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Trypanorhynch cestode larvae parasitizing *Hyporthodus niveatus* (Valenciennes, 1828) (Actinopterygii) collected from fish markets in the municipality of Niterói, RJ, Brazil

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Abstract

This study is a continuation of the survey about helminths parasitizing the white grouper, *Hyporthodus niveatus*, a marine fish purchased from fish markets in the municipality of Niterói, Rio de Janeiro State, Brazil. Specifically, this study reports the results of an investigation concerning trypanorhynch cestodes parasitizing this host. A total of 20 fish specimens were caught by professional fishermen off the coast of Rio de Janeiro State. The fish were measured and necropsied, and their organs were investigated for trypanorhynch cestodes. A total of 13 *H. niveatus* were parasitized by 67 specimens of trypanorhynch cestode plerocerci that were found infecting the visceral serosa, stomach, intestine, and abdominal musculature. The taxonomic identification of these parasites was based on morphological and morphometric characters using bright-field and scanning electron microscopies. Five trypanorhynch species were identified: *Pintneriella gymnorhynchoides*, *Grillotia (Christianella) carvajalregorum*, *Pterobothrium crassicolle*, *Callitetrarhynchus gracilis,* and *Callitetrarhynchus speciosus*, and their parasitic indices were presented. This is the first report on the occurrence of *P. gymnorhynchoides* in the Western Atlantic Ocean. Apart from the repugnance, the presence of cestode plerocerci is worrisome because of the potential risk of allergic reactions, thereby reinforcing the hygienic-sanitary significance of monitoring these parasites.

Keywords: *Hyporthodus niveatus*; trypanorhyncha; fish sanitary inspection.

Practical Application: Cestode larvae with repugnant aspect causing consumer rejection.

1 INTRODUCTION

Species of *Hyporthodus niveatus* (Valenciennes, 1828), commonly known as white grouper, occur in the Atlantic Ocean from Canada to southern Brazil (Froese & Pauly, 2021). The species has been intensively fished throughout this range and is highly appreciated as food.

The maintenance of hygienic-sanitary conditions in fish markets in the municipality of Niterói, Rio de Janeiro State, Brazil, has long been a concern for municipal health surveillance. For example, helminths have been found in the abdominal musculature and viscera serosa of *H. niveatus* in these fish markets, causing a repugnant appearance that results in local economic losses. Parasitism of this host by anisakids and acanthocephalans was reported in the first part of this survey (Menezes et al., 2023), and this study reports on parasitism by trypanorhynch tapeworms.

Cestodes of the order Trypanorhyncha are cosmopolitan parasites of marine fish and invertebrates, especially in tropical and subtropical regions. The adults inhabit the gastrointestinal tract of elasmobranchs, while the larvae are found in the celomic cavity, visceral serosa, and musculature of intermediate cephalopod, crustacean, and teleost hosts (Palm, 2004). Parasitism of Brazilian fish by trypanorhynch larvae has been reported in papers on taxonomy, parasite ecology, and hygienic-sanitary conditions (Felizardo et al., 2010; Leite et al., 2022; Miguel et al., 2022; Oliveira et al., 2019; São Clemente et al., 1997). Trypanorhynch larvae are significant due to their repugnant aspect, especially when present as massive infections in the musculature and organs, making commercialization infeasible due to sanitary inspection and/or consumer rejection, resulting in economic losses (Oliveira et al., 2019). The allergenic potential of some of these cestode species has been studied in tests carried out with murine models (Mattos et al., 2015).

Brazilian legislation concerning fish and their derived products establishes that any fish with a repugnant appearance, as in the case of any musculature possessing a massive parasitic infection, is considered improper for consumption (Brasil, 2017).

Some kinds of helminths parasitizing *H. niveatus*, such as digenetic trematodes, monogeneans, trypanorhynch cestodes, and more recently phyllometrid, anisakid, and raphydadscaridid nematodes and acanthocephalans, have been reported in studies concerning the composition and structure of parasitic communities. These helminths could be recognized as part of

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a community composition with a richness of species, suggesting the importance of their ecological traits and their significance with respect to sanitary fish inspection (Alves et al., 2017; Diniz et al., 2022; Eiras et al., 2016; Faria & Silva, 1934; Leite et al., 2022; Lima, 2004; Manter, 1947; Menezes et al., 2023; Moravec et al., 2020; Palm, 2004; Santos et al., 2000).

