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ORIGINAL PAPER

First Data on the Parasites of the Pacific Kingcroaker *Menticirrhus elongatus* (Perciformes: Sciaenidae): Description of a New Species of *Rhamnocercoides* (Dactylogyridea: Diplectanidae)

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Abstract

Introduction A new monogenean, *Rhamnocercoides lambayequensis* n. sp. (Dactylogyridea: Diplectanidae), is described based on the specimens collected from the gills of the Pacific kingcroaker *Menticirrhus elongatus* (Günther 1864) (Perciformes: Sciaenidae), a demersal fish endemic to Eastern Pacific, captured off the South American Pacific coast, Lambayeque Region, Peru.

Materials and Methods Monogeneans were fixed in hot 4% formalin. Some monogeneans were transferred directly onto a slide in a drop of glycerin–ammonium picrate mixture (GAP). Others were mounted stained with Gomori's trichrome in Canada balsam. Drawings were made using of a drawing tube.

Results The new species is mainly characterized by its MCO, which is tubular and straight, with external (distally expanded and bifurcated) and internal tubes (distally uncovered by external tube). *Rhamnocercoides lambayequensis* n. sp. is also characterized by having the following features: a weakly sclerotized almost pyriform vagina; haptoral acicular spines with expanded distal portion and by having a small group of haptoral accessory spines associated with haptoral lobes arranged as spikes.

Conclusions This is the first data on the parasites of *M. elongatus*, a little known, but popular fish in local markets. The present finding brings to two, the number of known species of *Rhamnocercoides* Luque and Iannacone 1991, and represents the sixth described marine diplectanid species infecting sciaenid fishes from Peru.

Keywords *Rhamnocercoides lambayequensis* n. sp. · Diplectanids · Gill parasite · Sciaenids · Marine fish · Taxonomy

Introduction

Menticirrhus elongatus (Günther 1864) (Perciformes: Sciaenidae) called Pacific kingcroaker, is a demersal fish endemic to Eastern Pacific, which inhabits coastal waters, especially along sandy shores and lagoons, over soft bottom, and gravel substrates to depth of 70 m [1–3]. This species is distributed from Baja California (Mexico) to Peru and is common in the northern Peru [4]. *Menticirrhus elongatus* feeds on polychaetes, crustaceans, and mollusks [1]. So far, there is no information about the monogenean parasites of this fish host [5–7].

During a parasitological survey of Peruvian marine fishes carried out from May 2017 through June 2018, several specimens of diplectanid monogeneans were found on the gill filaments of *M. elongatus* captured off the South Pacific coast, Lambayeque Region, northern Peru. Detailed morphological examination revealed that the parasites represent a new species of *Rhamnocercoides* Luque and Iannacone 1991, which is described and illustrated herein.

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Materials and Methods

Fish were collected from May 2017 through June 2018 from the coastal zone of Puerto Santa Rosa, Lambayeque Region, Peru (6°52′S, 79°55′W), using gillnets and were dissected immediately after capture. Gill arches were immediately removed and placed in vials containing heated sea water (60 °C). Each vial was vigorously shaken, and formalin was added to obtain a 4% solution. In the laboratory, the contents of each vial were examined under a stereo microscope and monogeneans were removed from the gill filaments or sediment using small probes. Several specimens fixed in formalin were mounted with a mixture of glycerin–ammonium picrate (GAP) to study sclerotized structures. After morphological evaluation, the monogeneans were remounted, dehydrated, clarified, and mounted in Canada balsam following the procedure of Ergens [8]. Other specimens were stained with Gomori's trichrome, clarified in eugenol, and mounted in Canada balsam. Monogeneans were examined using a compound Olympus™ BX51 photomicroscope equipped with normal light and differential interference contrast microscopy (DIC) optics and drawings were made using a drawing tube. Measurements are in micrometers, using straight-line distances between extreme points of the structures measured and are expressed as the range followed by the mean and number (n) of structures measured in parentheses. The length of the body represents the length of the body proper along with the haptor. The numbering of hook pairs follows the one recommended by Mizelle [9] and Mizelle and Price [10] for Ancyrocephalinae since they present the same distribution.

