







Two new species of *Anacanthorus* (Monogenoidea, Dactylogyridae) parasitizing serrasalmid fish in Brazil

Duas novas espécies de *Anacanthorus* (Monogenoidea, Dactylogyridae) parasitando peixes serrasalmideos no Brasil

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Abstract

During studies on fish parasites, two new species of *Anacanthorus* were found parasitizing serrasalmid fishes, *Anacanthorus simpliciphallus* sp. n. from the hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus* and *Anacanthorus brandtii* sp. n. from *Serrasalmus brandtii*. *Anacanthorus simpliciphallus* sp. n. resembles *Anacanthorus reginae* in the morphology of the male copulatory organ (MCO) and accessory piece but differs from *A. reginae* in terms of the smaller size of the accessory piece, which corresponds approximately half the size of the MCO and by the presence of a conspicuous metraterm, with a membranous terminal region. *Anacanthorus brandtii* sp. n. differs from *Anacanthorus scapanus* by the expansion of the accessory piece, from *Anacanthorus jegui* by the ratio MCO (male copulatory organ) /AP (accessory piece) and by the expansion of hook shank, from *Anacanthorus sciponophallus* and *A. reginae* by the ratio MCO/AP. *Anacanthorus brandtii* sp. n. can be distinguished from *A. reginae* and *A. simpliciphallus* sp.n. by the size of hooks which is similar in *A. reginae* and *A. simpliciphallus* sp. n. and dissimilar in *A. brandtii* sp. n. The two new species also differ from each other by the expansion of shank.

Keywords: *Anacanthorus* spp., Dactylogyridae, Neotropical Region, Serrasalmidae.

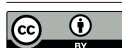
Resumo

Durante estudos em parasitos de peixes, duas novas espécies de *Anacanthorus* foram encontradas parasitando peixes serrasalmideos, *Anacanthorus simpliciphallus* sp. n. do híbrido *Piaractus mesopotamicus* x *Piaractus brachypomus* e *Anacanthorus brandtii* sp. n. de *Serrasalmus brandtii*. *Anacanthorus simpliciphallus* sp. n. assemelha-se a *Anacanthorus reginae* na morfologia do órgão copulatório masculino (OCM) e peça acessória (PA), mas difere de *A. reginae* pelo tamanho menor da peça acessória, que corresponde a aproximadamente metade do tamanho do OCM e pela presença de um metraterma conspícuo, com uma região terminal membranosa. *Anacanthorus brandtii* sp. n. difere de *Anacanthorus scapanus* pela expansão da peça acessória, de *Anacanthorus jegui* pela proporção OCM / PA e pela expansão da haste do gancho, e de *Anacanthorus sciponophallus* e *A. reginae* pela proporção OCM / PA. *Anacanthorus brandtii* sp. n. pode ser distinguido de *A. reginae* e *A. simpliciphallus* sp. n. pelo tamanho dos ganchos que é similar em *A. reginae* e *A. simpliciphallus* sp. n. e dissimilar em *A. brandtii* sp. n. As duas espécies novas também diferem entre si pela expansão da haste do gancho.

Palavras-chave: *Anacanthorus* spp., Dactylogyridae, Região Neotropical, Serrasalmidae.

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Introduction

Serrasalmidae, understood by fish known as piranhas and pacus, is a diverse family of freshwater fishes belonging to the order Characiformes, that is endemic throughout tropical and subtropical South America. *Piaractus mesopotamicus* (Holmberg, 1887) and *Piaractus brachypomus* (Cuvier, 1818), popularly known in Brazil as pacu and pirapitinga, respectively, are species characteristic of tropical waters and restricted to South America (Froese & Pauly, 2023). Crossing the female of *P. mesopotamicus* with the male of *P. brachypomus* results in the hybrid known as “patinga”, which has been gaining much ground in the Brazilian fish market (Ribeiro et al., 2016).

Serrasalmus brandtii Lutken, 1875 popularly known as white piranha and “pirambeba” is an endemic species of São Francisco River Basin (Britski et al., 1988; Jegú, 2003) and has a carnivorous feeding habit, being primarily piscivorous and secondarily insectivorous (opportunistic) (Pompeu & Godinho, 2003). The specimens generally inhabit lentic environments and are abundant in the Três Marias reservoir (Braga, 1975).

