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Ophiotaenia karipuna n. sp. (Eucestoda: Proteocephalidae), a parasite of *Erythrolamprus miliaris* (Linnaeus, 1758), with redescription of *Ophiotaenia arandasi* (Santos and Rolas, 1973) from the Brazilian Amazon

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ABSTRACT

Ophiotaenia is the most diverse genus among proteocephalids, composed of species commonly found parasitizing snakes worldwide. However, the diversity of *Ophiotaenia* in the Neotropical region is still underestimated. This study describes *Ophiotaenia karipuna* n. sp. found parasitizing *Erythrolamprus miliaris* in the State of Amapá, Brazil. Additionally, we redescribe *Ophiotaenia arandasi* based on a re-examination of type series and newly collected material from *Erythrolamprus taeniogaster* in the State of Pará, Brazil. The new species differs from its congeners in the following characteristics: scolex width, number of testes, relative length of the cirrus–sac, absence of a vaginal sphincter, presence of a vestigial apical organ resembling a sucker, and relative size of the ovary in relation to the surface of the proglottid. Furthermore, we provide taxonomic information for *Ophiotaenia arandasi* not reported in the original description, including morphology of embryophore, uterine development, and the absence of the vaginal sphincter in the species. *Ophiotaenia karipuna* n. sp. represents the 21st- species described in snakes -from the Neotropical region and the first formally described in the Brazilian Amazon. Additionally, we provide the first ultrastructural analysis, a new host, and locality records for *O. arandasi*.

1. Introduction

Ophiotaenia La Rue, 1911 is a polyphyletic genus belonging to the family Proteocephalidae La Rue, 1911 commonly found parasitizing reptiles and rarely amphibians worldwide (de Chambrier et al., 2021; Scholz et al., 2023a). The genus comprises about 20 species described in snakes from the Neotropical region. Two of them, namely *Ophiotaenia arandasi* (= *Proteocephalus arandasi*) (Santos and Rolas, 1973) and *Ophiotaenia hyalina* Rudin, 1917 are parasites of *Erythrolamprus miliaris* (= *Liophis miliaris*) (Linnaeus, 1758) from Brazil (Ammann and de Chambrier, 2008).

The taxonomic validity of *Ophiotaenia arandasi* has been under debate. Santos and Rolas (1973) originally described *O. arandasi* from *Erythrolamprus miliaris* in the State of Rio de Janeiro, Brazil. The authors did not provide details of important characters for a reliable species diagnosis, such as the presence or absence of a vaginal sphincter and the morphology of the eggs. The lack of information on these characteristics led de Chambrier et al. (2021) to consider *Ophiotaenia arandasi* as a *species inquirenda*. However, (de Chambrier et al., 2023; Scholz, 2023b) provided a worldwide list of *Ophiotaenia* species and considered *O. arandasi* valid. Therefore, the analysis of the type series of this species is still essential to define the validity of the species and differentiate it from its congeners.

Although the Neotropical region has the richest fauna of proteocephalids, most studies focus on fish parasites, while the diversity of reptile parasites remains underestimated (Rego, 1994; de Chambrier et al., 2004, 2015; Alves et al., 2017, 2021). Thus, we propose a new species of *Ophiotaenia* parasitic in *E. miliaris* (Dipsadidae) in the State of Amapá, Brazil, based on light and scanning electron microscopy (SEM). Additionally, we provide a redescription of *Ophiotaenia arandasi*

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parasitizing *Erythrolamprus taeniogaster* (Jan, 1863) in the -State of Pará, Brazil, representing the first ultrastructural analysis, a new locality and host record for this species.

2. Materials and methods

During a parasitological survey, one specimen of *Erythrolamprus miliaris* was manually collected in the "Parque Municipal Natural do Cancão" in the municipality of Serra do Navio, State of Amapá, Brazil (00°54′09.5"N 052°00′18.2"W). Additionally, four specimens of *E. taeniogaster* were collected from the Federal University of Pará (UFPA), municipality of Belém, State of Pará, Brazil (1°28′24.62"S; 48°27′25.43"W). The specimens were transported to the laboratory, where they were euthanized by injection of sodium thiopental, dissected, and examined for the collection of parasites.

The cestodes found were washed in saline solution (NaCl 0.9%) and fixed in heated 70% ethanol. For the morphological study, the cestodes were stained with Carmine acetic, differentiated in 1% hydrochloric alcohol, neutralized in alkaline alcohol, dehydrated in an increasing ethanol series, clarified in methyl salicylate, and mounted in Damar gum as permanent preparations. Some proglottids were sectioned transversely with the aid of a scalpel and mounted on slides for analysis of the longitudinal internal muscles. The eggs were immersed in distilled water and, after 24 h, were mounted on slides and clarified with 10% lactophenol. The slides of the cestodes and eggs were examined under an Olympus BX41 light microscope (Olympus, Tokyo, Japan) with a drawing tube attached and scanned using CorelDraw software.

For scanning electron microscopy (SEM) analysis, two scoleces and a portion of the strobila from both species were post-fixed in 1% OsO_4 and dehydrated in an increasing series of ethanol (30%–100%). The samples were then dried in a CO_2 critical point apparatus, mounted on metal stubs coated with gold–palladium, and examined using a Vega 3 electron microscope (TESCAN, Brno, Czech Republic) in the Laboratory of Structural Biology (LBE – ICB), at the Federal University of Pará (UFPA), Brazil.

We found specimens of *O. arandasi* in freshly collected host specimens of *Erythrolamprus taeniogaster*. Thus, we re-examined the type-series of *O. arandasi* deposited in the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC), State of Rio de Janeiro, Brazil (holotype: CHIOC 30827; paratypes: CHIOC 30830 a-b), for morphological comparisons and redescription of the species.

The morphological measurements of the specimens are presented as the values of the holotype and range in parentheses (reported in micrometers, except where indicated). Abbreviations used in the description: n = number of proglottids counted in parentheses.

3. Results

3.1. Redescription of Ophiotaenia arandasi (Santos and Rolas, 1973) (Figs. 1 and 2)

Syn: *Proteocephalus arandasi* (Santos and Rolas, 1973)

Type host: *Erythrolamprus miliaris* (Linnaeus, 1758) (Squamata: Dipsadidae)

Additional host: *Erythrolamprus taeniogaster* (Jan, 1863) (Squamata: Dipsadidae)

Type locality: São João de Meriti, State of Rio de Janeiro, Brazil (22°46′33.26"S; 43°21′38.90"W)

Additional localities: Federal University of Pará, Belém, State of Pará, Brazil (1°28′24.62"S; 48°27′25.43"W)

Site of infection: large intestine.

Prevalence of infection: Ophiotaenia arandasi was found in 3 out of the 4 specimens examined, with a prevalence of 75%.

Vouchers: CHIOC 40426 a-p deposited in the Helminthological -Collection of the Oswaldo Cruz institute– Rio de Janeiro, Brazil.

Description *(Based on five complete specimens newly collected and three specimens from the material deposited in the Collection of the Oswaldo Cruz Institute: CHIOC 30827; CHIOC 30830 a-b)*.

