Two new species of *Aristocleidus* (Monogenea) from the gills of the Mexican mojarra *Eugerres mexicanus* (Perciformes, Gerreidae) from southwestern Mexico

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**Abstract** – *Aristocleidus mexicanus* n. sp. and *Aristocleidus lacantuni* n. sp. are described from the gills of the Mexican mojarra *Eugerres mexicanus* (Gerreidae, Perciformes) from the Rio Lacantún basin, Chiapas State, Mexico. These new species differ from previously described congeneric species in the characteristics of several structures, including: (a) ventral anchors, with differences in length (i.e. 46–50 μm in *A. mexicanus* vs. 38–43 μm, 34–37 μm, and 26–33 μm in *Aristocleidus hastatus* Mueller, 1936, *Aristocleidus* sp. of Mendoza-Franco, Violante-González & Roche 2009, and *Aristocleidus lamothei* Kritsky & Mendoza-Franco, 2008, respectively) and shape (i.e. slightly angular union of elongate arcing shaft and point in *A. mexicanus* vs. point and shaft united at a conspicuous angular bend in *A. hastatus* and *Aristocleidus* sp., and evenly curved shaft and point in *A. lamothei*); (b) male copulatory organ, i.e. a coiled tube with less than one ring in *A. mexicanus* and *A. lacantuni* (vs. a coiled tube of about 1½ in *Aristocleidus* sp.); (c) distal end of the accessory piece (ornate in *A. mexicanus* vs. distally flattened and trifid in *A. hastatus* and *A. lamothei*, respectively); (d) vaginal tube (moderately long in *A. mexicanus* vs. short in *A. lamothei* and looping in *Aristocleidus* sp.); and (e) ventral bar (anteromedial process with terminal horn-like ornamentation in *A. lacantuni* vs. ornamentation absent in the other species). This study reports for the first time species of *Aristocleidus* from freshwater environments in Mexico.

**Key words:** *Aristocleidus*, Dactylogyridae, *Eugerres mexicanus*, Chiapas, Mexico, Gerreidae, Moronidae.

**Résumé** – Deux nouvelles espèces d’*Aristocleidus* (Monogenea) des branchies d’*Eugerres mexicanus* (Perciformes, Gerreidae) du sud-ouest du Mexique. *Aristocleidus mexicanus* n. sp. et *Aristocleidus lacantuni* n. sp. sont décrits des branches du poisson *Eugerres mexicanus* (Gerreidae, Perciformes) du bassin du Rio Lacantún, État du Chiapas, Mexique. Ces nouvelles espèces diffèrent des espèces congénères décrites précédemment par différentes structures : (a) anchors ventraux, avec des différences de longueur (soit 46-50 μm chez *A. mexicanus* contre respectivement 38-43 μm, 34-37 μm, et 26-33 μm chez *Aristocleidus hastatus* Mueller, 1936, *Aristocleidus* sp. de Mendoza-Franco, Violante-González & Roche, 2009 et *Aristocleidus lamothei* Kritsky & Mendoza-Franco, 2008, respectivement) et forme (contre distalement aplatie et trifide chez *A. mexicanus* vs. point et shaft uni à une confluence angulaire prononcée chez *A. hastatus* et *Aristocleidus* sp.); (b) organe copulateur mâle (tube enroulé avec moins d’un tour en *A. mexicanus* et *A. lacantuni* contre un tube enroulé d’environ ½ tour chez *Aristocleidus* sp.); (c) extrémité distale de la pièce accessoire (ornée chez *A. mexicanus* contre distalement aplatie et trifide chez *A. hastatus* et *A. lamothei*, respectivement); (d) tube vaginal (modérément long chez *A. mexicanus* vs. court chez *A. lamothei* et en boucle chez *Aristocleidus* sp.); et (e) barre ventrale (processus antéromédial avec ornementation terminale en forme de corne chez *A. lacantuni* contre ornementation absente chez les autres espèces). Cette étude rapporte pour la première fois des espèces d’*Aristocleidus* en eau douce au Mexique.

