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ORIGINAL PAPER

A New Genus of Ergasilidae (Copepoda: Cyclopoida) from the Gills of *Astyanax fasciatus* (Cuvier, 1819) (Actinopterygii: Characidae)

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Abstract

Purpose To describe a new genus and a new species of an ectoparasitic ergasilid (Copepoda, Ergasilidae) parasite of the red-tailed lambari, *Astyanax fasciatus*, from Jurumirim Reservoir (Upper Paranapanema River), São Paulo State, Brazil.

Methods The host fish were collected using multi-panel gill nets. The gill of each fish was washed and examined in a stereo microscope for copepods. The copepods found were stored in 70% ethanol, cleared in lactic acid, and mounted in Hoyer's medium. Some specimens were dissected in glycerol medium and then each dissected part was mounted on individual slides.

Results A new genus and a new species of Ergasilidae were described herein. *Duoergasilus basilongus* n. gen., n. sp. differs from all other ergasilids in having the second and third pair of biramous swimming legs (P2 and P3) each with a 2-segmented endopod, and by its unique maxillary basis, resembling a whip.

Conclusions The new copepod is the first 'four-legged' ergasilid with all swimming legs having a 2-segmented endopod. *Duoergasilus basilongus* n. sp. represents the first record of a parasitic copepod on *A. fasciatus* in Jurumirim Reservoir, as well as its represents the first description to species level of an ergasilid infecting an *Astyanax* species in Brazil. A key to the 28 accepted genera of Ergasilidae is provided.

Keywords Brazil · Ectoparasite · Freshwater · Identification key · Jurumirim · Teleostei

Introduction

The cyclopoid copepod family Ergasilidae Burmeister, 1835 represents one of the most important and numerous families of parasitic copepods in freshwater, typically found on fishes [1, 2]. The majority of the ergasilids are only known by the post-mated adult females, which represent the parasitic phase of their lifecycle, whereas the developmental stages (from nauplius to adults) and males are free-living organisms [3]. Although small, several species can cause severe damage to their hosts' organs [4, 5], such as when attached to the gills, ergasilids can induce epithelial hyperplasia, metaplasia, lamellar fusion, necrosis, an increase in mucus production, and/or an interruption of blood flow (e.g., tourniquet effect induced by species of *Acusicola* Cressey, 1970, *Amplexibranchius* Thatcher et Paredes, 1985, and *Miracetyma* Malta, 1993), which can lead to a decrease in respiratory efficiency, growth, or even lead their hosts' death [4, 5].

In Brazil, Ergasilidae is the largest family of parasitic crustaceans with about 69 species from 17 genera: *Acusicola*; *Amplexiobranchius*; *Brasergasilus* Thatcher et Boeger, 1983; *Ergasilus* von Nordmann, 1832; *Gamidactylus* Thatcher et Boeger, 1984; *Gamispatulus* Thatcher et Boeger, 1984; *Gamispinus* Thatcher et Boeger, 1984; *Gauchergasilus* Montú et Boxshall, 2002; *Miracetyma*; *Pindapixara* Malta, 1995; *Prehendorastrus* Boeger et Thatcher, 1990; *Pseudovaigamus* Amado, Ho et Rocha, 1995; *Rhinergasilus* Boeger et Thatcher, 1988; *Tiddergasilus* Marques et Boeger, 2018; *Therodamas* Krøyer, 1863; *Urogasilus* Rosim, Boxshall et Ceccarelli, 2013; and *Vaigamus* Thatcher et Robertson, 1984 [6, 7] Except for *Acusicola*, *Ergasilus*, and *Therodamas*, all others are endemic to Brazil [8]. Despite the high number of species known, some authors assume that the diversity of ergasilids in Brazil is still underestimated due the fact that only a small proportion of Brazilian fish species (about 6.5%

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of the 4290 species) have already been evaluated in relation to their parasitic crustacean fauna [6].

Astyanax Baird et Girard, 1854 is a speciose characid genus, with about 150 valid species [9]. Species of this genus have a wide distribution, occurring in diverse habitats within freshwater drainages from the southern United States to central Argentina [10]. In Brazil, *Astyanax fasciatus* (Cuvier, 1819) is one of the most abundant and widely distributed species [11]. This small characid is associated with a wide variety of parasitic invertebrates, especially parasitic helminths (see Table 2 for a list of parasite species reported for this fish), being considered one of the Neotropical fish species with the largest variety, and one of the most well-known parasite invertebrate faunas [12, 13]. So far, there is only one record of an ergasilid, *Ergasilus* sp., parasitizing the gills of *A. fasciatus* [14].

During a parasitological study of fishes from Jurumirim Reservoir (Upper Paranapanema River), São Paulo State, Brazil, we detected several individuals of an ergasilid species on the gills of the red-tailed lambari, *A. fasciatus*. Herein, we describe these specimens as a new species and propose a new genus to accommodate the new species.

Materials and Methods

Specimens of *A. fasciatus* were collected from April 2011 to October 2012 from Jurumirim Reservoir (Upper Paranapanema River) (23°28′20.28″S, 048°38′34.40″W), municipality of Angatuba, São Paulo State, Brazil. Fish were collected using multi-panel gill nets (3–14 cm mesh) soaked for 14 h. Hosts were individually stored in plastic bags and placed in a freezer before necropsy. The gills of each fish was thawed by placing them in a petri dish with tap water and examined for copepods using a stereomicroscope. Copepods were removed from the gill using a fine needle, stored in 70% ethanol, cleared in lactic acid, and mounted in Hoyer's medium. Whenever necessary, some specimens were dissected in glycerol medium and then each part was mounted on individual slides. Coverslips were sealed with transparent nail varnish.

Morphological analyses and measurements of whole/dissected copepods were made using a microscope with differential interference contrast optics (Leica DMLB 5000, Leica Microsystems). Drawings were made with the aid of a microscope (LeicaDMLS, Leica Microsystems, Wetzlar, Germany) equipped with a drawing tube. All measurements are in micrometres (μm) and presented as the mean and standard deviation followed by the range in parenthesis. Anatomical terms followed Boxshall and Montú [15], and that key was used to identify copepod specimens to family. The nomenclature used for the antennary segmentation have followed the following considerations: the ergasilid antenna is 4-segmented (comprising coxobasis and three endopodal segments) and the claw is an armature element derived from the third endopodal segment [16]. Ecological descriptors such as prevalence, mean abundance, and intensity were calculated in accordance with Bush et al. [17].

Type specimens (holotype and paratypes) were deposited in the Invertebrate Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA), municipality of Manaus, Amazonas State, Brazil.

Results

***Duoergasilus* n. gen.**

Diagnosis: Body cyclopiform, comprising prosome, urosome, and caudal rami; prosome consisting of cephalosome and first pedigerous somite (PS-1), separated dorsally by non-functional articulation fused ventrally, and three free pedigerous somites (PS-2–PS-4); urosome consisting of fifth pedigerous somite (PS-5), genital double-somite, and three free abdominal somites (AS-1–AS-3); caudal rami armed with four bare setae. Antennule 5-segmented. Antenna 3-segmented, comprising coxobasis, 2-segmented endopod (enp), and claw; claw bent at nearly right angle, bearing spine on concave margin. Buccal apparatus comprising labrum, mandible, maxillule, and maxilla. Mandible with two blades (anterior and posterior). Maxillule armed with three unequal distal setae. Maxilla 2-segmented, comprising syncoxa and basis; syncoxa broad, unornamented; basis with posterior part reduced, ending as thin extension. Four pairs of biramous swimming legs (P1–P4); P1–P3 with 2-segmented enp and 3-segmented exopod (exp); P4 with both rami 2-segmented. Fifth leg (P5) reduced, represented by bare seta. Egg sacs paired, multiseriate.