Dactylogyridae represents one of the most species-rich groups among helminths parasites of fishes (Boeger & Vianna, 2006; Cohen et al., 2013). Among all the genera of dactylogyrids, *Anacanthorus* Mizelle & Price, 1965 stand out as being highly diverse in species, distributed in a large number of host species among Neotropical freshwater fish (Cohen et al., 2013). Currently, this genus has 92 nominal species, among which 41 species (Table 1) parasitize Serrasalmidae fish, the most common host group for *Anacanthorus* spp. (Moreira et al., 2019). So far, species of *Piaractus* Eigenmann have been found to be parasitized by six species of Monogenoidea, among which *Anacanthorus* is the parasite genus most represented in this host genus: *Anacanthorus penilabiatum* Boeger, Husak & Martins, 1995; *Anacanthorus spathulatus* Kritsky, Thatcher & Kayton 1979; *Anacanthorus toledoensis* Leão, São Clemente & Cohen, 2015; *Mymarothecium ianwhittingtoni* Leão, São Clemente & Cohen, 2015; *Mymarothecium viatorum* Boeger, Piasecki & Sobocka, 2002; *Notozothecium janauachensis* Belmont-Jégu, Domingues, & Martins, 2004. These parasites have been recorded in Brazil and Peru (Kritsky et al., 1979; Boeger et al., 1995; Pamplona-Basilio et al., 2001; Martins et al., 2002; Cohen & Kohn, 2005, 2009; Lizama et al., 2007; Dinis-Vásquez et al., 2014; Leão et al., 2015, 2017; Oliveira & Tavares-Dias, 2016; Jerônimo et al., 2020; Moreira et al., 2019). During studies with fish parasites, a new species of *Anacanthorus* was found parasitizing the gills of a hybrid fish (*P. mesopotamicus* x *P. brachypomus*) that are commercialized in marketplace located in São Luís Island, Maranhão, Brazil, and another one in the endemic *S. brandtii* from São Francisco River and are described herein.

Table 1. *Anacanthorus* spp. parasites of Serrasalmidae from Neotropical Region. Scientific names of hosts are given according to accepted names in Froese & Pauly (2023).

MONOGENOIDEA	HOSTS	LOCALITIES	REFERENCES
<i>Anacanthorus amazonicus</i> Van Every & Kritsky, 1992	<i>Pristobrycon striolatus</i> , <i>Serrasalmus rhombeus</i> , <i>Serrasalmus altispinis</i> , <i>Serrasalmus</i> sp.	Bolivia, Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus anacanthorus</i> Mizelle & Price, 1965	<i>Pygocentrus nattereri</i>	Brazil*	Mizelle & Price (1965)
<i>Anacanthorus beleophallus</i> Kritsky, Boeger & Van Every, 1992	<i>Pristobrycon eigenmanni</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus brazilensis</i> Mizelle & Price, 1965	<i>P. nattereri</i>	Brazil*	Mizelle & Price (1965)
<i>Anacanthorus camposbaeae</i> Morey, Aliano & Grandez, 2019	<i>Myloplus schomburgkii</i>	Peru	Morey et al. (2019)
<i>Anacanthorus carmenrosae</i> Morey, Aliano & Grandez, 2019	<i>M. schomburgkii</i>	Peru	Morey et al. (2019)
<i>Anacanthorus catoprioni</i> Kritsky, Boeger & Van Every, 1992	<i>Catoprion mento</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus cinctus</i> Van Every & Kritsky, 1992	<i>P. striolatus</i> , <i>S. altispinis</i>	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus cladophallus</i> Van Every & Kritsky, 1992	<i>S. altispinis</i> , <i>S. spilopleura</i>	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus crytocaulus</i> Van Every & Kritsky, 1992	<i>S. altispinis</i> , <i>P. striolatus</i>	Brazil	Van Every & Kritsky (1992)

*Host obtained from Steinhart Aquarium, San Francisco, California

Table 1. Continued...