All the measurements of the specimens from the present study, the re-examination of the type series, and the data provided in the original description are given in Table 1. Proteocephalidae, strobila acraspedote, anapolytic. Immature proglottids wider than long to longer than wide, mature, pregravid and gravid proglottids much longer than wide.

Scolex with four lobes bearing spherical, uniloculated suckers directed laterally. Apical organ absent (Fig. 1A and 2A, B). Short neck (Fig. 1A). Scolex covered by numerous capilliform filitriches that gradually disappear along the neck (Fig. 2A–E).

Internal longitudinal musculature formed by numerous isolated muscle fibers. Two pairs of slightly sinuous osmoregulatory channels, located between testes and vitelline follicles. Ventral channels with thin walls, wider than the dorsal ones (Fig. 1F and G).

Testes medullary, oval to spherical, forming two lateral fields

Table 1
– Morphological and morphometric characters of *Ophiotaenia arandasi* parasite of *Erythrolamprus* spp. analyzed in the present study with new collected specimens, re-examination of the type-series and the original description by Santos and Rolas (1973).

Characteristics	*Ophiotaenia arandasi* Santos and Rolas (1973)		
	(present study)	(CHIOC 30.827, 30.830 a-b) (re-examined)	(Santos and Rolas, 1973)
Host	*E. taeniogaster*	*E. miliaris*	*E. miliaris*
Locality	Bélem, Pará (Brazil)	São João de Meriti, Rio de Janeiro (Brazil)	São João de Meriti, Rio de Janeiro (Brazil)
Total length	20–70mm	ND	80mm
Scolex width	361–431	315–478	390
Diameter of suckers	160–215	190–239	190
Apical organ	Absent	Absent	Absent
Neck width	231–315	263–331	ND
Neck length	526–947	421–605	ND
W/L of testes	15–36 × 17–36	32–43 × 31–45	30–40 × 30–40
Number of testes	50–105	41–90	70
W/L cirrus–sac	133–200 × 32–40	106–173 × 34–68	130 × 50
Relative size of cirrus–sac[a]	39–57%	35–45%	ND
Position of genital pore[b]	24–39%	27.1–39%	1/3
W/L ovary	66–186 × 117–269	106–247 × 160–289	ND/280
Relative size of ovary[c]	4.5–5.2%	4.7–5.5%	ND
W/L Mehlis' gland	24-50 × 24–68	24-52 × 34–68	ND
Position of vagina	Posterior/ anterior	Posterior/anterior	Posterior/anterior
Vaginal sphincter	Absent	Absent	ND
Poral vitelline follicles[d]	77–94%	78–89%	ND
Aporal vitelline follicles[e]	78–89%	83.5–89%	ND
Uterine diverticula	43–61	ND	ND
Uterine development	Type 1	Type 1	ND
hyaline outer envelope	22–52	ND	ND
Embryophore	17–26	ND	ND
Oncosphere	14–17	ND	ND

ND: not determined.
W/L, width/length.
[a] Ratio of the cirrus–sac length to the proglottid width (in %).
[b] Ratio of the genital pore position to the proglottid length (in %).
[c] Ratio of the ovary surface to the proglottid surface (in %, according to de Chambrier et al., 2021).
[d] Length of lateral band of vitelline follicles on poral side/proglottis length.
[e] Length of lateral band of vitelline follicles on aporal side/proglottis length.

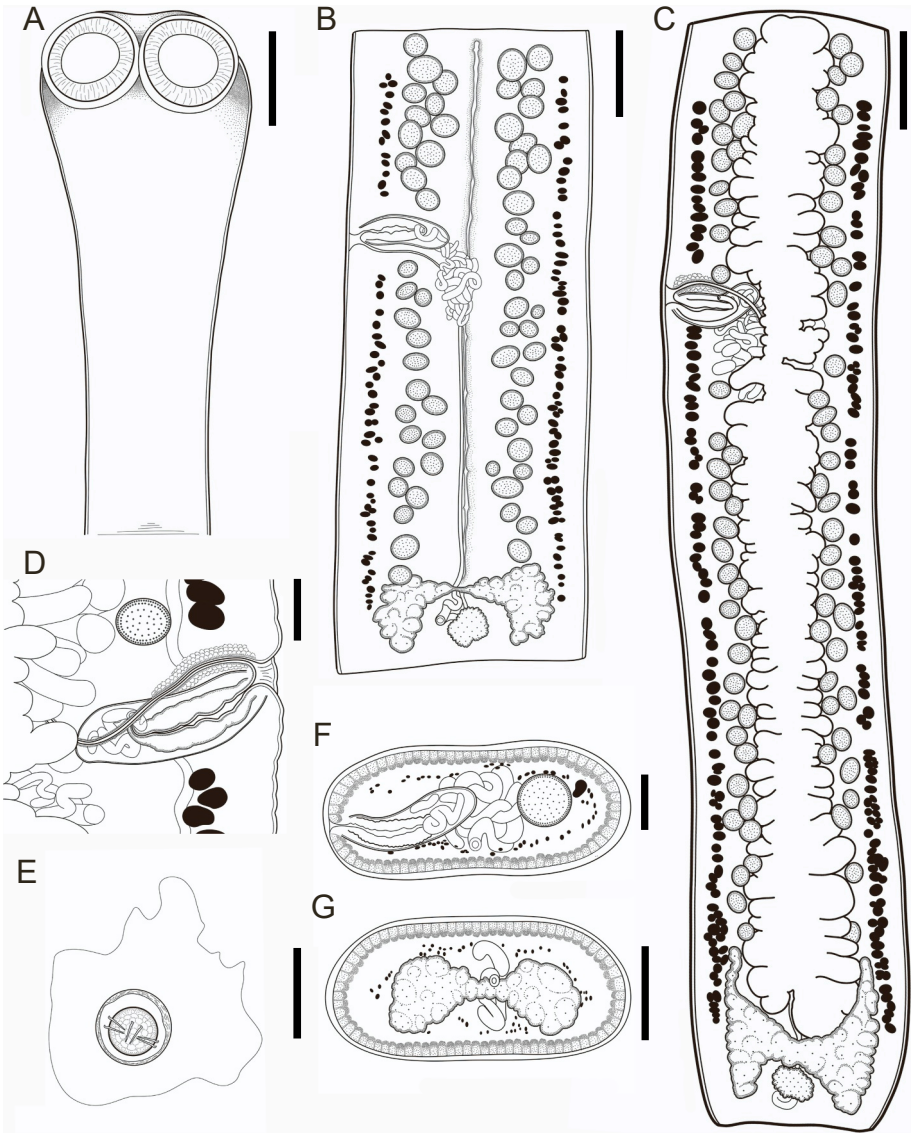

Figura 1. Line drawings of *Ophiotaenia arandasi*. A, scolex, frontal view. B, mature proglottid. C, gravid proglottid. D, terminal genitalia, ventro–dorsal. E, fully formed egg with fully developed embryonic hooks in the oncosphere. F–G, sections at the level of the cirrus–sac and the ovary, respectively. *Scale–bars:* A, C 200 μm; B 100 μm; D 100 μm; E 25 μm; F, G 100 μm.

converging in the anterior region. Testes fields located between anterior margin of proglottids and extending posteriorly to reach the ovary; not overlapping osmoregulatory channels and cirrus–sac, absent at level of uterine stem. Vas deferens strongly coiled, crossing midline of proglottid, occupying a large area (Fig. 1B and C). Large piriform cirrus–sac, almost all of them reach the midline of the proglottids (Fig. 1D). Narrow genital atrium. Genital pores irregularly alternating, located pre-equatorial from anterior margin of proglottid length (Fig. 1B and C).

