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RESEARCH ARTICLE

# Dactylogyrids (Platyhelminthes: Monogenoidea) from the gills of *Hassar gabiru* and *Hassar orestis* (Siluriformes: Doradidae) from the Xingu Basin, Brazil

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*http://zoobank.org/D9131C5F-DEF6-49DF-9876-CFA578CFAA9A*

ABSTRACT. Four species of *Cosmetocleithrum* (three new) and one new species of *Vancleaveus* are described or reported parasitizing the gills of doradid catfishes (Siluriformes) from Xingu River and related tributaries: *Cosmetocleithrum phryctophallus* **sp. nov.** and *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016 from *Hassar orestis*; *Cosmetocleithrum leandroi* **sp. nov.** from *Hassar gabiru*; *Cosmetocleithrum akuanduba* **sp. nov.** and *Vancleaveus klasseni* **sp. nov.** from *Hassar orestis* and *H. gabiru*. *Cosmetocleithrum phryctophallus* **sp. nov.** differs from its congeners by possessing a male copulatory organ (MCO) with 2 ½ counterclockwise rings, and an accessory piece with an elongate torch-shaped blade. *Cosmetocleithrum leandroi* **sp. nov.** has a MCO comprising a coil of about 3 ½ rings, a sigmoid accessory piece with a cup-shaped distal portion, a single type of hooks, and anchors with poorly differentiated roots. *Cosmetocleithrum akuanduba* **sp. nov.** is characterized mainly by having a J-shaped MCO, an elongate accessory piece with sharp distal region, distal portion with a small gutter, and a heavily sclerotized vagina with short "S"-shaped vaginal canal. *Vancleaveus klasseni* **sp. nov.** differs from the other species of the genus occurring in doradids by possessing anchors with triangular to subtriangular superficial root, developed deep root, and a coiled MCO with 2 ½ counterclockwise rings. *Cosmetocleithrum bifurcum* was reported for the first time parasitizing doradids from Brazilian Amazon.

KEY WORDS. Amazon, *Cosmetocleithrum*, *Vancleaveus*.

## INTRODUCTION

Freshwater catfish belonging to the Doradidae Bleeker, 1858 (Actinopterygii: Siluriformes) are endemic to the Neotropics, being reported in all basins of South America, mainly in Brazil, Peru, and Guianas (Birindelli 2014, Nelson et al. 2016). There are currently 65 species of Doradidae occurring in Brazilian inland waters, of which ~70% are reported from the Amazon Basin (Buckup et al. 2007, Birindelli 2014, Sabaj-Pérez and Hernández 2017). Within the Amazon Basin, 15 species of the following genera are reported to occur in the Xingu River: *Anadoras* Eigenmann, 1925 (1 species), *Doras* Lacepède, 1803 (1 species), *Hassar* Eigenmann & Eigenmann, 1888 (2 species), *Leptodoras* Boulenger, 1898 (2 species), *Megalodoras* Eigenmann, 1925 (1 species), *Nemadoras* Eigenmann, 1925 (1 species), *Ossancora* Sabaj-Pérez & Birindelli, 2011 (1 species), *Oxydoras* Kner, 1855 (1 species), *Platydoras* Bleeker, 1862 (2 species), *Rhinodoras* Bleeker, 1862 (1 species), *Rhynchodoras* Klausewitz & Rössel, 1961

Table 1. List of parasite species of *Vancleaveus* and *Cosmetocleithrum*, hosts species, host family, locality and references. AR = Argentina, BR = Brazil, PE = Peru.

| Parasite | Host | Family | Locality | References |
|---|---|---|---|---|
| *Vancleaveus janauacaensis* Kritsky, Thatcher & Boeger, 1986 | *Pterodoras granulosus* | Doradidae | BR | 1 |
| | | | AR | 3 |
| | | | PE | 8, 10 |
| | *Hoplias malabaricus* | Erythrynidae | BR | 9 |
| | *Pseudoplatystoma reticulatum* | Pimelodidae | BR | 12 |
| | *Pseudoplatystoma. corrucans* | Pimelodidae | BR | 12 |
| *Vancleaveus cicinnus* Kritsky, Thatcher & Boeger, 1986 | *Phractocephalus hemiliopterus* | Pimelodidae | BR | 1 |
| | *Fransciscodoras marmoratus* | Doradidae | BR | 4 |
| | *Pimelodus albicans* | Pimelodidae | AR | 3 |
| | *Pseudoplatystoma reticulatum* | Pimelodidae | BR | 12 |
| | *Pseudoplatystoma. corrucans* | Pimelodidae | BR | 12 |
| *Vancleaveus fungulus* Kritsky, Thatcher & Boeger, 1986 | *Pseudoplatystoma tigrinum* | Pimelodidae | BR | 1 |
| | *Pseudoplatystoma fasciatus* | Pimelodidae | BR | 5 |
| | | | PE | 8 |
| | *Pseudoplatystoma reticulatum* | Pimelodidae | BR | 12 |
| | *Pseudoplatystoma. corrucans* | Pimelodidae | BR | 12 |
| | *Pseudoplatystoma. corrucans* | Pimelodidae | PE | 5 |
| *Vancleaveus platyrhynchi* Kritsky, Thatcher & Boeger, 1986 | *Hemisorubim platyrhynchos* | Pimelodidae | BR | 1 |
| | | | PE | 8 |
| *Cosmetocleithrum bulbocirrus* Kritsky, Thatcher & Boeger, 1986 | *Pterodoras granulosus* | Doradidae | BR | 1 |
| | *Ageneiosus ucayalensis* | Auchenipteridae | BR | 11 |
| | *Hoplias malabaricus* | Erythrinidae | BR | 9 |
| | | | PE | 8 |
| *Cosmetocleithrum confusus* Kritsky, Thatcher & Boeger, 1986 | *Oxydoras niger* | Doradidae | BR | 1 |
| | | | PE | 2 |
| *Cosmetocleithrum gussevi* Kritsky, Thatcher & Boeger, 1986 | *Oxydoras niger* | Doradidae | BR | 1, 6 |
| | | | PE | 2 |
| *Cosmetocleithrum parvum* Kritsky, Thatcher & Boeger, 1986 | *Oxydoras niger* | Doradidae | BR | 1 |
| *Cosmetocleithrum rarum* Kritsky, Thatcher & Boeger, 1986 | *Oxydoras niger* | Doradidae | BR | 1 |
| *Cosmetocleithrum sobrinus* Kritsky, Thatcher & Boeger, 1986 | *Oxydoras niger* | Doradidae | BR | 1 |
| | | | PE | 2 |
| *Cosmetocleithrum longivaginatum* Suriano & Incorvaia, 1995 | *Pimelodus albicans* | Pimelodidae | AR | 3 |
| *Cosmetocleithrum striatuli* Abdallah, Azevedo & Luque, 2012 | *Trachelyopterus striatulus* | Auchenipteridae | BR | 7 |
| | *Auchenipterus nuchalis* | Auchenipteridae | BR | 15 |
| | *Trachelyopterus coriaceus* | Auchenipteridae | BR | 14 |
| | *Trachelyopterus galeatus* | Auchenipteridae | BR | 14 |
| *Cosmetocleithrum tortum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016 | *Nemadoras hemipeltis* | Doradidae | PE | 13 |
| *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016 | *Hassar orestis* | Doradidae | PE | 13 |
| *Cosmetocleithrum laciniatum* Yamada, Yamada, Silva & Anjos, 2017 | *Trachelyopterus galeatus* | Auchenipteridae | BR | 16 |
| *Paracosmetocleithrum trachydorasi* Acosta, Scholz, Blasco-Costa, Alves & da Silva, 2018 | *Trachydoras paraguayensis* | Doradidae | BR | 17 |

1. Kritsky et al. (1986); 2. Iannacone and Luque (1991); 3. Suriano and Incorvaia (1995); 4. Santos and Brasil-Sato (2006); 5. Takemoto et al. (2009); 6. Silva et al. (2011); 7. Abdallah et al. (2012); 8. Mendoza-Palmero et al. (2012); 9. Graça et al. (2013); 10. Mendoza-Palmero et al. (2015); 11. Ferreira and Tavares-Dias (2016); 12. Jeronimo et al. (2016); 13. Mendoza-Franco et al. (2016); 14. Pantoja et al. (2016); 15. Tavares-Dias (2017); 16. Yamada et al. (2017); 17. Acosta et al. (2018).

(1 species) and *Trachydoras* Eigenmann, 1925 (1 species) (Eler et al. 2007, Buckup et al. 2007, Birindelli et al. 2011).

Thirty-five species of metazoan parasites have been reported to infect doradids (i.e., 2 Acanthocephala, 1 Crustacea, 12 Nematoda and 20 Platyhelminthes) (Thatcher 2006, Kohn et al. 2007, Luque et al. 2011, Cohen et al. 2013, Mendoza-Franco et al. 2016, Acosta et al. 2018). Among these, monogenoids correspond to 30% (11 spp.) of this diversity (Table 1) (Cohen et al. 2013, Mendoza-Franco et al. 2016, Acosta et al. 2018). However, in spite of this diversity, only ~9% of the doradid

species have been investigated for monogenoidean parasites (i.e., *Franciscodoras marmoratus* [Lütken, 1874]; *Pterodoras granulosus* [Valenciennes, 1921]; *Oxydoras niger* [Valenciennes, 1821]; *Nemadoras hemipeltis* [Eigenmann, 1925], *Hassar orestis* [Steindachner, 1875]; *Trachydoras paraguayensis* [Eigenmann & Ward, 1907]) (Cohen et al. 2013, Mendoza-Franco et al. 2016, Acosta et al. 2018).

