

NEW SPECIES OF *RHABDOSYNCHUS* MIZELLE AND BLATZ 1941 (MONOGENOIDEA: DIPLECTANIDAE) FROM THE GILLS OF CENTROPOMID FISHES (TELEOSTEI) OFF THE PACIFIC COAST OF MEXICO

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ABSTRACT: In the course of the investigations into the fish parasites in the Tres Palos Lagoon in the State of Guerrero off the Pacific coast of Mexico, the following diplectanid species (Monogenoidea) from the gills of centropomids were found: *Rhabdosynochus alterinstitus* n. sp. from *Centropomus nigrescens*; *Rhabdosynochus lituparvus* n. sp., *Rhabdosynochus volucris* n. sp., and *Rhabdosynochus siliquaues* n. sp. from *Centropomus robalito* (Centropomidae). The apparent synapomorphic character supporting a sister relationship of these diplectanids is a single, sheathlike accessory piece comprising 3 distal branches of the male copulatory organ. The origin of the present diplectanid on centropomids is discussed, and it is suggested that this may be the result of allopatric speciation as a result of the uplift of the Panamanian Isthmus, thereby separating the Pacific and Atlantic Oceans during Pleistocene (3–5 million yr ago).

Species of *Centropomus* Lacépède, 1802, the only genus within the Centropomidae, fishes commonly known as snooks or robalos, are widely distributed in the eastern Pacific and western Atlantic coastal waters, and associated estuaries and rivers (Rivas, 1986; Tringali et al., 1999). Within this latter geographical area centropomids (*Centropomus undecimalis* [Bloch, 1792] [wild and cultivated] and *Centropomus ensiferus* Poey, 1860, of Florida and Puerto Rico, respectively) are parasitized by species of *Rhabdosynochus* *rhabdosynochus* Mizelle and Blatz, 1941, *Rhabdosynochus hargisi* Kritsky, Boeger, and Robaldo, 2001, and *Rhabdosynochus hudsoni* Kritsky, Boeger, and Robaldo, 2001 (see Kritsky et al., 2001). In the Tres Palos Lagoon, situated on the Mexican coast of the Pacific Ocean, in the State of Guerrero, centropomids are commercially exploited as food fish (Secretaría de Pesca, 1994; Briones, 1998). However, the parasite fauna of these fishes in the Tres Palos Lagoon is insufficiently known; most information is limited to helminths from species of other host families, i.e., *Dormitator latifrons* (Richardson, 1844) (Eleotridae) and *Ariopsis guatemalensis* Günther, 1864 (Ariidae) (Garrido-Olvera et al., 2003; Pilo, 2004; Gopar-Merino et al., 2005). Until recently, only 1 monogenoidean species was described from the gills of *Centropomus nigrescens* Günther 1864 (see Mendoza-Franco et al., 2006). A subsequent examination of gill samples of centropomids collected in 2003 from that lagoon was made to generate further information regarding monogenoids parasitizing these hosts. Four new species of *Rhabdosynochus* (Diplectanidae) were found parasitizing gills of *C. nigrescens* and *Centropomus robalito* Jordan and Gilbert, 1882, during this research. The results of the systematic evaluation of the monogenoids collected are described herein and a possible explanation about diversification of this parasite genus of tropical and subtropical centropomids is briefly discussed.

MATERIALS AND METHODS

Hosts were captured by hook-and-line and throw nets from August to November 2003 in the coastal lagoon of Tres Palos (16°47'N, 99°39'W) at the Pacific coast of the Guerrero state, Mexico (see Fig. 1 in Mendoza-Franco et al., 2006). The gills of each fish were removed and placed in fingers 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 mounted in Canada balsam. In addition, some specimens were mounted unstained in Gray and Wess's medium to obtain measurements and line drawings of haptor structures and the copulatory complex. All other measurements were obtained from unflattened specimens stained with Gomori's trichrome. Drawings were made with the aid of a drawing tube using an Olympus microscope with Nomarski interference contrast. Measurements, all in micrometers, represent straight-line distances between extreme points and are expressed as the mean followed by the range and number (n) of structures measured in parentheses; body length includes that of the haptor. Numbering of hook pairs follows the scheme illustrated in Kritsky et al. (2001). Type specimens are deposited in the National Helminthological Collection of Mexico (CNHE), Institute of Biology, National Autonomous University of Mexico, Mexico; and the United States National Parasite Collection, Beltsville, Maryland (USNPC) as indicated in the respective descriptions. For comparative purposes, the following specimens were examined: 6 paratypes of *R. hargisi* (USNPC 89784).