Ovaries medullar, butterfly-shaped, near the posterior margin of the proglottids (Fig. 1B and C). Vagina anterior or posterior to cirrus–sac, vaginal sphincter absent (Fig. 1B–D). Vitelline follicles oval, located in dorsal region, arranged in two lateral longitudinal bands on each side of proglottids, not reaching their anterior and posterior margins (Fig. 1B and C).

Vitelline follicles absent at level of cirrus–sac and vagina (Fig. 1D). Vitelline bands present on poral and aporal sides (Fig. 1B and C). Uterus medullar narrow and long, not reaching the margin posterior of proglottids, also not extending beyond the ovarian isthmus. Type 1 uterine development. Testes also present in gravid proglottids. Gravid proglottids with few lateral diverticula. Spherical intrauterine eggs, thin and hyaline outer envelope. Embryophore with two layers; spherical oncosphere, and six embryonic hooks (Fig. 1E).

3.1.1. Remarks

The *Ophiotaenia* species differ by scolex width, number of testes, relative size of the cirrus–sac, presence of the apical organ and vaginal sphincter, position of the genital pore in relation to the anterior margin of the proglottid, and relative size of the ovary in relation to the surface of the proglottid (de Chambrier et al., 2021).

Among the 32 known Neotropical species found in amphibians and reptiles, *Ophiotaenia arandasi* immediately differs from all its congeners found parasitizing anurans by the relative size of the cirrus–sac (35–45% in *O. arandasi* vs. <32% in *Ophiotaenia* spp. from anurans). Furthermore, based on the absence of an apical organ, *Ophiotaenia arandasi* resembles 11 species from Neotropics: *O. barbouri* Vigueras, 1934, *O. calmettei* Barrois, 1898, *O. euzeti* (de Chambrier, Vaucher and Renaud, 1992), *O. flava* Rudin, 1917, *O. habanensis* Freze and Ryšavý, 1976, *O. hyalina* Rudin, 1917, *O. macrobothria* Rudin, 1917, *O. micruricola* (Shoop and Corkum, 1982) Schmidt, 1986, *O. nattereri* (Parona, 1901), *O. paraguayensis* (Rudin, 1917), and *O. sanbernardinensis* Rudin, 1917

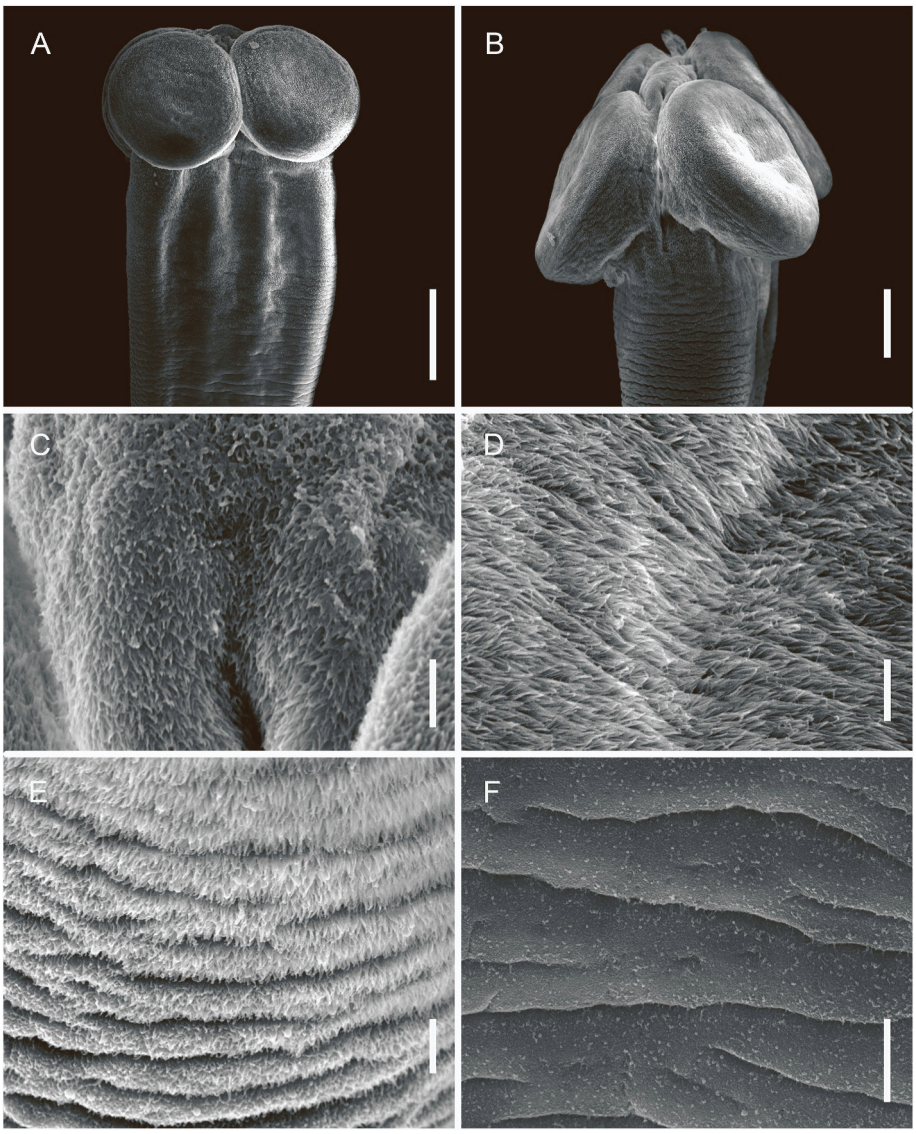

Figura 2. Scanning electron micrographs of *Ophiotaenia arandasi*. A, dorso-ventral view of the scolex. B, sub-lateral view of the scolex. C, microtriches at the apex of the scolex. D, luminal surface of the sucker. E, upper surface of the neck. F, posterior surface of the neck. *Scale–bars:* A 100 μm; B 50 μm; C, E 5 μm; F 10 μm.

(de Chambrier et al., 2021).

Of the previously mentioned species, only three lack a vaginal sphincter, similar to *O. arandasi*: *O. flava* and *O. macrobothria*, both from Brazil and *O. micruricola* from Mexico (de Chambrier et al., 2021). *Ophiotaenia barbouri* (Vigueras, 1934), a parasite of *Tretanorhinus variabilis* Duméril, Bibron, and Duméril, 1854 in Cuba, does not have information about the presence or absence of the vaginal sphincter. However, *Ophiotaenia arandasi* differs from *O. barbouri* by having a smaller scolex width (*O. arandasi* 315–478 vs *O. barbouri* 730) and larger relative size of the ovary in relation to the proglottid (*O. arandasi* 4.7–5.5% vs *O. barbouri* 2.9%).