During a study of monogenoids infecting doradid fish from the Xingu River and related tributaries, three new species of *Cosmetocleithrum* and a new species of *Vancleaveus* (Dactylogyridae) were found parasitizing the gills of *Hassar orestis* and *H. gabiru* Birindelli, Fayal & Wosiacki,2011. Descriptions of the new species are presented herein. *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016 is reported for the first time parasitizing *Hassar orestis* in Brazilian waters, and the first time parasitizing *H. gabiru*.

## MATERIAL AND METHODS

Hosts were collected by trammel net from the Xingu River and related tributaries (Amazon basin: Amazonas, Xingu, Iriri, and Paru sub-basins) during 2015 (Table 2). Host scientific names follow Eschmeyer et al. (2017). Names of the basins and sub-basins nomenclature follow the Agência Nacional de Águas, Ministério do Meio Ambiente, Brazil (http://hidroweb.ana.gov.br).

Gill arches were removed and placed in vials containing heated water (~65 °C). Each vial was vigorously shaken and formalin was added to obtain a 5% solution. In the laboratory, the contents of each vial were examined under a Leica S6D dissecting microscope and helminths were removed from the gills or sediment using small probes. Some specimens were stained with Gomori's trichrome (Humason 1979, Boeger and Vianna 2006) and mounted in Damar Gum or Canada balsam to determine internal soft structures and others were mounted in Hoyer's medium or Gray & Wess medium (Humason 1979, Boeger and Vianna 2006) for study of sclerotized structures. The measurements, all in micrometers, were obtained according to the procedures of Mizelle and Klucka (1953). Dimensions of organs and other structures represent the greatest measurement in dorso-ventral view; lengths of bent structures (i.e., bars and accessory piece) represent the straight line distances between extreme ends; lengths of anchors follow those presented in Fig. 6; total lengths of the MCO were carried out using IMAGEJ (Rasband 1997–2016) on drawing tube images. The average measurement is followed by the ranges and the number (n) of specimens measured in parentheses. Illustrations were prepared with the aid of a drawing tube on a Leica DM 2500 microscope with differential interference contrast and phase contrast optics. Definitions of prevalence, mean intensity and mean abundance follow Bush et al. (1997). Type specimens and vouchers were deposited in the following collections: Helminthological Collection of the Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, RJ, Brazil; Invertebrate Collection of the Instituto de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil; Invertebrate Collection of the Museu Paraense Emílio Goeldi (MPEG), Belém, PA, Brazil. Historical review of species containing relevant taxonomic contributions, such as description (descr), redescription (redes), synonymization (synon), new record (recor), citation (citat), figure (fig) are included after the valid species name.

Table 2. Host species, number of host specimens collected, localities and respective geographical coordinates.

| Species | N | Locality | Coordinates |
|---|---|---|---|
| *H. gabiru* | 2 | Iriri River, Brazil | 03°49′06,4″S, 52°41′25,8″W |
| | 19 | Ilha Grande – Xingu River, Brazil | 03°35′50,2″S, 52°21′22,5″W |
| | 6 | Gorgulho da Rita Community – Xingu River, Brazil | 03°21′15,7″S, 52°11′47,5″W |
| | 15 | Bacajá River, Brazil | 03°33′47,1″S, 51°36′50,3″W |
| *H. orestis* | 16 | Belo Monte Community – Xingu River, Brazil | 03°05′52,5″S, 51°43′18,0″W |
| | 8 | Vitória do Xingu – Xingu River, Brazil | 02°47′27,1″S, 51°59′50,0″W |
| Total | 66 | | |

## TAXONOMY

Class Monogenoidea Bychowsky, 1937
Subclass Polyonchoinea Bychowsky, 1937
Order Dactylogyridea Bychowsky, 1937
Dactylogyridae Bychowsky, 1933

### *Cosmetocleithrum phryctophallus* sp. nov.

http://zoobank.org/EB19025E-AC8F-4E74-BCF3-71932680832C
Figs 1–7

Type host. *Hassar orestis* (Steindachner, 1875), Doradidae

Site of infection. Gill filaments.

Type locality. Xingu River, Belo Monte Community, municipality of Vitória do Xingu, Pará (03°05′52.5″S, 51°43′18.0″W).

Prevalence. 100% of 16 hosts examined.

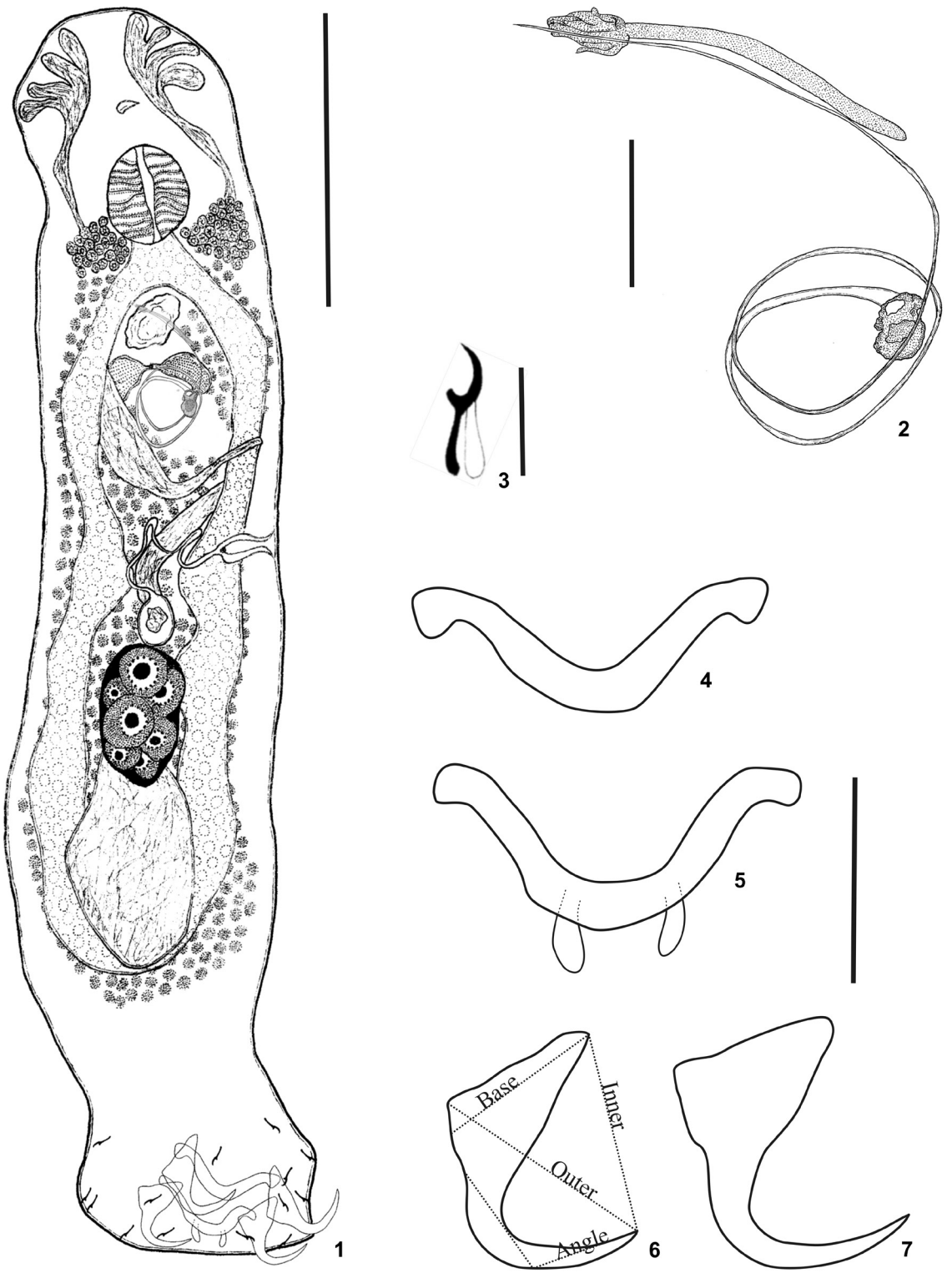
Mean intensity. 6.5 parasites per infected host.

Mean abundance. 6.5 parasites per host.

Other records. *Hassar orestis* (Prevalence: 100% of 8 hosts; Mean intensity: 6; Mean abundance: 6), Xingu River, municipality of Vitória do Xingu, Pará (02°47′27.1″S, 51°59′50.0″W).

Specimens deposited. Holotype 39055 a, and 9 paratypes, CHIOC 39055 b–g, INPA 770, MPEG 0135; 9 vouchers, CHIOC 39056 a–b, 39057 a–c, INPA 771–772, MPEG 0136.

