

A NEW SPECIES OF *STREPTARTEMON* FROM SOUTHEASTERN BRAZIL (GASTROPODA: STREPTAXIDAE)

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Abstract A new species of *Streptartemon* Kobelt, 1905 land snail from Santos, SE Brazil, is herein described as *Streptartemon waukeen* sp. nov., from specimens originally found in an urban garden. The new species is distributed along coastal urban areas from southern Espírito Santo state to São Paulo state. It can be diagnosed from its congeners by the following features: a comparatively small shell; the penultimate and body whorls bulging and rounded; a small and roughly circular aperture; and the lack of apertural lamellae/teeth. The new species also presents a bursa tract diverticulum, which is a plesiomorphic state in stylommatophoran snails, but absent in most streptaxid genera. Further details of the genital anatomy, as well as DNA barcoding information, are provided.

Key words anatomy, barcoding, COI, *Eupulmonata*, *Streptartemon waukeen* sp. nov., *Stylommatophora*.

INTRODUCTION

The family Streptaxidae is comprised of carnivorous pulmonate land snails, being distributed mainly throughout South America, Africa and tropical Asia, with a fossil record dating back to the Late Cretaceous of Europe (Zilch, 1960; Rowson *et al.*, 2010; Sutcharit *et al.*, 2010). The Asian and African branches of this family are reasonably well studied (e.g., Degner, 1934; van Bruggen, 1967, 1975; Gerlach & van Bruggen, 1999; Siriboon *et al.*, 2014a, 2014b), including published molecular phylogenies (Rowson *et al.*, 2010; Sutcharit *et al.*, 2010). The Neotropical branch of streptaxids, however, remains largely understudied (Sutcharit *et al.*, 2010), with the most recent comprehensive revisions being more than a century old (Tryon, 1885; Gude, 1902).

In any event, Streptaxidae is the fifth most diverse family in Brazil, represented by 54 species belonging to the subfamily Streptaxinae (Salvador, 2018, 2019). Rio de Janeiro state, in SE Brazil, seems to be something of a hotspot for streptaxids, with 18 of the 54 known Brazilian species occurring there, nine of which are endemics (Simone, 2006; Birckolz *et al.*, 2016; Salvador, 2018).

The genus *Streptartemon* Kobelt, 1905 counts with 16 species in Brazil, being almost exclusively distributed in the north and northeast regions of the country (Simone, 2006; Birckolz *et al.*, 2016). The southernmost records of the genus stem from Bahia and Mato Grosso do Sul

states (respectively, Simone, 2006; Salvador *et al.*, 2018). Outside Brazil, the genus is reported from Bolivia and northern South America, namely Colombia, Venezuela, Guyana, Suriname and French Guiana (Massemin *et al.*, 2009; Sutcharit *et al.*, 2010; Delannoye *et al.*, 2015). Furthermore, there are reported introductions to some Caribbean Islands (Delannoye *et al.*, 2015; Breure *et al.*, 2016).

Recent occasional collections in urban gardens in Santos municipality (São Paulo state, southeast Brazil) have recovered some specimens of *Streptartemon*. To our surprise, after a careful analysis we concluded they represent a new and yet unnamed species, which we describe herein.

MATERIAL AND METHODS

The collected material consisted in both dry shells and live specimens deposited in the malacological collections of Museum of New Zealand Te Papa Tongarewa (MNZ; Wellington, New Zealand), Museu de Zoologia da Universidade de São Paulo (MZSP; São Paulo, Brazil), and Museu Nacional do Rio de Janeiro (MNRJ, Rio de Janeiro, Brazil). All live specimens were fixed and preserved in 98% (MNZ) or 70% ethanol (MZSP and MNRJ). One paratype (juvenile specimen) had a small section of the foot clipped for molecular study. DNA extraction was conducted with DNeasy® Blood & Tissue Kit (QIAGEN N.V.), following standard protocol. The circa 650 bp fragment of the barcoding mitochondrial COI gene was targeted using primers LCOI and HCOI (Folmer

et al., 1994). The PCR protocol used included the following steps: (1) initial denaturation at 96°C (2 min); (2) 35 cycles of: (2a) denaturation at 94°C (30 s); (2b) annealing at 48°C (1 min); (2c) extension at 72°C (2 min); (3) final extension at 72°C (5 min). PCR products were quantified via agarose gel electrophoresis, cleaned following standard ExoSAP-IT™ protocol (Affymetrix Inc.), and Sanger sequenced. Resulting sequences were assembled and quality checked in Geneious Prime (v. 2019.0.3, Biomatters Ltd.), and then uploaded to NCBI GenBank.

