

TAXONOMY AND NOMENCLATURE

A new species of *Diaphorocleidus* (Monogenea: Ancyrocephalinae) from the gills of *Argonectes robertsi* (Characiformes) and new records of dactylogyrids parasitic on fishes from the Xingu River, Amazon Basin, Brazil

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ABSTRACT. *Diaphorocleidus altamirensis* sp. nov., parasitic on the gills of *Argonectes robertsi* Langeani, 1999 from the Xingu River, northern Brazil, is described. The new species differs from its six congeners by the morphology of the male copulatory organ (which comprises a coil of six rings), by the midventral vagina, and by the presence of only one pair of eyespots. It is the first species of *Diaphorocleidus* Jogunoori, Kritsky & Venkatanarasaiah, 2004 described from hemiodontid fishes. In addition, new host and geographical records of seven species of dactylogyrids found on fish from the Xingu River are reported.

KEY WORDS. Dactylogyridae, Hemiodontidae, Monogenea, Neotropics, Xingu River.

Monogeneans represent one of the main components of the parasite fauna of freshwater fishes in the Neotropical Region, and as many as 629 species have been reported by COHEN et al. (2013) from South America, most of which belonging to the Dactylogyridae and parasitizing on the gills of teleost fishes. However, the number of species of these ectoparasites has increased steadily, with descriptions of dozens new species in recent decades, especially from characiform fishes (COHEN et al. 2012, MOREIRA et al. 2015).

One of 39 genera of dactylogyrids parasitic on characiform fishes from South America, *Diaphorocleidus* (Monogenea: Dactylogyridae) was proposed by JOGUNOORI et al. (2004), with *D. armillatus* Jogunoori, Kritsky & Venkatanarasaiah, 2004 from the Neotropical *Gymnocorymbus ternetzi* (Boulenger, 1895) (Characidae) as the type species, introduced to India via the aquarium trade. They also proposed three new combinations, *D. affinis* (Mizelle, Kritsky & Crane, 1968) (syn. *Uroleidoides affinis* Mizelle, Kritsky & Crane, 1968), *D. kabatai* (Molnar, Hanek & Fernando, 1974) (syn. *U. kabatai* Molnar, Hanek & Fernando, 1974) and *D. microstomus* (Mizelle, Kritsky & Crane, 1968) (syn. *U. microstomus* Mizelle, Kritsky & Crane, 1968). At present, *Diaphorocleidus* includes six species, i.e., *D. affinis* (Mizelle, Kritsky & Crane, 1968) Jogunoori, Kritsky & Venkatanarasaiah, 2004 from *Bryconops*

affinis (Günther, 1864) (= *Creatochanes affinis*) (Iguanodectidae) in Brazil, *D. armillatus*, *D. kabatai* (Molnar, Hanek & Fernando, 1974) Jogunoori, Kritsky & Venkatanarasaiah, 2004 from *Astyanax bimaculatus* (Linnaeus, 1758) (Characidae) in Trinidad, *D. microstomus* (Mizelle, Kritsky & Crane, 1968) Jogunoori, Kritsky & Venkatanarasaiah, 2004 from *Hemigrammus microstomus* Durbin, 1918 (Characidae) in Brazil, *D. orthodus* Mendoza-Franco, Reina & Torchin, 2009 from *Astyanax orthodus* Eigenmann, 1907 (Characidae) in Panama and *D. petrosusi* Mendoza-Franco, Aguirre-Macedo & Vidal-Martínez, 2007 from *Brycon petrosus* Meek & Hildebrand, 1913 (Bryconidae) also in Panama (JOGUNOORI et al. 2004, MENDOZA-FRANCO et al. 2007, 2009). *Diaphorocleidus kabatai* was also recorded from *Steindachnerina insculpta* (Fernandez-Yépez, 1948) (Curimatidae) and from *Astyanax altiparanae* Garutti & Britski, 2000, both in Brazil (ALMEIDA & COHEN 2011, ACOSTA et al. 2013). In addition, CAMARGO et al. (2015) reported *Diaphorocleidus* sp. from *Ancestrorhynchus lacustris* (Lütken, 1875) (Ancestrorhynchidae) also in Brazil.