Ophiotaenia arandasi is distinguished from *O. flava* by the scolex width (*O. arandasi* 315–478 vs *O. flava* 500–600); the number of testes (*O. arandasi* 41–90 vs *O. flava* 45–60); and the relative size of the ovary (*O. arandasi* 4.7–5.5% vs *O. flava* 3.6%). Furthermore, *O. arandasi* differs from *O. macrobothria* in scolex width (*O. arandasi* 315–478 vs *O. macrobothria* 400–500) and the relative size of the cirrus–sac (*O. arandasi* 35–45% vs *O. macrobothria* >50%). Lastly, *Ophiotaenia arandasi* is morphologically distinct from *O. micruricola* in scolex width (*O. arandasi* 315–478 vs *O. micruricola* 720–760), by the number of testes (*O. arandasi* 41–90 vs *O. micruricola* 121–169), and the relative size of the cirrus–sac (*O. arandasi* 35–45% vs *O. micruricola* 14–20%).

3.2. *Ophiotaenia karipuna n. sp. Trindade, Rebêlo and Melo, 2024* (*Figs. 3–5*)

Type-and only host: Erythrolamprus miliaris (Linnaeus, 1758) (Squamata: Dipsadidae)

Type-and only locality: "Parque Natural Municipal do Cancão", Serra do Navio, State of Amapá, Brazil (00°54′09"N 52°00′18,2"W)

Site of infection: large intestine.

Prevalence of infection: Only a single host individual, prevalence of 100%.

Type–specimens: Holotype (CHIOC 40427 a) and 4 paratypes (CHIOC 40427 b–m) are deposited in the Helminthological Collection of the Oswaldo Cruz Institute Rio de Janeiro, Brazil.

Zoobank Registration: urn:lsid:zoobank.org:act:1AD48A93-4BF5-4D99-B5DA-928182C023CD

Etymology: The specific epithet honors the "Karipuna" indigenous group living in the north of Amapá State. This name is a not Latin or Greek word and is being established as a noun in apposition.

Description (*Based on holotype and 4 paratypes, whole specimens*).

Small worms, total body length 6.42 (6.42–9.26 mm). Maximum width up to 293 (267–307). Strobila acraspedote, anapolytic. Immature proglottids wider than long to longer than wide (Length: width ratio 0.028–1.42), mature, pregravid and gravid proglottids much longer than wide (Length: width ratio 1.72–3.76).

Scolex 213 (213–307) long and 533 (533–619) wide, wider than proliferative zone, 312 (275–331) wide and 347 (347–440) long (Fig. 3A, 5A–E). Scolex with four lobes bearing spherical, uniloculated suckers directed sublaterally, 227 (227–293) in diameter; scolex apex slightly dome–shaped, with vestigial subspherical muscular apical organ, 22 (18–32) in diameter (Fig. 3A and 5A, C). Scolex and strobila densely covered with capilliform filitriches (Fig. 3A, 5A–E).

Inner longitudinal musculature well-developed, formed by large bundles of muscle fibers (Fig. 4A–C) surrounding genital organs. Two pairs of osmoregulatory canals slightly sinuous, between testes and vitelline follicles, ventral canals thin–walled, wider 10 diameter, than dorsal canals, thick–walled, narrower 5 diameter, lateral to the vitelline follicles (Fig. 3B).

Two testicular fields situated between anterior margin of proglottids and anterior lobes of ovaries, not reaching ovary posteriorly. Testes in medullary region, spherical to oval, 51–64 (mean: 57; n = 10) in number, measuring 36 (31–36) long, 35 (30–35) wide. Testes overlapping vas deferens but never cirrus–sac, absent at level of uterine stem (Fig. 3B and C, 4A–C). Preporal testes, 34 (34–38), postporal testes 23 (20–28) and aporal testes 28 (25–28) in number. Vas deferens strongly coiled, directed anteriorly, crossing midline of proglottids (Fig. 3B and C). Cirrus–sac pear–shaped, 128 (120–139) long and 61 (53–67) wide, length representing 36.4% (36–44%, n = 10) of proglottid width (Fig. 4D) length–to–width ratio of cirrus–sac 0.41–0.48. Genital atrium narrow; genital pores irregularly alternating, slightly pre–equatorial to equatorial, situated at 48.2% (48–50%, n = 10) of proglottid length (Fig. 3B and C).

Ovary medular, butterfly–shaped, occupying 53.3% (53.3–70%, n = 10) of proglottid width, length represents 24.9% (21–26%, n = 10) of the proglottid length. (Fig. 3B and C). Relative size of ovary 6% (4.6–7%, n = 10) of proglottid size. Vagina anterior or posterior to the cirrus–sac (proglottids counted; n = 20); Vaginal sphincter absent (Fig. 1D). Mehlis' gland 37 (21–37) long and 29 (29–50) wide, representing 11.6%