Differential diagnosis: Four pairs of biramous legs; P1–P3 with 3-segmented exp and 2-segmented enp; P4 with both rami 2-segmented. Maxillary basis whip-shaped, with posterior part reduced, ending as a thin extension.

Type-species: *Duoergasilus basilongus* n. sp.

Etymology: The Latin "duo" (=two) refers to the presence of four pairs of biramous swimming legs, each having a 2-segmented endopod.

Remarks

Based on the key proposed by Boxshall and Montú [15], the new copepod is placed in the Ergasilidae, because it possesses: (1) mandible small, and armed with terminal blades; (2) adult female with copulatory pores not separated, and situated within dorsolaterally located paired genital apertures; (3) female body typically cyclopiform, with defined external

segmentation; and (4) P1–P3 with segmented rami. It also possesses features listed by Kabata [18] as diagnostic for this family as follow: (1) cephalosome separated or fused with PS-1; (2) abdomen comprising 1–3 segments; (3) antenna subchelate with, usually one, sometimes two or three, apical claws; and (4) maxilliped and P6 absent in adult females.

The new genus is mainly characterized by the possession of P2 and P3 with 2-segmented enp. Among the 28 valid genera of Ergasilidae, only the monotypic genus, *Urogasilus* possess P2 and P3 with 2-segmented enp. However, *Duoergasilus basilongus* n. sp. cannot be included as a member of *Urogasilus* by its possession of: (1) mandible armed with two blades (rather than one blade); (2) maxillary basis with posterior part reduced, ending as a thin extension (rather than tapering to trifid apex); (3) antenna 3-segmented (rather than 4-segmented); (4) claw with spine on concave margin (rather than without such spine); (5) abdomen 3-segmented (rather than 1-segmented); (6) P4 biramous (rather than reduced and represented by bare seta); and (7) egg sacs multiseriate (rather than uniseriate). In addition, the new genus is easily separated from *Urogasilus* in having PS-4, PS-5, and genital-double somites free (rather than fused to form a long trunk as in *Urogasilus*).

Among the four-legged genera (adult females with four pairs of biramous swimming legs), P4 with both rami 2-segmented has already been described as a diagnostic feature for adult females of *Pindapixara* and *Tiddergasilus*, and for some species of *Ergasilus* and *Neoergasilus* Yin, 1956 [19]. The new species shares with these four genera the same segmentation pattern of P4. In addition, based on morphological comparison of antenna, the new genera shares some antennary characters with *Tiddergasilus*, as: antenna 4-segmented, lacking enp-3; enp-2 shorter than previous segments and unornamented (e.g., lacking spines, spinules, or sensilla); and claw shorter than other antennary segments and with spine/indentation on concave margin. However, the new genus differs from these four genera, including *Tiddergasilus*, by the possession of the unique combination of features, as: (1) antennule 5-segmented (rather than 6-segmented); (2) antenna 3-segmented, lacking enp-3 (rather than 4-segmented as in *Ergasilus*, *Neoergasilus*, and *Pindapixara*); maxillary basis whip-shaped (rather than armed with multiple teeth along posterior margin); (3) P1 with 2-segmented exp (rather than 3-segmented as in *Ergasilus* and *Neoergasilus*); and (4) P2-P3 with 2-segmented enp (rather than 3-segmented). Additionally, the new genus diverges from *Ergasilus* and *Neoergasilus* in having antennary enp-2 straight, short (shorter than coxobasis and enp-1) and unornamented (rather than strongly curved, usually equal to or larger than previous antennary segments, and armed with one or two sensilla on concave margin). The new genus also differs from *Pindapixara* in having antennary claw short, shorter than previous segments (rather than longer than other antennary segments), and with a spine on concave margin (rather than lacking such spine).

Based on the morphological differences listed above, we propose here a new genus, *Duoergasilus* n. gen., to accommodate the new ergasilid species, *Duoergasilus basilongus* n. sp.

Family Ergasilidae Burmeister, 1835

Duoergasilus basilongus n. sp. (Figs 1, 2, 3, 4, 5)

Description of/female (based on 13 female specimens; no male observed): Overall length, from the anterior end of cephalothorax to posterior margin of caudal rami (excluding egg sacs), 684 ± 97 (583–827). Body cyclopiform (Fig. 1), comprising prosome, urosome, and caudal rami; prosome consisting of cephalosome and PS-1, separated dorsally by non-functional articulation but fused ventrally, and three free pedigerous somites. Cephalosome (Fig. 1b) with dorsal eyespot, tapering more sharply anteriorly than posteriorly, broadly rounded posteriorly, maximum width at the level of buccal apparatus, 352 ± 51 (307–408) long, 168 ± 6 (159–174) wide. Pedigerous somites decreasing gradually in width from anterior to posterior (Fig. 1b); PS-2 narrower than cephalothorax (Fig. 3a), with paired integumental windows laterally on tergite, 52 ± 6 (45–61) long, 168 ± 6 (159–174) wide; PS-3, 50.5 ± 8.5 (43–64) long, 130 ± 9 (121–148) wide; PS-4, 36 ± 5.5 (29.5–45) long, 88 ± 4.5 (82–95) wide.

Urosome consisting of PS-5, genital double-somite, and three free abdominal somites (Fig. 2a); PS-5 narrower than prosome somites, unornamented, 15 long, 65 wide; genital double-somite, 1.5 wider than long, bearing paired slit-like genital apertures dorsally (Fig. 3b), ornamented with paired spinule rows ventrally (Fig. 2a), 60 ± 3 (55–63) long, 90 ± 7 (76–97) wide; abdominal somites decreasing gradually in width from anterior to posterior (Fig. 2a); each somite ornamented with posterior spinule row along ventral margin; AS-1, 16 ± 3 (12–21) long, 48 ± 4.5 (43–57) wide; AS-2, 14 ± 5 (7–21) long, 42 ± 2 (40–44.5) wide; AS-3 (= anal somite) deeply incised in midline (Fig. 2a), with paired spinule rows on ventral surface, 19.5 ± 3 (17–23.5) long, 40 ± 2 (38–43.5) wide. Caudal ramus (Fig. 2b), two times longer than wide; each ramus ornamented with paired spinule rows on ventral surface, and armed with four bare setae; seta I and III shortest, both arising ventrally; seta II about three times longer than seta I and III; seta IV longest, 172 ± 36 (120–210) long. Egg sac paired, multiseriate, 415–534 long, 163–195 wide; egg spherical, 80–85 diameter (Fig. 1a).