DESCRIPTION

Rhabdosynochus alterinstitus n. sp.

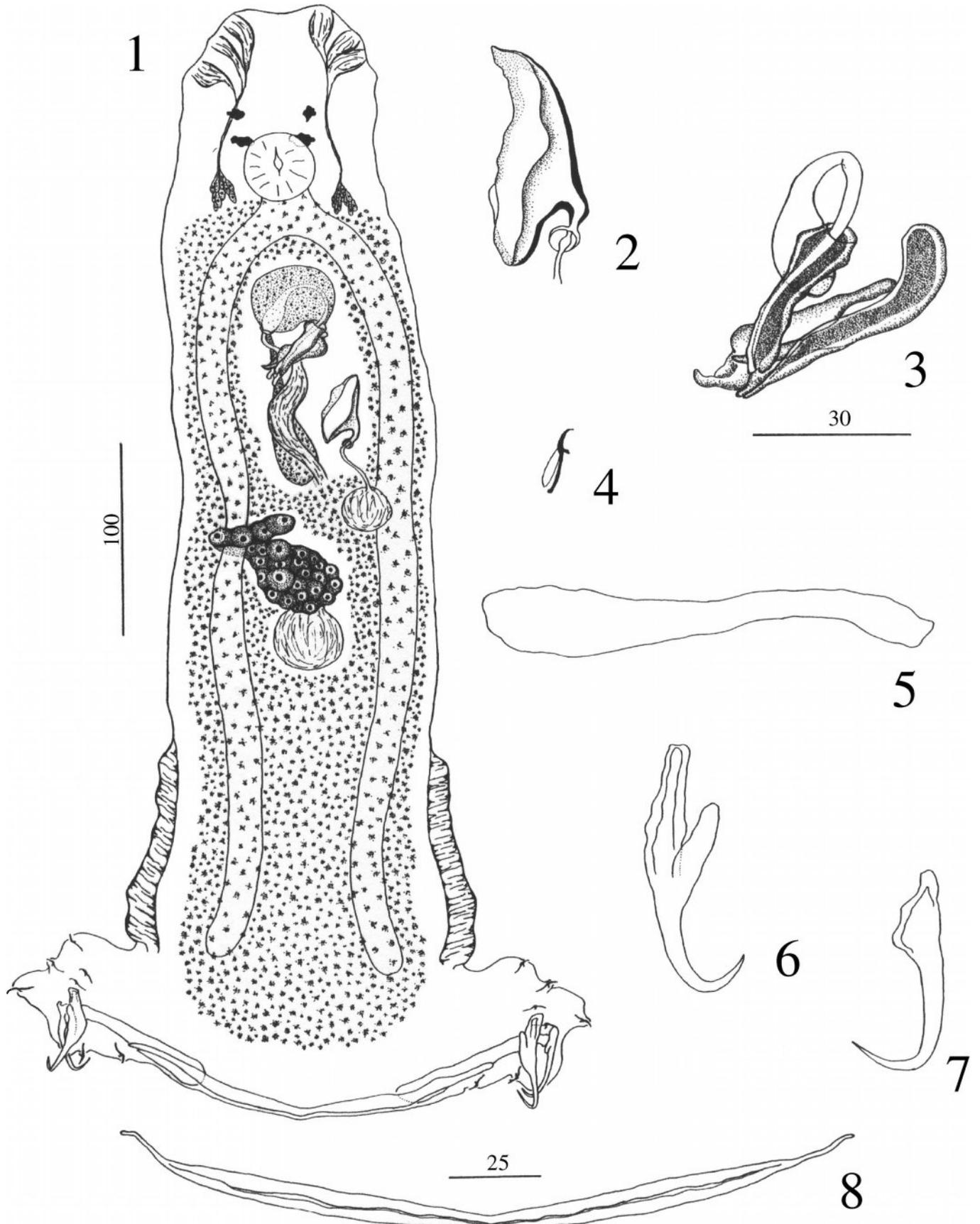
(Figs. 1–8)

