Neotropical Monogenoidea. 56. New species of *Anacanthorus* (Dactylogyridae) from the gills of matrinchã, *Brycon orthotaenia* (Characiformes: Characidae), in the Rio São Francisco, Brazil

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Abstract: *Anacanthorus franciscanus* sp. n. and *Anacanthorus brevicirrus* sp. n. (Dactylogyridae) are described from the gills of the matrinchã, *Brycon orthotaenia* Günther (Characidae), from the Rio São Francisco in Brazil. *Anacanthorus franciscanus* most closely resembles *Anacanthorus elegans* and *A. kruidenieri* from the matrinchão, *Brycon melanopterus*, of the Amazon River Basin. It differs from these species in part by having the bulbous proximal end of the hook shank with two translucent regions. *Anacanthorus brevicirrus* resembles *A. franciscanus*, *A. kruidenieri* and *A. elegans* but is differentiated from these species by its short straight male copulatory organ and by having one translucent region in the bulbous base of the hook shank.

Keywords: Monogenoidea, Dactylogyridae, *Anacanthorus*, *Anacanthorus brevicirrus*, *Anacanthorus franciscanus*, *Brycon orthotaenia*, Rio São Francisco, Brazil

The present study is a continuation of ongoing surveys by personnel of the Universidade Federal Rural do Rio de Janeiro documenting the diversity of parasites infecting the fishes of the Rio São Francisco Basin in Brazil (see Brasil-Sato 2003). In this paper, two new species of *Anacanthorus* Mizelle et Price, 1965 (Dactylogyridae) are described from the matrinchã, *Brycon orthotaenia* Günther, a commercially important characiform fish that is currently threatened with extinction in some reaches of the river basin (Lins et al. 1997, Sato 1999). The following species of Monogenoidea have previously been recorded from *Brycon* spp.: *Anacanthorus brevis* Mizelle et Kritsky, 1969, *Anacanthorus elegans* Kritsky, Thatcher et Kayton, 1979, *Anacanthorus kruidenieri* Kritsky, Thatcher et Kayton, 1979, *Anacanthorus spiralocirrus* Kritsky, Thatcher et Kayton, 1979, *Jainus amazonensis* Kritsky, Thatcher et Kayton, 1980 and *Tereancistrum kerri* Kritsky, Thatcher et Kayton, 1980 (all Dactylogyridae) from matrinchão, *Brycon melanopterus* (Cope) (Mizelle and Kritsky 1969, Kritsky et al. 1979, 1980); *Anacanthocotyle* sp. (Gyrodactylidae) from *Brycon americanus peruanus* (host not in FishBase) (Jara 1986); *Annulotrematoides bryconi* Cuglianna, Cordeiro et Luque, 2003 (Dactylogyridae) from matrinchã, *Brycon cephalus* (Günther) (Cuglianna et al. 2003); *Rhinoxenus anaclaudiae* Domingues et Boeger,

2005 (Dactylogyridae) from *Brycon* sp. (Domingues and Boeger 2005); and *Mazocraeoides* sp. (Mazocraeidae) from machaca, *Brycon quatemalensis* Regen (Fucuguchi-Suarez et al. 1988).

MATERIALS AND METHODS

Specimens of matrinchã were collected from the upper Rio São Francisco near the municipality of Três Marias (18°12'32"S, 45°15'41"W), State of Minas Gerais, Brazil, by professional fisherman during July, 2009. Methods of collection and preparation of helminths for study were those of Monteiro et al. (2010). Measurements, all in micrometres (µm), are the greatest straight-line distances between extreme points (i.e., distances along curves are not included in the dimension) and are presented as the mean followed by the range and number (n) of specimens measured in parentheses; body length included that of the haptor. Type specimens were deposited in the United States National Parasite Collection, Beltsville, Maryland, USA (USNPC), the Coleção Helmintológica do Instituto Oswaldo Cruz, Rio de Janeiro, Brazil (CHIOC), and the helminth collections of the Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil (INPA) and of the Institute of Parasitology, Academy of Sciences of the Czech Republic, České Budějovice, Czech Republic (IPCAS) as indicated in the respective descriptions. Voucher specimens of the host were deposited in the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZUSP 95166).