Rostrum quadrangular, ventrally directed, without sensilla or pores (Fig. 3c). Antennule 5-segmented (Fig. 3d), 115 ± 8.5 (98–127) long, 27 ± 2 (24–30) wide, setal formula: 12, 6, 4, 2, 7 (total 31); third to fifth segment, each armed with minute distal seta (arrowed in Fig. 3d). Antenna

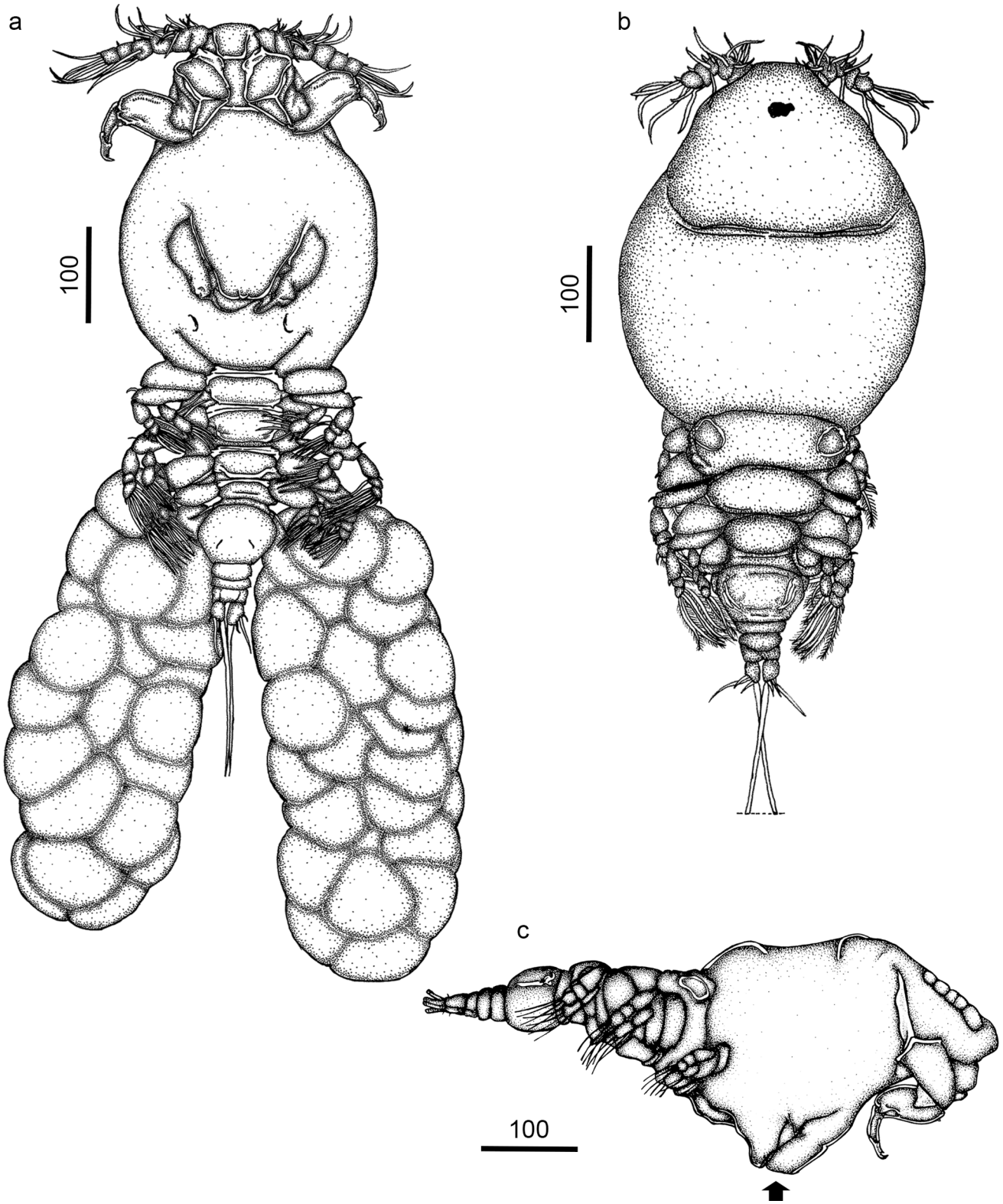

Fig. 1 *Duoergasilus basilongus* n. gen., n. sp.—adult female. **a** Body, ventral view. **b** Body, dorsal view. **c** Body and buccal apparatus (arrow), lateral view. Scale bars in micrometers (μm)

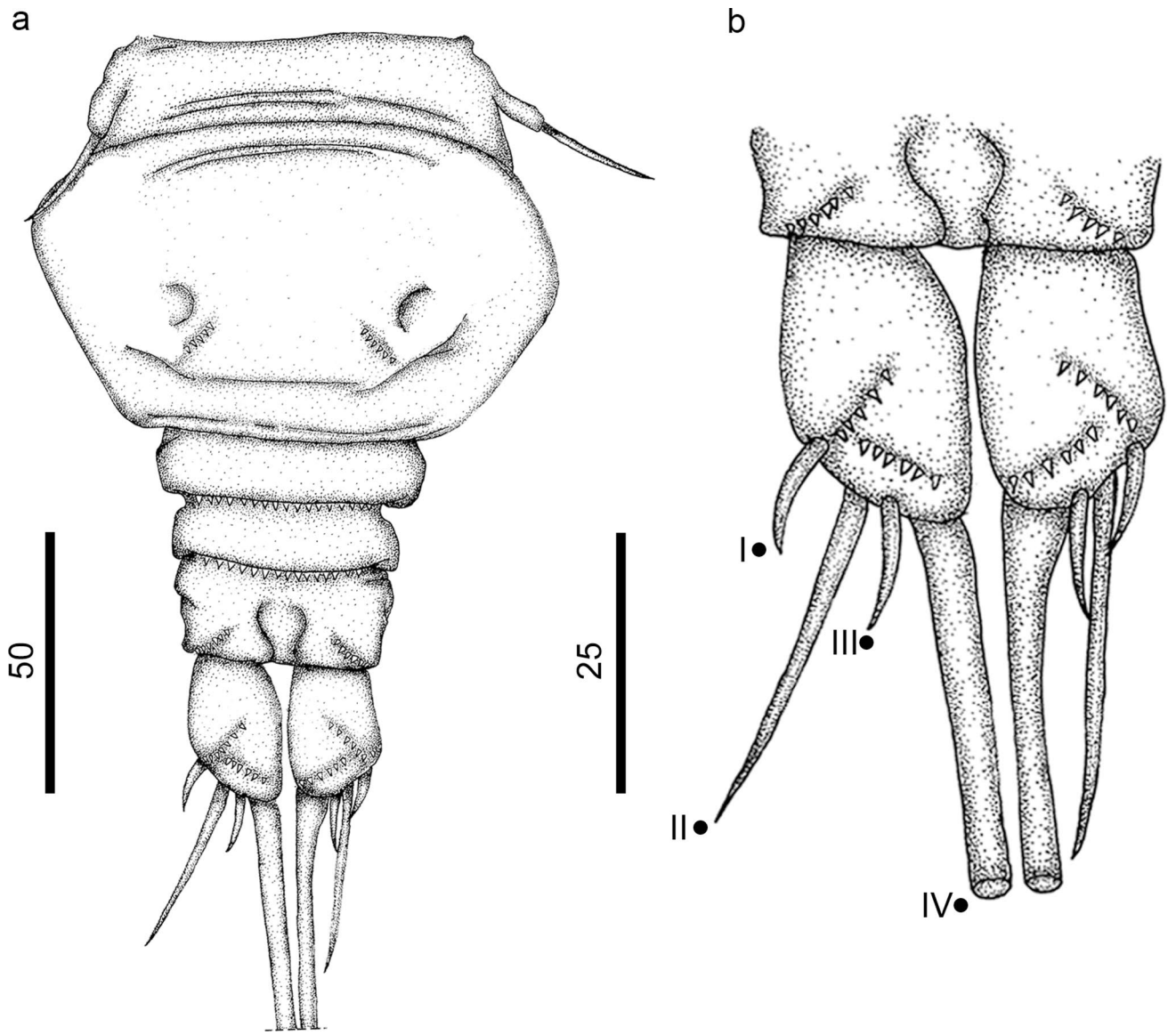

Fig. 2 *Duoergasilus basilongus* n. gen., n. sp.—adult female. **a** urosome, ventral view. **b** caudal rami armed with four setae (I–IV). Scale bars in micrometers (μm)