The following abbreviations are used herein.

Collection data: coll.=collector; sh=dry shell(s); spm=whole specimen(s). **Shell measurements:** D=greatest width of shell (perpendicular to H); H=shell length (parallel to shell axis); W=number of whorls. **Anatomical features:** ag=albumen gland; at=atrium; bc=bursa copulatrix; bd=bursa copulatrix duct; bt=bursa tract diverticulum; ep=epiphallus; fc=fertilization complex; gd=gametolytic duct; gs=gametolytic sac; hd=hermaphroditic duct; ov=oviduct; pe=penis; pm=penial protractor muscle; pr=prostate gland; ps=penial sheath; rm=penial retractor muscle; so=spermoviduct; sp=spine(s); sv=seminal vesicle; va=vagina; vd=vas deferens. Nomenclature for genital anatomy follows Barker (1999); the terms 'proximal' and 'distal' refer to position in relation to the atrium.

SYSTEMATICS

Family Streptaxidae Gray, 1860
Genus *Streptartemon* Kobelt, 1905
Streptartemon waukeen sp. nov.
(Figs 1–2)

ZooBank reg. nr. EB5A1CED-C842-4A44-841B-66F27B8C0810

Streptartemon cookeanus: Rodrigues *et al.*, 2016: 40, fig. 2E; Alexandre *et al.*, 2017: 34, fig. 2P.

Holotype MNZ M.328633, C.M. Cunha coll., 03/vi/2016 (Fig. 1A–C).

Paratypes All from type locality, MNRJ 23448, C.M. Cunha coll., 17/viii/2019 (2 sh +3 spm [dissected]); MNZ M.328634 (1 spm, juvenile) and MNZ M.328632 (12 sh; Fig. 1D–H), C.M. Cunha coll., 03/vi/2016; MZSP 150702, C.M. Cunha coll., 17/viii/2019, (3 sh +3 spm [dissected]).

Type locality Brazil, São Paulo state, Santos municipality, Ponta da Praia, 23°59'11.69"S 46°17'53.20"W (small urban garden area, under rocks).

Etymology The specific epithet, used in apposition, refers to Waukeen, a fictional goddess from the Forgotten Realms campaign setting of the Dungeons & Dragons role-playing game. Waukeen is the patron of commerce and civilization. The name alludes to the fact that the new species was found in the heart of the busiest port city in Latin America.

Diagnosis Shell small; penultimate and body whorls bulging and rounded; aperture small and roughly circular; apertural lamellae/teeth absent.

Description Shell (Figs 1A–H) small, globose, with bent in coiling axis towards final whorls; apex flattened. Color beige to ochre. Protoconch (1½ whorl) smooth; transition to teleoconch marked by clear arrested growth line. Teleoconch generally smooth, except for growth lines and irregular eventual thickened lines of growth arrest. Suture narrow and deep. Whorl outline convex; penultimate and body whorls start to bulge and change coiling axis, resulting in a seemingly bent shell with a laterally dislocate body whorl. Aperture rounded; callus usually present and weak. Peristome lightly thickened and deflected. Umbilicus narrow, deep and partially covered by peristome.

Body (Figs 1I–K) Pale yellow to bright yellow; ommatophora and dorsal region behind the head colored bright orange. Body long and narrow; ommatophora long; eye small.