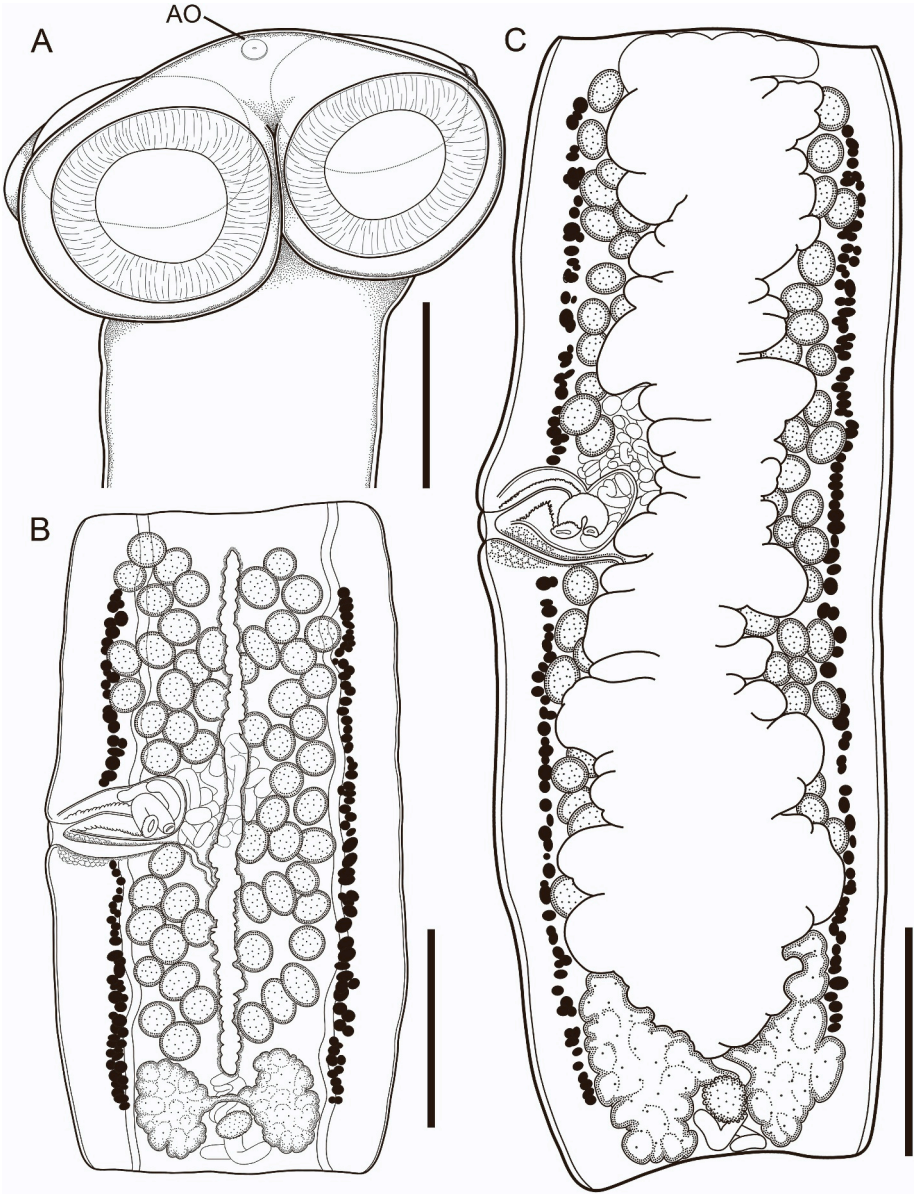

Fig. 3. Line drawings of *Ophiotaenia karipuna* n. sp. from Brazilian Amazon. A, scolex, frontal view. B, mature proglottid, ventral view. C, gravid proglottid, ventro–dorsal view. *Scale–bars*: A, B, C, 200 μm. Abbreviations: Apical organ, AO.

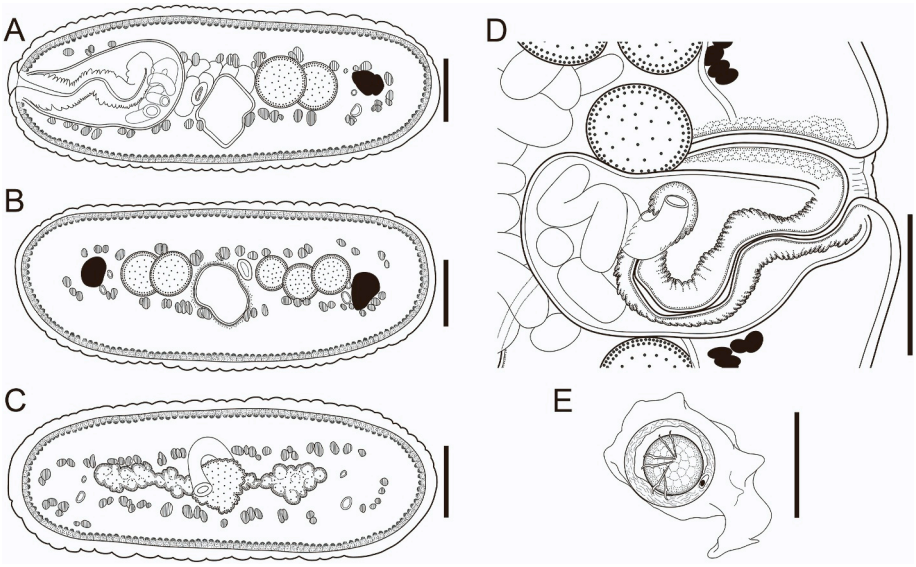

Fig. 4. Line drawings of *Ophiotaenia karipuna* n. sp. from Brazilian Amazon. A, section at the level of cirrus–sac. B, section at level of testes. C, section at level of ovary. D, terminal genitalia, ventro–dorsal. E, fully formed egg with fully developed embryonic hooks in the oncosphere. *Scale–bars*: A, B, C, D, 50 μm; E, 25 μm.

(11.6–19.4%, n = 10) of proglottid width (Fig. 3B and C).

Vitelline follicles oval in the dorsal region of proglottid, arranged in longitudinal lateral bands on each side of proglottid, not reaching anterior and posterior margins (Fig. 3B and C, 4A–C). Vitelline follicles absent at level of cirrus–sac and vagina (Fig. 4D). Length of vitelline bands represent 86.3% (77.2–87.5%, n = 10) and 81.1% (70.8–81.1%, n = 10) of proglottid's Length on poral and aporal sides, respectively (Fig. 3B and C). Uterus medular, gravid proglottids with 19–30 (n = 5) lateral branches (diverticula) on each side (Fig. 3C). Lateral diverticula, 19–30 at poral side and 22–28 aporal, type 1 development (Fig. 3B and C), testes present also in gravid proglottids (Fig. 3B). Intrauterine eggs spherical, with diameter hyaline outer envelope 26–45, inner envelope consists of two layers embryophore, 20–21 in diameter; oncosphere spherical 13–14 in diameter; embryonic hooks 5–6 long (Fig. 4E).

3.2.1. Remarks

The new species has scolex unarmed with unilocular suckers, vitelline follicles, ovary, uterus, and testicles in the medullary region and two testicular fields. These morphological characters are diagnostic for the genus *Ophiotaenia* (Rego, 1994).

Two species of proteocephalidean tapeworms have been recorded in *Erythrolamprus miliaris* in Brazil: *Ophiotaenia arandasi* and *O. hyalina* (Ammann and de Chambrier, 2008). Both species differ from *Ophiotaenia karipuna* n. sp. by the absence of an apical organ (present in *Ophiotaenia karipuna* n. sp). *Ophiotaenia arandasi* further differs from *Ophiotaenia karipuna* n. sp. in the width of the scolex (*O. karipuna* n. sp. 533–619, and *O. arandasi* 390) and the position of the genital pore (*O. karipuna* n. sp. 48–50%, compared to *O. arandasi* 35–45%). *Ophiotaenia hyalina* was described in a non-identified colubrid snake and Ammann and de Chambrier, 2008 recorded this species in *Erythrolamprus miliaris*. However, *O. hyalina* differs from *O. karipuna* n. sp. by a narrower scolex (*O. karipuna* n. sp. 533–619, compared to *O. hyalina* 680–800) and the absence of the vaginal sphincter (present in *O. hyalina*).

Only nine species have an apical organ among *Ophiotaenia* spp. from the Neotropical region. Of those, six were found in reptiles: *Ophiotaenia azevedoi* (de Chambrier, Vaucher and Renaud, 1992), *Ophiotaenia catzeflisi* ((de Chambrier, Vaucher and Renaud, 1992), *Ophiotaenia gilberti* Ammann and de Chambrier, 2008, *Ophiotaenia joanae* (de Chambrier and Paulino, 1997), *Ophiotaenia jarara* (Fuhrmann, 1927), and *Ophiotaenia nicoleae* Coquille and de Chambrier, 2008; and three in anurans: *O. bonariensis* Szidat et Soria, 1954, *O. ecuadorensis* Dyer, 1986, and *O. oumanskyi* de Chambrier and Gil de Pertierra, 2021 (see Table 2).