Examination of fishes from the lower reach of the Xingu River near Altamira, a tributary of the Amazon River in Brazil (State of Pará), has revealed dactylogyrid monogeneans on the gills of several fishes, including *Argonectes robertsi* Langeani, 1999 (Characiformes: Hemiodontidae). This fish occurs in the Tapajós,

Xingu, Tocantins and Capim River basins (FROESE & PAULY 2015). To date, only two monogeneans have been recorded parasitizing hemiodontids in South America, i.e., *Cleidodiscus microcirrus* Price & Schlueter, 1967 and *Monocleithrium lavergneae* Price & McMahon, 1966, both reported from *Hemiodus semitaeniatus* Kner, 1858 in Brazil. In contrast, no data exist on the parasites of *A. robertsi* (see COHEN et al. 2013).

Herein, we describe a new species of *Diaphorocleidus* collected from *A. robertsi* from the Xingu River in Brazil. In addition, several new host and geographical records of dactylogyrids parasitizing fishes from the Xingu River are provided.

MATERIAL AND METHODS

Fish were collected by local fishermen with nets and hooks in April 2013 from the Xingu River, a tributary of the Amazon River, around Altamira (3°12'S, 52°12'W), state of Pará, Brazil. Gills excised from fish were placed in Petri dishes with tap water and examined for monogeneans using dissecting microscope. Some monogeneans found were fixed in a mixture of glycerol-in-ammonium picrate (GAP) to study sclerotized structures. After morphological evaluation, the specimens were remounted, dehydrated and mounted in Canada balsam following the procedure of ERGENS (1969). Other specimens were fixed in 4% hot formalin, stained with Gomori's trichrome and mounted in Canada balsam to study internal organs; some worms were mounted in Gray and Wess medium (HUMASON 1979) to study sclerotized structures. Drawings were made with the aid of an Olympus BX53 microscope (Olympus Corporation, Tokyo, Japan) equipped with a drawing tube. Measurements, all in micrometers, represent straight-line distances between extreme points and are expressed as the range followed by the mean and number (n) of structures measured in parentheses; body length includes that of the haptor. Numbering (distribution) of hook pairs follows MIZELLE (1936) and MIZELLE & PRICE (1963). Type and voucher specimens were deposited in the Helminthological Collection of Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil.

TAXONOMY

Dactylogyridae Bychowsky, 1933 Ancyrocephalinae Bychowsky, 1937 *Diaphorocleidus altamirensis* sp. nov.

Figs. 1-8

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Description (based on 6 specimens): Body fusiform 345-414 (367, n = 6) long; greatest width 53-68 (62, n = 6) usually at level of gonads. Cephalic lobes poorly developed; 3 bilateral pairs of head organs; cephalic glands indistinct. Eyespots 2; accessory granules present in cephalic region. Pharynx spherical 13-24 (17, n = 6) in diameter; esophagus moderately long. Peduncle broad; haptor hexagonal, 56-71 (64, n = 6) wide. Ventral

anchor 45-50 (47, n = 6) long, with well-developed and elongate superficial root, shorter deep root, curved shaft and point; base 21-26 (23, n = 6) wide. Dorsal anchor 33-36 (34, n = 6) long, with well-developed superficial root, short deep root, straight shaft and curved point; base 14-20 (17, n = 6) wide. Ventral bar 40-57 (44, n = 6) long, with medial suture and expanded ends; dorsal bar 24-36 (30, n = 6), slender, widely U-shaped, with slightly expanded ends. Hooks similar each with protruding thumb, curved shaft and point, dilated shank; pairs 1 and 5 reduced in size; filamentous hooklet (FH) loop $\frac{1}{3}$ - $\frac{1}{2}$ shank length; hook pairs 1, 5 - 9-13 (11, n = 6) long; hook pair 2 - 16-20 (18, n = 6) long; hook pair 3 - 16-26 (20, n = 6); hook pairs 4, 6, 7 - 11-24 (19, n = 6) long. MCO comprising a delicate coil of 6 counterclockwise rings, base with lateral flange, diameter of first ring 8-12 (10, n = 5). Accessory piece 14-30 (22, n = 5) long, comprising two articulated subunits, distal subunit bifurcate, proximal subunit curved and elongate, serving as guide for MCO. Vaginal aperture midventral, a coiled tube leading into a medial seminal receptacle anterior to germarium. Gonads overlapping; germarium 40-54 (45, n = 3) long. Testis dorsal, slightly visible at end of germarium; seminal vesicle a distal expansion of vas deferens; prostatic reservoir single. Oviduct, ootype and uterus not observed. Vitellarium scattered throughout trunk, except in regions of reproductive organs.

