen seen by translucence) (L 10.0 mm); **2**. Same, profile; **3**. Same, dorsal view; **4**. Same, detail of apex, apertural view; **5**. Same, dorsal view; **6**. Specimen 108341♂, apertural view (specimen seen by translucence) (L 9.5 mm); **7**. Same, profile; **8**. Same, dorsal view; **9**. Same, detail of apex, profile; **10**. Shell 108271, apertural view (L 10.7 mm); **11**. Operculum 108341♀, outer view (L 2.2, W 1.3 mm); **12**. Same, inner view; **13**. Visceral mass 108341♂, apical view (W 2.0 mm).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end rounded, ventral to pericardium; ctenidial vein narrow, with uniformly width along its length; gill filaments triangular, ~1.5 times wider than tall, tip of each filament in almost perpendicular angulation, rod wide. Hypobranchial gland thin, white, inconspicuous. Pallial oviduct or prostate running along right side.

Visceral mass (Figs. 13, 22) Of 2.5 whorls posterior to pallial cavity, keeping 5-6 apical shell whorls empty (Figs. 1-3, 6-9). Digestive gland white, occupying most of inner space. Gonad beige, lying along inferior region of columellar side (Fig. 13). No distinct stomach or intestine. Pericardium located reaching left-posterior side of pallial cavity, dorsal to gill (Fig. 20: pc). Kidney (ki) small, located as anterior-right end of visceral mass.

Circulatory and excretory systems (Figs. 20, 22) Pericardium (pc) relatively small, ~1/6 whorl, shorter than half of adjacent region of width of visceral mass; ~half reaching pallial cavity, dorsal to gill posterior end. Auricle (au) simple, located just posterior to gill. Ventricle (ve) located posterior and right to auricle, clearly thicker than auricle. Kidney simple, solid, white, slightly larger than pericardium; antero-posteriorly flattened. Nephrostome (ne) small, located in middle of membrane between kidney and pallial cavity.

Digestive system (Figs. 18, 21) Rhynchostome (ry) simple, transverse, located in ventral side between both tentacles. Proboscis (pb) ~1.5 times longer than haemocoel: width relatively uniform along its length, except for weakly broader anterior quarter, stored irregularly coiled inside haemocoel; walls thick muscular, thickness ~1/3 of entire width; inner surface (in retracted condition) with simple, uniform longitudinal folds. Single retractor muscle (rm) located at short distance from rhynchostome, narrow originated from right side of haemocoel. Transition proboscis-esophagus simple, marked by abrupt decrease, lacking any odontophore vestige. Esophagus ~twice longer than proboscis, stored intensely and irregularly coiled inside haemocoel, contouring proboscis; its width varying along its length apparently disordered, with some regions ~twice broader than others; walls relatively thick, thickness ~1/3 of entire width; inner surface simple, smooth. Small pointed glandular region (eg) located between anterior and middle thirds of esophagus. Esophagus passing through diaphragmatic septum (Fig. 18: di) at left and ventral to pericardium, gradually broadening in a gastric region (Fig. 22: st), ~1/3 whorl in length, bearing branches to digestive gland. No clear stomach, intestine, rectum nor anus.

Genital system. Male (Figs. 22, 23) Testis described above (Figs. 13). Seminal vesicle (sv) thick, with 3-4 coils, becoming vas deferens very narrow short distance before pallial cavity; 1/3 whorl after seminal vesicle, vas deferens crossing to pallial floor, running on its right edge up to right side of nuchal region (Fig. 14: vd, 23: vg), with abrupt curve to left, reaching penis base; vas deferens becoming furrow (instead of tube) in middle level of its pallial portion. Penis weakly longer than and ~2/3 tentacle's width, originated from middle level of right tentacle, at short distance from its base; penis ~5 times longer than wide, ~twice wider than thick; penis furrow relatively shallow, running along middle-dorsal region. Penis tip flattened, bluntly tapering, curved inwards dorsally, forming stubby papilla (pp); penis furrow widening in base of curved tip.

