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First record of *Spirocamallanus krameri* (Nematoda: Camallanidae) in Brazil: Morphological review

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Abstract: This study aimed to describe the occurrence, morphology and prevalence of *Spirocamallanus krameri*, a parasite of *Hoplerythrinus unitaeniatus* collected in state of Pará, Brazil. The morphological and morphometric characteristics are consistent with the species *S. krameri*, by having a hexagonal mouth opening, 16 cephalic papillae and two lateral papillae on the amphids. The buccal capsule is internally different in both sexes, with (11–13) spiral ridges in males and (13–17) spiral ridges in females. The basal ring is well developed, and three teeth are present in males and absent in females. Ten sessile caudal papillae and a pair of phasmidial pores occur in males. The spicules are small, subequal, 81–101 µm in length and the tail is tapered. The vulva in females is postequatorial, the tail is conical with lateral phasmidial pores. Among the species of *Spirocamallanus* that have short spicules, the general morphology of *S. krameri* most resembles that of *S. inopinatus*, but differs from that species, which have two cephalic teeth visible (absent in *S. krameri*) and specimens of *S. inopinatus* do not have sexual dimorphism in the buccal capsule of present in *S. krameri*.
Key words: Fish, parasite, Procamallaninae, state of Pará.

INTRODUCTION

The family Camallanidae is divided into two subfamilies, Camallaninae (species with the buccal capsule divided into two halves) and Procamallaninae (species having a single, cup-like buccal capsule) (Railliet & Henry 1915, Yeh 1960). *Spirocamallanus* is one of six genera assigned to Procamallaninae (Olsen 1952). The other five genera are *Procamallanus*, *Malayocamallanus*, *Punctocamallanus*, *Spirocamallanoides* and *Denticamallanus* (Baylis 1923, Jothy & Fernando 1970, Moravec & Scholz 1991, Moravec & Thatcher 1997, Rigby & Rigby 2014, Pinheiro et al. 2018). *Spirocamallanus*, parasites of marine and freshwater fishes, is comprised of approximately 60 species distributed worldwide (Ramalho & Ailán-Choke 2017). In Brazil, 18 species of *Spirocamallanus* have been reported from fish to date (Luque et al. 2011, Rigby & Rigby 2014).

Members of *Spirocamallanus* are characterized by the presence of spiral ridges in the buccal capsule in both males and females (Moravec & Scholz 1991, Moravec & Thatcher 1997). Luque et al. (2011) reported the following species in Brazil: *S. inopinatus*, *S. iheringi*, *S. rarus* Travassos, Artigas & Pereira 1928; *S. amarali*, *S. hilarii* Vaz & Pereira 1934; *S. barroslimai* Pereira 1935; *S. pereirai* Annereaux 1946; *S. macaensis* Vicente & Santos 1972; *S. pimelodus* Pinto, Fabio, Noronha & Rolas 1974; *S. solani* Pinto, Fabio, Noronha & Rolas 1975; *S. paraensis* Pinto & Noronha 1976; *S. pexatus* Pinto, Fabio, Noronha

& Rolas 1976; *S. cruzi* Guimarães, Cristofaro & Rodrigues 1976; *S. caballeroi* (Bashirullah 1977) (Pavanelli et al. 2004); *S. halithophus* Fusco & Overstreet 1978; *S. pintoi* Kohn & Fernandes 1988; *S. freitasi* Moreira, Oliveira & Costa 1991; *S. saofranciscencis* Moreira, Oliveira & Costa 1994 and *S. belenensis* Giese, Santos & Lanfredi 2009.

This study reports the first occurrence of *Spirocamallanus krameri* (Petter 1974) parasitizing *Hoplerythrinus unitaeniatus* (Spix & Agassiz 1829) in Brazil; the parasite was found in the municipality of Tracuateua, state of Pará, eastern Brazilian Amazon; this report provides new morphological data for this helminth.

MATERIALS AND METHODS

Collection and examination of samples

Ninety-two specimens of *H. unitaeniatus* were obtained by donation. Fish were captured by artisanal fishermen in a dam lake located in the municipality of Tracuateua (01° 04' 34" S, 46° 54' 11" W), state of Pará. The fish were transported to the Laboratório de Histologia e Embriologia Animal, Instituto da Saúde e Produção Animal, Universidade Federal Rural da Amazônia, city of Belém, state of Pará, where they were weighed (g), and their total lengths were measured (cm). After biometric analysis, the animals were necropsied for helminths. The digestive tract of each specimen was isolated in a Petri dish containing physiological solution and analyzed using a stereomicroscope (LEICA-ES2). Helminth parasites were collected; washed in phosphate-buffered saline; fixed in hot ethanol, formaldehyde, and glacial acetic acid (AFA) fixative solution (93 parts 70% ethanol, 5 parts formaldehyde, and 2 parts glacial acetic acid); and stored in 70% ethanol. For study using light microscopy, helminths were clarified with Amman's lactophenol solution (Giese et al. 2009) and examined under a Leica DM2500 microscope with a drawing tube. The ecological indexes of parasitism were used according to Bush et al. (1997) and Bautista-Hernández et al. (2015).