Description (based on 10 type specimens, 5 mounted in Hoyer, 5 stained with Gomori's trichrome): Body fusiform, total length including haptor 356 (250–462; n = 10) long, 77 (62–95; n = 10) wide at level of germarium. Tegument smooth. (Fig. 1). Cephalic margin rounded, cephalic lobes inconspicuous; 3 or 4 bilateral pairs of head organs with rod-shaped secretion; cephalic glands unicellular, posterolateral to pharynx. Eyes, pigment




Figures 1–7. *Cosmetocleithrum phryctophallus* sp. nov.: (1) holotype whole-mount, ventral; (2) copulatory complex; (3) hook; (4) ventral bar; (5) dorsal bar; (6) ventral anchor; (7) dorsal anchor. Scale bars: 1 = 100 µm; 2, 4–7 = 25 µm; 3 = 10 µm.

granules (eye-spots), absent. Mouth subterminal; pharynx muscular, sub-spherical, 28 (24–33; n = 9) long, 23 (17–25; n = 9) wide; esophagus short, two intestinal ceca, confluent posteriorly; lacking diverticula. Haptor globose 67 (55–85; n = 9) wide. Anchors similar. Ventral anchor, superficial root, narrow triangular, well developed; deep root inconspicuous; slightly curved shaft and point, forming angle of approximately 90°; point extending just past level of tip of superficial root, outer 27 (24–31; n = 10) long, inner 28 (25–32; n = 10) long, base 18 (11–22; n = 10) (Fig. 6). Dorsal anchor, superficial root triangular, large; deep root inconspicuous; slightly curved shaft and point, forming angle of approximately 75°, point extending just past level of tip of superficial root, outer 28 (21–31; n = 8) long, inner 29 (27–31; n = 8) long, base 19 (16–31; n = 7) (Fig. 7). Ventral bar (Fig. 4) 35 (28–45; n = 10) long, 5 (3–7; n = 10 wide, broadly U-shaped with inflated ends, slightly curved in posterior direction. Dorsal bar (Fig. 5) 36 (28–45; n = 10) long, 4 (3–6; n = 10) wide, U-shaped with rounded ends, slightly curved; two submedial projections posteriorly directed. Hooks similar (Fig. 3), 13 (12–17; n = 10) long, with upright rounded thumb; slightly curved shaft, short; non-dilated shank; filamentous hooklet loop about shank length. Genital pore opening midventral, anterior to copulatory complex; muscular genital atrium. Testis post-germarial, dorsal to germarium, elongated 47 (31–69; n = 6) long, 33 (25–39; n = 6) wide. Vas deferens looping left of intestinal cecum; seminal vesicle a dilatation of vas deferens; long prostatic reservoir with medial constriction. Copulatory complex comprising MCO, accessory piece (Fig. 2). MCO, coiled sclerotized tube 236 (201–299; n = 7) long, with 2 ½ counterclockwise rings, with tapered distal region, base MCO, wide sclerotized margin. Accessory piece 36 (31–50; n = 6) long, non-articulated with MCO, comprising straight rod, distal end with elongate torch-shaped blade, guarding termination of MCO. Germarium 44 (31–69; n = 8) long, 23 (17–31; n = 8) wide, pyriform. Eggs, Mehlis' gland, ootype and uterus not observed. Vagina slightly sclerotized, vaginal pore sinistral, marginal or submarginal, vaginal vestibule cup-shaped, long vaginal canal, sigmoid, slightly sclerotized; seminal receptacle oval. Vitelline follicles dense, coextensive with ceca.

Comparative measurements. Table 3.

Etymology. The specific name (a noun) is from Greek (*phryctos* = burning torch + *phallos* = penis) and refers to the unique shape of the accessory piece.

Remarks. *Cosmetocleithrum phryctophallus* sp. nov. resembles *Cosmetocleithrum akuanduba* sp. nov. by sharing similar morphology of the haptoral structures. However, it can be easily distinguished from *C. akuanduba* sp. nov. due to the presence of a coiled MCO (J-shaped in *C. akuanduba* sp. nov.) and by having a lightly sclerotized vagina with a sigmoid vaginal canal (heavily sclerotized vagina with short, "S"-shaped vaginal canal in *C. akuanduba* sp. nov.). The new species also differs from *C. akuanduba* sp. nov. and all other congeneric species by possessing an accessory piece with an elongate torch-shaped blade.

Table 3. Comparative measurements (µm) of specimens of *Cosmetocleithrum phryctophallus* sp. nov. from the gills of *Hassar orestis* from two locations. MCO = male copulatory organ.

| | Belo Monte | N | Vitória do Xingu | N |
|---|---|---|---|---|
| Body | | | | |
| Length | 356 (250–462) | 10 | 350 (245–510) | 6 |
| Width | 77(62–95) | 10 | 70(62–90) | 6 |
| Haptor | | | | |
| Wide | 67,5(55–85) | 9 | 60,5(50–85) | 7 |
| Pharynx | | | | |
| Length | 28(24–33) | 9 | 28(24–33) | 6 |
| Width | 23(17–25) | 9 | 20(17–23) | 7 |
| MCO length | 236(201–299) | 7 | 230(201–290) | 7 |
| Accessory piece | | | | |
| Length | 36 (31–50) | 6 | 34 (31–45) | 5 |
| Ventral Bar | | | | |
| Length | 35(28–45) | 10 | 38(28–45) | 8 |
| Width | 5(3–7) | 10 | 4(3–7) | 10 |
| Dorsal Bar | | | | |
| Length | 46(28–45) | 10 | 35(23–46) | 5 |
| Width | 4(3–6) | 10 | 4(3–6) | 4 |
| Ventral Anchor | | | | |
| Outer | 27(24–31) | 10 | 25(24–30) | 5 |
| Inner | 28(25–32) | 10 | 27(23–35) | 3 |
| Base | 18(11–22) | 10 | 17(11–18) | 8 |
| Dorsal Anchor | | | | |
| Outer | 29(27–31) | 8 | 25(21–30) | 5 |
| Inner | 28(21–31) | 8 | 27(27–30) | 8 |
| Base | 19(16–21) | 7 | 17(16–20) | 7 |
| Germarium | | | | |
| Length | 44(31–69) | 8 | 40(31–67) | 8 |
| Width | 23(17–31) | 8 | 25(17–30) | 8 |
| Testis | | | | |
| Length | 47(31–79) | 6 | 45(30–79) | 6 |
| Width | 33(25–39) | 6 | 30(25–39) | 6 |
| Hooks | 13 (12–17) | 10 | 15 (12–17) | 10 |

## *Cosmetocleithrum leandroi* sp. nov.

http://zoobank.org/C76094F5-7967-4AD3-BD04-0575F829E30C
Figs 8–14

Type host. *Hassar gabiru* Birindelli, Fayal & Wosiacki, 2011, Doradidae

Site of infection. Gill filaments.

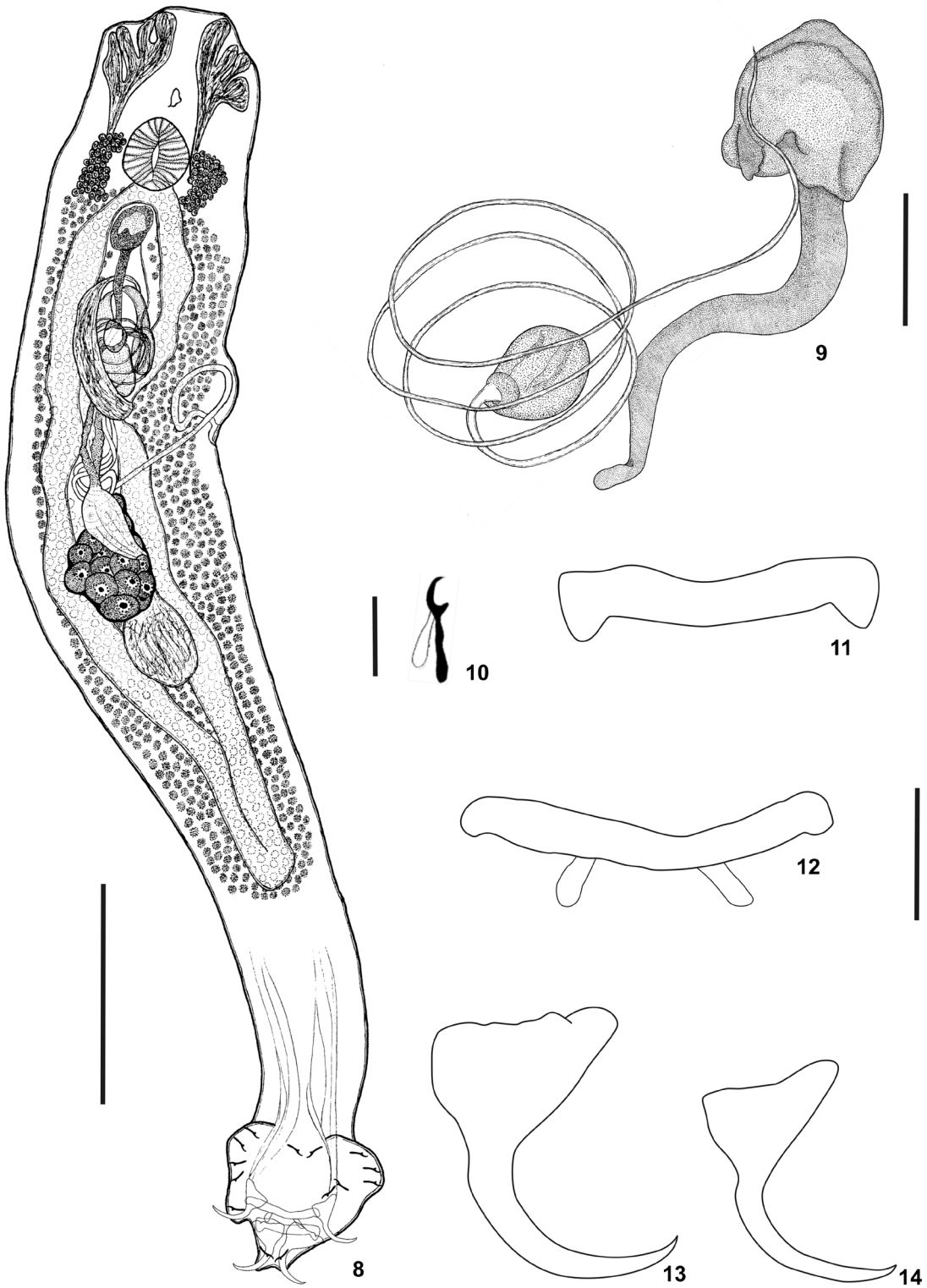
Type locality. Bacajá River, municipality of Altamira, Pará (03°33'47.1"S, 51°36'50.3"W).