3-segmented (Fig. 3e), comprising coxobasis, 2-segmented enp, and claw; coxobasis broad, bearing short naked seta, 81 ± 7.5 (71–95) long, 57 ± 5 (49–63) wide; enp-1 ornamented with spinule row along outer margin, 84.5 ± 3 (78–88) long, 46 ± 4 (41–54) wide; enp-2 unornamented, 44 ± 3 (38–47) long, 14 ± 1 (13–17) wide; claw shorter than previous segments, bent at nearly a right angle, armed with spine on concave margin, 25.5 ± 2 (21–29) long, 22 ± 3 (16–27) wide (Fig. 3f). Buccal apparatus comprising labrum, mandible, maxillule, and maxilla (Fig. 4a); labrum broad, tapering posteriorly, partially covering other buccal components (Fig. 4b); ventral body wall forming floor for buccal appendages, with distal margin thicker than lateral margins (Fig. 4c); mandible armed with two blades (anterior and posterior blade), and hook-like filament; anterior blade with spinules along posterior margin, armed with apical tooth; posterior blade scimitar-shaped, with two apical teeth (Fig. 4d); maxillule narrowing distally, armed with three unequal distal setae (Fig. 4e); maxilla 2-segmented, comprising syncoxa and basis; syncoxa broad, unornamented, non-covered by labrum; basis with posterior part reduced, ending as a thin extension (Fig. 4f).

P1–P4 biramous (Fig. 5), comprising coxa, basis, and segmented rami (enp and exp); coxa unornamented; basis bearing bare outer seta; basis of P2–P4 ornamented with spinules on dorsal surface; enp 2-segmented (including enp-1 and enp-2); enp-1 (= proximal segment) and enp-2 (= distal segment) with spinules along outer margin; exp

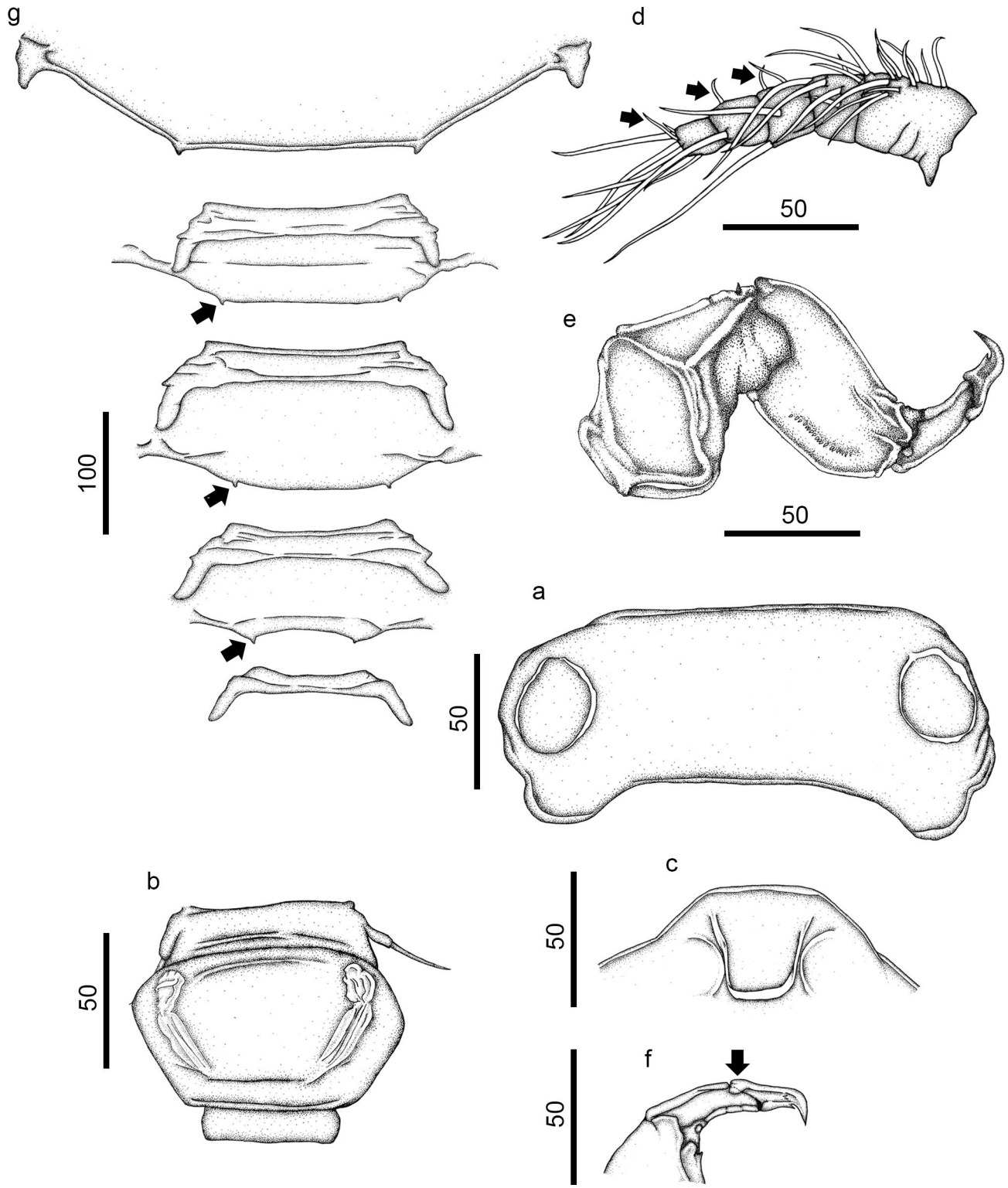

Fig. 3 *Duoergasilus basilongus* n. gen., n. sp.—adult female. **a** second free pedigerous somite, showing lateral integumental windows. **b** genital double-somite, dorsal view. **c** rostrum. **d** antennule, with distal minute seta on segments III to V (arrows). **e** antenna. **f** distal end of antenna. **g** intercoxal sclerites and interpodal plates, with paired spine-projections on dorsal-margin (arrows). Scale bars in micrometers (μm)