Type host: *Argonectes robertsi* Langeani, 1999 (Characiformes, Hemiodontidae).

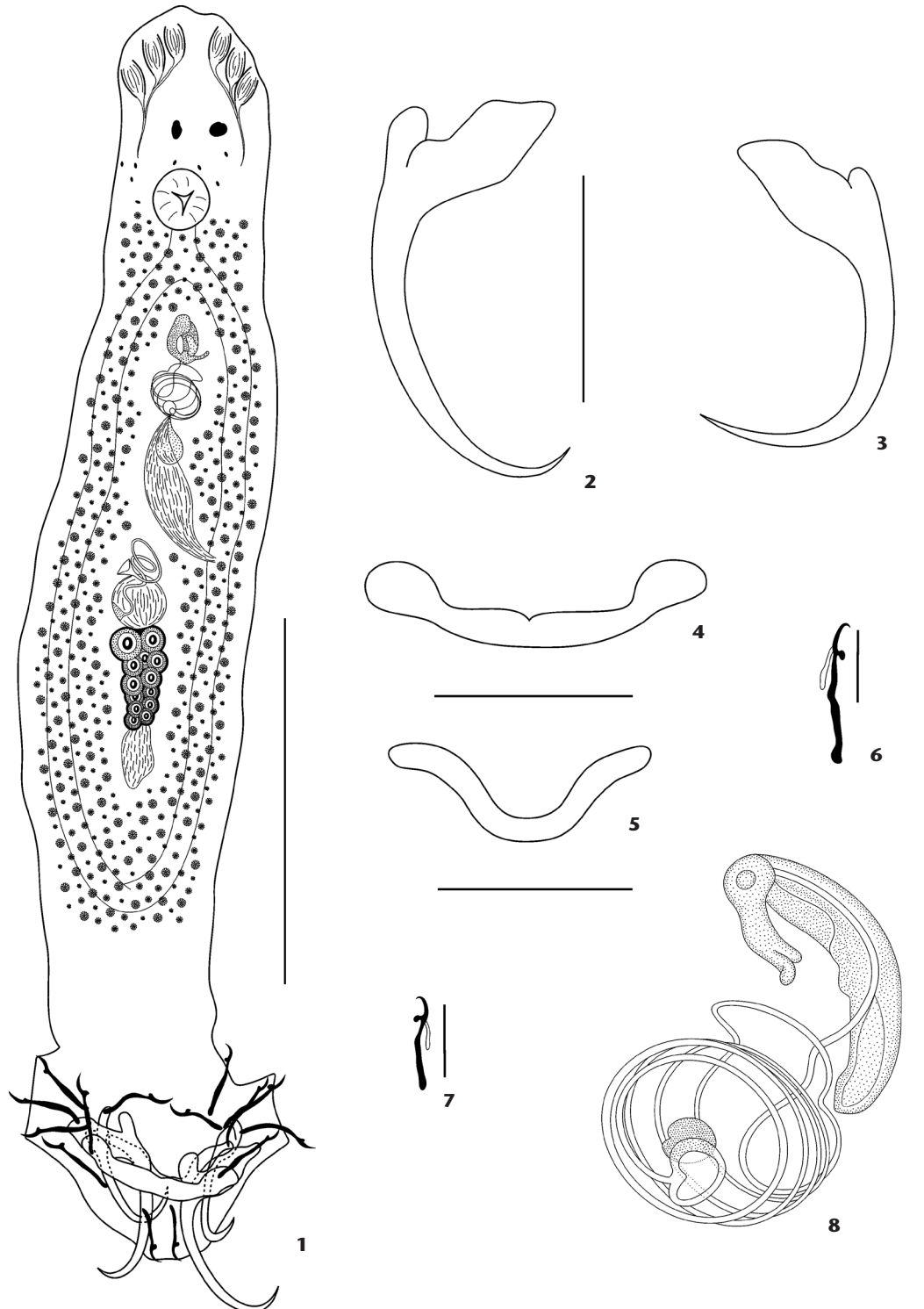
Site of infection: Gills.