For morphometric analysis, 10 males, 10 females, 20 eggs (from an allotype female), and 20 intrauterine larvae (from an allotype female) were used. Measurements are given in micrometers unless otherwise noted and are presented as minimum and maximum values followed by the mean in parentheses. For scanning electron microscopy (SEM), helminths were washed in phosphate-buffered saline with a pH of 7.0 (3.12 g sodium phosphate monobasic, 2.83 g sodium phosphate dibasic, and 17 g sodium chloride in 200.0 ml of distilled water), postfixed in 1% osmium tetroxide, dehydrated to the critical point using CO_2, coated with gold+palladium, and studied using a scanning electron microscope (VEGA 3 LMU/TESCAN) in the Laboratório de Histologia e Embriologia Animal, Instituto da Saúde e Produção Animal, Universidade Federal Rural da Amazônia - UFRA, campus Belém, state of Pará, Brazil. The host scientific name is following FishBase (Froese & Pauly 2018). To avoid confusion, only the names of genera of helminths are abbreviated and not those of hosts.

RESULTS

Description

Order Spirurida Chitwood, 1933

Family Camallanidae Railliet & Henry, 1915

Spirocamallanus krameri (Petter 1974) (Fig. 1)

Medium-sized nematode with a finely and transversely striated cuticle. Mouth aperture hexagonal, pair of small lateral amphids, 16 cephalic papillae disposed in three concentric circles, the first inner circle with eight papillae and the second and third outer circles with four papillae each (Fig. 1a, d) and two lateral amphidial