Prevalence. 100% of 15 hosts examined.

Mean intensity. 20 parasites per infected host.

Mean abundance. 20 parasites per host.

Other records. *Hassar gabiru* (Prevalence: 100% of 19 hosts; Mean intensity: 15; Mean abundance: 15), Ilha Grande,




Figures 8–14. *Cosmetocleithrum leandroi* sp. nov.: (8) holotype whole-mount, ventral; (9) copulatory complex; (10) hook; (11) ventral bar; (12) dorsal bar; (13) ventral anchor; (14) dorsal anchor. Scale bars: 8 = 100 µm; 9, 11–14 = 25 µm; 10 = 10 µm.

Xingu River, municipality of Altamira, Pará (03°35'50.2"S, 52°21'22.5"W); *Hassar gabiru* (Prevalence: 100% of 2 hosts; Mean intensity: 2.5; Mean abundance: 2.5), Iriri River, municipality of Altamira, Pará (03°49'06.4"S, 52°41'25.8"W).

Specimens deposited. Holotype, CHIOC 39053 a, and 8 paratypes, CHIOC 39053 b–f, INPA 773, MPEG 0137; 8 vouchers, CHIOC 39054 a–c, INPA 774, MPEG 0138–0140.

Description (based on 10 type specimens, 6 mounted in Hoyer, 4 stained with Gomori's trichrome): Body robust, fusiform, total length including haptor 712 (575–835; n = 8) long, 132 (102–157; n = 8) wide, at level of germarium. Tegument smooth (Fig. 8). Cephalic margin broad; cephalic lobes poorly differentiated; 4 or 5 bilateral pairs of head organs with rod-shaped secretion; cephalic glands unicellular, posterolateral to pharynx. Eyes, pigment granules (eye-spots), absent. Mouth subterminal; pharynx muscular, spherical, 39 (33–46; n = 7) long, 36 (30–42; n = 7) wide; esophagus short; two intestinal ceca, confluent posteriorly, lacking diverticula. Haptor subtriangular 89 (65–110; n = 8) wide. Anchors similar, base wide, superficial and deep root poorly developed. Ventral anchor, curved shaft and point, forming angle of approximately 85°, point extending just past level of tip of superficial root, outer 40 (25–45; n = 10) long, inner 45 (28–52; n = 10) long, base 26 (16–30; n = 10) (Fig. 13). Dorsal anchor, slightly curved shaft and point, forming angle of approximately 110°, point extending just past level of tip of superficial root, outer 35 (30–39; n = 10) long, inner 38 (36–42; n = 10) long, base 20 (15–23; n = 10) (Fig. 14). Ventral bar (Fig. 11) 44 (32–57; n = 9) long, 6 (4–9; n = 8) wide, straight with knobbed ends. Dorsal bar (Fig. 12) 49 (35–65; n = 10) long, 6 (3–8; n = 10) wide, straight with inflated or rounded ends; two submedial projections posteriorly directed. Hooks similar (Fig. 10), 14 (13–15; n = 8) long, with upright rounded thumb; slightly curved shaft, short; non-dilated shank; filamentous hooket about ½ shank length. Genital pore opening to left of body midline, anterior to copulatory complex; muscular genital atrium. Testis post-germarial, dorsal to germarium, ovoid, 43 (43–44; n = 2) long, 27 (24–30; n = 2) wide. Vas deferens looping left of intestinal cecum; seminal vesicle a dilatation of vas deferens; prostatic reservoir with medial constriction. Copulatory complex comprising MCO, accessory piece (Fig. 9). MCO, coiled sclerotized tube, 572 (550–637; n = 9) long, with 3 ½ counterclockwise rings, with tapered distal region, base of MCO sclerotized. Accessory piece 121 (110–130; n = 5) long, non-articulated with MCO, comprising sigmoid rod, with cup-shaped distal region. Germarium 85 (65–106; n = 5) long, 49 (39–62; n = 5) wide, pyriform. Eggs, Mehlis' gland, ootype and uterus not observed. Vagina heavily sclerotized, vaginal pore sinistral, marginal or submarginal, vaginal canal long, convoluted, heavily sclerotized, proximal region looped, distal region sigmoid; seminal receptacle pyriform. Vitelline follicles dense, coextensive with ceca.

Comparative measurements. Table 4.

Etymology. The specific name is in honor of Dr Leandro Melo de Sousa, Universidade Federal do Pará, Brazil, in recognition of his valuable work on the fish diversity of Xingu River, and also because the specific name of the host species, "gabiru", is the nickname of Dr de Souza (Birindelli et al. 2011). Now, Dr de Sousa has the host and parasite named after him.

Table 4. Comparative measurements (µm) of specimens of *Cosmetocleithrum leandroi* sp. nov. from the gills of *Hassar gabiru* from three locations.

| | Bacajá River | N | Xingu River | N | Iriri River | N |
|---|---|---|---|---|---|---|
| Body | | | | | | |
| Length | 712(575–835) | 8 | 700(535–820) | 5 | 715(580–830) | 6 |
| Width | 132(102–157) | 8 | 125(100–150) | 6 | 130(102–157) | 5 |
| Haptor | | | | | | |
| Wide | 89(65–110) | 8 | 90(65–100) | 5 | 89(65–110) | 8 |
| Pharynx | | | | | | |
| Length | 39(33–46) | 7 | 40(33–43) | 7 | 39(33–46) | 7 |
| Width | 36(30–42) | 7 | 30(30–45) | 6 | 36(30–42) | 7 |
| MCO length | 572(550–637) | 9 | 570(550–640) | 5 | 570(550–637) | 9 |
| Accessory piece | | | | | | |
| Length | 121(110–130) | 5 | 119(100– 135) | 6 | 125(103–120) | 5 |
| Ventral Bar | | | | | | |
| Length | 44(32–57) | 9 | 40(32–50) | 5 | 44(32–57) | 9 |
| Width | 6(4–9) | 8 | 5(4–8) | 7 | 6(4–9) | 8 |
| Dorsal Bar | | | | | | |
| Length | 49(35–65) | 10 | 50(35–60) | 5 | 49(35–65) | 8 |
| Width | 6(3–8) | 10 | 5(3–6) | 5 | 5(3–8) | 8 |
| Ventral Anchor | | | | | | |
| Outer | 40(25–45) | 10 | 40(27–45) | 4 | 45(25–45) | 7 |
| Inner | 45(28–52) | 10 | 45(30–50) | 5 | 45(28–52) | 8 |
| Base | 26(16–30) | 10 | 27(16–27) | 16 | 27(16–30) | 7 |
| Dorsal Anchor | | | | | | |
| Outer | 35(30–39) | 10 | 34(22–39) | 6 | 34(22–39) | 7 |
| Inner | 38(36–42) | 10 | 37(21–42) | 7 | 37(21–42) | 6 |
| Base | 20(15–23) | 10 | 20(15–23) | 6 | 20(15–23) | 8 |
| Germarium | | | | | | |
| Length | 85(65–106) | 5 | 80(65–106) | 5 | 80(65–106) | 6 |
| Width | 49(39–62) | 5 | 49(39–62) | 4 | 49(39–62) | 5 |
| Testis | | | | | | |
| Length | 43(43–44) | 2 | 42(43–44) | 3 | 43(43–44) | 5 |
| Width | 27(24–30) | 2 | 27(24–30) | 2 | 27(24–30) | 5 |
| Hooks | 14(13–15) | 8 | 14(13–15) | 6 | 13(13–15) | 6 |

Remarks. *Cosmetocleithrum leandroi* sp. nov. resembles *Cosmetocleithrum longivaginatum* Suriano & Incorvaia, 1995 by the general morphology of the bars and by the presence of a long vaginal canal (see Suriano and Incorvaia 1995). However, the new species differs from *C. longivaginatum*, mainly by possessing a MCO comprising a coil of about with 3 ½ rings (6 rings in *C. longivaginatum*) and a sigmoid accessory piece with the distal portion cup-shaped (straight, non-expanded distal accessory piece in *C. longivaginatum*). Also, *C. leandroi* has hooks with similar size, whereas *C. longivaginatum* has 2 different sizes of hooks (pairs 2 to 5 are smaller than pairs 1, 6 and 7). Finally,

these species differ in the shape of their anchors, i.e., *C. longivaginatum* has well-defined roots, whereas *C. leandroi* has poorly differentiated roots.

## *Cosmetocleithrum akuanduba* sp. nov.

http://zoobank.org/14BE47EB-2B58-4854-BDA2-907115610047
Figs 15–22

Type host. *Hassar gabiru* Birindelli, Fayal & Wosiacki, 2011, Doradidae

Site of infection. Gill filaments.

Type locality. Ilha grande, Xingu River, municipality of Altamira, Pará (03°35'50.2"S, 52°21'22.5"W).

Prevalence. 52% of 19 hosts examined.

Mean intensity. 3 parasites per infected host.

Mean abundance. 1.6 parasites per host.