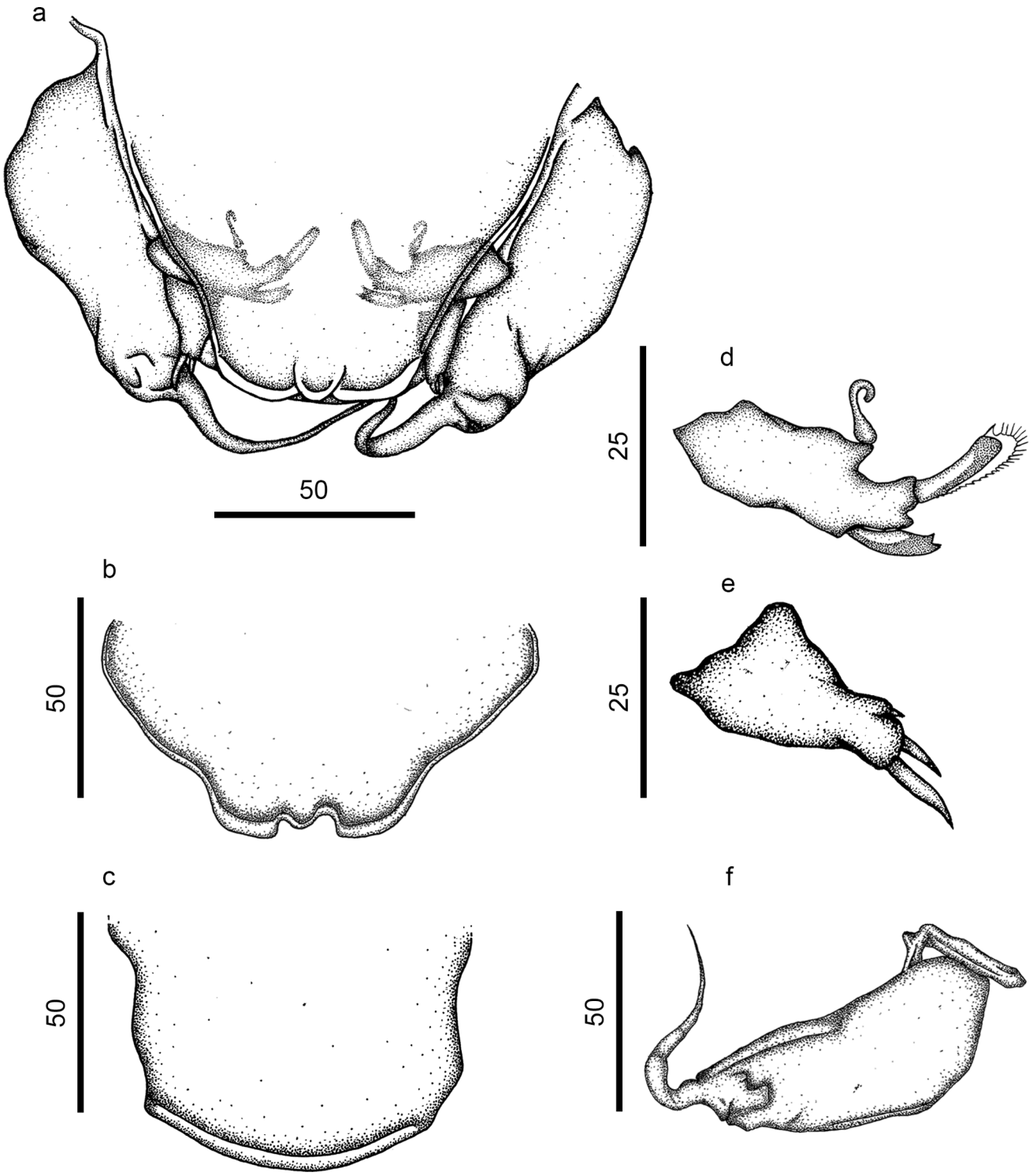

Fig. 4 *Duoergasilus basilongus* n. gen., n. sp.—adult female. **a** buccal apparatus (complete). **b** labrum. **c** ventral body wall. **d** mandible. **e** maxillule. **f** maxilla. Scale bars in micrometers (μm)

3-segmented, except for 2-segmented exp of P4; exopodal segments lacking spinules. P5 reduced (Figs. 2a, 3b), represented by bare seta. Spine and setal formula of biramous swimming legs as presented in Table 1.

Intercoxal sclerites slender, unornamented, both ends directed posteriorly (Fig. 3g). Interpodal plates with paired spine-like process on posterior margin (arrowed in Fig. 3g); interpodal plate of P4, absent.

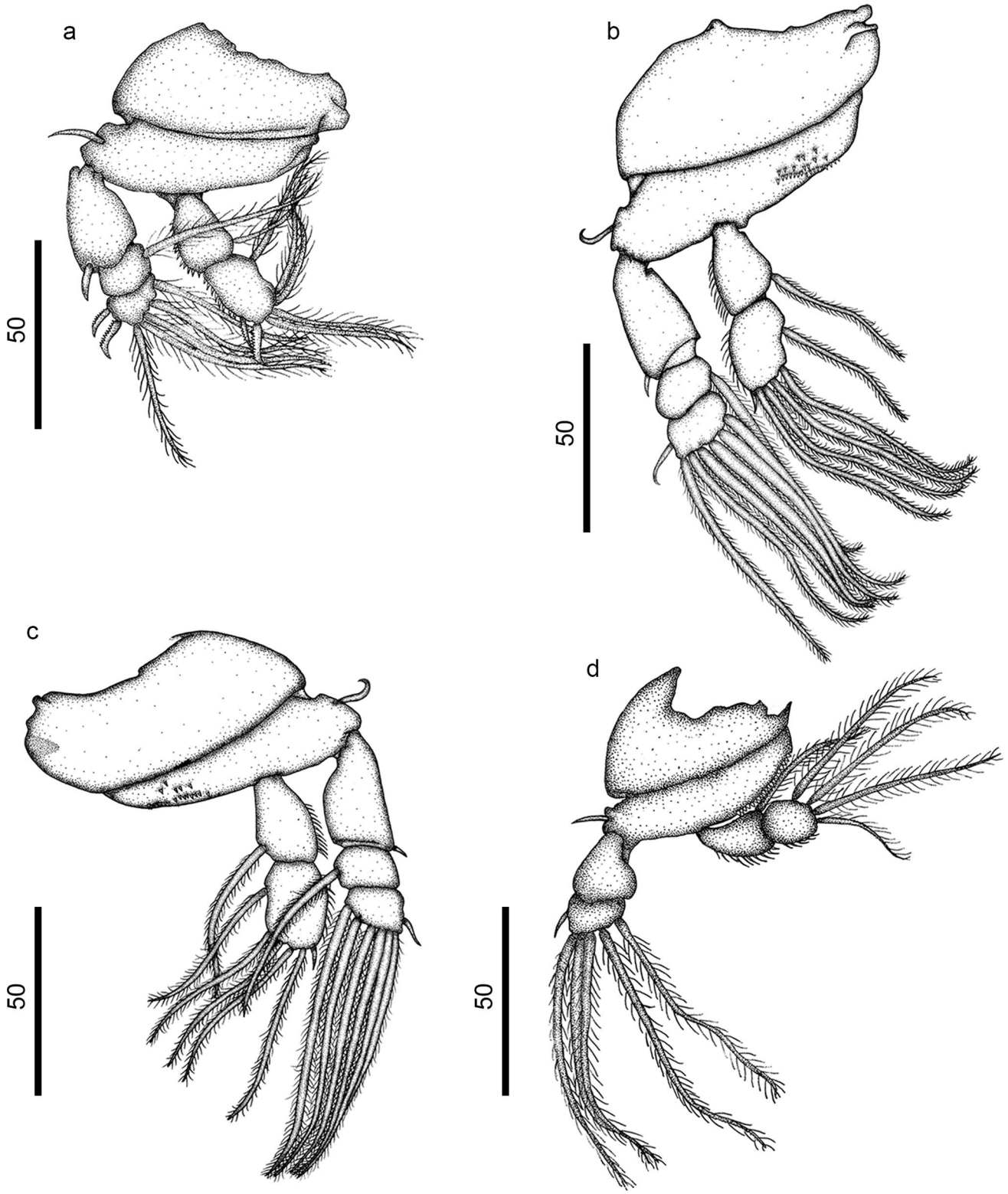

Fig. 5 *Duoergasilus basilongus* n. gen., n. sp.—adult female. **a** Leg 1. **b** Leg 2. **c** Leg 3. **d** Leg 4. Scale bars in micrometers (μm)