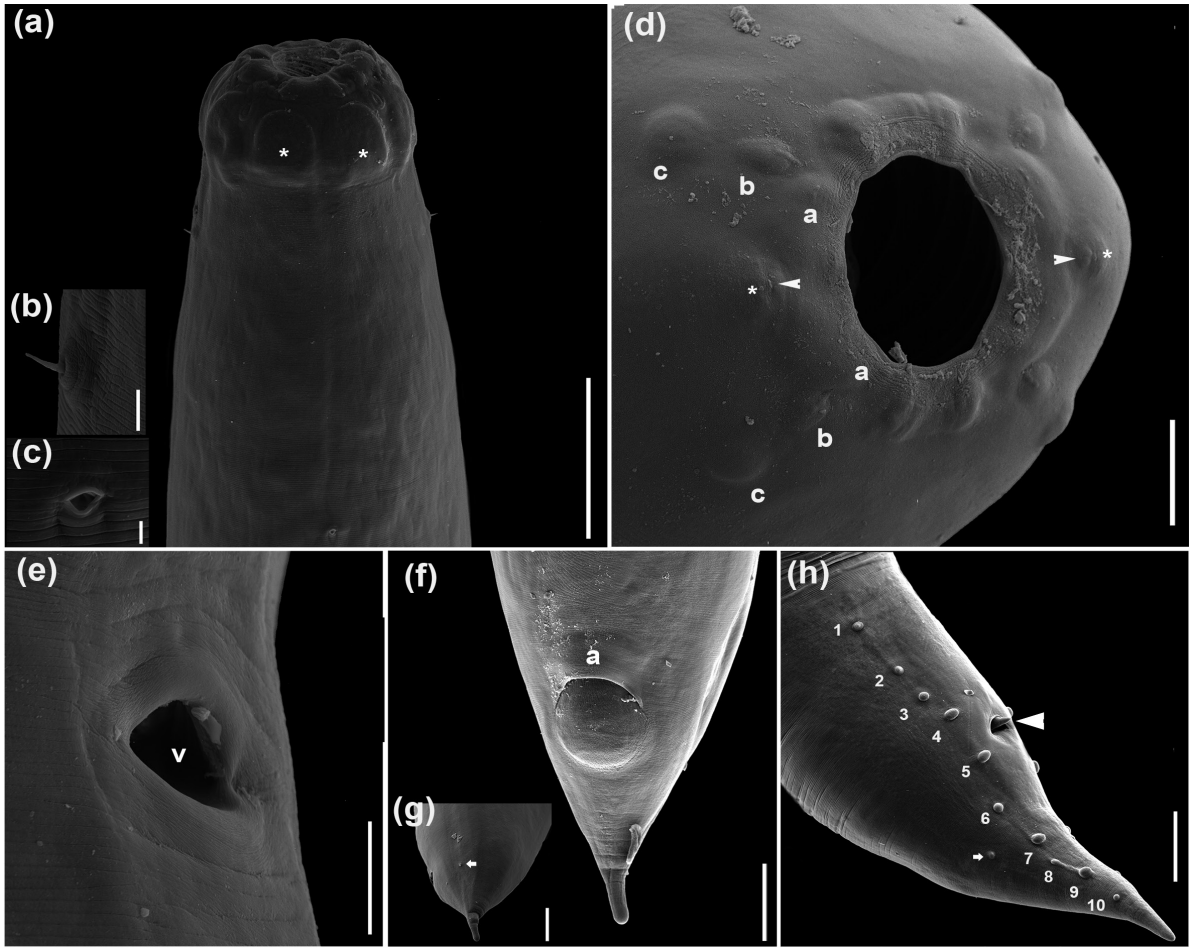

Figure 1. Scanning electron microscopy of *Spirocamallanus krameri*: **(a) Cephalic region view: mouth aperture and buccal capsule internally sustained by 8 elongated internal supports (*), deirids and excretory pore. Scale bars = 100 µm. (b) Detail of deirids. Scale bars = 5 µm. (c) Detail of excretory pore and finely and transversely striated cuticle. Scale bars = 2 µm. (d) Mouth aperture hexagonal, cephalic papilla (a,b,c), amphidial papillae (*) and amphid (arrowhead). Scale bars = 20 µm. (e) Vulva (v), vulval lips not elevated. Scale bars = 10 µm. (f) Female tail, anus (a). Scale bars = 50 µm. (g) Detail of lateral phasmidial pores (arrowhead). Scale bars = 50 µm. (h) Tail of male, ventral-lateral views; cloacal opening, spicule (arrowhead), four Precloacal papillae, six postcloacal papillae and lateral phasmidial pores (arrowhead). Scale bars = 50 µm.**

papillae. Buccal capsule brown-orange, wider than long, thick walled; internally sustained by eight rigid structures in the form of a shell (plates) (Fig. 1a); capsule internally different between sexes in males, the spiral ridges occupy up to the middle third of the surface, and those in females occupy the complete capsule; basal ring well developed, with three large teeth in males that are absent in females. Muscular oesophagus somewhat shorter than glandular oesophagus. Deirids are situated between the buccal capsule and nerve ring (Fig. 1b).

Male (based on 10 specimens): Body 7 (6-8) mm long; maximum width at esophageal/intestinal junction 229 (16-266). Buccal capsule including basal ring 71 (66-75) long and 91 (81-103) wide; basal ring 75 (67-85), spiral ridges ranging from 11-13. Maximum width/length ratio of buccal capsule 1:1.28 (1:1-1.5). Deirids, nerve ring and excretory pore 120 (95-150), 161 (140-173)

and 310 (261-382), respectively, from anterior extremity (Fig. 1b, c). Muscular portion of oesophagus 309 (273-366) long and 106 (93-133) wide; glandular portion of oesophagus 443 (366-526) long and 103 (80-133) wide. Length ratio of muscular/glandular oesophagus 1:1.4 (1:1.2-1.8). Length of entire oesophagus and buccal capsule constituting 8.7% (7-10.6) of body length. Papillae sessile, distributed as 4 pairs of precloacal papillae and 6 pairs of postcloacal papillae, one pair of phasmids lateral, between the 6th and 7th pairs of postcloacal papillae (Fig. 1h). Spicules small and subequal, morphologically similar and sclerotised; short spicule 90 (81-101) and large spicule 95 (83-101) long. Gubernaculum and caudal alae absent. Tail conical, 216 (150-308) long.

Female (based on 10 larvigerous specimens): Body 14 (10-16) mm long; maximum width at esophageal/intestinal junction 379 (326-433). Buccal capsule including basal ring, 96 (88-106) × 144 (101-136); basal ring 84 (73-92), spiral ridges ranging from 13-17. Maximum width/length ratio of buccal capsule 1:1.18 (1:1-1.3). Deirids, nerve ring and excretory pore 131 (100-147), 210 (177-247) and 410 (337-460), respectively, from anterior extremity. Muscular portion of oesophagus 383 (333-453) long and 127 (107-147) wide; glandular portion of oesophagus 554 (486-620) long and 144 (80-167) wide. Length ratio of muscular/glandular oesophagus 1:1.5 (1.3-1.6). Length of entire oesophagus and buccal capsule constituting 13% (11-15) of body length. Vulva postequatorial, 11 (7-12) mm from anterior extremity, 71-82% of body length. Vulval lips not elevated (Fig. 1e). Uterus filled with eggs 62 long by 55 wide and larvae 477 (353-520) long. Phasmids small, lateral and tail conical, 176 (120-223) long; finger-like cuticular projection absent (Fig. 1f, g).

Taxonomic Summary:

Species. *Spirocamallanus krameri* (Petter 1974)

Type host. *Hoplerythrinus unitaeniatus* (Spix & Agassiz 1829) (Characiformes: Erythrinidae), common names. Jeju, aimará, boca de moça, traíra pixuna, and yuyu. Average length and average weight of fish hosts 13 cm and 42.6 g, respectively.

Sex. Males (45), females (39) and immatures (8)

Site of infection. Mid intestine, pyloric caecum.

Biome. Amazon;

Locality. Municipality of Tracuateua, state of Pará, eastern Brazilian Amazon.

Infection rate.

Prevalence: 76%, total intensity: 172, mean intensity: 3, mean abundance: 2 and amplitude: 1–8.