MONOGENOIDEA	HOSTS	LOCALITIES	REFERENCES
<i>Anacanthorus gravihamulatus</i> Van Every & Kritsky, 1992	<i>S. altispinis</i> , <i>S. rhombeus</i> , <i>P. eigenmanni</i> , <i>Serrasalmus</i> sp.	Bolívia, Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus hoplophallus</i> Kritsky, Boeger & Van Every, 1992	<i>Myloplus rubripinnus</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus jegui</i> Van Every & Kritsky, 1992	<i>Metynnis lippincottianus</i> , <i>P. eigenmanni</i> , <i>Pristobrycon</i> sp., <i>S. rhombeus</i> , <i>S. altispinis</i> , <i>Serrasalmus spilopleura</i> , <i>Serrasalmus</i> sp.	Bolívia, Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus lasiophallus</i> Van Every & Kritsky, 1992	<i>P. striolatus</i>	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus lepyrophallus</i> Kritsky, Boeger & Van Every, 1992	<i>S. elongatus</i> , <i>S. altispinis</i> , <i>S. maculatus</i> , <i>S. marginatus</i> , <i>Serrasalmus</i> sp.	Brazil	Kritsky et al. (1992)
<i>Anacanthorus maltai</i> Boeger and Kritsky, 1988	<i>P. nattereri</i>	Brazil	Boeger & Kritsky (1988)
<i>Anacanthorus mastigophallus</i> Kritsky, Boeger & Van Every, 1992	<i>P. eigenmanni</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus mesocondylus</i> Van Every & Kritsky, 1992	<i>S. spilopleura</i> , <i>Serrasalmus</i> sp., <i>P. eigenmanni</i> , <i>Pristobrycon</i> sp.,	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus myleusi</i> Moreira, Carneiro, Ruz & Luque, 2019	<i>M. schomburgkii</i>	Brazil	Moreira et al. (2019)
<i>Anacanthorus neotropicalis</i> Mizelle & Price, 1965	<i>P. nattereri</i>	Brazil*	Mizelle & Price (1965)
<i>Anacanthorus palamophallus</i> Kritsky, Boeger & Van Every, 1992	<i>P. eigenmanni</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus paraspathulatus</i> Kritsky, Boeger & Van Every, 1992	<i>Mylossoma duriventris</i> , <i>M. aureum</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus paraxaniophallus</i> Moreira, Carneiro, Ruz & Luque, 2019	<i>Serrasalmus maculatus</i> , <i>S. marginatus</i>	Brazil	Moreira et al. (2019)
<i>Anacanthorus pedanophallus</i> Kritsky, Boeger & Van Every, 1992	<i>M. rubripinnis</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus penilabiatus</i> Boeger, Husak & Martins, 1995	<i>Colossoma macropomum</i> , <i>C. macropomum</i> x <i>Piaractus mesopotamicus</i> , <i>Piaractus brachypomus</i> , <i>P. mesopotamicus</i> , <i>P. brachypomus</i> x <i>P. mesopotamicus</i>	Brazil	Boeger et al. (1995), Pamplona-Basilio et al. (2001), Martins et al. (2002), Lizama et al. (2007), Cohen & Kohn (2009), Leão et al. (2017), Jerônimo et al. (2020)
<i>Anacanthorus periphallus</i> Kritsky, Boeger & Van Every, 1992	<i>S. altispinis</i> , <i>Serrasalmus</i> sp.	Brazil	Kritsky et al. (1992)
<i>Anacanthorus prodigiosus</i> Van Every & Kritsky, 1992	<i>S. elongatus</i> , <i>S. altispinis</i> , <i>S. rhombeus</i> , <i>Serrasalmus</i> sp.	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus ramosissimus</i> Van Every & Kritsky, 1992	<i>Serrasalmus elongatus</i>	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus reginae</i> Boeger & Kritsky, 1988	<i>P. nattereri</i>	Brazil, Peru	Boeger & Kritsky (1988), Iannacone & Luque (1993)
<i>Anacanthorus rondonensis</i> Boeger & Kritsky, 1988	<i>P. nattereri</i> , <i>S. rhombeus</i>	Brazil, Bolívia	Boeger & Kritsky (1988), Córdova & Pariselle (2007)
<i>Anacanthorus scapanus</i> Van Every & Kritsky, 1992	<i>S. spilopleura</i>	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus sciponophallus</i> Van Every & Kritsky, 1992	<i>S. altispinis</i> , <i>S. elongatus</i> , <i>S. maculatus</i> , <i>S. rhombeus</i> , <i>S. spilopleura</i> , <i>Serrasalmus</i> sp.	Bolívia, Brazil	Van Every & Kritsky (1992), Córdova & Pariselle (2007)
<i>Anacanthorus serrasalmi</i> Van Every & Kritsky, 1992	<i>S. altispinis</i> , <i>S. elongatus</i> , <i>S. rhombeus</i> , <i>Serrasalmus</i> sp., <i>Pristobrycon</i> sp.,	Brazil	Van Every & Kritsky (1992)
<i>Anacanthorus spathulatus</i> Kritsky, Thatcher & Kayton, 1979	<i>C. macropomum</i> , <i>C. macropomum</i> x <i>P. brachypomus</i> , <i>P. brachypomus</i> , <i>P. mesopotamicus</i>	Brazil, Peru, Venezuela	Kritsky et al. (1979), Aragot et al. (2002), Fischer et al. (2003), Centeno et al. (2004), Lizama et al. (2007), Morais et al. (2009), Godoi et al. (2012), Santos et al. (2013), Soberon et al. (2014), Dias & Tavares-Dias (2015), Oliveira & Tavares-Dias (2016), Silva et al. (2022)