Table 1 Armature of swimming legs of *Duoergasilus basilongus* n. gen., n. sp.—adult female

Swimming leg	Coxa	Basis	Endopod	Exopod
P1	0–0	1–0	0–1; II–5	I–0; 0–1; II–5
P2	0–0	1–0	0–1; I–5	I–0; 0–1; I–6
P3	0–0	1–0	0–1; I–5	I–0; 0–1; I–6
P4	0–0	1–0	0–1; 0–4	0–0; I–5

Roman numeral = spines; arabic numerals = setae. P1–P4 = first to fifth swimming leg

Type host: *Astyanax fasciatus* (Cuvier, 1819) (Characiformes: Characidae), red-tailed lambari.

Site of infection: Gill filaments.

Prevalence and intensity of infection: Nine of 67 hosts examined (13.4%) were infected with 15 ± 6 (1–49) specimens of *D. basilongus* n. sp.

Type locality: Jurumirim Reservoir, Upper Paranapanema River (23°28′20.28″S, 48°38′34.40″W), municipality of Angatuba, São Paulo State, Brazil.

Specimens deposited: Holotype, INPA 2498; paratypes, INPA 2499 and INPA 2500.

ZooBank registration: urn:lsid:zoobank.org:act:DD878EA5-BB75-4F3B-8B67-B5A4F2FFF440.

Etymology: From Latin, the specific epithet refers to the elongate distal portion of the maxillary basis.

Remarks

Duoergasilus basilongus n. sp. is the type species of the newly erected genus and differs from all other ergasilid species by the characteristics mentioned in the diagnosis of the new genus (see above). The new species close resembles *Tiddergasilus iheringi* (Tidd, 1942) in having some features listed by Marques and Boeger [7] as diagnostic for this species, as (1) P1 enp 2-segmented, (2) spines on P2 exp present, (3) P4 enp 2-segmented, (4) antenna with short enp-2 (about three times shorter than previous segment); and (5) Claw with a sub-proximal indentation/spine on concave margin. However, *D. basilongus* differs from *T. iheringi* by having all swimming legs with 2-segmented enp (rather than P2 and P3 with 3-segmented enp in *T. iheringi*); an antennule 5-segmented (rather than 6-segmented in *T. iheringi*); and by the maxillary basis with posterior part reduced, ending as a thin extension (rather than toothed on convex margin in *T. iheringi*).

The following taxonomic key is provided for Ergasilidae genera, including the most recently described genera (e.g., *Majalincola* Tang et Kalman, 2008, *Tiddergasilus*, and *Urogasilus*) and the new genus proposed herein:

1A—Cephalosome with post-oral or pre-oral elongation (neck) ….. 2

1B—Body typically cyclopiform; cephalosome without such elongation ….. 5

2A—Antennary region of cephalosome separated from oral region by neck; mouthparts located posteriorly to neck ….. 3

2B—Antennary region of cephalosome not separated from oral region by neck; mouthparts located anteriorly to neck ….. 4

3A—Pedigerous somites and urosomites well-defined, not fused; P1 with enp 3-segmented; P5 with 1-segmented exp, armed with two setae ….. *Majalincola*

3B—Pedigerous somites and urosomites ill-defined, without clear external segmentation; P1 with enp 2-segmented; P5 reduced, represented by seta ….. *Therodamas*

4A—P4 absent ….. *Mugilicola* Tripathi, 1960

4B—P4 biramous, with 2-segmented enp and 1-segmented exp ….. *Paeonodes* Wilson C.B., 1944

5A—Large, posteriorly directed stylets (retrostylets) present at posterolateral angles of dorsal cephalic shield ….. 6

5B—Dorsal cephalic shield without such stylets ….. 10

6A—Antenna with single claw ….. 7

6B—Antenna with two claws ….. 8

7A—P4 with 3-segmented enp and 2-segmented exp ….. *Pseudovaigamus*

7B—P4 with 2-segmented enp and 1-segmented exp ….. *Vaigamus*

8A—Rostrum with posteriorly directed spine (rostral spine); large spatulate process present adjacent to retrostylets on dorsal cephalic shield ….. *Gamispatulus*

8B—Rostrum without such spine; retrostylets simple, without adjacent process ….. 9

9A—Antennule 6-segmented ….. *Gamidactylus*

9B—Antennule 5-segmented ….. *Gamispinus*

10A—P4 biramous ….. 14

10B—P4 reduced or absent ….. 11

11A—Fourth pedigerous, fifth pedigerous, and genital-double somites fused to form trunk; P2-P3 with enp 2-segmented ….. *Urogasilus*

11B—Fourth pedigerous, fifth pedigerous, and genital-double somites not fused to form trunk; P2-P3 with enp 3-segmented ….. 12

12A—P4 absent ….. *Brasergasilus*

12B—P4 reduced, represented by seta ….. 13

13A—Antennal enp-1 produced proximally to form long acute process; enp-2 longer than claw, strongly recurved ….. *Abergasilus* Hewitt, 1978

13B—Antennal enp-1 without such process; enp-2 shorter than claw, non-recurved ….. *Rhinergasilus*

14A—Antenna with extremely elongated enp-1; enp-2 modified to receive claw of opposite antenna ….. 15

14B—Antenna not interlocking in this manner ….. 17

15A—P1 with enp-2 rod-shaped, unarmed ….. *Miracetyma*

15B—P1 with enp-2 armed with at least three elements (spines and/or setae) ….. 16

16A—P1 with enp-2 cylindrical, ending in three small points, without setae ….. *Amplexibranchius*

16B—P1 with enp-2 armed at least with five elements (two spines and three or more setae) ….. *Acusicola*

17A—Antenna with three claws ….. *Paraergasilus* Markevich, 1937

17B—Antenna with one or two claws ….. 18

18A—Antenna with two claws ….. *Thersitina* Norman, 1905

18B—Antenna with single claw ….. 19

19A—Antennal segments covered by loose, hyaline, cuticular membrane ….. *Dermoergasilus* Ho et Do, 1982

19B—Antennal segments not covered by loose, hyaline, cuticular membrane ….. 20

20A—Antennal enp-1 and enp-2 with one or two prominent teeth on inner margin ….. *Prehendorastrus*

20B—Antennal enp-1 and enp-2 without such teeth ….. 21

21A—P2–P3 with enp 2-segmented ….. *Duoergasilus* n. gen.