Type locality: Xingu River around Altamira (3°12'S, 52°12'W), state of Pará, Brazil.

Type specimens: Holotype and five paratypes deposited as CHIOC 38406a-f.

Etymology: This species is named for the type locality from which it was collected.

Remarks. *Diaphorocleidus* includes species with overlapping gonads, submarginal sinistral vaginal pore, a coiled male copulatory organ with counterclockwise rings, unarticulated to accessory piece and hook shank with two subunits. The midventral vaginal aperture of *D. altamirensis* sp. nov. is the only major difference of this species from congeners, but this unusual vaginal morphology does not seem us to justify proposal of a new genus. In addition to the position of the vagina, *D. altamirensis* differs from all congeners by having a male copulatory organ with 6 counterclockwise rings (2-3 in *D. affinis*, 2 in *D. armillatus*, 1-1½ in *D. kabatai* and in *D. petrosusi*, 1½-2½ in *D. microstomus* and 1 in *D. orthodusus*), by the accessory piece comprising two subunits (distal bifurcate and proximal curved and elongate) and by the presence of just one pair of eyespots. *Diaphorocleidus petrosusi* also possesses an accessory piece subdivided in two parts, plate-shaped, but *D. altamirensis* sp. nov. can be easily distinguished by the haptor structures and by the coiled vaginal tube (a nondilated sclerotized in *D. petrosusi*), which is also a unique feature of this new species. None of the two dactylogyrids recorded from *H. semitaeniatus*



Figures 1-8. *Diaphorocleidus altamirensis* sp. nov.: (1) whole mount (composite, ventral view); (2) ventral anchor; (3) dorsal anchor; (4) ventral bar; (5) dorsal bar; (6) hook (pair 2); (7) hook, pair 5; (8) copulatory complex (dorsal). Scale bars: 1 = 100 μ m, 2-5 = 25 μ m, 6-7 = 10 μ m, 8 = 20 μ m.

in Brazil, i.e., *C. microcirrus* and *M. laverigneae*, shows similarity with *D. altamirensis*.

New host and geographical records. In addition to the new species described above, another seven species of gill monogeneans of the family Dactylogyridae were found on four species of fishes during parasitological surveys carried out in the Xingu River. All fishes represent new hosts of these monogeneans and except for *Jainus amazonensis* Kritsky, Thatcher & Kayton, 1980, all parasites are reported from the Xingu River, Amazon basin, for the first time (Table 1).

DISCUSSION

The present study provides the first data on the monogenean parasites of *A. robertsi*. Currently the family Hemiodontidae comprises five genera and 31 species of fishes distributed in South America (FROESE & PAULY 2015). They are poorly studied fishes and only very few species were examined for parasites (AZEVEDO et al. 2009, COHEN et al. 2013, SILVA JÚNIOR 2014), indicating that many new taxa of parasites can be discovered.

Species of *Diaphorocleidus* have been recorded from characiform fishes, mainly characids, in a large area which spans from Trinidad through Panama to Brazil, i.e., the Caribbean Region, Central America and South America. Most dactylogyrid monogeneans, including those of Ancyrocephalinae, are considered highly host-specific (BOEGER & VIANNA 2006). Therefore, such large distribution area is uncommon in species-poor Neotropical genera. However no information exists on interrelations of species of *Diaphorocleidus* to reconstruct possible evolutionary history of this monogenean group in the Neotropical region.

Diaphorocleidus altamirensis sp. nov. is the third species of the genus described in Brazil, but is the first species found on a hemiodontid, which also belongs to the order Characiformes. *Diaphorocleidus* can be easily distinguished from the other genera

of dactylogyrids associated with hemiodontids, i.e., *Cleidodiscus* Mueller, 1934 and *Monocleithrium* Price & McMahon, 1966. *Monocleithrium* is a monospecific genus, with *M. laverigneae* as its type and only species, which is characterized by having two pairs of eyespots, tandem gonads, coiled MCO with accessory piece directly articulated, and dorsal bar absent. In contrast, *Diaphorocleidus* exhibits overlapping gonads, a MCO unarticulated to accessory piece and a pair of bars (one ventral and one dorsal). *Cleidodiscus* is a poorly known genus of ancyrocephaline monogeneans and its taxonomic status remains unclear, especially because inadequate descriptions of its species. Many of the species originally described as members of *Cleidodiscus* have been then transferred to other genera (e.g., *Calpidothecium*, *Pithanothecium*, *Urocleidoides*; see BOEGER & VIANNA 2006, COHEN et al. 2013). Diagnostic features of *Cleidodiscus* are two pairs of eyespots, accessory piece generally articulated to MCO basally and the vagina usually present and opening at the left margin of the body near the middle length of the trunk, thus showing no similarity to *Diaphorocleidus*.