Description: Body 579 (500–650; n = 21) long, broad posteriorly; 118 (100–142; n = 23) wide at level of germarium. Scales on body surface not observed. Cephalic margin broad; cephalic lobes moderately developed; cephalic glands at level of pharynx. Eyes 4; members of posterior pair larger and closer together than members of anterior pair; accessory granules usually absent or few in cephalic area. Pharynx subspherical, 32 (25–38; n = 20) in diameter; esophagus short. Peduncle broad, with narrow bilateral membranous frills; haptor 254 (217–282; n = 20) wide. Anchors dissimilar; ventral anchor 53 (50–55; n = 11) long, with elongate roots, curved shaft, recurved point extending to level of tip of superficial root; deep root channeled; anchor base 19 (17–23; n = 6) wide. Dorsal anchor 43 (40–46; n = 34) long, with triangular base, slightly curved shaft, point extending slightly past level of tip of superficial anchor root; anchor base 16 (15–18; n = 19) wide. Ventral bar 186 (177–200; n = 17) long, narrow, elongate, with delicate tapered ends; paired dorsal bar 79 (70–89; n = 43) long, medially expanded. Hook 14 (13–15; n = 35) long, with elongate slightly depressed thumb, delicate point, uniform shank; filamentous hooklet (FH) loop nearly shank length. Copulatory complex 50 (45–55; n = 15) long. Male copulatory organ (MCO) a loose coil of about ½ ring, frequently appearing inverted U-shaped; base elongate ovate, with basal opening

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FIGURES 1–8. *Rhabdosynochus alterinstitus* n. sp. (1) Whole mount (composite, ventral view). (2) Vagina (ventral view). (3) Copulatory complex (ventral view). (4) Hook. (5) Dorsal bar. (6) Ventral anchor. (7) Dorsal anchor. (8) Ventral bar. Scale bars: 1, 100 μm ; 2–7, 30 μm ; 8, 25 μm .

directed posteriorly. Accessory piece comprising 3 subunits: 1 variable, proximally hook shaped; 1 tongue shaped, proximally bifurcate; 1 comprising delicate sheath enclosing the distal portion of the copulatory organ. Testis 25 (20–37; $n = 9$) wide, subspherical; course of vas deferens in relation to gut not observed; seminal vesicle a simple dilation of vas deferens, lying along body midline; prostatic reservoir pyriform, lying dorsal to seminal vesicle; prostatic cells (glands) anteroventral to MCO, from base to the U-shaped shaft of the copulatory organ. Germarium 49 (33–68; $n = 21$) wide, looping right intestinal cecum; oviduct observed, ootype not observed; vagina sclerotized, funnel shaped, opening into small seminal receptacle lying to left of body midline; vitellaria dense throughout trunk, except in regions of reproductive organs.

Taxonomic summary

Type host: Black snook *Centropomus nigrescens* (Centropomidae).

Site of infection: Gills.

Type locality/collection date: Tres Palos lagoon, Pacific coast of Mexico, August 2003.

Specimens deposited: Holotype, CNHE (5796); 12 paratypes, CNHE (5797), and 7 paratypes, USNPC (99632).

Prevalence and intensity of infections: Twenty fish (average size 26 ± 5 cm of total length) infected of 49 examined (41%); mean intensity of infection 7 ± 4 worms per infected fish.

Etymology: The specific name is from Latin (*altera* = another, a second + *instita* = border or flounce on a robe) and refers to the similarity of this species to *R. hargisi*, both species possessing bilateral frills on the peduncle.

Remarks

This species most closely resembles *R. hargisi* from *C. undecimalis* of Brazil (cultured), Puerto Rico, and Florida by possessing bilateral membranous frills on peduncle. It differs from *R. hargisi* by having longer ventral (length 50–55 vs. 36–47 in *R. hargisi*) and dorsal (40–46 vs. 35–43 in *R. hargisi*) anchors, shorter accessory piece enclosing the distal portion of the U-shaped shaft of the copulatory organ (accessory piece is a comparatively longer tube in *R. hargisi*, length 46–53 [6 paratypes USNPC 89784] vs. 30–33 in *R. alterinstitus* n. sp.), poorly developed frills (well developed in *R. hargisi*), and by the position and dimension of the vagina (on the left margin with diagonal aperture [33–40 wide] oriented to body midline vs. horizontal opening [13–18 wide, 6 paratypes USNPC 89784] on the middle portion of the body in *R. hargisi*). Prostatic cells surrounding copulatory organ were clearly stained in all studied specimens of *R. alterinstitus* n. sp.

Rhabdosynochus lituparvus n. sp.