*Host obtained from Steinhart Aquarium, San Francisco, California

MONOGENOIDEA	HOSTS	LOCALITIES	REFERENCES
<i>Anacanthorus spinatus</i> Kritsky, Boeger & Van Every, 1992	<i>M. rubripinnus</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus stachophallus</i> Kritsky, Boeger & Van Every, 1992	<i>P. nattereri</i>	Brazil, Peru	Kritsky et al. (1992), Iannacone & Luque, 1993
<i>Anacanthorus stagmophallus</i> Kritsky, Boeger & Van Every, 1992	<i>M. rubripinnis</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus strongylophallus</i> Kritsky, Boeger & Van Every, 1992	<i>M. lippincottianus</i>	Brazil	Kritsky et al. (1992)
<i>Anacanthorus thatcheri</i> Boeger & Kritsky, 1988	<i>P. nattereri</i>	Brazil, Peru	Boeger & Kritsky (1988), Iannacone & Luque (1993)
<i>Anacanthorus toledoensis</i> Leão, São Clemente & Cohen, 2015	<i>P. mesopotamicus</i>	Brazil	Leão et al. (2015)
<i>Anacanthorus xaniophallus</i> Kritsky, Boeger & Van Every, 1992	<i>P. eigenmanni</i> , <i>Pristobrycon</i> sp.	Brazil	Kritsky et al. (1992)

*Host obtained from Steinhart Aquarium, San Francisco, California

Material and Methods

One hybrid specimen of *P. mesopotamicus* x *P. brachypomus* purchased from a fish market on São Luís Island, State of Maranhão, which had been brought to the market from a fish farm established in the municipality of Matinha (3°05'13.5"S, 45°02'56"W) and 168 specimens of *S. brandtii* captured by local fishers in Três Marias Reservoir (18°12'59"S, 45°17'34"W), Upper São Francisco River, Minas Gerais State, Brazil and sent to the "Centro Integrado de Recursos Pesqueiros e Aquicultura (CIRPA)" of the "Companhia de Desenvolvimento dos Vales do São Francisco e Parnaíba (CODEVASF)" were examined for Monogenoidea. The gills were removed and placed in vials containing hot water (~65°C) and were shaken. Absolute ethanol was added to reach a concentration of 70%. Monogenoids were picked from the sediment and from the gill arches with the aid of a stereoscopic microscope. Some specimens were mounted in Hoyer's medium to study of the sclerotized parts and others were stained with Gomori's trichrome and mounted in Canada balsam (Humason, 1979; Boeger & Vianna, 2006). The specimens were observed using an Olympus BX 41 microscope with phase contrast and Zeiss Axioskop 2 Plus microscope with differential interference contrast, both equipped with a camera lucida for drawings. All measurements are presented in micrometers, and the range is followed by the mean in parentheses and the number of specimens measured. Identification of the authors and nomenclatural acts for the taxon was in accordance with the guidelines provided in Article 50.1 and recommendation 50A of the International Code of Zoological Nomenclature (ICZN), which specifically pertains to authorship identity. The holotype and paratypes for each parasite species were deposited in the Helminthological Collection of the Oswaldo Cruz Institute (CHIOC), Rio de Janeiro, Brazil.