Ophiotaenia azevedoi a parasite of *Bothrops jararaca* (Wied–Neuwied, 1824) differs from the new species in scolex width (*O. azevedoi* 630–735 vs *O. karipuna* n. sp. 533–619). In addition, the new species has a smaller number of testes than *O. azevedoi* (51–64 vs 88–212, respectively). The species also differ in the relative length of the cirrus–sac (*O. karipuna* n. sp. 36–44% vs *O. azevedoi* 17–26%) and the morphology of the vaginal sphincter, which is absent in the new species, but present in *O. azevedoi*. Additionally, the new species has a larger ovarian surface relative to the proglottid than *O. azevedoi* (4.6–7% vs 1.9%, respectively) (de Chambrier, Vaucher and Renaud, 1992).

Ophiotaenia karipuna n. sp. differs from *Ophiotaenia catzeflisi*, a parasite of *Bothrops jararaca*, by a smaller scolex (*O. karipuna* n. sp. 533–619 vs *O. catzeflisi* 990–1.220). Furthermore, the new species has suckers directed laterally, whereas *O. catzeflisi* has suckers elevated and directed anteriorly. *Ophiotaenia catzeflisi* exhibits abundant circular musculature in the upper lateral region of the sucker (absent in *O. karipuna* n. sp.). The new taxon also differs in the lesser number of testes (*O. karipuna* n. sp. 51–64 vs *O. catzeflisi* 107–158), and in the relative size of the cirrus–sac (*O. karipuna* n. sp. 36–44% vs *O. catzeflisi* 14–22%) (de Chambrier, Vaucher and Renaud, 1992).

Ophiotaenia karipuna n. sp. can be differentiated from *Ophiotaenia gilberti*, a parasite of *Thamnodynastes pallidus* (Linnaeus, 1758), by the width of the scolex (*O. karipuna* n. sp. 533–619 vs *O. gilberti* 140–145), relative length of the cirrus–sac (*O. karipuna* n. sp. 36–44% vs *O. gilberti* 15–23%) and diameter of the embryophore (*O. karipuna* n. sp. 21 vs *O. gilberti* 27–28). The new species also differs in the absence of a vaginal sphincter (present in *O. gilberti)* and in the presence of a muscular apical organ (glandular in *O. gilberti)* (Ammann and de Chambrier, 2008).

Ophiotaenia joanae, a parasite of *Xenodon neuwiedii* Gunther, 1863, is easily distinguished from the new species because it has a metascolex (absent in *O. karipuna* n. sp). In addition, *O. joanae* has a highly developed apical glandular organ that is larger than the sucker, whereas in *O. karipuna* n. sp., the apical organ is a vestigial sucker (de Chambrier, Vaucher and Renaud, 1992).

The new species can be distinguished from *Ophiotaenia jarara*, a parasite of *Bothrops jararaca*, by the width of the scolex (*O. karipuna* n. sp. 533–619 vs *O. jarara* 1.100–1.200), the number of testes (*O. karipuna* n. sp. 51–64 vs *O. jarara* 150) and the position of the vagina (posterior–anterior in *O. karipuna* n. sp. vs only anterior in *O. jarara*) (de Chambrier, d'Alessio and de Azevedo Corrêa, 1991).

Ophiotaenia karipuna n. sp. can be distinguished from *Ophiotaenia*

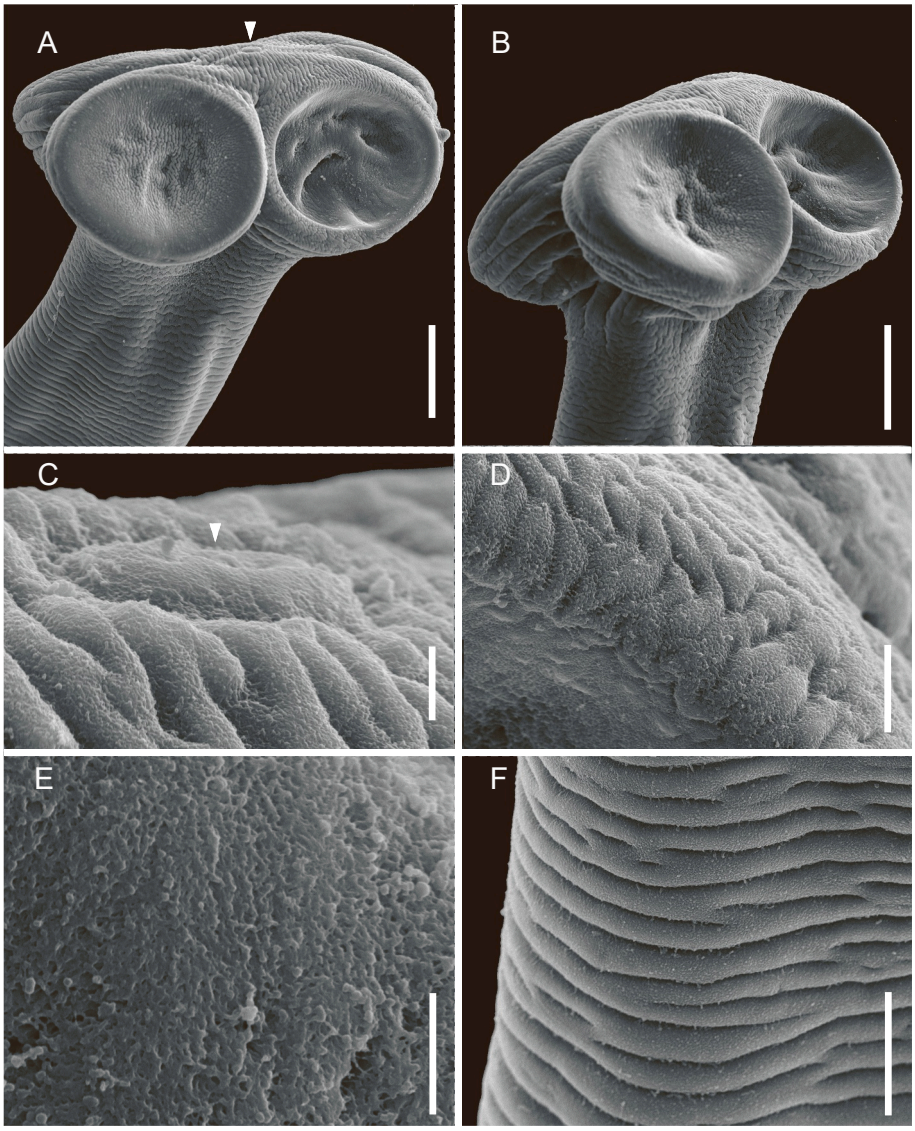

Fig. 5. Scanning electron micrographs of *Ophiotaenia karipuna* n. sp. A, subapical view of the scolex (arrows indicate apical organ). B, scolex latero–ventral view. C, detail of the apex of scolex (arrows indicate apical organ). D, tegument surface on the upper edge of the sucker. E, tegument surface of luminal region of suckers. F, tegument surface between suckers and neck. *Scale–bars*: A, B, 100 μm; C, E, 5 μm; D, 10 μm; F, 30 μm.

nicoleae, a parasite of *Thecadactylus rapicauda* (Houttuyn, 1782) (Gekkonidae), by the width of the scolex (*O. karipuna* n. sp. 533–619 vs *O. nicoleae* 325–340), number of testes (*O. karipuna* n. sp. 51–64 vs *O. nicoleae* 142–204), and presence of the vaginal sphincter (absent in *O. karipuna* n. sp. vs present in *O. nicoleae*) (Coquille and de Chambrier, 2008).