Fishes were identified using the keys of Peruvian marine fishes of Chirichigno and Vélez [3] and Chirichigno and Cornejo [4]. Prevalence and mean intensity of infection were estimated according to Bush *et al*. [11]. Type material was deposited in the Helminthological Collection of the Museum of Natural History at the San Marcos University (MUSM), Peru. For comparative purposes, type specimens of *R. menticirrhi* Luque and Iannacone 1991 (MUSM 3288, neotype; MUSM 3289–3291, paratypes) deposited in the MUSM, were studied.

Result

- Order Dactylogyridea Bychowsky 1933
- Diplectanidae Monticelli 1903
- *Rhamnocercoides* Luque and Iannacone 1991
- *Rhamnocercoides lambayequensis* n. sp.
- Fig. 1(1–13)

Description (based on 5 specimens mounted in GAP and 13 specimens stained with Gomori's trichrome): body elongate (Fig. 1), 786–803 (797; $n = 18$) long; greatest width 136–153 (147; $n = 18$) usually at level of middle trunk region. Tegument with scales, in posterior portion of trunk (Fig. 1); scales effortlessly lost in fixed specimens. Cephalic region slightly broad; cephalic lobes moderately developed; three bilateral pairs of conspicuous head organs; bilateral pair of unicellular cephalic glands at pharyngeal level. Two pairs of eye-spots present, equidistant, posterior pair larger than anterior pair. Pharynx spherical, 43–60 (54; $n = 11$) in diameter; esophagus short; intestinal caeca unbranched, extending from anterior to near posterior end of trunk, not confluent posteriorly. Peduncle slightly broad, short. Haptor subtriangular (Fig. 1), differentiated from body proper, 158–175 (169; $n = 10$) long; 435–452 (446; $n = 10$) wide, with two well-developed lateral lobes. Anchors dissimilar (Fig. 1–3), without fine conspicuous alae. Ventral anchor 79–96 (90; $n = 8$) long, with rounded and short superficial root, well-elongate and hardy deep root, curved shaft, and recurved point; point surpassing level of tip of superficial root; base 8–10 (9; $n = 8$) wide (Fig. 2). Dorsal anchor 83–98 (94; $n = 6$) long, with inconspicuous superficial root, elongate deep root, straight shaft, and recurved point; base 5–7 (6; $n = 6$) wide (Fig. 3). Ventral bar 372–389 (382; $n = 10$) long, elongate, broadly V-shaped, with acute ends anteriorly directed; ventral longitudinal groove present; posteromedial short projection and anteromedial constriction present (Fig. 4). Dorsal bars 119–136 (130; $n = 9$) long, rod-shaped with spatulate medial end and cylindrical lateral extremity (Fig. 5). Fourteen similar hooks, 10–13 (11; $n = 10$) long, each with depressed obtuse thumb, slender and curved shank, and short point; filamentous hook (FH) loop about shank length (Fig. 6); hook pair 1 at level of ventral bar; hook pair 5 at level of distal ventral anchor shaft, others submarginal pairs on lateral haptoral lobes (Fig. 1). Haptoral acicular spines ventral and dorsal, arranged in 4 rows (Fig. 1); rows 1 and 4 with haptoral acicular spines with acute distal portion (HAA) (Fig. 1, 7); rows 2 and 3 with HAA and with haptoral acicular spines with expanded distal portion (HAE) (Fig. 1, 8); posterior haptoral acicular spines larger than anterior spines. Haptoral accessory spines at level of ventral bar with hook-like distal portion and with a delicate umbelliform membrane (HSH) (Fig. 1, 9); arranged diagonally in each lateral extremity of the ventral bar; anterior spines larger than posterior spines (Fig. 1). Haptoral accessory spines associated with haptoral lobes (HSL), with similar morphology to the haptoral acicular spines; medial spines larger than lateral spines (Fig. 1, 10). Haptoral accessory spines associated with points of the anchors (HSA), arranged as spikes (Fig. 1, 11). Haptoral accessory spines at level of anterior margin