(Figs. 9–15)

Description: Body 293 (260–337; $n = 11$) long, fusiform, with parallel lateral margins; 57 (37–82; $n = 11$) wide at level of germarium. Tegument smooth. Cephalic margin broad; cephalic lobes moderately developed; cephalic glands at level of pharynx. Eyes 4; members of posterior pair of eyes larger and closer together than members of anterior pair; accessory granules usually absent or few in cephalic area. Pharynx subspherical to ovate, 18 (15–20; $n = 9$) in greatest width; esophagus short to nonexistent. Peduncle broad; haptor 138 (110–175; $n = 9$) wide. Anchors dissimilar; ventral anchor 38 (36–39; $n = 11$) long, with elongate deep root, evenly curved shaft, point acutely recurved not reaching level of tip of superficial root. Dorsal anchor 32 (30–33; $n = 13$) long, with narrow deep root, lacking superficial root, straight shaft, nonrecurved point reaching past level of tip of superficial root; anchor base 10 (10–11; $n = 3$) wide. Ventral bar 90 (84–93; $n = 9$) long, broadly V-shaped, ends tapered and recurved anteriorly, ventral longitudinal groove; paired dorsal bar 34 (32–38; $n = 13$) long, rod-shaped with spatulate medial end, subterminally arced. Hook 11 (11–12; $n = 12$) long, with elongate, slightly depressed thumb, delicate point, slightly expanded with tapered end; FH loop nearly shank length. Copulatory complex 20 (19–22; $n = 4$) long. MCO comprising a base with conspicuous sclerotized margin from which a straight tube arises to form 2 rings; basal opening directed posteriorly. Accessory piece 12–15 long, comprising variable sheath, enclosing distal portion of the copulatory organ. Testis subspherical 21 (18–24; $n = 6$) in diameter, course

of vas deferens not observed; seminal vesicle a simple dilation of vas deferens, lying to left of body midline dorsal to seminal receptacle; prostatic reservoir not observed. Germarium 23 (20–26; $n = 7$) wide; elongate pyriform, diagonal, looping right intestinal cecum, slightly overlapping testis; ootype not observed; uterus extending anteriorly on body midline; vagina lightly sclerotized, funnel shaped, opening into small seminal receptacle near midline; vitellaria throughout trunk, except absent in regions of the reproductive organs.

Taxonomic summary

Type host: Yellowfin snook *C. robalito* (Centropomidae).

Site of infection: Gills.

Type locality/collection date: Tres Palos lagoon, Pacific coast of Guerrero, Mexico, August 2003.

Specimens deposited: Holotype, CNHE (5798); 5 paratypes, CNHE (5799) and 5 paratypes USNPC (99633).

Prevalence and intensity of infections: Thirteen fish (average size 19 ± 2 cm of total length) infected of 47 examined (28%); mean intensity of infection 2 ± 1 worms per infected fish.

Etymology: The specific name is from Latin (*litus* = sea-shore + *parvus* = smaller) and refers to the habitat and the smaller size of this species.

Remarks

This species resembles *Rhabdosynochus volucris* n. sp. by the comparative morphology of the copulatory complex. In *R. lituparvus* n. sp., the vaginal tube opening into seminal receptacle is longer than that found in *R. volucris*.

Rhabdosynochus volucris n. sp.

(Figs. 16–23)

Description: Body 318 (242–397; $n = 31$) long, rod-shaped; 59 (37–77; $n = 31$) wide near level of testis. Tegument smooth. Cephalic margin broad; cephalic lobes moderately developed; cephalic glands at level of pharynx. Eyes 4; members of anterior pair of eyes smaller and closer together than members of posterior pair; accessory granules usually absent or few in cephalic area. Pharynx subspherical, 20 (13–26; $n = 33$) in greatest width; esophagus short to nonexistent. Peduncle broad; haptor 94 (70–130; $n = 18$) wide. Anchors dissimilar; ventral anchor 31 (27–34; $n = 30$) long, with well-developed roots, evenly curved shaft, nonrecurved point reaching level of tip of superficial anchor root; anchor base 11 (9–12; $n = 16$) wide. Dorsal anchor 30 (28–32; $n = 40$) long, with triangular base, straight shaft, nonrecurved point extending past tip of superficial anchor root; anchor base 9 (8–10; $n = 21$) wide. Ventral bar 56 (52–60; $n = 18$) long, slender with tapered ends, slightly constricted midregion, ventral groove; paired dorsal bar 27 (25–31; $n = 52$) long, robust, straight with expanded medial end, subterminal lateral inflation. Hook 11 (11–12; $n = 51$) long, with elongate, slightly depressed thumb, delicate point, uniform shank; FH loop nearly shank length. Copulatory complex 36 (26–44; $n = 36$) long. MCO an ascendant sclerotized straight tube, twisted to form a poorly defined ring; basal opening directed posteriorly. Accessory piece comprising 3 distal branches, opposite E-shaped, elongate lateral branches like wings, medial branch enclosing distal end of the copulatory organ. Testis 27 (25–30; $n = 4$) in diameter, subspherical; course of vas deferens not observed; seminal vesicle a simple dilation of vas deferens, lying on left side of body midline, dorsal to vagina; prostatic reservoir not observed. Germarium 31 (25–48; $n = 25$) wide, elongate pyriform, diagonal, looping right intestinal cecum, slightly overlapping testis; oviduct, ootype not observed; vagina slightly sclerotized, corrugated bulb shaped, opening into small seminal receptacle at midline; vitellaria co-extensive with gut, absent in regions of reproductive organs.