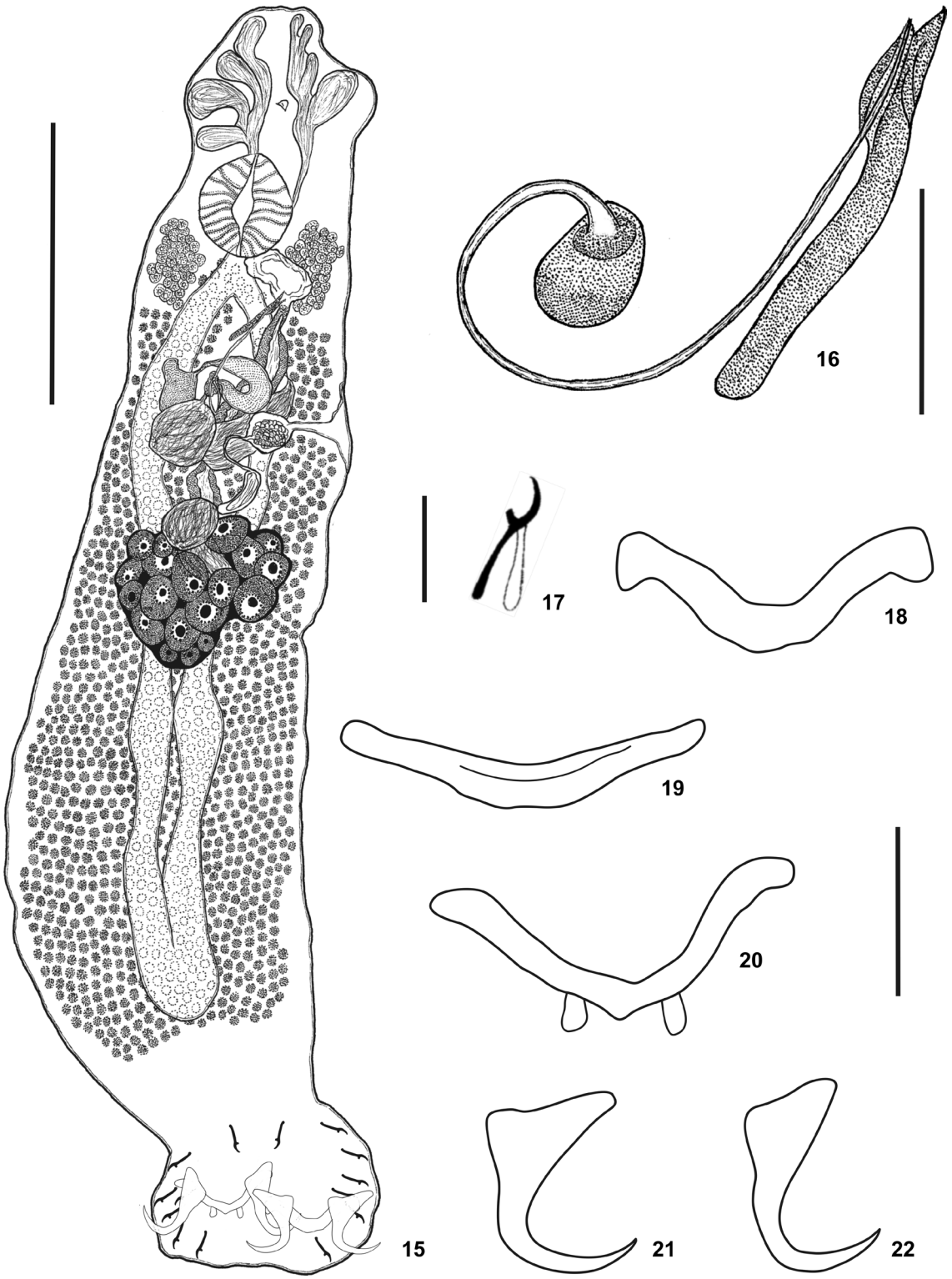
Other records. *Hassar gabiru* (Prevalence: 100% of 2 hosts; Mean intensity: 2.5; Mean abundance: 2.5) Iriri River, municipality of Altamira, Pará (03°49'06.4"S, 52°41'25.8"W); *Hassar gabiru* (Prevalence: 60% of 15 hosts; Mean intensity: 3.8; Mean abundance: 2.3) Bacajá River, municipality of Altamira, Pará (03°33'47.1"S, 51°36'50.3"W); *Hassar orestis* (Prevalence: 62% of 24 hosts; Mean intensity: 2.3; Mean abundance: 1.5), Xingu River, Belo Monte Community, municipality of Vitória do Xingu, Pará (03°05'52.5"S, 51°43'18.0"W; 02°47'27.1"S, 51°59'50.0"W).

Specimens deposited. Holotype, CHIOC 39045 a, and 6 paratypes, CHIOC 39045 b-e, INPA 776, MPEG 0141; 8 vouchers, CHIOC 39046 a–b, 39047 a–c, INPA 777, MPEG 0142.

Description (based on 7 type specimens, 1 mounted in Hoyer, 6 stained with Gomori's trichrome): Body fusiform, total length including haptor 451 (360–517; n = 5) long, 110 (92–130; n = 5) wide at level of germarium. Tegument smooth (Fig. 15). Cephalic margin broad; cephalic lobes poorly differentiated; 4 bilateral pairs of head organs with rod-shaped secretion; cephalic glands unicellular, posterolateral to pharynx. Eyes, pigment granules (eye-spots), absent. Mouth subterminal; pharynx muscular, spherical, 32 (30–35; n = 5) long, 28 (25–30; n = 5) wide; esophagus short; two intestinal ceca, confluent posteriorly, lacking diverticula. Haptor globose 90 (75–117; n = 5) wide. Anchors similar. Ventral anchor, superficial root narrow subtriangular, well developed; deep root inconspicuous; slightly curved shaft and point, forming angle of approximately 75°, point extending just past level of tip of superficial root, outer 27(25–29; n = 7) long, inner 30 (25–41; n = 7) long, base 19 (17–20; n = 7) (Fig. 21). Dorsal anchor, superficial root subtriangular; deep root inconspicuous; slightly curved shaft and point forming angle of approximately 70°, point extending just past level of tip of superficial root, outer 25 (22–29; n = 5) long, inner 30 (29–32; n = 5) long, base 19 (17–20; n = 5) (Fig. 22). Ventral bar, variable (Figs 18–19) 41 (30–57; n = 7) long, 6 (4–10; n = 7) wide, broadly U-shaped or straight with inflated or rounded ends. Dorsal bar (Fig. 20) 41 (31–56; n = 7) long, 5 (4–6; n = 7) wide, V-shaped with rounded ends, two submedial projections posteriorly directed. Hooks similar (Fig. 17), 13 (13–14; n = 7) long, with upright truncate thumb; slightly curved shaft, short; non-dilated shank; filamentous hook about shank length. Genital pore opening midventral, anterior to copulatory complex; muscular genital atrium. Testis post-germarial (observed on paratypes), dorsal to germarium, ovoid, 56 (51–64; n = 3) long, 40 (32–47; n = 3) wide. Vas deferens looping left of intestinal cecum; seminal vesicle a dilatation of vas deferens; long prostatic reservoir with medial constriction. Copulatory complex comprising MCO, accessory piece (Fig. 16). MCO with tubular coiled shaft of less than one counterclockwise ring, frequently appearing J shaped, 68 (54–76; n = 4) long, with tapered distal region; base sclerotized, bulbous. Accessory piece 23 (18–30; n = 5) long, non-articulated with MCO, comprising straight rod, with tapered distal region,

Table 5. Comparative measurements (μm) of specimens of *Cosmetocleithrum akuanduba* sp. nov. from the gills of *Hassar gabiru* from three locations.

| | Xingu River | N | Iriri River | N | Bacajá River | N |
|---|---|---|---|---|---|---|
| Body | | | | | | |
| Length | 451(360–517) | 5 | – | – | 421(290–490) | 4 |
| Width | 110(92–130) | 5 | – | – | 102(72–150) | 4 |
| Haptor | | | | | | |
| Wide | 90(75–117) | 5 | – | – | 87(67-105) | 4 |
| Pharynx | | | | | | |
| Length | 32(30–35) | 5 | – | – | 28(20–35) | 4 |
| Width | 28(25–30) | 5 | – | – | 26(17–36) | 4 |
| MCO length | 68(54–76) | 4 | 78(74–86) | 5 | 94(86–98) | 5 |
| Accessory piece | | | | | | |
| Length | 23(18–30) | 5 | 27(20–37) | 4 | 29(22–34) | 4 |
| Ventral Bar | | | | | | |
| Length | 41(30–57) | 7 | 47(45–50) | 5 | 35(32–38) | 3 |
| Width | 6(4–10) | 7 | 5(4–6) | 5 | 3(3–4) | 2 |
| Dorsal Bar | | | | | | |
| Length | 41(31–56) | 7 | 44(40–47) | 4 | 36(35–38) | 2 |
| Width | 5(4–6) | 7 | 4(4–5) | 4 | 3(3–4) | 3 |
| Ventral Anchor | | | | | | |
| Outer | 27(25–29) | 7 | 29(28–30) | 4 | 24(23–25) | 2 |
| Inner | 30(25–41) | 7 | 27(27–29) | 4 | 28(27–29) | 2 |
| Base | 19(17–20) | 7 | 20(19–21) | 4 | 17(15–20) | 2 |
| Dorsal Anchor | | | | | | |
| Outer | 25(22–29) | 5 | 29(26–31) | 5 | 24(20–29) | 2 |
| Inner | 30(29–32) | 5 | 28(26–30) | 5 | 25(21–29) | 2 |
| Base | 19(17–20) | 5 | 19(17–22) | 5 | 16(15–17) | 2 |
| Germarium | | | | | | |
| Length | 51(47–55) | 5 | – | – | 37(31–47) | 3 |
| Width | 42(35–52) | 5 | – | – | 24(17–31) | 3 |
| Testis | | | | | | |
| Length | 56(51–64) | 3 | – | – | 55 | 1 |
| Width | 40(32–47) | 3 | – | – | 27 | 1 |
| Hooks | 13 (13–14) | 7 | 13(12–14) | 16 | – | – |




Figures 15–22. *Cosmetocleithrum akuanduba* sp. nov.: (15) holotype whole-mount, ventral; (16) copulatory complex; (17) hook; (18–19) ventral bar; (20) dorsal bar; (21) ventral anchor; (22) dorsal anchor. Scale bars: 15 = 100 µm; 16, 18–22 = 25 µm; 17 = 10 µm.

distal portion with a small gutter guarding distal portion of shaft of MCO. Germarium 51 (47–55; n = 5) long, 42 (35–52; n = 5) wide, oval. Uterus delicate, ventral. Eggs, Mehlis' gland and ootype not observed. Vagina heavily sclerotized, vaginal pore sinistral, marginal or submarginal, vaginal canal slightly sclerotized, proximal region "S"-shaped, distal region expanded; seminal receptacle, spherical. Vitelline follicles dense, coextensive with ceca.