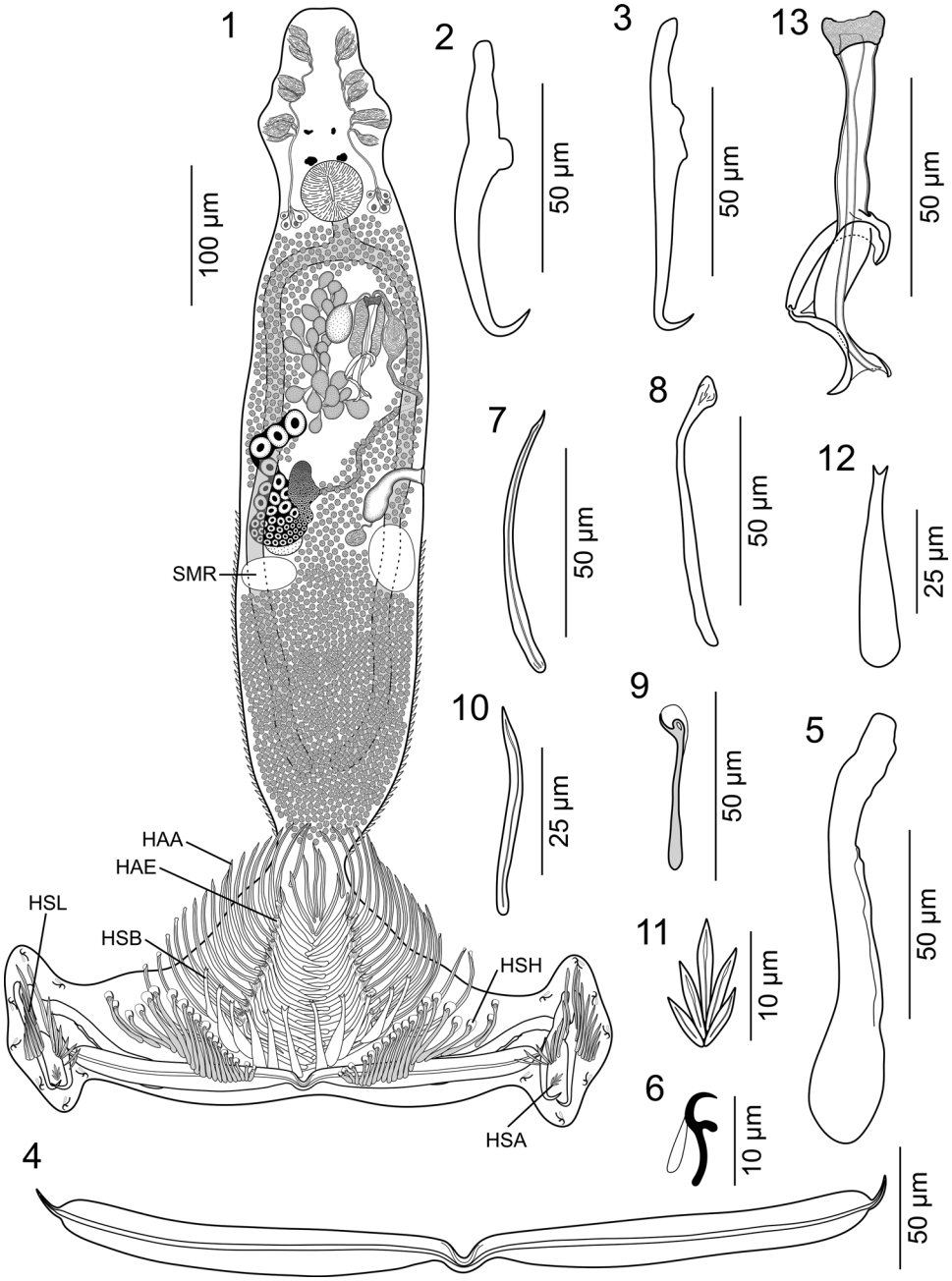

Fig. 1 **1–13** *Rhamnocercoides lambayequensis* n. sp. (Diplectanidae) from the gills of the Pacific kingcroaker *Menticirrhus elongatus* (Günther, 1864) (Perciformes: Sciaenidae). **1.** Whole worm, ventral view. SMR, semicircular muscular rings. **2.** Ventral anchor. **3.** Dorsal anchor. **4.** Ventral bar. **5.** Dorsal bar. **6.** Hook. **7.** Haptoral acicular spines with acute distal portion (HAA). **8.** Haptoral acicular spines with an expanded distal portion (HAE). **9.** Haptoral accessory spines with a hook-like distal portion and a delicate umbelliform membrane (HSH). **10.** Haptoral accessory spines associated with haptoral lobes (HSL). **11.** Small group of haptoral accessory spines associated with haptoral lobes arranged as spikes (HAS). **12.** Haptoral accessory spines with bifid distal portion (HSB). **13.** Male copulatory organ

of ventral bar with bifid distal portion (HSB) (Fig. 1, 12). Male copulatory organ (MCO) tubular, straight, 76–93 (87; $n = 12$) long, composed of two nested tubes (internal and external tubes); external tube distally expanded and bifurcated, left branch short, right branch long and slightly sinuous; distal portion of the internal tube uncovered by external tube (Fig. 13). Testis dorsal to ovary, not lobulated, 50–68 (62; $n = 8$) long, 27–42 (36; $n = 8$) wide; vas deferens looping left intestinal caeca, dilating to form big fusiform seminal vesicle in left side of trunk, lateral to MCO; one oval prostatic reservoir, dextrolateral to MCO; prostatic glands conspicuous, intercaecal. Ovary 98–102 (99; $n = 8$) long, 47–64 (58; $n = 8$) wide, elongate, overlapping testis, looping dorsoventrally right intestinal caeca; oviduct, oötype, and uterus not observed. Vaginal aperture sinistral at level of ovary; vaginal vestibule short, almost piriform, weakly sclerotized; vaginal duct narrow, short, running posteriorly to join small subspherical seminal receptacle (Fig. 1). Two semicircular muscular rings (SMR) present, posterior to testis (Fig. 1). Vitelline follicles dense, extending from posterior level of pharynx to posterior end of trunk, absent in regions of reproductive organs. Eggs not observed.