The new species differs from *O. bonariensis*, a parasite of *Leptodactylus latrans* (Steffen, 1815), in the width of the scolex (*O. karipuna* n. sp. 533–619 vs *O. bonariensis* 300), number of testicles (*O. karipuna* n. sp. 51–64 vs *O. bonariensis* 120–140), and relative size of the cirrus–sac (*O. karipuna* n. sp. 36–44% vs *O. bonariensis* 23–26%).

Ophiotaenia karipuna also differs from *O. ecuadorensis*, a parasite of *Boana geographica* (Spix, 1824), in the number of testes (*O. karipuna* n. sp. 51–64 vs *O. ecuadorensis* 92–121), relative size of the cirrus–sac (*O. karipuna* n. sp. 36–44% vs *O. ecuadorensis* 23–32%), and position of the vagina (posterior-anterior in *O. karipuna* n. sp. vs posterior in O. *ecuadorensis*). *Ophiotaenia karipuna* n. sp. is easily distinguished from *O. oumanskyi*, a parasite of *Lepidobatrachus laevis* Budget, 1899, by the absence of a vaginal sphincter (present in *O. oumanskyi*).

Some authors did not mention in original description the presence or absence of the apical organ for *Ophiotaenia crotali* Lopez–Neyra and Diaz–Ungria (1958), *Ophiotaenia elongata* Fuhrmann, 1927, and *Ophiotaenia racemosa* (Rudin, 1917; de Chambrier et al., 2021), also Neotropical species. However, *O. crotali* and *O. racemosa* can be differentiated from the new species by the presence of a vaginal sphincter, which is absent in *O. karipuna* n. sp. (Lopez–Neyra and Diaz–Ungria, 1958; Rudin, 1917). *Ophiotaenia elongata* differs in the relative size of the ovary, which is markedly smaller than the new species (2.5% in *O. elongata* vs. 4.6–7% in *O. karipuna* n. sp.) and by a smaller number of testes (26–44 in *O. elongata* vs 51–64 in the new taxon).

Additional morphometric and morphological data of the new species, as well as other Neotropical species of *Ophiotaenia*, are given in Table 2.

4. Discussion

In the present study, we add new morphological data on *Ophiotaenia arandasi*, based on the re-examination of type series and newly collected material of the species. Herein, we provide information on the absence of the vaginal sphincter, and double layer in the embryophore of the

Table 2
Morphological and metric characters of the valid species of *Ophiotaenia* parasitizing amphibians and reptiles in the Neotropical region. All measurements are given in micrometers.

Species	Host species	Host Family	Country	Scolex width	Apical organ	Number of testes	Relative size of cirrus-sac[a]	Position of genital pore[b]	Position of Vagina	Vaginal sphincter	Ovary surface[c]	Reference
Ophiotaenia karipuna n. sp.	*Erythrolamprus miliaris*	Dipsadidae	Brazil	533–619	present	51–64	36–44%	48–50%	ant-post	absent	4.6–7%	This study
O. arandasi	*Erythrolamprus miliaris*	Dipsadidae	Brazil	315–478	absent	41–90	35–45%	27–39%	ant-post	absent	4.7–5.5%	This study
O. alessandrae	*Boana boans*	Hylidae	Ecuador	475	absent	86–128	11–17%	35–53%	ant/post	present	5.6%	Marsella and de Chambrier, 2008
O. azevedoi	*Bothrops jararaca*	Viperidae	Brazil	630–735	present	88–212	17–26%	40–55%	ant–post	present	1.9%	de Chambrier, Vaucher and Renaud, 1992
O. barbouri	*Tretanorhinus variabilis*	Dipsadidae	Cuba	730	absent	46–58	ND	33%	posterior	ND	2.9%	de Chambrier et al. (2021)
O. bonariensis	*Leptodactylus latrans*	Leptodactylidae	Argentina	300	present	120–140	23–26%	32–34%	ND	ND	6.9%	Scholz et al. (2023a)
O. bonneti	*Phyllomedusa vaillanti*	Hylidae	Costa Rica	280–385	absent	100–177	15–24%	15–29%	anterior	absente	6.9%	de Chambrier et al., 2006
O. bufonis	*Peltophryne peltocephala*	Bufonidae	Cuba	740	absent	180–220	20%	44–48%	ant/post	ND	7.1%	Scholz et al. (2023a)
O. ceratophryos	*Ceratophrys ornate*	Ceratophryidae	Argentina	700	absent	ND	16–20%	38%	ND	ND	7.9%	Scholz et al. (2023a)
O. calamensis	*Telmatobius dankoi*	Telmatobiidae	Chile	225–296	absent	34–60	20–38%	25–50%	ant/post	ausent	4.5%	Puga and Formas, 2005
O. calmettei	*Bothrops lanceolatus*	Viperidae	Martinique	1000–1300	absent	130–160	17–25%	50%	posterior	present	2.2%	de Chambrier et al. (2021)
O. catzeflisi	*Bothrops jararaca*	Viperidae	Brazil	990–1220	present	107–158	14–22%	40–54%	ant–post	present	2.1%	de Chambrier, Vaucher and Renaud, 1992
O. crotali	*Crotalus durissus*	Viperidae	Venezuela	ND	ND	308–412	7–12%	41–43%	ND	present	2.8%	Lopez–Neyra and Diaz–Ungria, 1958
O. elongata	Snake	ND	Brazil	ND	ND	26–44	ND	50%	ND	ND	2.5%	de Chambrier et al. (2021)
O. euzeti	*Bothrops jararaca*	Viperidae	Brazil	300–310	absent	116–141	25–34%	24–42%	ant-post	present	2.2%	de Chambrier, Vaucher and Renaud, 1992
O. ecuadorensis	*Boana geographicus*	Hylidae	Ecuador	450	present	92–121	23–32%	42–45%	posterior	ND	7.1%	Scholz et al. (2023a)
O. flava	*Coluber* sp	Colubridae	Brazil	500–600	absent	45–60	50%	20–40%	ant-post	absent	3.6%	Rudin (1917)
O. gilberti	*Thamnodynastes pallidus*	Dipsadidae	Paraguay	140–145	present	57–91	15–23%	42–50%	ant–post	present	3.7%	Ammann and de Chambrier, 2008
O. habanensis	*Tropidophis pardalis*	Tropidophiidae	Cuba	360	absent	31–51	>50%	60%	ND	present	2.7%	Freze and Ryšavý, 1976
O. hernandezi	*Rana* sp.	Ranidae	Guatemala	880	absent	59–78	24–26%	17–18%	posterior	ND	7.8–9.9%	Scholz et al. (2023a)
O. hyalina	*Coluber* sp.	Colubridae	Brazil	680–800	absent	50–55	50%	33%	ant-post	present	5.5%	Rudin (1917)
O. jarara	*Bothrops jararaca*	Viperidae	Brazil	1100–1200	present	150	27–34%	50%	anterior	absent	2.4%	de Chambrier, d'Alessio and de Azevedo Corrêa, 1991
O. joanae	*Xenodon neuwiedii*	Dipsadidae	Brazil	480–790	present	147–210	14–25%	28–56%	ant–post	present	3.1%	de Chambrier and Paulino (1997)
O. macrobothria	*Micrurus corallinus*	Elapidae	Brazil	400–500	absent	50–60	>50%	20–33%	ant-post	absent	4.4%	Rudin (1917)
O. micruricola	*Micrurus diastema*	Elapidae	Mexico	720–760	absent	121–169	14–20%	48–56%	posterior	absent	3.2%	Shoop and Corkum (1982)
O. nattereri	*Coluber* sp.	Colubridae	Brazil	250	absent	80–100	28–33%	<50%	ant-post	present	ND	de Chambrier et al. (2021)
O. noei	*Calyptocephalella gayi*	Calyptocephalellidae	Chile	410–580	absent	200–250	22–27%	39%	ant-post	ND	6.6%	Scholz et al. (2023a)
O. nicolae	*Thecadactylus rapicauda*	Phyllodactylidae	Ecuador	325–340	present	142–204	21–33%	34–53%	ant–post	present	4.9%	Coquille and de Chambrier (2008)
O. olseni	*Boana geographica*	Hylidae	Ecuador	430–490	absent	126–160	19%	59%	posterior	ND	6.5%	Scholz et al. (2023a)