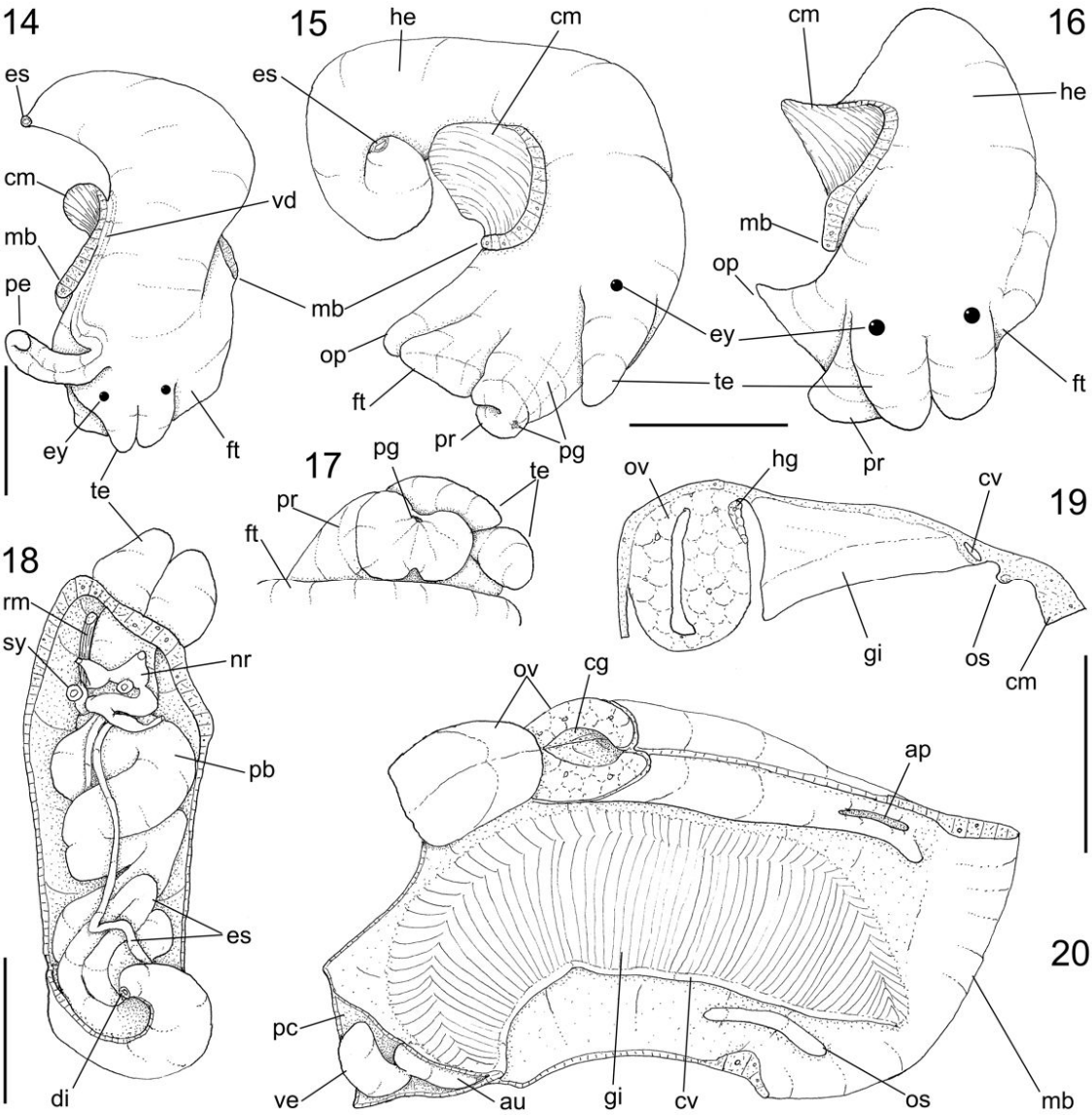
Female (Fig. 20) Visceral structures similar in location and size to those of male. Pallial oviduct (ov) relatively simple, entirely closed (tubular). Capsule gland (cg) white, occupying entirely pallial oviduct, except for short distance preceding female aperture (ap). Female aperture flanked by thin walls, as longitudinal slit, relatively simple, with small papilla anterior to it.

Central nervous system (Figs. 24, 25) Nerve ring located ventral to proboscis base (Figs. 18, 21: nr). Each cerebral ganglion (ce) with ~3 times broader than adjacent esophageal transverse section; oval, cerebral commissure ~half of each ganglion length. Right pleural ganglion indistinct from right cerebral ganglion; left pleural ganglion with ~half size of left cerebral ganglion, and located ventrally, very close to it. Pair of pedal ganglia (pn) of similar size and shape than cerebral ganglia. Statocysts (sy) with single statolith. Supra- and subesophageal ganglion with about same size as left pleural ganglion, located close to nerve ring, with indistinct connective. Connectives between three main ganglia very short, mostly discernible in right side.