RESULTS

Anacanthorus franciscanus sp. n. Figs. 1–4

Description. Body fusiform, 685 (581–828, $n = 12$) long, with narrow cephalic region, broad peduncle, bilobed haptor; greatest body width 95 (78–135, $n = 12$) at level of male copulatory organ (MCO). Two terminal, 2 bilateral cephalic lobes well developed; terminal lobes appearing as single lobe when extended. Head organs usually indistinct; cephalic glands not observed. Four eyespots; members of posterior pair slightly farther apart, larger than those of anterior pair; chromatic granules small, subspherical to ovate; few accessory granules scattered in cephalic region. Pharynx subspherical, 34 (29–44, $n = 10$) wide; oesophagus elongate. Haptor 66 (51–107, $n = 11$) long, 80 (50–105, $n = 12$) wide; haptoral lobes well developed. Hooks similar in size and shape; each 34 (31–36, $n = 13$) long, with proximal bulbous base containing 2 translucent regions, elongate slender shank, reduced thumb, evenly curved shaft and open point; filamentous hook (FH) loop about 1/4 shank length. Single pair of 4As, each 12 (10–14, $n = 2$) long, with slight proximal expansion. Gonads tandem or slightly overlapping, intercaecal, lying in posterior half of trunk; testis ovate, 120 (98–152, $n = 6$) long, 30 (20–45, $n = 6$) wide; germarium pyriform, 62 (51–78, $n = 7$) long, 32 (20–42, $n = 6$) wide. Distal portion of uterus weakly sclerotized; vitellaria comprising 2 bilateral bands of follicles coextensive with oesophagus and intestine; bands confluent at oesophageal level and posterior to gonads; transverse vitelline duct immediately anterior to germarium; vagina absent. MCO 99 (93–107, $n = 9$) long (from the base to recurve), a long tube lacking developed base, with recurve (reflex) at about 2/3 distance to distal flared tip. Accessory piece 45 (40–51, $n = 9$) long, a membranous sheath covering about 1/2 proximal portion of MCO between the base and recurve. Seminal vesicle a simple elongate slight dilation of vas deferens; prostatic reservoir posterior to base of MCO on body midline.

Type host and locality: Matrinchã, *Brycon orthotaenia* Günther – Rio São Francisco near Três Marias, State of Minas Gerais, Brazil (18°12'32"S, 45°15'41"W); 19 July 2009.

Site of infection: Gills.

Specimens studied: Holotype, CHIOC 37330; 21 paratypes, CHIOC 37331a–e, 37332, INPA 524a–f, USNPC 102884, IPCAS M-507.

Etymology: The specific name refers to the Rio São Francisco from which the helminth was collected.

Remarks. The basic morphology of the MCO and haptoral hooks of *A. franciscanus* closely resembles that of *Anacanthorus elegans* and *Anacanthorus kruidenieri* from the matrinchão, *Brycon melanopterus*, occurring in the Amazon River drainage. *Anacanthorus franciscanus* is differentiated from the latter two species by the reflex

of the MCO occurring at about 2/3 the length from its base (reflex about 1/2 the distance in *A. elegans*; near the distal tip in *A. kruidenieri*) and by having two translucent regions in the bulbous base of the hook shank (bulbous base small and lacking translucence in *A. elegans*; base large with one translucent region in *A. kruidenieri*). *Anacanthorus franciscanus* differs further from *A. kruidenieri* by having a membranous accessory piece in the copulatory complex (accessory piece rod-shaped in *A. kruidenieri*) (see Kritsky et al. 1979).