Taxonomic summary

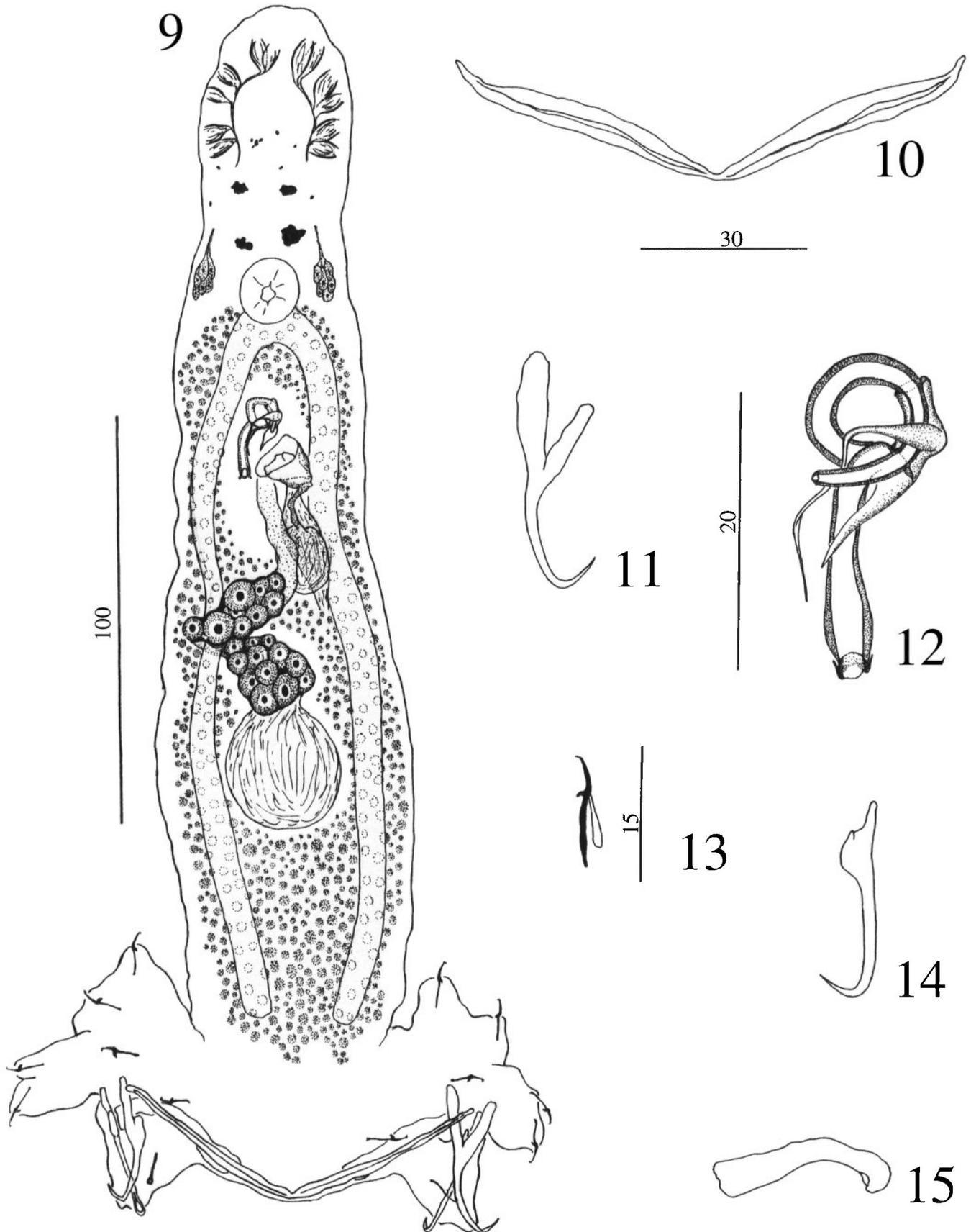
Type host: Yellowfin snook *C. robalito* (Centropomidae).