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Introduction

Gerreidae comprises a group of marine and/or brackish water fish commonly known as mojarras distributed along the subtropical and tropical coastal areas of the world. In the Americas, Gerreidae consists of 22 valid species belonging to four genera: Gerres Quoy & Gaimard, Diapterus Ranzani, Eucinostomus Baird & Girard, and Eugerres Jordan & Evermann [2]. Eugerres includes seven species from which only Eugerres mexicanus (Steindachner, 1863) and Eugerres castro-aguirrei González-Acosta & Rodiles-Hernández, 2013 are confined to freshwater habitats in southeastern Mexico and northern Guatemala [2–4]. Diapterus auratus Ranzani, 1842, Diapterus peruvianus (Cuvier), Diapterus rhombeus (Cuvier), Eugerres brasilianus (Cuvier), Eugerres plumieri (Cuvier), and Gerres cinereus Jordan & Evermann of the Gulf (coastal areas from the States of Veracruz and Yucatán) and Pacific (a coastal lagoon from the state of Guerrero) of Mexico and Panama are known to be parasitized by species of Aristocleidus Mueller, 1936 (Dactylogyridae), i.e., A. hastatus (type specimen of the genus), Aristocleidus lamoihei Kritsky & Mendoza-Franco, 2008, and Aristocleidus sp. of Mendoza-Franco et al. [8, 11]. On the other hand, only A. hastatus has been described from the gills of the striped bass, Roccus lineatus (Bloch) [now Morone saxatilis (Walbaum)] (Moronidae) in the Peace River near Fort Ogden, Florida [16]. During investigations into the helminth fauna of fishes from the Rio Lacantún basin in the state of Chiapas (Mexican Pacific), two undescribed species of Aristocleidus were found on the gills of the Mexican mojarra E. mexicanus in January and August 2014. These new species are described in this article.

Materials and methods

Host specimens of E. mexicanus were captured by hook-and-line and throw nets in January and August 2014 in the Rio Lacantún basin in the state of Chiapas, Mexico (16°09′96.6″ N, 90°95′56.9″ W). Live fish were sacrificed bloodlessly by puncturing the brain region (a needle is introduced dorsally via the eye socket and moved about to destroy bloodlessly by puncturing the brain region (a needle is introduced dorsally via the eye socket and moved about to destroy the spinal cord) [13]. The gills of each fish were removed and placed in finger bowls containing 4–5% formalin solution to fix any of the ectoparasites that might be present. Subsequently, parasites were isolated and stained with Gomori’s trichrome and-line and throw nets in January and August 2014. These new species are described in this article.

Direction of the coil of the copulatory organ, i.e., clockwise, was determined using the procedure suggested by Kritsky et al. [7]. Haptoral terminology for species of Aristocleidus is that provided by Kritsky & Mendoza-Franco [8]. Type specimens are deposited in the National Helminthological Collection of Mexico (CNHE), Institute of Biology, National Autonomous University of Mexico, Mexico.

Results

Aristocleidus mexicanus n. sp.

urn:lsid:zoobank.org:act:8CE4BC57-1863-4101-9A8D-409B5A1476D3

Type-host: Eugerres mexicanus (Steindachner, 1863) (Perciformes, Gerreidae).

Site of infection: Gill lamellae.

Type locality and collection date: Rio Lacantún basin (16°09′96.6″ N, 90°95′56.9″ W), August 2014.

Specimens deposited: holotype, 12 paratypes and 6 vouchers in CNHE (9872, 9873, and 9874, respectively).

Etymology: named after its host.

Description (Figs. 1–8)

Diagnosis (based on 13 specimens collected in August and on 6 collected in January [brackets]) includes the following: Body 515 (425–630; n = 10) long; greatest width 118 (85–150; n = 10) usually near gonads. Cephalic lobes well developed; each head organ comprising groupings of terminations of cephalic-gland ducts. Pharynx 35 (25–45; n = 10) wide, subspherical. Testis 30–40 (n = 2) long, 18 (17–20; n = 3) wide, pyriform; seminal vesicle comparatively large, fusiform, lying in the midline of body; prostatic reservoir pyriform. Copulatory complex 39 (27–50; n = 12) [47 (43–51; n = 5)] long. Male copulatory organ (MCO) comprising proximal funnel-shaped base with proximal thickened edge, coiled tube of less than one ring; J-shaped accessory piece, terminally ornate. Prostatic glands conspicuous surrounding dorsal region of prostatic reservoir. Germarium 54 (35–75; n = 6) long, 19 (15–25; n = 5) wide; vaginal vestibule thick walled, internal, communicating with vaginal pore by short duct; vaginal tube moderately long, delicate, extending to ovate seminal receptacle; vitellarium dense, vitelline ducts not observed. Haptor 102 (90–120; n = 9) wide. Ventral anchor 48 (46–50; n = 22) [50 (43–57; n = 8)] long, with variably bent roots, slightly angular union of elongate arcing shaft and straight point (see Au, Sh and Po in Fig. 2); base 15 (13–18; n = 17) [18 (16–20; n = 8)]. Dorsal anchor 48 (43–51; n = 15) [51 (48–57; n = 11)] long, with elongate superficial root, short to non-existent deep root, slightly arc-shaped, elongate recurved point. Ventral bar 26 (23–30; n = 12) [33 (31–35; n = 3)] long, bilaterally flattened with well-differentiated anteromedial process which is basally covered by a vellum-like fine tissue, a concavity divided into two lateral rounded expansions distally. Dorsal bar 45 (42–47; n = 13) [57 (50–67; n = 3)] long, with slightly expanded ends, indistinct saucer-shaped flange closely appressed to bar proper. Hook 12 (12–13; n = 14)
[12 (11–13; \(n = 14\)) long; filamentous hooklet (FH) loop about 70% shank length.