Genital system (Fig. 2) **Atrium** (at) long, about the same as width as penis and vagina. **Penis** (pe) with tick muscular wall; internal surface armed with longitudinal folds housing small black spines (sp) ("hooks" in Schileyko, 2000). **Penial sheath** (ps) with muscular wall, with smooth internal surface, and about the same length as penis. **Penial protractor muscle** (pm) long and thin, originating near genital orifice wall and inserting posteriorly in the edge of penial sheath. **Penial retractor muscle** (rm) long, about 3 times as wide as penial protractor muscle, originating at body wall [or diaphragm] and inserting at junction of penis and vas deferens. **Vas**

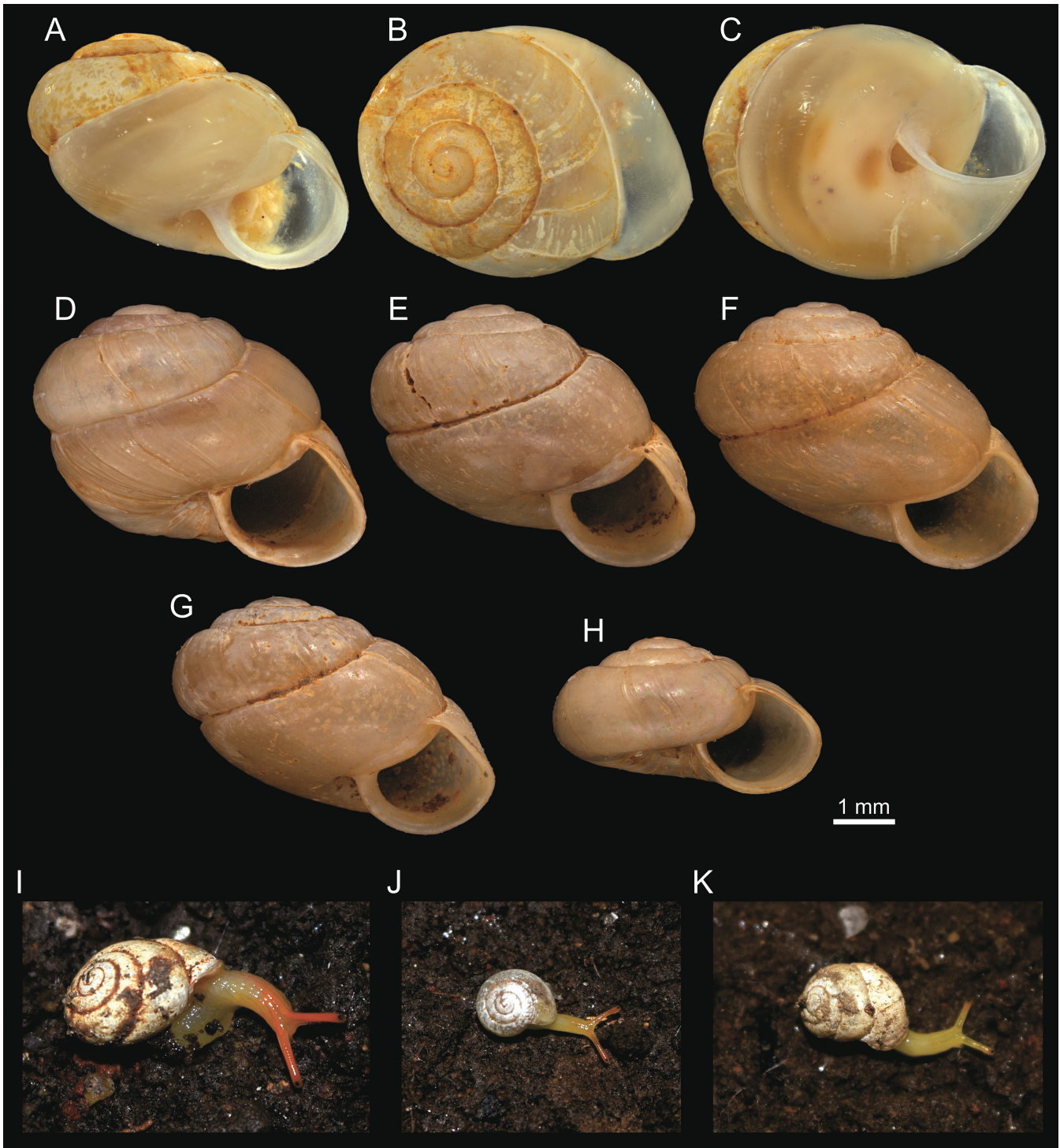


Figure 1 *Streptartemon waukeen* sp. nov. **A–C.** Holotype MNZ M.328633; © MNZ (Te Papa). **D–H.** Paratypes MNZ M.328632 (H shows a juvenile shell); © MNZ (Te Papa). **I–K.** Live specimens photographed in the laboratory (J shows a juvenile, and K shows the unusual yellow-bodied individual).