Anacanthorus brevicirrus sp. n. Figs. 5–8

Description. Body fusiform, 590 (476–659, $n = 4$) long, with broad cephalic region, short tapered peduncle, bilobed haptor; greatest body width 79 (64–100, $n = 4$) usually posterior to testis. Terminal, 2 bilateral cephalic lobes well developed; terminal lobe may appear double. Three pairs of head organs. Postpharyngeal cephalic glands indistinct, posterolateral to pharynx; prepharyngeal cephalic glands usually visible anterior to eyespots. Four eyespots; members of posterior pair usually slightly farther apart or equidistant, larger than those of anterior pair; chromatic granules small, subspherical to ovate; few accessory granules scattered in cephalic region. Pharynx subspherical, 28 (22–32, $n = 3$) wide; oesophagus elongate. Haptor 45 (30–58, $n = 4$) long, 64 (55–70, $n = 4$) wide; haptoral lobes well developed. Hooks similar in size and shape; each 35 (31–37, $n = 20$) long, with small proximal bulbous base containing translucent spot, elongate slender shank, reduced thumb, nearly straight shaft, open point; FH loop about 1/2 shank length. Single pair of 4As, each 10 (9–13, $n = 6$) long. Gonads tandem or slightly overlapping, intercaecal, lying in posterior half of trunk; testis ovate, 57 (47–67, $n = 2$) long, 27 (18–36, $n = 2$) wide; germarium pyriform, 79 (58–118, $n = 4$) long, 32 (24–48, $n = 4$) wide. Distal portion of uterus weakly sclerotized (if at all); vitellaria comprising 2 bilateral bands of follicles coextensive with oesophagus and intestine; bands confluent at oesophageal level and posterior to testis; transverse vitelline duct anterior to germarium; vagina absent. MCO 36 (30–41, $n = 10$) long, a short broad tube lacking developed base. Accessory piece 16 (11–22, $n = 8$) long, a membranous tape-like structure partially encircling distal half of MCO. Seminal vesicle a simple elongate dilation of vas deferens; small prostatic reservoir posterior to base of MCO.

Type host and locality: Matrinchã, *Brycon orthotaenia* Günther – Rio São Francisco near Três Marias, State of Minas Gerais, Brazil (18°12'32"S, 45°15'41"W); 19 July 2009.

Site of infection: Gills.

Specimens studied: Holotype, CHIOC 37333a; 13 paratypes, CHIOC 37333b, c, 37334, INPA 523a–c, USNPC 102883, IPCAS M-508.

Figs. 1–8. *Anacanthorus* spp. from the matrinhã, *Brycon orthotaenia*, from the Rio São Francisco, Brazil. **Figs. 1–4.** *Anacanthorus franciscanus* sp. n. **Fig. 1.** Whole mount (ventral view, composite). **Fig. 2.** Copulatory complex (ventral view). **Fig. 3.** 4A. **Fig. 4.** Hook. **Figs. 5–8.** *Anacanthorus brevicirrus* sp. n. **Fig. 5.** Copulatory complex (ventral view). **Fig. 6.** Hook. **Fig. 7.** 4A. **Fig. 8.** Whole mount (ventral, composite). Figs. 1 and 8 are presented to the respective 200 µm scales; Figs. 2–7 are to the 30 µm scale.

Etymology: The specific name is from Latin [*brevi* = short, *cirrus* = a curl (of hair)] and refers to the MCO.

Remarks. Based on the comparative morphology of the hooks, *A. brevicirrus* apparently shares an evolutionary history with *A. elegans*, *A. franciscanus* and *A. kruidenieri*, all of which are parasites of species of *Brycon*.

Anacanthorus brevicirrus is easily differentiated from the latter three species by having a short straight MCO (MCO elongate, with recurve in latter three species). Among species of *Anacanthorus*, only *A. euryphallus* Kritsky, Boeger et Van Every, 1992 from *Triportheus* spp. (Characidae) possesses a MCO comprising a broad short tube

similar to that of *A. brevicirrus*. However, the accessory piece of *A. euryphallus* is a branched rod, while that of *A. brevicirrus* is membranous (see Kritsky et al. 1992).