Comparative measurements. Table 5.

Etymology. The name *akuanduba* refers to a divinity called "Akuanduba" of the Arara native people from the Xingu Basin in Pará. According Arara mythic narratives, Akuanduba played his flute to bring order to the world. One day, because of human disobedience, they were thrown into the water. The few survivors had to learn from scratch how to give continuity to life.

Remarks. *Cosmetocleithrum akuanduba* sp. nov. resembles *Cosmetocleithrum parvum* Kritsky, Thatcher & Boeger, 1986 and *Cosmetocleithrum sobrinus* Kritsky, Thatcher & Boeger, 1986 by having a "J" -shaped MCO (see Kritsky et al. 1986). However, the new species differs from these two species by possessing an elongate accessory piece, with sharp distal region, distal tip with a small gutter (accessory piece with proximal arm, hollow bulbous portion distally in *C. parvum*, and accessory piece large, globose, and apparently hollow in *C. sobrinus*). Also *C. akuanduba* has a dorsal anchor with a broad subtriangular superficial root, undeveloped deep root, evenly curved shaft with angle of approximately 70°; (narrow, subrectangular superficial root; developed deep root; evenly curved shaft with angle of approximately 70° and 80° in *C. parvum* and *C. sobrinus*, respectively). The morphological variations in the ventral bar of *C. akuanduba* (Figs 18–19) reported from different hosts and localities (i.e., *H. orestis* collected below the Volta Grande and *H. gabiru* collected above the Volta Grande rapids) were considered intraspecific variations.

## *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016

Figs 23–29

Syn. *Cosmetocleithrum* sp. 8 Mendoza-Palmero, Blasco-Costa & Scholz, 2015

*Cosmetocleithrum bifurcum*, Mendoza-Franco et al. (2016): 858–859, figs 6a–h, (descr).

Type host. *Hassar orestis* (Steindachner, 1875), Doradidae.

Type locality. Aquarium Momón River, Iquitos, Peru (03°44'56" S, 73°15'13" W).

Site of infection. Gill filaments.

Other records. *Hassar orestis* (Prevalence: 100% of 16 hosts examined; Mean intensity: 9.35 parasites per infected host; Mean abundance: 9.35 parasites per host), Xingu River, Belo Monte Community, municipality of Vitória do Xingu, Pará (03°05'52.5"S, 51°43'18.0"W); *Hassar orestis* (Prevalence: 100% of 8 hosts; Mean intensity: 12.6; Mean abundance: 12.6) Xingu River, municipality of Vitória do Xingu, Pará (02°47'27.1"S, 51°59'50.0"W); *Hassar gabiru* (Prevalence: 100% of 2 hosts; Mean intensity: 1; Mean abundance: 1) Iriri River, municipality of Altamira, Pará (03°49'06.4"S, 52°41'25.8"W); *Hassar gabiru* (Prevalence: 84% of 19 hosts; Mean intensity: 2.6; Mean abundance: 2.2), Ilha Grande, Xingu River, municipality of Altamira, Pará (03°35'50.2"S, 52°21'22.5"W); *Hassar gabiru* (Prevalence: 100% of 15 hosts; Mean intensity: 2.6; Mean abundance: 2.6), Bacajá River, municipality of Altamira, Pará (03°33'47.1"S, 51°36'50.3"W).

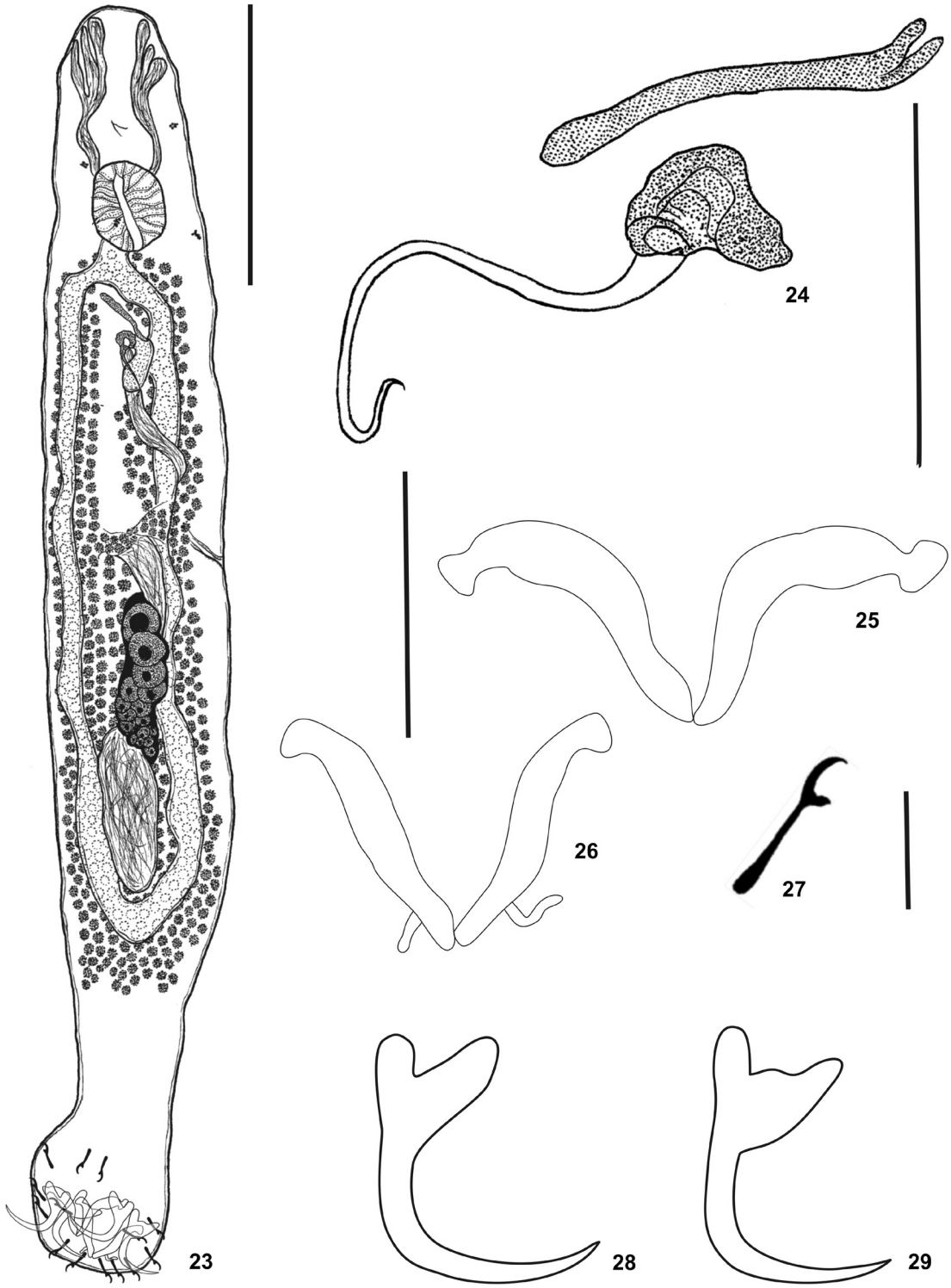
Specimens deposited. 17 vouchers, CHIOC 39048 a–b, 39049 a–c, 39050, 39051 a–c, 39052 a–b, INPA 780–781, MPEG 0145–0148.

Comparative measurements. Table 6.