deferens (vd) slender, originating at the end of epiphallus, distally entering penial sheath, running free inside the penial sheath chamber until near proximal end; then, it makes a U-turn and becomes immersed in the penial sheath's wall

and increasing about twice in diameter. Vas deferens leaves penial sheath distally and runs posteriorly as a free duct that inserts in the anterior end of prostate gland. **Epiphallus** (ep) spherical, about half width of penis and very short. **Vagina**

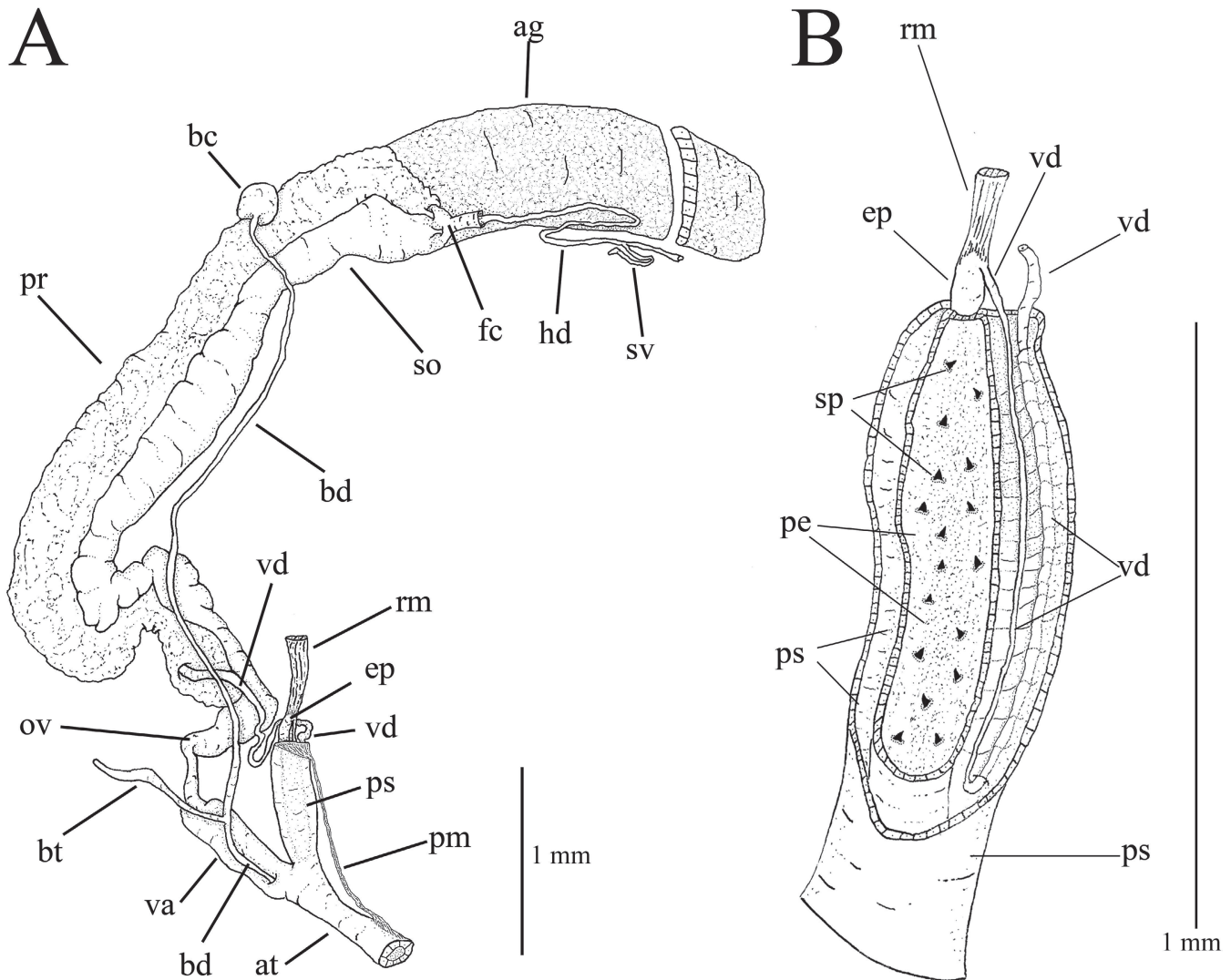


Figure 2 Genital anatomy of *Streptartemon waukeen* sp. nov. **A.** Genital system in dorsal view, with albumen gland sectioned transversally (to show its thickness). **B.** Detail of the penis in dorsal view, sectioned longitudinally.

(va) stout, about half the length of penis. **Bursa copulatrix** (bc) ovate, about same width as penial sheath. **Bursa copulatrix duct** (bd) long and tubular, extending as far as albumen gland. **Bursa tract diverticulum** (bt) blind-ended tube, about same width as bursa copulatrix duct and less than $\frac{1}{4}$ of bursa copulatrix duct's length. Free **oviduct** (ov) long and