Material examined. Representative specimens were deposited in the Coleção de Invertebrados não Arthropoda of the Museu Paraense Emílio Goeldi (MPEG), Belém, state of Pará, Brazil (MPEG 0206; MPEG 0207; MPEG 0208; MPEG 0209), (Access number: 20190400001).

Other material examined. *Spirocamallanus inopinatus* loaned by the CHIOC: CHIOC 31.315A-B, CHIOC 31.323A-B, CHIOC 31.324, CHIOC 31.325A-B, CHIOC 31.326A-B, CHIOC 31.327, CHIOC 31.328 and CHIOC 31.329; *S. rarus* loaned by the CHIOC: CHIOC 31.027A-B, CHIOC 31.328A-C; *S. pexatus* loaned by the CHIOC: CHIOC 31.086A-D, CHIOC 31.087, CHIOC 31.088A-B, CHIOC 31.089A-B and 32.504A-B; *S. paraensis* loaned by the CHIOC: CHIOC 31.342A-E and *S. saofranciscensis* loaned by the CHIOC: CHIOC 37.857, CHIOC 37.858 and CHIOC 38.042.

DISCUSSION

The family Camallanidae was established for species with a prominent, sclerotized buccal capsule. *Spirocamallanus krameri* can be identified as a member of Camallanidae because it has a sclerotized buccal capsule and

of Procamallaninae because the buccal capsule is cup like. Although there is some overlap in the characteristics of the six genera currently assigned to Procamallaninae, *S. krameri* is assigned to *Spirocamallanus*, which has, according to Moravec & Thatcher (1997) spiraling ridges on the inner surface of the buccal capsule in both sexes.

Spirocamallanus krameri found as an intestinal parasite of the pyloric caecum of *Hoplerythrinus unitaeniatus* in Tracuateua, Pará State, Oriental Amazon, has characteristics that are consistent with the description of this species, including the presence of a hexagonal buccal opening, two amphids on each side, two amphidial papillae, eight inner papillae surrounding the oral opening and eight outer cephalic papillae arranged in two concentric circles of four papillae each and two lateral amphidial papillae. The buccal capsule is sustained by a shell (plates) and the capsule differs internally between sexes (in males, the spiral ridges occupy up to the middle third of the capsule surface, and in females they occupy the complete capsule), and the basal ring is well developed, supporting three teeth in males.

Spirocamallanus krameri is redescribed morphologically and morphometrically in this work and is reported for the first time in Brazil. This species was described by Petter (1974) as a parasite of *Hoplerythrinus unitaeniatus* that were purchased in a market in Cayenne, the capital of French Guiana (an overseas territory of France on the Atlantic Coast of South America). However, that author used only a male and a female for the description. Moravec et al. (1997) redescribed *S. krameri* (as *P.* (*S.*) *krameri*) collected from *Hoplerythrinus unitaeniatus* in Venezuela, expanded the geographical distribution of the species and addied new morphological data based on two specimens of males and ten of females.

Specimens of *Spirocamallanus krameri* from the Brazilian Amazon feature 11–13 spiral ridges on the buccal capsule of males and 13–17 on that of females. Moravec et al. (1997), the the redescription of *S. krameri* from Venezuela, reported 16–20 spiral ridges on the capsule in both sexes, which differs from the findings in the original description by Petter (1974), which included 10–15 spiral ridges; the differences in the numbers of spiral ridges are due to Petter (1974) measuring the number of spiral ridges in the capsule apically and Moravec et al. (1997) observing the number of spiral ridges using a lateral view of the capsule, the latter of which is described by the author as the primary mode of observation that should be used in descriptions of nematodes in this genus. Morphometric comparisons between the descriptions of *S. krameri* are shown in Table I, including the additional data presented in this study.

Spirocamallanus krameri presents a well-developed basal ring supporting teeth only in males, with lateral alae absent and short spicules (90–95). This size differs from spicules of *S. amarali* (230–550), *S. iheringi* (240–450), *S. freitasi* (172–534), *S. rarus* (220–640), *S. solani* (210–450), *S. cruzi* (300–530), and *S. pimelodus* (160–480) [Syn. = *S. intermedius*, (240–630)], including the marine species *S. macaensis* (250–620), which all have long spicules. However, the specimens used in the present study have spicules that are slightly longer than those described for this species by Petter (1974) (75–80) and Moravec et al. (1997) (72–87).

The morphology of spicules makes *S. krameri* similar to *S. inopinatus*, a parasite of *Leporinus copelandii* Steindachner 1875 (Characiformes: Anostomidae); *S. hilarii*, a parasite of *Salminus hilarii* Valenciennes 1850 (Characiformes: Bryconidae); *S. pintoi*, a parasite of *Corydoras paleatus* (Jenyns 1842) (Siluriformes: Callichthyidae); *S. paraensei*, a

Table I. Comparison of morphometric characteristics of *Spirocamallanus krameria* with other species of *Spirocamallanus* in Brazil that have short spicules: [a] Measurements in micrometers unless indicate; [b] Abbreviations: L = length; W = width, Ratio oral capsule W/L = Ratio of maximum width/length ratio of buccal capsule, Ratio M/G = Ratio of muscular and glandular esophagus lengths, Ratio L/Oc and esophagus= Length of entire esophagus and buccal capsule representing of body length; [c] Calculated from original data; [d] two lateral papillae on the amphids; [e] +1 pairs of phasmids; [f] Taken after Moravec, Wolter & Körting, 1999; [g] Calculated from anterior extremity.