21B—P2–P3 with enp 3-segmented ….. 22

22A—Antennal claw barbed, with conspicuous barb on concave margin ….. *Gauchergasilus*

22B—Antennal claw without such barb ….. 23

23A—Basis of P1 with posterior spinous process between rami; enp-2 with large spatulate spine on outer margin ….. *Neoergasilus*

23B—Basis of P1 without such process; enp-2 without modified spine ….. 24

24A—P1 with enp-2 about 2.0 times longer than other endopodal segments ….. *Nipergasilus* Yamaguti, 1939

24B—P1 with endopodal segments similar in size ….. 25

25A—First to fourth pedigerous somite inflated and fused to cephalosome ….. *Teredophilus* Rancurel, 1954

25B—Pedigerous somites typically well defined, rarely all fused ….. 26

26A—Free pedigerous somites about equal in width or weakly tapering posteriorly ….. *Sinergasilus* Yin, 1949

26B—Prosome tapering distally ….. 27

27A—Antennal enp-2 shorter than claw; enp-1 and enp-2 without sensillum on inner margin; claw recurved ….. *Pindapixara*

27B—Antennal enp-2 typically longer than claw; enp-1 and enp-2 typically armed with one or two sensilla; claw curved ….. *Ergasilus*

Discussion

The Jurumirim dam is the first of 11 cascading dams along the main course of Paranapanema River and creates a reservoir for regulating others further downstream. This dam lake harbours a native ichthyofauna consisting of 50 species representing 14 families, mostly of Characiformes (Characidae, 17 spp.; including five species of *Astyanax*) and Siluriformes (see [20]). With regard to the parasite fauna, over than 50 parasite species have already been reported parasitizing fishes in this reservoir, with a predominance of monogeneans (about 35 spp.) [20–23]. The majority of the reports contain a description of new parasite species [21–23] or the record of new hosts and/or localities for several parasites [24–31]. In relation to the parasitic crustacean fauna, one cymothoid isopod was found parasitizing *Galeocharax knerii* (Steindachner, 1879), and two copepods, *Ergasilus chelangulatus* Thatcher et Brasil-Sato, 2008 and *Lernaea cyprinacea* Linnaeus, 1758 were reported parasitizing *Pimelodus maculatus* Lacepède, 1803 and *Steindachnerina insculpta* (Fernández-Yépez,1948), respectively [20, 24, 28]. Acosta et al. [30] has evaluated the helminth fauna of *A. fasciatus* from the Taquari River, a tributary of Jurumirm Reservoir, and found seven species of monogeneans, two digeneans (including a non-identified metacercaria), and two nematodes (including a non-identified larva). The monogeneans, *Notozothecium* sp. and *Cacatuocotyle paranaensis* Boeger, Domingues et Kritsky, 1997, represented the first record of these parasites on *A. fasciatus* (see Acosta et al. [30]). Despite this study, there is no report of parasitic crustaceans on *A. fasciatus* in Jurumirm Reservoir, so this represents the first study about the parasitic crustacean fauna of *A. fasciatus* in this dam lake.

Astyanax is a speciose genus with over than 150 valid species [9], many of which have recently discovered [32]. In Brazil, *Astyanax* is also a diversified genus, with several species occurring in different rivers and other aquatic habitats [11]. Although some *Astyanax* spp. have been extensively studied in spite of their parasitic fauna, such as *Astyanax lacustris* (Lütken, 1875) (=*Astyanax altiparanae* Garutti et Britski, 2000) and *A. fasciatus*, there are few records of parasitic crustaceans associated with fishes from this genus (see Luque et al. [6]). Currently, over than 90 parasites species from seven phyla have already been reported parasitizing *A. fasciatus* in the Neotropical region (Table 2). Ergasilids were reported from three *Astyanax* spp.: *Astyanax altiparanae* Garutti et Britski, 2000 (*Acusicola* sp., *Brasergasilus* sp., and *Vaigamus* sp.), *Astyanax bimaculatus* (Linnaeus, 1758) (*Ergasilus* sp.), and *A. fasciatus* (*Ergasilus* sp.) [6, 14]. Paraguassú and Luque [14] have evaluated the parasite fauna of four fish species from Lajes Reservoir in the State of Rio de Janeiro and found *Ergasilus* sp. parasitizing the gills of A. *fasciatus*. It was the first record of an ergasilid parasitizing the gills of this fish, however, the authors did not provide a morphologic description or images of the specimens found (see [14]).

Duoergasilus basilongus n. sp. represents the first record of a parasitic copepod on *A. fasciatus* in Jurumirim

Table 2 Metazoan parasites of *Astyanax fasciatus* (Cuvier, 1819)

Parasite	Site	References
Acanthocephala		
Quadrigyrus torquatus Van Cleave, 1920	Intestine	[33]
Pseudoleptorhynchoides lamothei Salgado-Maldonado, 1976	Intestine	[34]
Southwellina hispida (Van Cleave, 1925) (larvae)	Liver, mesentery	[34]
Annelida		
Hirudinea		
Glossiphoniidae gen. sp.	Gill,skin	[14, 35]
Arthropoda		
Branchiura		
Argulus sp.	Fins, skin	[34]
Dipteropeltis hirundo Calman, 1912	Gill	[6]
Copepoda		
Ergasilus sp.	Gill	[14, 35, 36]
Lernaea cyprinacea Linnaeus, 1758	Unspecified site	[37]
Cnidaria		
Myxozoa		
Henneguya bergamini Guimarães, 1931	Body cavity	[38, 39]
Henneguya cesarpintoi Guimarães, 1931	Gill cavity	[38–40]
Henneguya hoimba Cordeiro et Gioia, 1987	Gill	[35, 36, 38, 39]
Henneguya wenyoni Pinto, 1928	Gill	[33, 40]
Henneguya travassosi Guimarães et Bergamini, 1933	Muscles, skin	[35, 36, 38–40]
Henneguya sp.	Blood	[41]
Mollusca		
Bivalvia		
Diplodon delodontus (Lamarck, 1819)	Fins, gill, skin	[35]
Nematoda		
Ascarididae gen. sp (larvae)	Unspecified site	[42]
Brevimulticaecum sp. (larvae)	Body cavity, intestinal cecum	[43]
Capillaria (Hepatocapillaria) cyprinodonticola Huffman et Bullock, 1973	Intestine. liver	[44]
Capillaria sentinosa Travassos, 1927	Intestine	[30]
Capillaria sp.	Intestine	[30, 42]
Capillostrongyloides sentinosa Travassos, 1927	Stomach	[30, 33, 36, 42, 45]
Capillostrongyloides sp.	Intestine	[46]
Contracaecum sp. (adult and larvae)	Body cavity, intestine, liver, mesentery, stomach	[30, 36, 42–44]
Contracaecum sp. type 1 (larvae)	Body cavity	[30, 36, 42]
Contracaecum sp. type 2 (larvae)	Body cavity	[30, 36, 42]
Eustrongylides sp.	Body cavity	[43]
Goezia sp. (larvae)	Stomach	[43]
Oligogonotylus manteri Watson, 1976	Intestine	[46]
Olmeca laurae Lamothe-Argumedo et Pineda-López, 1990	Intestine	[46]
Paraseuratum albidum Kloss, 1966	Intestine	[33, 42]
Procamallanus (Spirocamallanus) hilarii Vaz et Pereira, 1934	Intestine, stomach	[30, 36, 42, 47]
Procamallanus (Spirocamallanus) iheringi Travassos, Artigas et Pereira, 1928	Intestine	[33, 42]
Procamallanus (Spirocamallanus) inopinatus Travassos, Artigas et Pereira, 1928	Intestine	[30, 33, 36, 42, 48, 49]