Except for *J. amazonensis*, all dactylogyrids collected from the Xingu River, represent new geographical records from the Amazon River basin; all of them also expand host ranges of respective species. The records of *J. amazonensis*, *J. leporini* Abdallah, Azevedo & Luque, 2012, and *J. piava* Karling, Bellay, Takemoto & Pavanelli, 2011 on *Anostomoides passionis* Santos & Zuanon, 2006 are noteworthy because they represent the first data on the parasites of this fish host, which has been described just recently.

Based on the study and other recent accounts on the monogenean parasites of fishes from the Xingu River (MOREIRA et al. 2015, PASCHOAL et al. 2016), we assume that the actual diversity of monogeneans in the Amazon River basin and South America in general is still poorly known and discovering many new taxa, especially on poorly studied fish hosts, can be anticipated.

Table 1. New host and geographical records of dactylogyrids parasitizing fish from the Xingu River, Amazon basin, Brazil.

Species	Host	Host family	River basin/Country	References
Characiformes				
<i>Apedunculata discoidea</i> Cugliana, Cordeiro & Luque, 2009 (CHIOC 38405)	<i>Prochilodus lineatus</i> , <i>P. argenteus</i> , <i>P. nigricans</i> *	Characidae	Paraná, São Francisco and Amazon (Brazil)**	CUGLIANA et al. (2009), MONTEIRO & BRASIL-SATO (2014)
<i>Jainus amazonensis</i> Kritsky, Thatcher & Kayton, 1980 (CHIOC 38407)	<i>Brycon melanopterus</i> , <i>B. cephalus</i> , <i>Anostomoides passionis</i> *	Characidae and Anostomidae	Amazon (Brazil and Peru)	KRITSKY et al. (1980), ANDRADE et al. (2001), DELGADO et al. (2014)
<i>Jainus leporini</i> Abdallah, Azevedo & Luque, 2012 (CHIOC 38408)	<i>Leporinus copelandii</i> , <i>Anostomoides passionis</i> *	Anostomidae	Southeast Atlantic, Amazon (Brazil)**	ABDALLAH et al. (2012)
<i>Jainus piava</i> Karling, Bellay, Takemoto & Pavanelli, 2011 (CHIOC 38409)	<i>Schizodon borelli</i> , <i>Anostomoides passionis</i> * (Anostomidae)	Anostomidae	Paraná, Amazon (Brazil)**	KARLING et al. (2011)
<i>Tereancistrum toksonum</i> Lizama, Takemoto & Pavanelli, 2004 (CHIOC 38411)	<i>Prochilodus lineatus</i> , <i>P. nigricans</i> *	Characidae	Paraná (Argentina and Brazil), Amazon (Brazil)**	LIZAMA et al. (2004), CEMES & GERIVASONI (2013)
Perciformes				
<i>Sciadicleithrum kritskyi</i> Bellay, Takemoto, Yamada & Pavanelli, 2009 (CHIOC 38410)	<i>Geophagus proximus</i> , <i>G. argyrostictus</i> *	Cichlidae	Paraná, Amazon (Brazil)**	BELLAY et al. (2009)
Siluriformes				
<i>Amphocleithrium paraguayensis</i> Price & Romero, 1969 (CHIOC 38404a-c)	<i>Pseudoplatystoma corruscans</i> , <i>P. fasciatum</i> *, <i>Pseudoplatystoma</i> sp.	Pimelodidae	Paraguay-Paraná (Paraguay), Paraná (Argentina and Brazil), Amazon (Brazil)**	PRICE & ROMERO (1969), SURIANO & INCORVAIA (1995), TAKEMOTO et al. (2009)

*New host record, **New geographical record.

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