Results

TAXONOMY

Class Monogenoidea Bychowsky, 1937

Subclass Polyonchoinea Bychowsky, 1937

Order Dactylogyridea Bychowsky, 1937

Family Dactylogyridae Bychowsky, 1933

Subfamília Anacanthorinae Mizelle & Price, 1965

Anacanthorus Mizelle & Price, 1965

Anacanthorus simpliciphallus Silva, Cohen, Costa & Justo sp. n. (Figure 1a-d; Figure 2a-c).

Type host: Hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus* (Characiformes, Serrasalmidae)

Site in host: Gill lamellae

Type-locality: Marketplace on São Luis Island, Maranhão state, host specimen obtained from a fish farm established in the municipality of Matinha (3°05'13.5"S, 45°02'56" W).

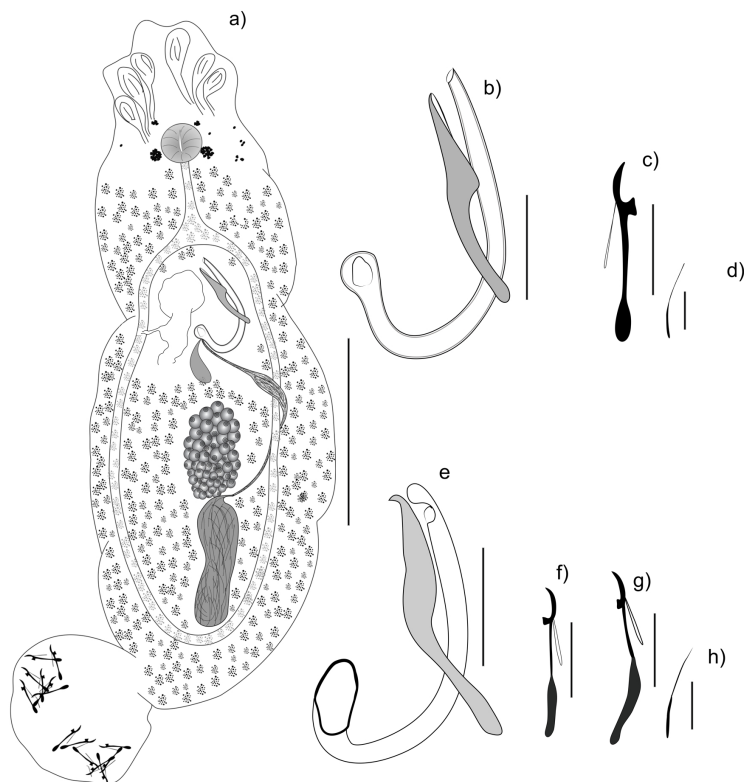


Figure 1. a-d: *Anacanthorus simpliciphallus* sp. n. parasite of hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus*. (a): Total view, ventral (composite) (b): MCO (c) Hook (d) Hook 4A; e-h: *Anacanthorus brandtii* sp. n. parasite of *Serrasalmus brandtii*: (e): MCO (f) Hook pairs 1,5 (g) Hook pairs 2,4,6,7 (h) Hook 4A. Scale bars: (a) 100 µm (b, e) 20 µm (c, f, g) 10 µm (d, h) 5 µm.