**Differential diagnosis**

Placement of this new species in *Aristocleidus* is based on agreement with the amended generic diagnosis provided by Kritsky and Mendoza-Franco [8], i.e., species with gonads overlapping, ventral anchors with deeply incised base forming deep and superficial roots, a coiled tube of the MCO (non-articulated with the accessory piece) in a clockwise orientation, and haptoral hooks with upright acute thumb, slender shank comprising one subunit and FH loop. *A. mexicanus* n. sp. most resembles *A. hastatus* and *Aristocleidus* sp. from *Gerres cinereus* from Chautengo Lagoon from Guerrero State (Mexican Pacific) in having ventral bar with conspicuous anteromedial process and by the general morphology of the vaginal tube. *A. mexicanus* n. sp. differs from these two latter species and *A. lamothei* mainly in the length (i.e., 46–50 \(\mu\)m vs. 38–43, 34–37, and 26–33, respectively) and shape (i.e., slightly angular union of elongate arcing shaft and point [see Au, Sh and Po, respectively, in Fig. 2] vs. point and shaft united at a conspicuous angular bend in *A. hastatus* and *Aristocleidus* sp. and evenly curved shaft and point in *A. lamothei*) of their ventral anchors and by having a coiled tube of the MCO with less than one ring (a coiled tube of about 1½ in *Aristocleidus* sp.), a vaginal tube moderately long (short vaginal tube in *A. lamothei* and looping in *Aristocleidus* sp.), and an ornate distal end of the accessory piece (distally flattened and trifid accessory piece in *A. hastatus* and *A. lamothei*, respectively) [8, 11].

*Aristocleidus lacantuni* n. sp.

urn:lsid:zoobank.org:act:6A4D7AD9-B9D8-48E7-85FF-37A182476C2D
Type-host: *Eugerres mexicanus* (Steindachner, 1863) (Perciformes, Gerridae).

Site of infection: Gill lamellae.

Type locality and collection date: Rio Lacantún basin (16°09′96.6″ N, 90°95′56.9″ W), August 2014.

Specimens deposited: holotype, three paratypes in CNHE (9875 and 9876, respectively).

Etymology: named after the location (i.e., Rio Lacantún) from which this species was found.

**Description** (Figs. 9–14)

Diagnosis (based on four specimens) includes the following: Body 302–342 long; greatest width 90–102 usually near body midlength. Cephalic lobes well developed; each head organ comprising groupings of terminations of cephalic-gland ducts. Pharynx 27 wide, subspherical to elongate ovate. Testis ovate; seminal vesicle comparatively large, fusiform; prostatic reservoir pyriform. Copulatory complex 27 (23–30; n = 4) long. MCO comprising proximal funnel-shaped base, coiled tube loose, comprising about 0.5 poorly defined ring, appearing U-shaped; poorly defined Z-shaped accessory piece. Germarium 44–48 long, 16 wide; vaginal tube short, opening on left side of the body, poorly sclerotized (not depicted); vitellarium dense, vitelline ducts not observed. Haptor 55–58 wide. Ventral side of the body, poorly sclerotized (not depicted); vitellarium reservoir pyriform. Copulatory complex 27 (23–30; n = 4) long. MCO comprising proximal funnel-shaped base, coiled tube loose, comprising about 0.5 poorly defined ring, appearing U-shaped; poorly defined Z-shaped accessory piece. Germarium 44–48 long, 16 wide; vaginal tube short, opening on left side of the body, poorly sclerotized (not depicted); vitellarium dense, vitelline ducts not observed. Haptor 55–58 wide. Ventral anchor 26 (25–28; n = 7) long, with straight shaft and elongate arcing point, base with fused roots, ventrally bent; base 10 (9–11; n = 7). Dorsal anchor 36 (35–38; n = 7) long, with elongate superficial root with a small distal knob-like extension, short to non-existent deep root, slightly arced shaft, elongate recurved point. Ventral bar 26 (24–28; n = 3) long, with conspicuous intermedial process with terminal horn-like ornamentation; dorsal bar 25 (22–29; n = 3) long, straight, rod-shaped. Hook 11 (10–13; n = 10) long; FH loop about 60% shank length.