Table 6. Comparative measurements (μm) of specimens of *Cosmetocleithrum bifurcum* from the gills of *Hassar orestis* and *H. gabiru* from Brazil and *H. orestis* from Peru. BR = Brazil, PE = Peru.

| | *H. orestis (BR) | N | **H. orestis (PE) | N | *H. gabiru (BR) | N |
|---|---|---|---|---|---|---|
| Body | | | | | | |
| Length | 292(197–405) | 8 | (322–420) | 17 | 244(150–325) | 8 |
| Width | 80(65–107) | 8 | (51–80) | 16 | 65(52–82) | 8 |
| Haptor | | | | | | |
| Length | 59(52–65) | 8 | (35–40) | 14 | 43(35–62) | 6 |
| Width | 44(37–55) | 8 | (47–59) | 14 | 48(37–55) | 6 |
| Pharynx | | | | | | |
| Length | 22(19–28) | 9 | (21–25) | 17 | 22(17–27) | 8 |
| Width | 25(15–31) | 9 | – | – | 20(16–24) | 8 |
| MCO length | 38(33–44) | 7 | (31–50) | 13 | 31(30–33) | 7 |
| Accessory piece | | | | | | |
| Length | 21(20–25) | 4 | (20–23) | 15 | 16(13–20) | 4 |
| Ventral Bar | | | | | | |
| Length | 46(37–55) | 6 | (33–40) | 14 | 32(26–39) | 10 |
| Width | 4(3–4) | 7 | – | – | 2(2–3) | 11 |
| Dorsal Bar | | | | | | |
| Length | 31(20–50) | 5 | (31–38) | 14 | 30(22–40) | 8 |
| Width | 3(3) | 7 | – | – | 2(2–3) | 9 |
| Ventral Anchor | | | | | | |
| Outer | 29(25–31) | 8 | 27 | 1 | 28(25–31) | 9 |
| Inner | 23(21–25) | 8 | 19 | 1 | 21(19–24) | 9 |
| Base | 14(12–16) | 8 | (11–12) | 25 | 12(9–17) | 9 |
| Dorsal Anchor | | | | | | |
| Outer | 27(25–33) | 7 | 23 | 1 | 24(17–30) | 8 |
| Inner | 20(18–23) | 7 | 18 | 1 | 21(18–29) | 8 |
| Base | 13(11–17) | 7 | (10–12) | 24 | 11(9–12) | 8 |
| Germarium | | | | | | |
| Length | 28(46–55) | 9 | (55–63) | 3 | 42(36–49) | 5 |
| Width | 22(17–31) | 9 | (23–40) | 3 | 19(17–24) | 5 |
| Testis | | | | | | |
| Length | 49(41–60) | 8 | (83–99) | 3 | 41(32–47) | 5 |
| Width | 24(19–31) | 8 | (30–47) | 3 | 24(19–30) | 5 |
| Hooks | 15 (15–16) | 6 | 15 | 37 | 14(13–15) | 7 |

* Present study
** Mendoza Franco et al. (2016)




Figures 23–29. *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016: (23) voucher whole-mount, ventral; (24) copulatory complex; (25) ventral bar; (26) dorsal bar; (27) hook; (28) ventral anchor; (29) dorsal anchor. Scale bars: 23 = 100 µm; 24–26, 28, 29 = 25 µm; 27 = 10 µm.

Remarks. A comparative analysis of *Cosmetocleithrum bifurcum* Mendoza-Franco, Mendoza-Palmero & Scholz, 2016 and specimens of *Cosmetocleithrum* from Xingu River and related tributaries indicated that they are conspecific, mainly because they both share the morphology of the copulatory complex, bars and anchors. The specimens studied here also are similar morphometrically to those specimens from the type host and locality. Mendoza-Franco et al. (2016) recognized differences between hook pair 7 and the other hook pairs (Mendoza-Franco et al. 2016: figs 6G–H), where hook pair 7 has a shaft longer and shank more slender than the other hook pairs. The specimens studied here have hooks similar in shape with erect thumb (thumb directed posteriorly in Mendoza-Franco et al.'s specimens), and evenly curved shaft and point (long shaft, delicate point in Mendoza-Franco et al.'s specimens). *Cosmetocleithrum bifurcum* was primarily characterized by possessing a MCO with about 1–1.5 rings, whereas the specimens studied in the present paper have a sigmoid MCO. However, these variations do not seem to be sufficient enough evidence to propose a new species and we consider them as intraspecific variations.

## *Vancleaveus klasseni* sp. nov.

http://zoobank.org/BC5808A4-0404-43A0-872D-234B15A188CF
Figs 30–36

Type host. *Hassar orestis* (Steindachner, 1875), Doradidae

Site of infection. Gill filaments.

Type locality. Xingu River, Belo Monte Community, municipality of Vitória of Xingu, Pará (03°05'52.5"S, 51°43'18.0"W; 02°47'27.1"S, 51°59'50.0"W).

Prevalence. 50% of 24 hosts examined

Mean intensity. 2.3 parasites per infected host.

Mean abundance. 1.6 parasites per host.

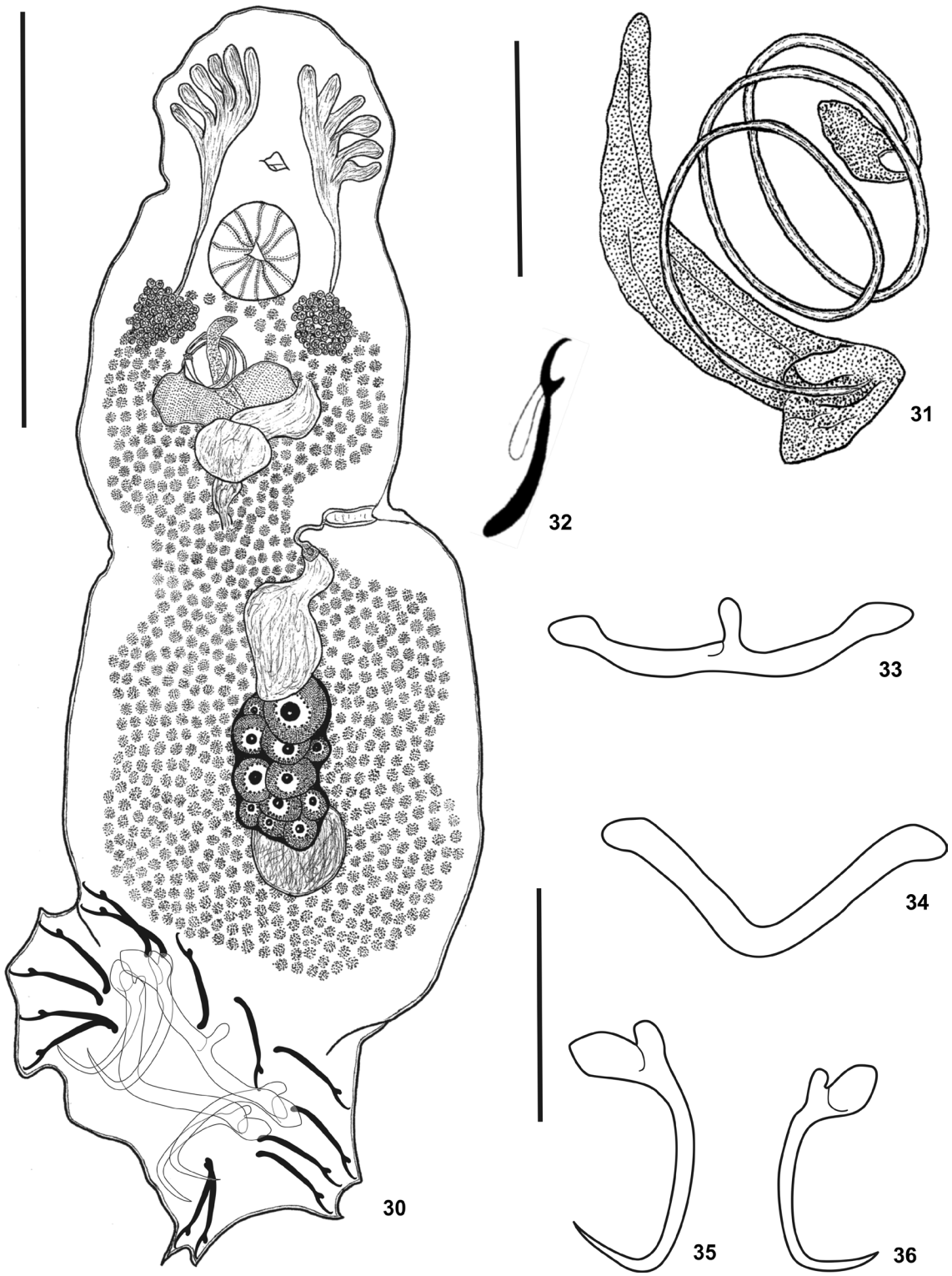
Other records. *Hassar gabiru* (Prevalence: 30% of 15 hosts; Mean intensity: 2; Mean abundance: 0.6), Bacajá River, municipality of Altamira, Pará (03°33'47.1"S, 51°36'50.3"W); *Hassar gabiru* (Prevalence: 16% of 12 hosts; Mean intensity: 2; Mean abundance: 0.3), Ilha Grande, Xingu River, municipality of Altamira, Pará (03°35'50.2"S, 52°21'22.5"W).

Specimens deposited. Holotype CHIOC 39058 a, and 9 paratypes, CHIOC 39058 b–h, INPA 778, MPEG 0143; 4 vouchers, CHIOC 39059–39060, INPA 779, MPEG 0144.