Taxonomic Summary

- Type host: *Menticirrhus elongatus* (Günther 1864) (Perciformes: Sciaenidae), Pacific kingcroaker.
- Site in host: gill filaments.
- Type locality: Puerto Santa Rosa, Lambayeque Region, Peru, South Pacific Ocean (6°52′S, 79°55′W).
- Prevalence: 2 of 5 hosts infected (40%) with a total of 18 worms.
- Mean intensity of infection: nine monogeneans per infected host (range 6–12).
- Type material: holotype, MUSM 4713; 17 paratypes, MUSM 4714a-q.
- Etymology: this species is named for the type locality from which specimens were collected.

Remarks Based on the presence of 11–13 rows of haptoral acicular spines with the acute distal portion, acicular spines with the bifid distal portion and acicular spines with the hook-like distal portion [11], the newly collected specimens from *M. elongatus* are assigned to *Rhamnocercoides*. *Rhamnocercoides lambayequensis* n. sp. is mainly characterized by its MCO, which is tubular and straight, with external (distally expanded and bifurcated) and internal tubes (distally uncovered by external tube) (MCO tubular with two knobs on proximal region and the distal portion of external tube expanded and with funnel-shaped in *R. menticirrhi* Luque and Iannacone 199). *Rhamnocercoides lambayequensis* n. sp. also differs from the type- and only species of the genus, *R. menticirrhi* from the snakehead kingcroaker *M. ophicephalus* (Jenyns 1840) in Peru, by having a weakly sclerotized almost piriform vagina (a sacciform vagina with proximal sclerotized cup-like sheath in *R. menticirrhi*); haptoral acicular spines with expanded distal portion (haptoral acicular spines only with acute distal portion in *R. menticirrhi*) and by having a small group of haptoral accessory spines associated with haptoral lobes arranged as spikes (absent in *R. menticirrhi*). In addition, *R. lambayequensis* n. sp. differs from *R. menticirrhi* by the size of the ventral bar (372–389 in *R. lambayequensis* n. sp. versus 234–242 in *R. menticirrhi*) and by the width of the haptor (435–452 in the new species versus 263–344 in *R. menticirrhi*).