Caracteres	*Spirocamallanus krameri*		*S. krameri*		*S. krameri*		*S. inopinatus*		*S. hilarii*	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Hosts Type locality Authority	*Hoplerythrinus unitaeniatus* Traquateua, Pará, Brazil In this study		*Hoplerythrinus unitaeniatus* French Guiana Petter 1974		*Hoplerythrinus unitaeniatus* Venezuela Moravec et al. 1997		*Leporinus* sp. Brazil Travassos, Artigas & Pereira 1928		*Astyanax fasciatus* and *Astyanax* sp. Vaz & Pereira 1934	
Length (mm)[a]	7 (6–7.8)	14 (10–16)	7	14–20	5.77–6.90	15.82–24.64	5.12	16–30	6	14
Width	229 (166–266)	379 (326–433)	250	460	272–286	625–666	240	800	200	360
Oral capsule (L)[b]	71 (66–75)	96 (88–106)	50	100	51–66	96–108	90	120	57	62
Oral capsule (W)	91 (81–103)	114 (101–136)	90	100	75–93	120–129	–	–	57	62
Ratio oral capsule W/L	1:1.28	1:1.18	1:1.8 [c]	1:1 [c]	1:1.4 [c]	1:1.2 [c]	–	–	1:1 [c]	1:1 [c]
Mouth opening	Hexagonal		Hexagonal		Circular		Circular		Circular	
Cephalic papillae	16 (+1) [d]	16 (+1) [d]	14	14	8	8	–	–	–	–
Oral ridge	11–13	13–17	16–20		10–12	14–15	15	15		14–16
Theeth	Present	–	Present	–	Present	–	Absent	Absent	Absent	Absent
Deirid	120 (95–150)	131 (100–147)	100	140	108–120	165–168	–	–	–	–
Nervous ring	161 (140–173)	210 (177–247)	180	250	150–177	218–258	250–320	250–320	200	200
Excretory Pore	310 (261–383)	410 (337–460)	475	500	326	435–476	320	320	360	360

Table I. Continuation

Muscular oesophagus (L)	309 (273–366)	383 (333–453)	325	400	286–299	408–462	360	450	410	410
Glandular oesophagus (L)	443 (366–526)	554 (486–620)	450	575	449–476	639–666	560–760	560–760	1500	2020
Ratio M/G[b]	1:1.4 (1:1.2–1.8)	1:1.5 (1:1.3–1.6)	1:1.38 [c]	1:1.44 [c]	1:1.5–1.7	1:1.4–1.6	1:1.83 [c]	1:1.47 [c]	1:3.7 [c]	1:5 [c]
Ratio L/ Oc and oesophagus	8.7% (7–10.6)	13% (11–15)	11.78% [c]	6.3% [c]	12.4% [c]	5.9% [c]	21.68% [c]	5.35% [c]	32.8% [c]	17.8% [c]
Vulva (mm)	–	11 (7–12)	–	11.1	–	11.29–13.68	–	–	–	–
Precloacal papillae	4	–	4	–	4	–	2	–	3	–
Additional papillae	–	–	–	–	–	–	–	–	2	–
Postcloacal papillae	6 (+1) [e]	–	5 (+1) [e]	–	6	–	6	–	3	–
Small spicule	90 (81–101)	–	75	–	72–87	–	120	–	62	–
Large spicule	95 (83–101)	–	80	–	75–87	–	120	–	82	–
Gubernaculum	Absent		Absent		Absent		Absent		Absent	
Tail	216 (150–308)	176 (120–223)	280	150	160	160	200	200	160	120
Caudal alae	Absent		Absent		Absent		Absent		Absent	
Numbers of specimens	10	10	1	1	–	–	–	–	–	–
Caracteres	***S. pexatus***		***S. paraensis***		***S. pintoi***		***S. saofranciscencis***		***S. belenensis***	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Hosts Type locality	*Trichomycterus brasiliensis* Espírito Santo, Brazil Pinto, Fabio, Noronha & Rola 1976		*Erythrinus erythrinus* Pará–Brazil Pinto & Noronha 1976		*Corydora paleatus* Paraná, Brazil Kohn & Fernandes 1988		*Tetragonopterus chalceus* and *Acestrorhynchus lacustris* Minas Gerais, Brazil Moreira, Oliveira & Costa 1991		*Ageneiosus ucayalensis* Pará, Brazil Giese, Santos, Lanfredi 2009	
Length (mm)[a]	3.72–4.26	12.77–20.48	5.2–7.7	12.6–15.7	4.67	21.8–26	4.15–6.29	11.05–18.96	3.5–6.5	10.4–25
Width	210–240	450–720	180–310	310–440	250	950–1160	230–280	480–680	142–210	320–450