Figure 2. Light photomicrographs of *Anacanthorus simpliciphallus* sp. n. parasite of hybrid *Piaractus mesopotamicus* x *Piaractus brachypomus*. (a): Total view, ventral (b) Copulatory complex (c) Haptor. Scale bars. (a) 100 µm, (b) 30 µm; (c) 30 µm.

Parasitological indexes: Total number of hosts: 1; total number of parasites: 7

Type-material: Holotype CHIOC 40268 a; Paratypes CHIOC 40268 b-g.

Etymology: The species name is from Latin (*simplex*=simples + *phallus*=penis) and refers to the morphology of the male copulatory organ.

DESCRIPTION: (Based on seven specimens: six mounted in Hoyer's medium and one mounted in Gomori's trichrome). Body elongated, fusiform, 262–550 (422, n= 5) long including the haptor, by 88–145 (123, n= 5) wide at the level of germarium. Two terminal, and two bilateral well developed cephalic lobes; three bilateral pairs of head organs. Two pairs of eyes equidistant, anterior pair smaller than posterior pair, slightly closer together than posterior pair; pairs slightly close to each other; accessory granules sparse in the cephalic region. Pharynx subspherical, 20 and 27 (n= 2) in diameter; long oesophagus. Two intestinal caeca confluent posterior to the gonads, lacking diverticula. Gonads overlapping; testis dorsal to germarium, 60–100 (86; n= 4) long, vas deferens looping intestinal caeca, single prostatic reservoir pyriform. Copulatory complex comprising male copulatory organ (MCO) and accessory piece (AP). MCO tubular, heavily sclerotized, J-shaped, with slightly sclerotized walls, base with smooth margin, 65–83 (73; n= 7) long. Accessory piece with a terminal flap, non articulated to MCO base, 37–45 (41; n= 7). Ratio MCO/AP 1:0.48-1:0.58 (1:0.55, n=7). Germarium 35 and 40 (n= 2) long by 40 and 45 (n= 2) wide. Metraterm conspicuous, with membranous terminal region. Genital pore and eggs not observed. Peduncle short. Haptor armed with 7 pairs of hooks (4 ventral, 3 dorsal), 2 pairs (1 dorsal, 1 ventral) of 4A's, 60–135 (93, n= 5) wide. Hooks similar in shape and size, each with truncate slightly depressed thumb, curved shaft, short point, shank proximal expansion 0.3 shank length, 20–24 (21; n= 20) long; filamentous hook (FH loop) delicate, extending as far as half of the shank. Similar 4A hooks, 9–12 (10; n= 10). Vitellaria dense, dispersed throughout the trunk, absent in the region of reproductive organs and copulatory complex.

Remarks: *Anacanthorus simpliciphallus* sp. n. differs from all congeneric species mainly in terms of the morphology of the accessory piece. The new species resembles *Anacanthorus reginae* Boeger & Kritsky, 1988, in the morphology of the male copulatory organ (J-shaped) and in that the accessory piece is not articulated to the MCO base and has a terminal flap. Both species differs mainly with regard to the ratio between MCO and accessory piece [practically the same size (MCO 57–76; accessory piece 42–67) in *A. reginae* x accessory piece 50% the size (MCO 65–83; accessory piece 37–45) in *Anacanthorus simpliciphallus* sp. n. and with regard to the size of hooks (23–34 (28) in *A. reginae* and 20–24 (21) in the new species). Moreover, the new species can be differentiated from *A. reginae* in that it has a metraterm conspicuous, with a membranous terminal region.

Anacanthorus brandtii Santos-Clapp, Cohen, Justo & Brasil-Sato sp. n. (Figure 1e-h; Figure 3a-c).

Type host: *Serrasalmus brandtii* Lütken, 1875 (Characiformes, Serrasalmidae)

Site in host: Gill lamellae

Type-locality: Três Marias Reservoir (18°12'59" S, 45°17'34" W), Upper São Francisco River, Minas Gerais State.

Parasitological indexes: Total number of hosts: 145; total number of parasites: 142

Type-material: Holotype CHIOC 40263 a; Paratypes CHIOC 40263 b; 40264; 40265; 40266 a,b; 40267 a, b.