Site of infection: Gills.

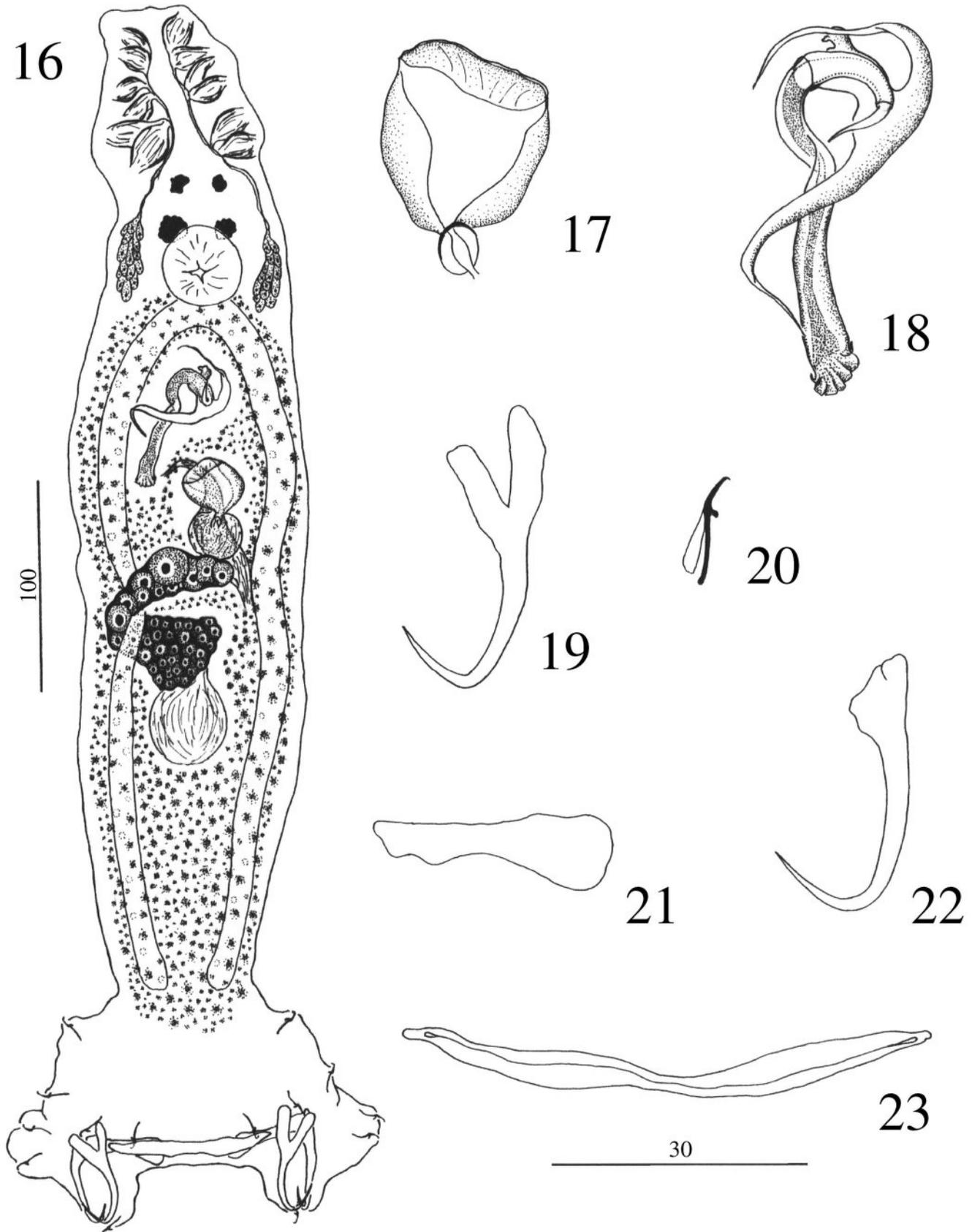
Type locality/collection date: Tres Palos lagoon, Pacific coast of Guerrero, Mexico, August 2003.

Specimens deposited: Holotype, CNHE (5800); 20 paratypes, CNHE (5801), and 15 paratypes, USNPC (99634).