Table I. Continuation

Oral capsule (L)[b]	53–59	66	70–80	80–100	54	60–71	40–50	60–80	55–75	85–111
Oral capsule (W)	46–59	53–66	90–100	100–110	45	46–56	45–60	70–100	50–70	80–107
Ratio oral capsule W/L	1:09 [c]	1:09 [c]	1:1.2 [c]	1:1.16 [c]	1:0.8 [c]	1:1.16 [c]	1:1.16 [c]	1:1.2 [c]	1:0.9 [c]	1:0.95 [c]
Mouth opening	Circular		Circular		Circular[f]		Hexagonal		Hexagonal	
Cephalic papillae	–	–	–	–	4	4	12	12	8	8
Oral ridge	5–7	3–4	14–16	14–16	6	9–10	11–15	15–17	8–10	9–13
Theeth	Absent	Absent	Absent	Absent	Absent	Absent	Present	Present	Absent	Absent
Deirid	–	–	–	–	–	–	85–98	101–109	76–130	110–205
Nervous ring	140–160	160–260	140–180	210–230	112	120–158	150–180	180–240	150–200	200–275
Excretory Pore	280	140–290	–	–	156	300	250–300	280–510	200–295	226–421
Muscular oesophagus (L)	300	420–500	340–360	430–440	228	266–296	280–320	340–380	219–285	340–410
Glandular oesophagus (L)	300–360	530–660	470–560	470–560	587	862–1045	500–550	630–790	410–520	530–740
Ratio M/G	1:1 [c]	1:1.3 [c]	1:1.5 [c]	1:1.18 [c]	1:2.6	1.3.4	1:1.72–83	1:1.72–2.19	1:1.5–2	1:1.2
Ratio L/Oc and oesophagus	17% [c]	7% [c]	14.57% [c]	7.34% [c]	18.6% [c]	5.4% [c]	16.7% [c]	7.6% [c]	15.74% [c]	6% [c]
Vulva (mm)	–	6.78–13.04	–	13.43[g]	–	16	–	5.82–10.88	–	5.8–13.6
Precloacal papillae	3	–	7	–	4	–	3	–	3	–
Additional papillae	2	–	1	–	–	–	2	–	1	–
Postcloacal papillae	2	–	11	–	2	–	5	–	4–5	–
Small spicule	90–110	–	70–90	–	82	–	83–95	–	58–80	–
Large spicule	90–110	–	70–90	–	94	–	71–83	–	50–75	–
Gubernaculum	Absent		Absent		Absent		Absent		Absent	
Tail	150	410	170–180	140–200	120	223–392	160–220	120–210	160–210	150–285
Caudal alae	Absent		Absent		Absent		Absent		Absent	
Numbers of specimens	–	–	1	4	1	3	3	13	9	10

parasite *Erythrinus erythrinus* (Bloch & Schneider 1801) (Characiformes: Erythrinidae); *S. pexatus*, a parasite of *Trichomycterus brasiliensis* Lütken 1874 (Syn. = *Pygidium brasiliensis*) (Siluriformes: Trichomycteridae); *S. saofranciscencis*, a parasite of *Tetragonopterus chalceus* Spix & Agassiz 1829 (Characiformes: Characidae) and *Acestrorhynchus lacustris* (Lütken 1875) (Characiformes: Acestrorhynchidae) and *S. belenensis*, a parasite of *Ageneiosus ucayalensis* Castelnau 1855 (Siluriformes: Auchenipteridae). All of these are parasites of freshwater fish and they have subequal spicules that are small and morphologically similar.

Compared to the species with short spicules, *S. krameri* has 10 pairs of papillae (four pairs of precloacal papillae and six pairs of postcloacal papillae), which differentiates it easily from *S. pintoi*, which has four pairs of precloacal papillae and two pairs of postcloacal papillae; *S. pexatus*, which has three pairs of precloacal papillae, an additional two pairs of sessile ventral papillae surrounding the cloacal opening and two postcloacal papillae; the Amazonian species *S. paraensis*, which has 19 pairs of caudal papillae; and *S. belenensis*, which has three pairs of precloacal papillae and 4–5 pairs of postcloacal papillae, although *S. belenensis* has a hexagonal oral cavity. *Spirocamallanus krameri* also differs from *S. belenensis* by not presenting fringes on the banks of the oral opening and by having a knurled basal ring and two small cuticular projections pointed at the end of the tail.

Spirocamallanus krameri differs from *S. saofranciscencis* in the number of cephalic papillae (18 pairs *vs* 12 pairs), the smaller size of the buccal capsule in the latter species, the number and distribution of the caudal papillae in the males, distributed in three precloacal papillae, an additional two pairs of sessile ventral papillae surrounding the cloacal opening and five postcloacal papillae. The species redescribed herein differs from *S. hilarii* by having a circular buccal opening, a larger glandular oesophagus, and the distribution of caudal papillae with three precloacal papillae, an additional two pairs of sessile ventral papillae surrounding the cloacal opening and three pairs postcloacal papillae. Morphometric comparisons between *S. krameri* and the species of *Spirocamallanus* that feature short spicules are presented in Table I.