Etymology: The new species is named after the specific epithet of the host, *Serrasalmus brandtii*

DESCRIPTION: (Based on 30 specimens mounted in Hoyer's medium). Body elongated, fusiform, 295–595 (433, n= 12) long including the haptor, by 100–165 (130, n= 12) wide at the level of germarium. Two terminal, and two bilateral cephalic lobes; three bilateral pairs of head organs. Two pairs of eyes, anterior pair smaller than posterior pair, slightly closer together than posterior pair; accessory granules distributed in the cephalic region. Pharynx subspherical, long oesophagus. Intestinal caeca lacking diverticula. Gonads overlapping; testis dorsal to germarium, 70–130 (84; n=6) long, vas deferens looping intestinal caeca, prostatic reservoir not observed. Copulatory complex comprising male copulatory organ (MCO) and accessory piece. MCO as a J-shaped tube, with slightly sclerotized walls, expanded base with smooth margin, 60–78 (70; n=13) long. Accessory piece with a midlength expansion extended to distal region, non articulated to MCO base, 38–45 (41; n= 13). Ratio MCO/AP 1:0.58-1:0,63 (1:0.6, n=13) Germarium, metraterm, genital pore and eggs not observed. Peduncle inconspicuous. Haptor armed with 7 pairs (4 ventral, 3 dorsal) of hooks, 2 pairs (1 dorsal, 1 ventral) of 4A's, 68–120 (94, n=12) wide. Hooks similar in shape, each with truncate slightly depressed thumb, curved shaft, short point, pairs 1,5, 20–24 (22, n=13) long, proximal expansion 0.4 shank length, pairs 2–4,6,7, 28–32 (30, n=13) long, proximal expansion 0.6 shank length; Filamentous hook (FH loop) delicate, extending until up to half of the shank. Similar 4A hooks, 10–15 (12; n=6). Vitellaria dense, dispersed throughout the trunk, absent in the region of reproductive organs and copulatory complex.