DISCUSSION

Anacanthorus currently includes 63 species from the gills of Neotropical characiform fishes (Thatcher 2006) and is primarily characterized by dactylogyrids lacking a vagina and haptor anchor/bar complexes (Kritsky et al. 1992). The genus was established by Mizelle and Price (1965) for three species from the gills of a red piranha, *Serrasalmus nattereri* Kner [now *Pygocentrus nattereri* Kner] (Serrasalminidae), held in the Steinhart Aquarium in San Francisco, California. Of the 42 valid species of *Brycon* (see Froese and Pauly 2009), only the matrinchão, *B. melanopterus* from the Amazon Basin, has been previously documented as a host for species of the genus (Mizelle and Kritsky 1969, Kritsky et al. 1979).

All previously described species of *Anacanthorus* are from fishes of the Amazon River Basin, except *Anacanthorus penilabiatu*s Boeger, Husak et Martins, 1995, which was originally described from *Piaractus mesopotamicus* (Holmberg) (Serrasalminidae) cultivated in the State of São Paulo, Brazil (Boeger et al. 1995). *Anacanthorus penilabiatu*s has subsequently been reported from *P. mesopotamicus*, *Piaractus brachypomum* (Cuvier) and *Colossoma macropomum* (Cuvier) (all Serrasalminidae), maintained in fish ponds in the Brazilian states of Ceará and São Paulo (Pamplona-Basilio et al. 2001, among others). Cohen and Kohn (2009) also reported *A. penilabiatu*s on *P. mesopotamicus* from outside the Amazon Basin, but it is unclear from the presentation of the results of their study whether or not the helminth occurred in a natural habitat (Itaipu Hydroelectric Power Station Reservoir on the Paraná River). Finally, Santos (2008) and Albuquerque (2009) recorded unidentified species of *Anacanthorus* from the gills of *Pygocentrus piraya* (Cuvier) and *Serrasalmus brandtii* Lütken (both Serrasalminidae) and *Triportheus guentheri* (Garman) (Characidae) from the Rio São Francisco drainage, respectively. Thus, *A. franciscanus* and *A. brevicirrus* from the Rio São Francisco are the first identified and described members of the genus clearly recorded from a natural habitat outside of the Amazon Basin.

The Rio São Francisco drainage in Brazil shares diverse biological components with those of other river

systems in South America (Hubert and Renno 2006). For example, of eight dactylogyrid species occurring on the gills of the catfish, *Pimelodus maculatus* Lacépède, in the Rio São Francisco Basin, only two, *Demidospermus ichthyocercus* Monteiro, Kritsky et Brasil-Sato, 2010 and *Ameloblastella sato*i Monteiro, Kritsky et Brasil-Sato, 2010, are currently restricted to this river system (Monteiro et al. 2010); the remaining six dactylogyrid species on this host also occur in the Platina (Paraná) Drainage of Brazil and Argentina (Kritsky and Gutiérrez 1998, Cohen and Kohn 2008, Santos et al. 2007). The biogeographical explanation for the distributions of these dactylogyrids is in part confounded because of natural and artificial watershed transpositions that have occurred between the Rio São Francisco and the Platina basins (Filho and Buckup 2005) which might have allowed parasite dispersal between the two river systems. Thus, both vicariance and dispersal are likely required to explain extant distributions of these parasites.

The present study suggests that a vicariance/coevolutionary model might be responsible for *A. franciscanus* and *A. brevicirrus* on *B. orthotaenia* in the Rio São Francisco. These parasite species are morphologically similar to *A. kruidenieri*, *A. brevis* and *A. elegans* from *B. melanopterus* from the Amazon River, suggesting that a common ancestor existed for the five dactylogyrid species. Supporting this are the morphological characteristics of the haptor hooks (straight open point and shaft and presence of translucent regions in the base of the shaft) and copulatory complex (broad tubular MCO and presence of a membranous accessory piece in four of the five species) and the apparent restricted distributions of the respective hosts and their *Anacanthorus* spp. in the two river systems. In addition, the morphological features of the species of *Anacanthorus* from *Brycon* spp. are not shared with any other members of *Anacanthorus* from unrelated hosts and may represent derived synapomorphic characters that might signal the presence of a monophyletic lineage within the genus (see Kritsky et al. 1992).

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