Prevalence and intensity of infections: Twenty fish (average size 19



FIGURES 9–15. *Rhabdosynochus lituparvus* n. sp. (9) Whole mount (composite, ventral view). (10) Ventral bar. (11) Ventral anchor. (12) Copulatory complex. (13) Hook. (14) Dorsal anchor. (15) Dorsal bar. Scale bars: 1, 100 μm ; 10–11 and 14–15, 30 μm ; 12, 20 μm ; 13, 15 μm .



FIGURES 16–23. *Rhabdosynochus volucris* n. sp. (16) Whole mount (composite, ventral view). (17) Vagina. (18) Copulatory complex. (19) Ventral anchor. (20) Hook. (21) Dorsal bar. (22) Dorsal anchor. (23) Ventral bar. All figures are drawn to the 30- μ m scale, except 16 (100 μ m).

± 2 cm of total length) infected of 47 examined (42%); mean intensity of infection 8 ± 4 worms per infected fish.

Etymology: The specific name from Latin reflects the morphology of the lateral branches of the accessory piece (*volucris* = flying, winged).

Remarks

On the basis of comparative morphology of the copulatory complex, *R. volucris* n. sp. most closely resembles *R. lituparvus* n. sp. It differs from this species by having a robust and straight dorsal bar with expanded medial end and a subterminal lateral inflation (rod-shaped with spatulate medial end, subterminally arced in *R. lituparvus* n. sp.) and by having a dorsal anchor without a narrow deep root (dorsal anchor with a narrow deep root in *R. lituparvus* n. sp.).

Rhabdosynochus siliquaus n. sp. (Figs. 24–30)

Description: Body 339 (275–425; $n = 18$) long, fusiform, tapered anteriorly; 60 (45–80; $n = 18$) wide near body midlength. Cephalic margin broad; cephalic lobes moderately developed; cephalic glands at level of pharynx. Eyes 4; members of posterior pair of eyes larger and closer together than members of anterior pair; accessory granules usually absent or few in cephalic area. Pharynx subspherical to ovate, 20 (17–23; $n = 19$) in greatest width; esophagus short to nonexistent. Peduncle narrow; haptor 144 (100–180; $n = 10$) wide. Anchors dissimilar; ventral anchor 50 (47–54; $n = 23$) long, with elongate roots (deep root longest), curved shaft and point extending slightly past level of tip of superficial root; anchor base 14 (13–15; $n = 3$) wide. Dorsal anchor 50 (46–53; $n = 27$) long, with triangular base, thumblike deep root, evenly curved shaft, straight recurved point extending past tip of superficial root; anchor base 14 (12–15; $n = 16$) wide. Ventral bar 93 (80–118; $n = 14$) long, undulate, with tapered ends, ventral groove; paired dorsal bar 38 (34–46; $n = 43$) long, with posteromedial spinous projection at proximal end, subterminally arced. Hook 11 (10–12; $n = 27$) long, with elongate, slightly depressed thumb, delicate point, uniform shank; FH loop nearly shank length. Copulatory complex 27 (21–37; $n = 12$) long. MCO a loose coil of about 1 ring; base with delicate sclerotized basal margin; MCO opening directed posteriorly. Accessory piece comprising 3 subunits: 1 podlike, sigmoid; 1 with distal hook; 1 comprising delicate sheath enclosing the U-shaped shaft of the copulatory organ. Testis 20 (16–25; $n = 16$) in diameter, subspherical; vas deferens not observed; seminal vesicle a simple dilation of vas deferens, lying on left side of body midline, dorsal to vagina; prostatic reservoir not observed. GERMARIUM 31 (25–48; $n = 12$) wide, looping right intestinal cecum; oviduct, ootype not observed; vagina slightly sclerotized, bulb shaped, opening into small seminal receptacle midline; vitellaria throughout trunk, except absent in regions of reproductive organs.

Taxonomic summary

Type host: Yellowfin snook *C. robalito* (Centropomidae).

Site of infection: Gills.

Type locality/collection date: Tres Palos lagoon, Pacific coast of Guerrero, Mexico, August 2003.

Specimens deposited: Holotype, CNHE (5802); 10 paratypes, CNHE (5803), and 3 paratypes, USNPC (99635).

Prevalence and intensity of infections: Seventeen fish (average size 19 ± 2 cm of total length) infected of 47 examined (36%); mean intensity of infection 5 ± 3 worms per infected fish.