Measurements (in mm) MZSP 108341 ♀= 10.0 by 3.8; ♂= 9.5 by 3.0; 108271= 10.7 by 3.8 (apex broken).

Figures 14-20. *Scalenostoma subulatum* anatomy

14. Head-foot, male, dorsal view; **15**. Same, female right view; **16**. Same, dorsal view; **17**. Same, detail of anterior region, ventral view; **18**. Head and haemocoel, ventral view, foot and columellar muscle removed; **19**. Pallial cavity roof, transverse section in middle level of osphradium; **20**. Same, ventral, inner whole view, adjacent pericardial region also shown, transverse section artificially done in oviduct. Scales= 1 mm.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Distribution Still debatable, officially the species is circumtropical, worldwide, but, as discussed below, it is possible that actually there are several similar-shaped species.

Habitat No detailed information about this on the examined specimens. They were collected under rocky bottoms, ~10 m depth, by scuba-diver. Species of the genus *Scalenostoma* has been referred as living into coral cavities (Chemnitz, 1795; Warén 1980), but this has not been confirmed here, as corals are rare in Trindade. However, possibly this species is not parasitic on corals, but on some echinoderm (Warén, personal communication).

Material examined BRAZIL. **Espírito Santo** (J. B. Mendonça col.); Ilha de Trindade, Orelhas Bay, 20°29'70.2"S, 29°20'32.9"W, MZSP 108271, 1 shell (30.v.2012); Enseada do Meio, 20°29'32.3"S, 29°20'32.6"W, MZSP 108341, 1♂, 1♀ (22.vi.2012).

DISCUSSION

Despite some anatomical information has been available in the literature (Warén, 1980, 1983), as the kind of operculum, acrembolic proboscis and lack of radula, no anatomical description or illustration of *Scalenostoma subulatum* has been so far published. The foregut of *S. lodderae* (Petterd, 1884) is schematically figured (Warén, 1980: 202, fig. 67), showing some similarities with that described herein (Fig. 21). The long and coiled-stored proboscis is similar, however, *S. lodderae* has a glandular sheath in anterior esophagus that is absent in *S. subulatum*. On the other hand, *S. subulatum* has a distinct glandular hump separating the anterior from middle esophagus (Fig. 21: eg), which is absent in *S. lodderae*. If these differences are indicative of specific or generic levels is difficult to interpret in the present juncture of knowledge.

In the modification level for simplification to parasitism, *Scalenostoma subulatum* appears to possess an intermediary degree. It lacks radular apparatus and odontophore, which are present in some more basal genera (Warén, 1983). It also lacks a clear gastric area, as well as intestine, pallial rectum and anus. These structures are present at least in *Annulobalcis aurisflamma* Simone & Martins (1995, fig. 24), and their absence indicate that the animal ingests only what it needs, lacking any excretions. Even the secretory system appears to be very simple (Fig. 22), indicating no hard effort to eliminate toxins, expected for cnidarian hunters. On the other hand, *S. subulatum* does not have the high degree of simplification of other eulimid genera (Warén, 1983), which entirely lack digestive system and other organs.