Moravec et al. (1997) reported that *Spirocamallanus krameri* is morphologically similar to *S. inopinatus*, but that they differ in the morphology of the buccal capsule. Petter (1974) proposed that *S. krameri* exhibits sexual dimorphism in the buccal capsule, namely, that in males, the spiral ridges occupy up to the middle third of the capsule surface, and, in females, they occupy the complete interior surface of the capsule. They also reported that *S. inopinatus* has a hexagonal oral opening and teeth at the base of the basal ring in males; wheres, *S. inopinatus* has no teeth at the base of the ring and has a circular mouth opening.

The examination of ultrastructural features revealed features in this species that have never before been studied using SEM: hexagonal oral opening, details of the 18 cephalic deirids and papillae, the excretory pore and the vulva, the pattern of papillae in males and details of the phasmidial pores in both sexes. Thus, these findings confirm the identity of *S. krameri* and the presence of the species in Brazil

Finally, the studies presented here in provide ecological information on the prevalence, morphology and morphometry of the species. The new report of its geographical distribution in Brazil increases our knowledge of the biodiversity of Brazil.

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REFERENCES

ANNEREAUX RF. 1946. A new nematode *Procamallanus pereirai* with a key to the genus. Trans Am Microsc Soc 65: 299-303.

BASHIRULLAH AKM. 1977. Two new camallanid nematodes from marine fishes of Venezuela. Publicación de la Universidade Nacional Autónoma del México (UNAM) 4: 391-400.

BAUTISTA-HERNÁNDEZ CE, MONKS S, PULIDO-FLORES G & RODRÍGUEZ-IBARRA AE. 2015. Revisión bibliográfica de algunos términos ecológicos usados en parasitología, y su aplicación en estudios de caso. In: Estudios en biodiversidad. vol. I. Lincoln, Nebraska: Zea Books, p. 11–19.

BAYLIS HA. 1923. Report on a collection of parasitic nematodes, mainly from Egypt. Part III. Camallanidae, etc. with a note on *Probstmatria* and an Appendix on Acanthocephala. Parasitol 15: 24-38.

BUSH AO, LAFFERTY KD, LOTZ JM & SHOSTAK AW. 1997. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. J Parasitol 83: 575-583.

CHITWOOD BG. 1933. A revised classiflcation of the nematoda. J Parasitol 20: 131.

FROESE, R & PAULY D. 2018. FishBase. World Wide Web electronic publication. www.fishbase.org. (accessed January 10, 2018).

FUSCO AC & OVERSTREET RM. 1978. *Spirocamallanus cricotus* sp. n. and *S. halitrophus* sp. n. (Nematoda: Camallanidae) from fishes in the northern Gulf of Mexico. J Parasitol 64: 239-244.

GIESE EG, SANTOS JN & LANFREDI RM. 2009 A new species of Camallanidae from *Ageneiosus ucayalensis* (Pisces: Siluriformes) from Pará State, Brazil. J Parasitol 95: 407-412.

GUIMARÃES JF, CRISTOFARO R & RODRIGUES HO. 1976. Alguns nematódeos de peixes de Salvador, Bahia. Atas Soc Biol Rio de Janeiro 18: 21-25.

JOTHY AA & FERNANDO CH. 1970. A new camallanid nematode, *Malayocamallanus intermedius* gen. et. sp. nov., from a Malayan freshwater fish, *Fluta alba* (Zuiew) witha key to the genera of the subfamily Procamallaninae. Helminthology 11: 87-91.

KOHN A & FERNANDES BMM. 1988. Helminth parasites of fishes from the hydroelectric power station of Eletrosul (Brazil). I – *Procamallanus petterae* n. sp. and *Spirocamallanus pintoi* n. sp. (Nematoda, Camallanidea) from the Reservoir of "Salto Osório". Mem Inst Oswaldo Cruz 83: 293-298.

KOHN A, FERNANDES BMM, PIPOLO HV & GODOY MP. 1988. Helmintos parasitos de peixes das Usinas Hidrelétricas Eletrosul (Brasil). II. Reservatórios de Salto Osório e de Salto Santiago. Bacia do Rio Iguaçu. Mem Inst Oswaldo Cruz 83: 299-303.

LUQUE JL, AGUIAR JC, VIEIRA FM, GIBSON DI & SANTOS CP. 2011. Checklist of nematoda associated with the fishes of Brazil. Zootaxa 3082: 1-88.

MORAVEC F. 1998. Nematodes of freshwater fishes of the neotropical region. Academia, Praha, 464 p.

MORAVEC F, PROUZA A & ROYERO R. 1997. Some nematodes of freshwater fishes in Venezuela. Folia Parasitol 44: 33-47.

MORAVEC F & SCHOLZ T. 1991. Observations on some nematodes parasitic in freshwater fishes in Laos. Folia Parasitol 38: 163-178.

MORAVEC F & SEY O. 1988. Nematodes of freshwater fishes from North Vietnam. Part 1. Camallanoidea and Habronematoidea. Acta Soc Zool Bohem 52: 128-148.