Discussion

Rhamnocercoides, as amended by Chero *et al.* [11], is distinguished from other diplectanid genera occurring in marine sciaenid fishes by a combination of characters including the morphology of the male copulatory organ (composed of two nested tubes, lacking accessory piece), ventral bar (with anteromedial constriction and posteromedial projection), and the haptor having different types of haptoral accessory spines (haptoral acicular spines with the acute distal portion, acicular spines with the bifid distal portion and acicular spines with the hook-like distal portion) [11]. *Rhamnocercoides menticirrhi* is the only known species described in the genus and was described from *M. ophicephalus* collected from Peru [11, 12]. *Rhamnocercoides lambayequensis* n. sp. from *M. elongatus* off Peru is the second species described in *Rhamnocercoides* and represents the first parasite species described from *M. elongatus*, a poorly studied fish with relation to its parasites [5–7]. Based on this and other previous reports [11–15], species of *Rhamnocercoides* are confirmed as natural gill parasites of sciaenid fishes belonging to *Menticirrhus* and apparently restricted to the Eastern Pacific.

Eight diplectanid monogenean species from the genera *Diplectanum* Diesing, 1858 (3 spp.), *Pseudorhabdosynochus* Yamaguti, 1958 (1 species), *Rhamnocercoides* (1), and *Rhamnocercus* Monaco, Wood and Mizelle, 1954 (3) have been described or reported infecting the gills of five fish species from Peru [6, 11, 14]. From these, three species are known parasitizing the gills of a freshwater fish captured in northeast Peru, namely *Diplectanum decorum* Kritsky and Thatcher, 1984; *D. pescadae* Kritsky and Thatcher, 1984 and *D. piscinarius* Kritsky and Thatcher, 1984 from the South American silver croaker *Plagioscion squamosissimus* (Heckel 1840), a freshwater sciaenid [6, 16]. The other five species of diplectanids infect marine fishes in central Peru, four of this species are gill parasites of sciaenid fishes, i.e., *R. menticirrhi* from *M. ophicephalus*, *Rhamnocercus oliveri* Luque and Iannacone, 1991 and *R. stelliferi* Luque and Iannacone, 1991 from the minor stardrum *Stellifer minor* (Tschudi 1846) and *R. dominguesi* from the Peruvian banded croaker *Paralonchurus peruanus* (Steindachner 1875); and the last species, *Pseudorhabdosynochus jeanloui* Knoff, Cohen, Cárdenas, Cárdenas-Callirgos and Gomes, 2015 infect the gills of the Pacific creolefish *Paranthias colonus* (Valenciennes 1846), a marine neritic fish of the family Serranidae. The new species described here increases the number of diplectanids species that infect sciaenid fishes to eight. Five undescribed species of Diplectanids have been also reported infecting four marine sciaenid fishes in Peru [6], suggesting that Peruvian marine fishes could harbor an exceptionally diverse suite of diplectanid species. Furthermore, considering that there are about 44 marine sciaenid species in Peru [17] and that only four (< 10%) species have parasitological records [6], many new taxa of diplectanids, especially on poorly studied fish hosts, could be discovered.

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Author Contributions The study was designed by JDC, CLC, and JLL. Collection of parasites was performed by JDC, CLC, and GS. Laboratories were performed by JDC, CLC, and GS. The manuscript was written by JDC and CLC and subsequently revised by all other authors.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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

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