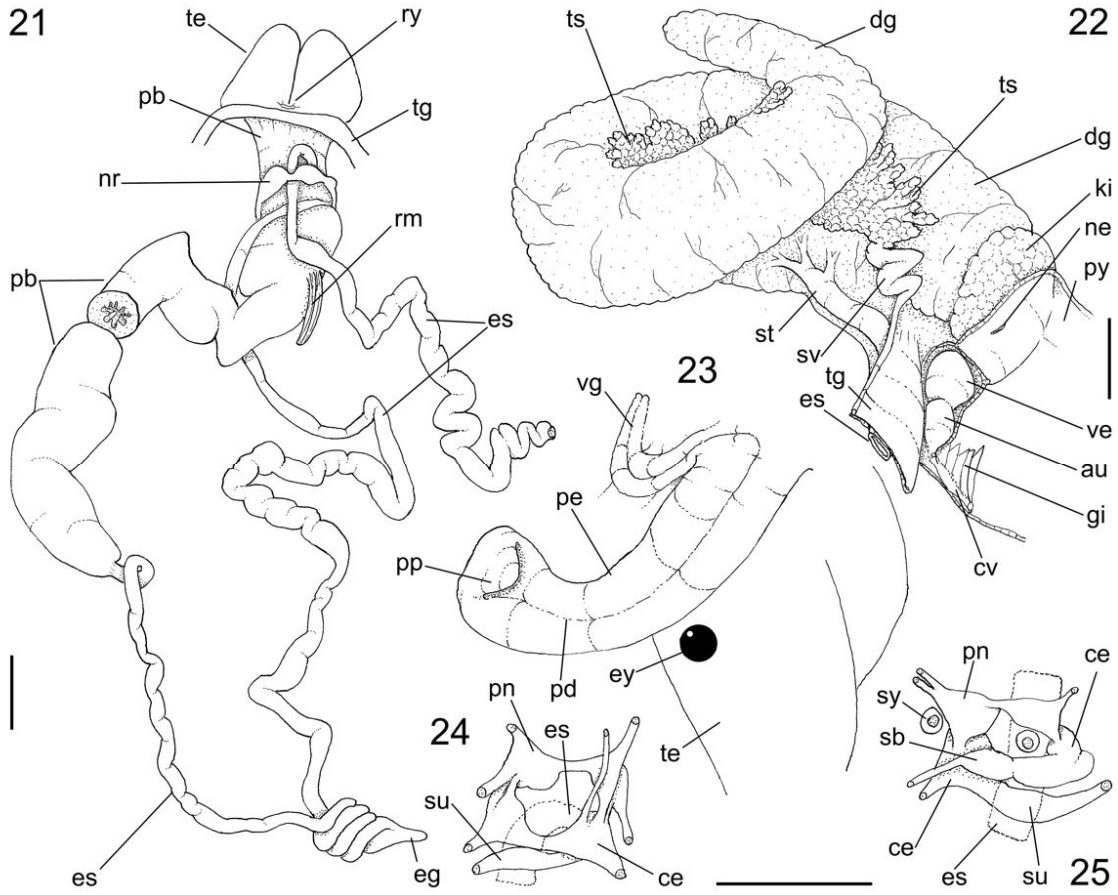
Beyond the mid- and hindguts, there are other structures that look somewhat simple if compared with other caenogastropods, such as the male and female genital systems [e.g., short seminal vesicle (Fig. 22: sv), lack of distinct prostate, lack of annexed gland in pallial oviduct (Fig. 20)], and in the central nervous system. In the former, the lack of distinct right pleural ganglion is a noteworthy feature, which possibly is fused with the right cerebral ganglion (Fig. 24). On the other hand, the complexity of the foot appears to be a distinction of the genus or species. The presence of a large propodial region (Figs. 15, 17), with an enormous (for a caenogastropod) and single pedal gland (pg) is remarkable. Besides, the current opening of the pedal gland of a eulimid is a slit between the propodium and mesopodium, its aperture in the propodium tip looks exclusivity. Besides, several small-sized eulimids also bear a posterior pedal gland, which is absent in *Scalenostoma*.

Complex structures in the penis are normally useful for eulimid taxonomy. That of *Scalenostoma subulatum* is, however, relatively simple, possessing only a stubby and curved terminal papilla. However, the presence of a well-developed male (Figs. 6-8) with the same size and shell-shape of the female (Figs. 1-3) precludes the possibility of the species to be a protandrous hermaphrodite, in such the narrow, initial phase could be masculine, and the wide, final phase could be feminine (Warén, 1983). As the males and females are same-sized and shaped, the indications are that they are currently dioic, at least in that studied region. However, based on the small sample, it is premature to conclude anything in definitive in regard to the species' sexuality.

Comparing the shell shape of the examined specimens (Figs 1-10), all collected in a same place, it is possible to show some small distinctions, but they appear to have a same general plan. This does not occur if the comparisons extend to supposed conspecific specimens from other distant regions (e.g., Warén, 1980: 201). As nothing beyond the shell has been known, it is a quite possible that actually those specimens belong to distinct species. The present paper brings the anatomical description at least from specimens from middle south Atlantic Ocean. The expectations are for the paper being used for further comparisons, in such additional anatomical differences can appear.

Figures 21-25. *Scalenostoma subulatum* anatomy

21. Foregut, ventral view, anterior structures of head-foot also shown, anterior region as in situ, remaining regions mostly deflected; **22**. Visceral mass, mostly ventral view, posterior region of pallial cavity also shown, floor of pallial cavity still connected and deflected to left, ventral wall of pericardium removed; **23**. Penis region, dorsal view, topology of adjacent structures of head also shown; **24**. Nerve ring, dorsal view, topology of esophagus also shown; **25**. Same, ventral view. Scales= 0.5 mm.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