(*continued on next page*)

Table 2 (*continued*)

Species	Host species	Host Family	Country	Scolex width	Apical organ	Number of testes	Relative size of cirrus-sac[a]	Position of genital pore[b]	Position of Vagina	Vaginal sphincter	Ovary surface[c]	Reference
O. aumanskyi	*Lepidobatrachus laevis*	Ceratophryidae	Paraguay	350–410	present	85–119	20–27%	35–61%	ant/post	present	6.7–8.3%	de Chambrier and Gil De Pertierra, 2012
O. paraguayensis	*Hydrodynastes gigas*	Dipsadidae	Paraguay	240	absent	238–344	12–19%	27–39%	ant-post	present	3.3%	Rudin (1917)
O. racemosa	*Coluber* sp.	Colubridae	Brazil	540–650	ND	80–120	33%	33%	ant-post	present	4.3%	de Chambrier et al. (2021)
O. sanbernardinensis	*Helicops leopardinus*	Dipsadidae	Paraguay	230–250	absent	70–102	ND	20–40%	ant-post	present	5.0%	Rudin (1917)

ND: not determined.

[a] Ratio of the cirrus–sac length to the proglottid width (in %).

[b] Ratio of the genital pore position to the proglottid length (in %).

[c] Ratio of the ovary surface to the proglottid surface (in %, according to de Chambrier et al., 2021).

eggs. Finally, we observed type 1 uterine development in both materials of *Ophiotaenia arandasi*, contrary to Scholz et al. (2023b) that assigned type 2 for this species. All this newly provided data confirm that *Ophiotaenia arandasi* is a valid taxon.

Intraspecific variations have been reported in other *Ophiotaenia* species, mainly in characters such as: number of uterine diverticula, size of scolex, number and average size of testes (Rego, 1962; Scholz et al., 2023a). However, we did not find intraspecific variation in the morphometric data among specimens of the present study, re-examination of type series and measurements provided in the original description of Santos and Rolas (1973) from *E. miliaris*. Additionally, despite some studies suggest that *Ophiotaenia* spp. exihibit host specificity (Ammann and de Chambrier, 2008; de Chambrier et al., 2015), there are some reports of *Ophiotaenia* species in multiple congeneric hosts (Santos and Rolas, 1973; de Chambrier, Vaucher and Renaud, 1992; de Chambrier et al., 2023). Our findings and those previous reports suggest that the host specificity of *Ophiotaenia* might be less strict than it was previously assumed.

The hosts registered for *O. arandasi* are phylogenetically related and their geographical distributions overlap (Entiauspe-Neto et al., 2021). *E. taeniogaster* is more abundant in the Amazon and the northern Atlantic Forest, while *E. miliaris* is widely distributed in the Atlantic Forest, and other regions in brazilian territory, except Pampas Grasslands (Nogueira et al., 2019). Our results support that sympatric hosts, might share some cestode taxa since they are exposed to similar ecological and phylogenetic conditions (Aho, 1990; Krasnov et al., 2011).

Ophiotaenia karipuna n. sp. is the third species described parasitizing *Erythrolamprus miliaris* in Brazil. Although, *O. arandasi* and *O. hyalina* parasitize the same host species, they differ in various morphological aspects, primarily in the absence of the apical organ, present in *O. karipuna*.

Our study provides an ultrastructural analysis for *O. karipuna* n. sp. and *O. arandasi*. The SEM images showed details of the distribution of microtrichia on the tegument surface, on the upper edge of the sucker, luminal region of the suckers, and tegument surface between the suckers and the neck in both species. Additionally, it was possible to observe the presence of a vestigial apical sucker in *O. karipuna* n. sp., a unique characteristic of the new species compared to its Neotropical congeners.

The morphological data obtained by light and scanning electron microscopy strongly support the independent species-status of *O. karipuna* n. sp. from *Erythrolamprus miliaris*. The taxonomic validity of *O. arandasi* is confirmed based on a re-examination of the type series, and new collected specimens. We also provide the first ultrastructural analysis of the species, and new host and locality records. Therefore, considering the great diversity of snakes and the comparatively small number of *Ophiotaenia* species in Brazil, future studies of proteocephalids are valuable insights into the systematics and evolutionary history of the group.

Ethics approval

All procedures contributing to this work comply with all applicable institutional, national, and international guidelines for animal care and use Animal Research Ethics Committee, Federal University of Pará, under license N8341260821CEUA/UFPa. The present study was approved by Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), Brazil, and host specimens were collected under license number SISBIO: 53,527–4.

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CRediT authorship contribution statement

Luiz Felipe Ferreira Trindade: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Adriano José Silva Félix:** Conceptualization, Data curation, Formal analysis, Methodology, Resources, Writing – review & editing. **Gabriel Lima Rebêlo:** Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Jorge Kevin Silva Neves:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Deivyson João Malcher Paixão:** Investigation, Data curation, Formal analysis, Writing – review & editing. **Marcos Roberto Dias-Souza:** Data curation, Methodology, Visualization, Writing – review & editing. **Carlos Eduardo Costa-Campos:** Conceptualization, Funding acquisition, Methodology, Resources, Visualization, Writing – review & editing. **Jeannie Nascimento Santos:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. **Francisco Tiago Vasconcelos Melo:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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