thick. **Spermoviduct** (so) enlarged and folded. **Prostate gland** (pr) occupying about the same volume as and bound to spermoviduct. **Fertilization complex** (fc) thick and muscular, proximally located as a continuation of spermoviduct and prostate gland, distally originating a hermaphroditic duct. **Hermaphroditic duct** (hd) long, narrow and slightly convoluted tube running ventrally along albumen gland; bears a single small seminal vesicle. **Seminal vesicle**

(sv) elongated, sac-like, about same width as hermaphroditic duct, but much shorter. **Albumen gland** (ag) solid, white, elliptical and about three times longer than large.

Molecular data COI barcode (paratype MNZ M.328634), GenBank reg. nr. MN967080.

Shell measurements Holotype: W = $4\frac{3}{4}$; H = 4.3 mm; D = 5.6 mm. Mean (n = 12): W = $4\frac{3}{4}$ (max 5, min $4\frac{1}{2}$); H = 4.5 ± 0.3 mm (max 5.1, min 4.2); D = 5.3 ± 0.3 mm (max 5.8, min 4.9).

Occurrence Brazil. **Espírito Santo state**; Guarapari municipality: photograph (1 sh, C. Henckes coll.; Conquiliologistas do Brasil, 2019). **Rio de Janeiro state**; Rio de Janeiro municipality: literature record (Universidade Federal do