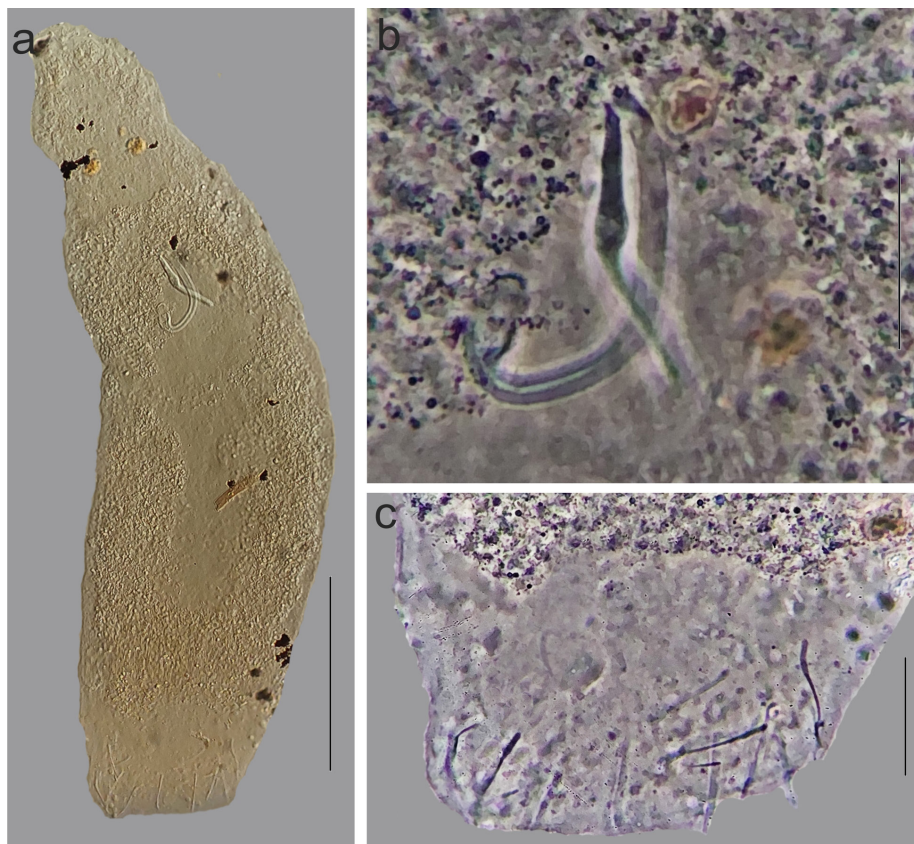


Figure 3. Light photomicrographs of *Anacanthorus brandtii* sp. n. parasite of *Serrasalmus brandtii*. (a): Total view, ventral (b) Copulatory complex (c) Haptor. Scale bars. (a) 100 μ m, (b) 30 μ m; (c) 20 μ m.

Remarks: *Anacanthorus brandtii* sp. n. is closely related to species previously described from *Serrasalmus* spp. as *Anacanthorus scapanus*, *Anacanthorus jegui*, *Anacanthorus sciponophallus*, *A. reginae* and *A. simpliciphallus* sp. n. by the morphology of copulatory complex. The new species differs from *A. scapanus* by the expansion of the accessory piece (subterminal in *A. scapanus* vs midlength expansion in the *A. brandtii* sp. n.), from *A. jegui* by the ratio MCO/AP (MCO 48 and AP 39 in *A. jegui* and MCO 70 vs AP 41 in the new species) and by the expansion of hook shank (0.3 and 0.4 in *A. jegui* vs 0.4 and 0.6 in *A. brandtii* sp. n.). The new species can be differentiated from *A. sciponophallus* and *A. reginae* by the ratio MCO/AP (MCO 76–82 and AP 74–79 in *A. sciponophallus* from different hosts, MCO 67 and AP 59 in *A. reginae* vs MCO 70 and AP 41 in the new species). The new species can also be distinguished from *A. reginae* and *A. simpliciphallus* sp. n. by the size of hooks which is similar in *A. reginae* and *A. simpliciphallus* sp. n. vs dissimilar in *A. brandtii* sp. n. The two new species also differ by the expansion of shank (0.3 in *A. simpliciphallus* sp. n. vs 0.4 and 0.6 in *A. brandtii* sp. n.).

Discussion

The new species are allocated in *Anacanthorus* because they possess a bilobed haptor with 7 pairs of hooks and 2 pairs of reduced hooks (4A's), lacking anchors and bars, have tandem or slightly overlapping gonads, post-ovarian testis, modified (thickened or sclerotized) distal uterine wall or metraterm and vagina is absent (Kritsky et al., 1979, 1992).

Anacanthorus species are exclusively parasites of Neotropical characiforms, and so far, 19 species have been reported from Bryconidae, 8 from Erythrinidae, 21 from Triportheidae, and 44 from Serrasalmidae. Kritsky & Thatcher (1974) described *Anacanthorus colombianus* Kritsky & Thatcher, 1974 from *Salminus affinis* Steindachner, 1880 and also reported its presence in *Oreochromis mossambicus* (Peters, 1852), a cichlid fish within the order Cichliformes. According to these authors, this latter occurrence was apparently accidental. Given the absence of further records in this order, it is considered that *Anacanthorus* spp. is specific to characiform fishes. Species of this genus have been found in five countries in the Neotropical Region (Brazil, Bolivia, Colombia, Peru, and Venezuela), and Brazil stands out as the country with the largest number of occurrences (156) (Boeger et al., 2023).

The sclerotized structures such as the copulatory complex and hooks of *Anacanthorus* species appear to have a high specificity in terms of morphology with regard to the host family level (Santos et al., 2019). *Anacanthorus* species that parasitize members of the family Serrasalmidae present the characteristic of a J-shaped MCO, an accessory piece that is not articulated to the MCO, hooks with truncated thumb and a shank with proximal dilation (Boeger & Kritsky, 1988; Kritsky et al., 1992; Van Every & Kritsky, 1992). The finding of two new species of *Anacanthorus* in serrasalmid hosts presenting morphological characteristics similar to those previously described on these hosts (Table 1) confirms that the lineages of the parasites from serrasalmid hosts shared those features.

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Ethics declaration

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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