MORAVEC F & THATCHER VE. 1997. *Procamallanus* (*Denticamallanus* subgen. n.) *dentatus* n. sp. (Nematoda: Camallanidae) from the characid fish, *Bryconops alburnoides*, in the Brazilian Amazon. Parasite 4: 239-243.

MORAVEC F, WOLTER J & KÖRTING W. 1999. Some nematodes and acanthocephalans from exotic ornamental freshwater fishes imported into Germany. Folia Parasitol 46: 296-310.

MOREIRA NIB, OLIVEIRA CL & COSTA HMA. 1991. A new helminth parasite of fish: *Spirocamallanus freitasi* sp.n.

(Nematoda: Camallanidae). Mem Inst Oswaldo Cruz 86: 429-431.

MOREIRA NIB, OLIVEIRA, CL & COSTA HMA. 1994. *Spirocamallanus inopinatus* (Travasso, Artigas & Pereira, 1928) e *Spirocamallanus saofranciscencis* sp. n. (Nematoda: Camallanidae) em peixes da Represa de Três Marias. Arq Bras Med Vet Zootec 46: 485-500.

OLSEN LS. 1952. Some nematodes parasitic in marine fishes. Publ Inst Mar Sci 2: 175-215.

PAVANELLI GC, MACHADO MH, TAKEMOTO RM, GUIDELLI GM & LIZAMA MAP. 2004. Helminth fauna of fishes: diversity and ecological aspects. p. 309-329 in Thomaz SM, Agostinho AA and Hahn NS (Eds), The upper Paraná river and its floodplain: Physical aspects, ecology and conservation. Backhuis Publishers.

PEREIRA C. 1935. Ascaridata e Spirurata parasitos de peixes do Nordeste do Brasileiro. Arq Inst Biol 6: 53-62.

PETTER JA. 1974. Deux nouvelles espèces de nematodes Camallauina parasites de *Hoplerythrinus unitaeniatus* (Characidac, Cypriniformes) en Guyane; création d'une nouvelle famille: les Guyanemidae (Dracunculoidea). Bull Mus Natl Hist Nat 156: 803-812.

PINHEIRO RHDS, MELO FTDV, MONKS S, DOS SANTOS JN & GIESE EG. 2018. A new species of *Procamallanus* Baylis, 1923 (Nematoda, Camallanidae) from *Astronotus ocellatus* (Agassiz, 1831) (Perciformes, Cichlidae) in Brazil. ZooKeys 790: 21-33.

PINTO RM, FABIO SP, NORONHA D & ROLAS T. 1974. *Procamallanus* Brasileiros - Parte I (Nematoda: Camallanoidea). Mem Inst Oswaldo Cruz 72: 205-211.

PINTO RM, FABIO SP, NORONHA DE & ROLAS T. 1975. Novas contribuições ao conhecimento do gênero *Procamallanus* (Nematoda: Camallanoidea). Mem Inst Oswaldo Cruz 73: 183-191.

PINTO RM, FABIO SP, NORONHA DE & ROLAS T. 1976. Novas considerações morfológicas e sistemáticas sobre os *Procamallanus* Brasileiros (Nematoda: Camallanoidea). Mem Inst Oswaldo Cruz 74: 77-84.

PINTO RM & NORONHA D. 1976. *Procamallanus* brasileiros (Nematoda: Camallanoidea): considerações finais, com chave para determinação das espécies. Mem Inst Oswaldo Cruz 74: 323-339.

RAILLIET A & HENRY A. 1915. Sur less nematodes du genre *Camallanus* Railliet & Henry, 1915 (*Cucullanus* auct., non Mueller, 1777). Bull Soc Pathol Exot 8: 117-119.

RAMALLO G & AILÁN-CHOKE LG. Observations on two *Procamallanus* (*Spirocamallanus*) species (Nematoda: Camallanidae) from freshwater fishes in Argentina, including description of *Procamallanus* (*Spirocamallanus*) *juana* sp. nov. Zootaxa 4323: 286-294.

RIGBY MC & RIGBY E. 2014. Order Camallanida: Superfamilies Anguillicoloidea and Camallanoidea. In: Handbook of zoology: Gastrotricha, Cycloneuralia and Gnathifera: Vol. 2, Nematoda. Berlin: Walter De Gruyter, p. 637-659.

TRAVASSOS L, ARTIGAS PE & PEREIRA C. 1928. Fauna helmintológica dos peixes de água doce do Brasil. Arq Inst Biol 1: 5-68.

VAZ Z & PEREIRA C. 1934. Contribuição ao conhecimento dos nematoides de peixes fluviais do Brasil. Arq Inst Biol 5: 87-103.

VICENTE JJ & SANTOS E. 1972. Sobre um novo nematódeo camalanídeo parasito de peixe marinho (Nematoda: Camallanoidea). Atas Soc Biol Rio de Janeiro 15: 145-147.

YEH LS. 1960. On a reconstruction of the genus *Camallanus* Railliet and Henry, 1915. J Helminthol 34: 117-124.

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