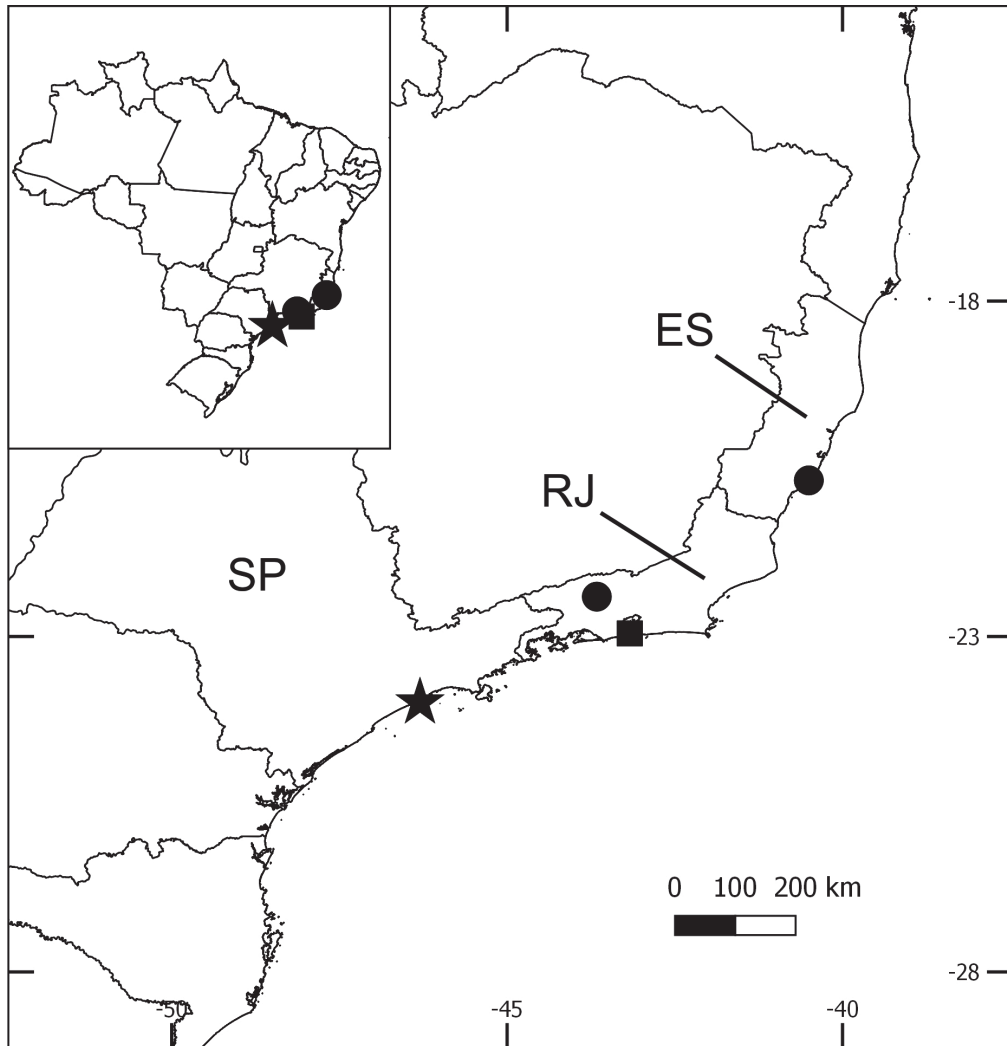


Figure 3 Map of SE Brazil showing the occurrences of *Streptartemon waukeen* sp. nov. Star=type locality; square=literature record; circles=online records (approximated locality). Abbreviations: ES: Espírito Santo state; RJ, Rio de Janeiro state; SP: São Paulo state.

Estado do Rio de Janeiro, Urca campus, G.L. Alexandre *et al.* coll. 2015–2016; Rodrigues *et al.*, 2016; Alexandre *et al.*, 2017); Vassouras municipality: photograph (1 sh, city center, A.F. Diogo coll. ix/2010; Santos, 2011), photograph (1 sh, city center, R. Santos coll. 02/xi/2010; Santos, 2011), photograph (1 spm, city center, 16/i/2011). **São Paulo state**; Santos municipality: types.

Distribution Along coastal urban areas from southern Espírito Santo state to eastern São Paulo state (Fig. 3).

DISCUSSION

Even though the present specimens have been found in an anthropically disturbed area, we are confident it has enough distinct features to

be considered a hitherto undescribed species. *Streptartemon waukeen* sp. nov. can be readily distinguished from its congeners based on the lack of apertural barriers on the shell. The presence of two or three apertural barriers (including an elongated parietal lamella) is deemed to be the norm in this genus (Zilch, 1960; Schileyko, 2000).

Streptartemon waukeen sp. nov. displays a reasonable degree of conchological variability: from shells with more bulging whorls and a larger aperture (Fig. 1D) to shells diagonally elongated and with a narrower D-shaped aperture (Fig. 1F). It is worthwhile to note that shells of juvenile specimens (Fig. 1H) lacking the final diagnostic whorls can be easily confused with other juvenile streptaxids and also with adult Scolodontidae. Furthermore, while the body is

usually yellow with bright orange ommatophores and head (Figs 1I–J), a single adult specimen presented a fuller yellow coloration, with only the very tip of the ommatophores being orange (Fig. 1K).