Etymology: The specific name is from Latin (*siliqua* = pod, shell) and refers to the shape of the accessory piece.

Remarks

This species is easily differentiated from its congeneric species by having a podlike accessory piece and a posteromedial spinelike projection on the dorsal bar. A spinous projection at the proximal end has been also reported in other species of the Diplectanidae, i.e., *R. hudsoni* and *Protolamellodiscus senilobatus* Kritsky, Jiménez-Ruiz, and Sey, 2000 (Kritsky et al., 2000, 2001).

DISCUSSION

This study represents the first finding of species of *Rhabdosynochus* (*R. alterinstitus* n. sp., *R. lituparvus* n. sp., *R. volucris*

n. sp., and *R. siliquaus* n. sp.) on centropomids (*C. nigrescens* and *C. robalito*) from the Pacific coast of Mexico. Results presented herein show that these species of *Rhabdosynochus* more closely resemble each other than the known species from the Atlantic (*R. rhabdosynochus*, *R. hargisi*, and *R. hudsoni* from *C. undecimalis* of Florida and *C. ensiferus* of Puerto Rico [see Kritsky et al., 2001]), suggesting that the Pacific forms have undergone allopatric speciation since isolation and subsequent divergence of a common ancestor within this latter geographical area, i.e., by allopatric separation initiated by the rise of Central American Isthmus (3 million yr ago [mya]) (Tringali et al., 1999). The apparent synapomorphic character supporting sister relationships of *Rhabdosynochus* from the Pacific is the sheath-like accessory piece comprising 3 distal branches (as an accessory piece comprising several subunits in species from the Atlantic) (Kritsky et al., 2001; present study).

In a phylogenetic hypothesis for Centropominae grounded on molecular data (Tringali et al., 1999), 4 major clades, each representing a total of 12 species of *Centropomus*, are present. On the basis of this hypothesis, a sister-species relationship is suggested between *C. robalito* (from the Pacific) basal lineage and the clade containing *C. undecimalis* (from the Atlantic). Analysis of this hypothesis indicates that the species from the Pacific appear to have diverged during the Pliocene rise of the isthmus (3 mya), while the *C. undecimalis* group diverged around the time of the late Miocene closure (24 mya) (Tringali et al., 1999). On the basis of this hypothesis and host specificity of *Rhabdosynochus*, the common ancestor for this parasite genus could have originated on an early marine centropomid form inhabiting both the Atlantic and Pacific (before formation of the Panamanian Isthmus) followed by its Neotropical forms closely tied to estuarine habitat in the Pacific waters. Furthermore, ecological diversification within *Centropomus* appears to be reflected in the size, i.e., centropomids from the Pacific are small-bodied species compared with those from the Atlantic (Tringali et al., 1999).

In this context, species of *Rhabdosynochus* from *C. undecimalis* and *C. ensiferus* in the Atlantic waters probably have had more opportunity to specialize on predictable resources, i.e., those that are stable through time, thus minimizing extinction risks. For example, most *Lamellodiscus* (Diplectanidae) specialists that infect marine fish in the Mediterranean tend to use a larger host than generalist (Desdevises et al., 2002). So, if this applies for *Rhabdosynochus* spp., then probably determinants of host specificity and taxonomic diversification of this parasite genus are highly constrained by phylogeny, but also linked to host size.

This present paper represents the third report of diplectanids from the west coast of Mexico. *Heteroplectanum oliveri* Leon Rêgagnon, Pérez Ponce de León, and García Prieto, 1997 (Diplectanidae) from *Kyphosus elegans* (Kyphosidae) and *Cornutohaptor nigrescens* Mendoza-Franco, Violante-González, and Vidal-Martínez, 2006 (Diplectanidae) from *C. nigrescens* (Centropomidae) were originally described from the Mexican coast of the Pacific Ocean (Chamela Bay, in the State of Jalisco and the Tres Palos Lagoon, in the State of Guerrero, respectively) (see Leon-Rêgagnon et al., 1997; Mendoza-Franco et al., 2006). Along the Pacific coast of Mexico only 2 (*C. nigrescens* and *C. robalito*) of 6 species of *Centropomus* have been studied for monogenoids (Mendoza-Franco et al., 2006; present study). It

is apparent that further survey of the *Rhabdosynochus* group infesting *Centropomus* spp. from the eastern Pacific (between Gulf of California and Peru) and the western Atlantic (between the Florida peninsula and Brazil) will be necessary to understand the evolutionary history of *Rhabdosynochus* spp. in the subtropical and tropical areas.

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