Description (based on 10 type specimens, 3 mounted in Hoyer, 7 stained with Gomori's trichrome): Body fusiform, total length including haptor 315 (215–517; n = 9) long, 89 (65–122; n = 9) wide, at level of germarium. Tegument smooth (Fig. 30). Cephalic margin rounded, cephalic lobes inconspicuous; 5 or 6 bilateral pairs of head organs with rod-shaped secretion; cephalic glands unicellular, posterolateral to pharynx. Eyes, pigment granules (eye-spots), absent. Mouth subterminal; pharynx muscular, spherical, 33 (25–36; n = 8) long, 17 (15–20; n = 8) wide; esophagus short; two intestinal ceca, confluent posteriorly, lacking diverticula. Haptor hexagonal 71(52–90; n = 9) wide. Anchors similar. Ventral anchor, divergent roots; superficial root triangular, well developed, with conspicuous fold; deep root developed; slightly curved shaft and point, forming angle of approximately 65°, point extending just past level of tip of superficial root, outer 24 (21–28; n = 6) long, inner 28 (27–32; n = 6) long, base 10 (8–12; n = 6) (Fig. 35). Dorsal anchor, divergent roots; superficial root subtriangular, with conspicuous fold; deep root developed; slightly curved shaft and point, forming angle of approximately 80°, point extending just past level of tip of superficial root, outer 24 (18–27; n = 4) long, inner 29 (29–30; n = 4) long, base 10 (10–11; n = 4) (Fig. 36). Ventral bar (Fig. 33) 35 (27–45; n = 10) long, 4 (3–5; n = 10) wide, broadly U-shaped with inflated ends, posteromedial projection devel-

Table 7. Comparative measurements (μm) of specimens of *Vancleaveus klasseni* sp. nov. from the gills of *Hassar orestis* and *H. gabiru* from Xingu River Basin.

| | *H. orestis* | N | *H. gabiru* | N |
|---|---|---|---|---|
| Body | | | | |
| Length | 315(215–517) | 9 | 267(215–320) | 2 |
| Width | 89(65–122) | 9 | 76(65–87) | 2 |
| Haptor | | | | |
| Wide | 71(52–90) | 9 | 61(55–67) | 2 |
| Pharynx | | | | |
| Length | 33(25–36) | 8 | 29(28–30) | 2 |
| Width | 17(15–20) | 8 | 18 | 2 |
| MCO length | 96(88–106) | 6 | 98(90–104) | 3 |
| Accessory piece | | | | |
| Length | 16 (15–18) | 5 | 23(21–25) | 2 |
| Ventral Bar | | | | |
| Length | 35(27–45) | 10 | 38(36–40) | 2 |
| Width | 4(3–5) | 10 | 4 | 3 |
| Dorsal Bar | | | | |
| Length | 29(21–38) | 10 | 29(28–30) | 3 |
| Width | 3(2–3) | 10 | 3(2–4) | 3 |
| Ventral Anchor | | | | |
| Outer | 24(21–28) | 6 | 26(25–28) | 3 |
| Inner | 28(27–32) | 6 | 28(27–30) | 3 |
| Base | 10(8–12) | 6 | 11(11–12) | 3 |
| Dorsal Anchor | | | | |
| Outer | 24(18–27) | 4 | 21(19–23) | 4 |
| Inner | 29(29–30) | 4 | 25(25–26) | 4 |
| Base | 10(10–11) | 4 | 10 | 4 |
| Germarium | | | | |
| Length | 45(29–62) | 2 | 40 | 1 |
| Width | 18(16–20) | 2 | 29 | 1 |
| Testis | | | | |
| Length | 25(20–30) | 2 | – | – |
| Width | 19(19–20) | 2 | – | – |
| Hooks | 21(20–25) | 10 | 22(21–26) | 4 |




Figures 30–36. *Vancleaveus klasseni* sp. nov.: (30) holotype whole-mount, ventral; (31) copulatory complex; (32) hook; (33) ventral bar; (34) dorsal bar; (35) ventral anchor; (36) dorsal anchor. Scale bars: 30 = 50 µm; 31 = 10 µm; 32–36 = 25 µm.

oped. Dorsal bar (Fig. 34) 29 (21–38; n = 10) long, 3 (2–3; n = 10) wide, V-shaped, with slightly inflated ends. Hooks similar (Fig. 32), 21 (20–25; n = 10) long, with upright slightly acute thumb; slightly curved shaft, short; dilated shank; filamentous hook about ½ shank length. Genital pore opening midventral, anterior to copulatory complex. Testis post-germarial, dorsal to germarium, ovoid 25 (20–30; n = 2) long, 19 (19–20; n = 2) wide. Vas deferens looping left of intestinal cecum; seminal vesicle a dilatation of vas deferens; transversally elongated prostatic reservoir. Copulatory complex comprising MCO, accessory piece (Fig. 31). MCO a coiled sclerotized tube, 96 (88–106; n = 6) long, with 2 ½ counterclockwise rings, with tapered distal region; base a cap with sclerotized margin. Accessory piece 16 (15–18; n = 5) long, elongated, non-articulated with MCO, with tapered proximal region, distal end with small gutter guarding termination of MCO. Germarium 45 (29–62; n = 2) long, 18 (16–20; n = 2) wide, elongate. Eggs, Mehlis' gland, ootype and uterus not observed. Vagina slightly sclerotized, ventral, opening sinistrally; vaginal canal slightly sclerotized, distal region with a bulb serving the connection to the seminal receptacle; seminal receptacle, pyriform. Vitelline follicles dense, coextensive with ceca.

Comparative measurements. Table 7.

Etymology. The species is dedicated to Dr. Gregory J. Klassen in recognition for his work on systematics of monogenoids.

Remarks. *Vancleaveus klasseni* sp. nov. differs from its congeners by (1) possessing anchors with divergent roots; superficial root triangular to subtriangular, well developed, with conspicuous fold; deep root developed; curved shaft and point; (2) MCO a coiled sclerotized tube with 2 ½ rings, base with sclerotized margin; and (3) accessory piece with small gutter in the distal.

## DISCUSSION

There are 14 genera of monogenoidean gill parasites associated with six freshwater siluriform families from Neotropics (Braga et al. 2014, Acosta et al. 2018). From this diversity, 11 species of monogenoids from three genera (i.e., *Cosmetocleithrum*, *Paracosmetocleithrum* Acosta, Scholz, Blasco-Costa, Alves & da Silva, 2018 and *Vancleaveus*) are known parasitizing fishes from the Doradidae (Table 1). The richness of monogenoids parasitizing doradids seems to be variable. The doradid, *O. niger* is infected with five different species while other species, for example, bear a single or a few species. Considering the recent evaluation of the number of doradid species, approximately 94 species (Birindelli 2014, Sabaj-Pérez and Hernández 2017), and assuming the presence of two species of monogenoids per host species, a roughly estimated 7% of monogenoidean parasites of Doradidae are known to date.

Species of *Cosmetocleithrum* and *Paracosmetocleithrum* are exclusively found infecting neotropical fishes from the Order Siluriformes. Except for *Cosmetocleithrum striatuli* Abdallah, Azevedo & Luque, 2012, *Cosmetocleithrum laciniatum* Yamada, Yamada, Santos & Anjos, 2017, which occur in different species of Auchenipteridae, and *Cosmetocleithrum longivaginatum*, parasitizing the gills of *Pimelodus albicans* (Valenciennes, 1840) (Pimelodidae), the other species of *Cosmetocleithrum* are restricted to species of Doradidae. *Paracosmetocleithrum trachydorasi* Acosta, Scholz, Blasco-Costa, Alves & da Silva, 2018 is reported from the gills of the doradid, *T. paraguayensis*. On the other hand, species of *Vancleaveus* are primarily parasitic on pimelodid hosts, except for *Vancleaveus klasseni* sp. nov. which is restricted to the doradids; *Vancleaveus cicinnus* Kritsky, Thatcher & Boeger, 1986, shared by species of Doradidae and Pimelodidae; and *Vancleaveus janauacaensis* Kritsky, Thatcher & Boeger, 1986 occurring on species of Doradidae, Pimelodidae and Erythrinidae (Characiformes) (Table 1). According to Graça et al. (2013), the occurrence of *V. janauacaensis* on the erythrinid, *Hoplias malabaricus* (Bloch, 1794) seems to be accidental since the prevalence and mean intensity were low, 4% of 54 hosts and 1 parasite per infected fish, respectively.

Despite the occurrence of *Cosmetocleithrum* and *Vancleaveus* parasitizing the gills of doradids, the most recent cladistic hypothesis for dactylogyrids from catfishes does not support their sister relationship. Mendoza-Palmero et al. (2015) studying partial sequences of the 28S rRNA gene of dactylogyrids, provided a cladistic hypothesis, where monogenoids infecting Neotropical siluriforms are represented by two distinct lineages. In their analysis, species of *Vancleaveus* appears in a clade with species of *Ameloblastella* Kritsky, Mendoza-Franco & Scholz, 2000 and *Unibarra* Suriano & Incorvaia, 1995, closely related to other freshwater dactylogyrids (ie., *Ancyrocephalus* Creplin, 1839, *Onchocleidus* Mueller, 1936, *Ligictaluridus* Beverley-Burton, 1984, *Actinocleidus* Mueller, 1937) parasitizing siluriforms and perciforms with Holartic and Neotropical distributions; while *Cosmetocleithrum* arises as a sister group of *Demidospermus* and unidentified dactylogyrids that occur on pimelodid catfishes. Besides these freshwater dactylogyrid taxa from South America, the clade composed by *Cosmetocleithrum*, *Demidospermus* and Dactylogyridae spp. also includes marine and freshwater dactylogyrids from Eurasia, Africa and South America, supporting the hypothesis of host switching among species of those genera.

Braga et al. (2015) related that the knowledge of phylogenetic relationships of monogenoidean lineages represents the most important information in the task of reconstructing the histories of parasite-host relationships. Understanding patterns in reconstructions of histories in parasite-host systems permits us to manifest possible events of co-speciation, horizontal transference, duplication and extinction. Future studies could elucidate the evolutionary relationships that exist between the lineages on monogenoids and their doradid hosts. The acknowledgement of phylogenetic relationships between the parasite lineages, as well as information about geological events associated with the origin of host-parasite lineages could contribute to a much better comprehension of the evolutionary background involving this host-parasite system.

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