Conchologically, the most similar species is *S. cookeanus* (Baker, 1914), which also lacks apertural barriers. However, *S. waukeen* sp. nov. is nearly half the size of *S. cookeanus*, also having more bulging and rounded penultimate and body whorls. This marked and non-overlapping difference in size has been shown to be a useful diagnostic feature in other Brazilian streptaxids (Salvador *et al.*, 2018). Furthermore, *S. glaber* (L. Pfeiffer, 1849), a species commonly introduced elsewhere (Delannoye *et al.*, 2015), is of similar size to *S. waukeen* sp. nov.; however, it is less bent laterally and has a small parietal tooth, being easily distinguishable from *S. waukeen* sp. nov.. It also lacks the diverticulum (see below).

The genital anatomy of *Streptartemon waukeen* sp. nov. (Fig. 2) is in line to what has been described for *S. deplanchei* (Drouët, 1859) and *S. glaber* (Baker, 1926; Tillier, 1980; Schileyko, 2000) and other South American streptaxids. Given that the latter's description of *S. glaber* is very brief, and the lack of information from most other species, it is presently not possible to define what consists valuable taxonomic characters. In any event, features of the reproductive system of Streptaxidae (including the widespread penial armature consisting of spines/hooks) have not been deemed good taxonomical characters by previous researchers (e.g., Sutcharit *et al.*, 2010). Nevertheless, one anatomical character is worth mentioning: the bursa tract diverticulum.

The bursa tract diverticulum is present in several lineages of stylommatophoran snails, and this is considered a plesiomorphic state (Barker, 2001; Koene & Schulenburg, 2005; Beese *et al.* 2006, 2008). *Streptartemon waukeen* sp. nov. has a bursa tract diverticulum (Fig. 2). However, the diverticulum is absent in most Streptaxidae genera, Neotropical or otherwise (Schileyko, 2000, 2018; Chaijirawong *et al.*, 2008; de Winter & Vastenhout, 2013; Simone, 2013; Siriboon *et al.*, 2013, 2014a; Páll-Gergely *et al.*, 2015; Inkhavilay *et al.*, 2016), including *S. glaber* (Baker, 1926; Schileyko, 2000). It has only been observed in *S. deplanchei* (Tillier, 1980), which is similar to *S. waukeen* sp. nov., and in the genus *Hypselartemon* Wenz, 1947 (Barbosa *et al.*, 2008). In the latter

genus, the diverticulum is proportionately wider and longer than in *S. waukeen* sp. nov.

Even though we have sequenced the barcoding region of the COI gene of *S. waukeen* sp. nov., there is no data on other congeners for meaningful comparison. The only barcoded species is *S. extraneus* Haas, 1955 (GenBank Reg. Nr. HQ328175) from the work of Rowson *et al.* (2010). The similarity between the COI sequences of *S. waukeen* sp. nov. and *S. extraneus* is only 72.0%, which is a low value but not unusual for supposed congeners in stylommatophoran lineages (e.g., Breure & Romero, 2012). In any event, more meaningful comparisons will have to wait until more molecular-grade material of this species and its congeners becomes available.

The present records represent the southernmost occurrences of the genus *Streptartemon* in South America. The regions where *S. waukeen* sp. nov. was found in Espírito Santo, Rio de Janeiro and São Paulo states (Fig. 3) are all urban areas. Alexandre *et al.* (2017) reported this species as one of the most abundant in their study area, alongside the achatinoid snail *Subulina octona* (Bruguière, 1789). Rodrigues *et al.* (2016) reported that the species was found feeding on *Subulina octona*.

Even though it is surprising to find a new species inside a large city, it is not unprecedented. Another land snail, although an operculate one, was recently described from a park within the megalopolis of São Paulo (*Adelopoma paulistanum* Martins & Simone, 2014), less than 100km away from Santos. Surveys in urban areas are typically neglected and deemed unimportant, but it has been repeatedly shown that for invertebrate taxa, several new discoveries still await in those settings (e.g., Martins & Simone, 2014; Hartop *et al.*, 2015, 2016); this might be even more exacerbated in tropical environments. Urban parks and gardens might act as refuges inside cities, so it has been suggested that these places might require a different and more focused kind of conservation measure (Simone, 2015) that still allows public access and recreation.

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