**Differential diagnosis**

The morphology of the haptoral and copulatory sclerites of this species clearly allows its formal generic assignment within *Aristocleidus*. *A. lacantuni* n. sp. resembles *A. hastatus* and *A. lamothei* in the length of the copulatory complex, i.e., 23–30 vs. 27–36 and 22–26, respectively. It differs from these latter species as well as *A. mexicanus* n. sp. and *Aristocleidus* sp. in having shorter anteromedial process of the ventral bar (comparatively larger in *A. hastatus*, *A. mexicanus* n. sp., and *Aristocleidus* sp. and indistinct in *A. lamothei*) and a ventral anchor with straight shaft and elongate arcing point (point and shaft united at a conspicuous angular bend in *A. hastatus* and *Aristocleidus* sp., evenly curved shaft and point in *A. lamothei*, and elongate arcing shaft and straight point [slightly angular union] in *A. mexicanus* n. sp.) [8, 11].

**Discussion**

The diagnostic characters used previously to differentiate species of *Aristocleidus* involved the morphology of the haptoral armament (i.e., shape of the connection between shaft and point of anchors) and copulatory complex (i.e., shape of the distal end of the accessory) [8, 11]. This study showed that these characters are reliable for separation of *A. mexicanus* n. sp. and *A. lacantuni* n. sp. The occurrence of species of *Aristocleidus* on primarily marine fish (i.e., species of *Diapterus*) has generated the hypothesis that these parasite species originated in the marine environment [8]. For example, *A. hastatus* and *A. lamothei* have been reported from *Eugerres plumieri*, *Diapterus auratus*, and *Diapterus rhombeus* from rivers (i.e., Rio Maquinas in Veracruz State) and/or estuarine systems (i.e., Ria Celestún in Yucatán State) draining to the Gulf of Mexico. Similarly, on the Pacific coast of Mexico and Panama, these monogeneans as well as *Aristocleidus* sp. have been reported from *Diapterus peruvianus* and *Gerres cinereus* from the Chautengo and Tres Palos Lagoons in Guerrero State and *Eugerres brasilius* from Gatun Lake in Panama [8, 11]. However, this study demonstrates that *A. mexicanus* n. sp. and *A. lacantuni* n. sp. in *Eugerres mexicanus* are clearly secondary invaders of freshwater. *E. mexicanus* inhabit freshwater habitats along the rivers Grijalva-Usamacinta and Coatzacoalcos basins in southeastern Mexico (Chiapas, Tabasco, and Veracruz) and northern Guatemala [14, 15], with a noteworthy distribution in highlands with elevations of 100–300 m [4] (i.e., Rio Lacantún basin) and the northern part of Guatemala (upper Usamacinta). Thus, a marine ancestor of these monogeneans along with their hosts could have colonized this freshwater environment from which they speciated through adaptive
processes (evolutionary radiation of fish in this region indicates old ichthyofauna dated from the late Cretaceous [60 Mya]) [1, 10]. To date, A. mexicanus n. sp. and A. lacantuni n. sp. appear to be limited or dominant under freshwater conditions, while their euryhaline or marine congeneric species are absent or uncommon. In fact, there are other examples of tropical marine species of monogeneans that have secondarily invaded freshwater, i.e., species of Euryhalioptera Kritsky & Boeger, 2002 (Dactylogyridae) and Diplectanum Diesing, 1858 (Diplectanidae) from South American freshwater croakers, Plagioscion spp. (Sciaenidae) [6, 9]. Examination of other freshwater gerreids in the Rio Lacantún basin (i.e., Eugerres castroaguirrei González-Acosta & Rodiles-Hernández 2013) would help to clarify the rule of the freshwater vs. saltwater on the presence or absence of species of Aristocleidus. For example, salinity has been reported to be a determining factor for the occurrence of species of Rhabdosynochus (Diplectanidae) on snooks, Centropomus spp. (Centropomidae) in Florida [5].

Knowledge about the phylogenetic affinities between gerreids and the moronid type host (i.e., M. saxatilis) of the first described species of Aristocleidus (i.e., A. hastatus) is unknown. Chen et al. [2] provided a molecular phylogenetic hypothesis using four genera (D. auratus plus E. plumieri and Eucinostomus gula [Linnaeus]). These gerreids within the phylogenetic hypothesis of Chen et al. [2] suggest that this gerreid group is comparatively old and predates the origins of the Moronidae. If this were true, then, the occurrence of A. hastatus on M. saxatilis apparently took place comparatively recently and probably corresponds to the concomitant colonization of an anadromous common ancestor to this host family that gave rise to the north American estuarine and freshwater species [17]. It is clear that further surveys of species of Aristocleidus infesting gerreids (and probably moronids) from the western Atlantic and the eastern Pacific will be necessary to understand the diversification of Aristocleidus spp. in the tropical areas.

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