Table 2 (continued)

Parasite	Site	References
Procamallanus (Spirocamallanus) neocaballeroi Caballero-Deloya, 1977	Intestine	[30, 49, 50]
Procamallanus (Spirocamallanus) rebecae (Andrade-Salas, Pineda-López et García-Magaña, 1994)	Intestine	[46]
Procamallanus (Spirocamallanus) saofrancicensis Moreira, Oliveira et Costa, 1994	Intestinal cecum, intestine	[30, 42, 43]
Procamallanus (Spirocamallanus) sp. (adult and larvae)	Intestine	[42, 51]
Procamallanus sp. (adult and larvae)	Body cavity, intestine	[42, 43]
Rhabdochona acuminata Molin, 1860	Intestine	[14, 30, 36, 42]
Rhabdochona fasciata Kloss, 1966	Intestine	[30, 33]
Rhabdochona mexicana Caspeta-Mandujano, Moravec et Salgado-Maldonado, 2000	Intestine	[34, 44, 46, 52]
Rhabdochona sp.	Body cavity, intestinal cecum, intestine	[43]
Spinitecus rodolphiheringi Vaz et Pereira, 1934	Stomach	[43]
Spiroxys sp. (larvae)	Body cavity, intestine, liver, stomach	[43]
Pletyheminthes		
Trematoda		
Acanthostomum americanum Pérez-Vigueras, 1956		[46]
Allocreadiidae gen. sp.	Intestine	[50]
Antorchis lintoni Travassos, Artigas et Pereira, 1928	Intestine	[30, 33, 36]
Ascocotyle (Phagicola) longa Ransom, 1920	Heart, liver, mesentery,	[34]
Ascocotyle (Phagicola) nana (Ransom, 1920)	Gill, intestinal wall, liver, mesentery, muscles, viscera	[53]
Ascocotyle (Ascocotyle) tenuicollis (Price, 1935)	Heart, muscles	[53]
Auricolostoma astyanace Scholz, Aguirre-Macedo et Choudhury, 2004	Intestine	[30, 46, 54]
Austrodiplostomum compactum Lutz, 1928	Eye	[54]
Bacciger astyanactis Lunaschi, 1998	Rectum	[55, 56]
Chalcinotrema ruedasueltensis Thatcher, 1978	Intestine	[30, 33, 57]
Centrocestus formosanus (Nishigori, 1924)	Gill	[34, 44]
Clinostomum complanatum (Rudolphi, 1814)	Body cavity, fins, operculum	[44]
Dadaytremoides grandistomis Thatcher, 1979	Intestine	[30, 33, 58]
Dendrochis retrobiloba Volonterio et Ponce de Léon, 2005	Swim bladder	[59]
Echinochasmus leopoldinae (Scholz, Ditrich et Vargas-Vazquez, 1996)	Gill, stomach wall	[34]
Echinochasmus macrocaudatus Ditrich, Scholz et Vargas-Vazquez, 1997	Gill	[60]
Genarchella astyanactis (Watson, 1976)	Stomach	[46, 60–62]
Genarchella fragilis Lunaschi, 1990	Stomach	[56]
Genarchella genarchella (Travassos, Artigas et Pereira, 1928)	Unspecified site	[36]
Genarchella overstreeti (Brooks, Mayes et Thorson, 1979)	Stomach	[56, 63]
Genarchella parva Travassos, Artigas et Pereira, 1928	Intestine, Stomach	[30, 36, 56, 62]
Halipegus dubius Klein, 1905	Unspecified site	[33]
Halipegus tropicus Manter, 1936	Unspecified site	[30, 33]
Halipegus sp.	Unspecified site	[30, 64]
Magnivitellinum simplex Kloss, 1966	Intestine	[34, 44, 46, 50, 56]
Oligogonotylus manteri Watson, 1976	Intestine	[46]
Olmeca laurae Lamothe-Argumedo et Pineda-López, 1990	Intestine	[46]

Table 2 (continued)

Parasite	Site	References
Prosorhynchus costai Travassos, Artigas et Pereira, 1928	Unspecified site	[30, 33, 36]
Prosthenhystera obesa Diesing, 1850	Gall bladder	[30, 33, 46, 50, 60]
Saccocoelioides chauhani Lamothe-Argumedo, 1974	Intestine	[46, 65]
Saccocoelioides octavus Szidat, 1970	Intestine, Pyloric cecum	[30, 33, 56]
Saccocoelioides sp.	Unspecified site	[50]
Uvulifer sp.	Fins, skin	[44]
Wallinia brasiliensis Dias, Müller, Almeida, Silva, Azevedo, Pérez-Ponce de Léon et Abdallah, 2018	Intestine	[66]
Cestoda		
Dendrouterina papillifera (Fuhrmann, 1908)	Gall bladder	[67]
Glossocercus aurita (Rudolphi, 1819)	Body, liver, mesentery	[44, 67]
Schyzocotyle acheilognathi (Yamaguti, 1934)	Intestine	[44]
Monogenea		
Anacanthocotyle anacanthocotyle Kritsky et Fritts, 1970	Fins, gill, skin	[30, 33, 46, 68–70]
Cacatuocotyle guaibensis Gallas, Calegaro-Marques et Amato, 2014	Skin	[71]
Cacatuocotyle paranaensis Boeger, Domingues et Kritsky, 1997	Skin	[30]
Characithecium costaricensis Price et Bussing, 1967	Gill, nasal operculum, skin	[30, 33, 35, 44, 46, 70–76]
Characithecium triprolatum Gallas, Calegaro-Marques et Amato, 2016	Gill, skin	[77]
Diaphorocleidus kabatai Molnar, Hanek et Fernando, 1974	Gill, nasal operculum, skin	[30, 33, 36, 75]
Gyrodactylus neotropicalis Kritsky et Fritts, 1970	Fins, gill, skin	[30, 33, 46, 68–70]
Gyrodactylus sp.	Skin	[30]
Jainus hexops Kritsky et Leiby, 1972	Gill	[30, 33, 46, 72, 76]
Jainus sp.	nasal operculum, skin	[30]
Notozothecium sp.	Skin	[30]
Palombitrema heteroancistrium Price et Bussing, 1968	Gill	[30, 46, 70, 72, 74–76, 78, 79]
Urocleidoides anops Kritsky et Thatcher, 1974	Gill	[70]
Urocleidoides strombicirrus Price et Bussing, 1967	Gill	[30, 33, 46, 74–76]
Urocleidoides trinidadensis Molnar, Hanek et Fernando, 1974	Unspecified site	[33]
Trinibaculum pinctiarum Narciso, Brandão, Yamada, Benine et Silva, 2014	Gill	[21]

Reservoir, as well as represents the first description to species level of an ergasilid infecting an *Astyanax* species in Brazil.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Ethical Standards All applicable international, national, and/or institutional guidelines for the use and care of animals were followed.

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