Thus, this investigation aimed to: (1) identify the species of cestode larvae parasitizing *H. niveatus* acquired from markets in the municipality of Niterói, Rio de Janeiro State, by means of morphological and morphometric analyses using optical and scanning electron microscopies of specimens retrieved from the site of infection; (2) present their parasitic indices and infection sites; and (3) emphasize the hygienic-sanitary significance of these parasites to collective human health and provide baseline data for subsequent investigations.

2 MATERIAL AND METHODS

A total of 20 specimens of *H. niveatus* (42–67 cm total length), caught by professional fishermen, were purchased from fish markets in the municipality of Niterói, Rio de Janeiro State, Brazil, between March 2021 and September 2022. The fish were transported on ice to the laboratory (Laboratório de Inspeção e Tecnologia de Pescado, Faculdade de Veterinária, Universidade Federal Fluminense, RJ) where they were identified according to Figueiredo and Menezes (1980) and submitted to necropsy, and the internal organs and musculature were examined. After necropsy, the musculature was transferred to Petri dishes containing a physiological solution of 0.65% NaCl, and the cestode blastocysts were removed from the musculature and organs for further investigation. The plerocerci were removed from the blastocysts under the stereomicroscope with the aid of sharp needles, to release the larvae, which were placed in Petri dishes with distilled water, and put in the refrigerator for at least 24 h to permit relaxing of the scolices and extroversion of the tentacles. Some of these helminths were fixed in AFA and preserved in 70 ºGL ethanol. The cestodes were collected, fixed, and preserved according to Knoff and Gomes (2012).

The trypanorhynch plerocerci were stained with Langeron's carmine, clarified in beechwood creosote, and preserved as whole mounts on Canada balsam according to Knoff and Gomes (2012).

The taxonomic classification of the order Trypanorhyncha followed Palm (2004), and the trypanorhynch cestode larvae were identified according to Beveridge and Campbell (2000, 2003), Carvajal and Rego (1985), Diniz et al. (2022), Kuraiem et al. (2016), Leite et al. (2022), Menezes et al. (2018), Palm (2004), and São Clemente (1986). The measurements were obtained by bright-field microscopy using an Olympus BX 41 microscope, the samples were analyzed by bright-field microscopy using a Zeiss Axiophot microscope equipped with Nomarski's differential interference contrast apparatus, and the images were obtained using a Canon digital camera (Power Shot A640) in the Laboratório de Helmintos Parasitos de Vertebrados, Instituto Oswaldo Cruz, FIOCRUZ, RJ. Some specimens were prepared for scanning electron microscopy (SEM) according to Torres et al. (2013). The samples preserved in ethanol were dehydrated in an ethanol series (70–100º GL), CO_2 critical point dried, coated in gold, and then examined and photographed using a SEM (Jeol JSM-6390LV), with an acceleration voltage of 15 kV. The measurements were reported in millimeters (mm) with the averages in parentheses unless otherwise indicated.

The parasitic indices of prevalence, mean intensity/intensity, and mean abundance/abundance were calculated according to Bush et al. (1997). Representative specimens of each parasite species were deposited in the Coleção Helmintológica do Instituto Oswaldo Cruz (Helminth Collection of the Oswaldo Cruz Institute) – CHIOC, Rio de Janeiro, RJ, Brazil.

3 RESULTS

A total of 13 *H. niveatus* (65%) were found to be parasitized by 67 trypanorhynch cestode plerocerci, belonging to two superfamilies. Five species, one of the superfamily Gymnorhynchoidea and four of the superfamily Lacistorhynchoidea, were found infecting the visceral serosa, stomach, intestine, and abdominal musculature.

Most of the cestode larvae were alive and showed great motility. Figure 1 shows one of the caught fish with the abdominal

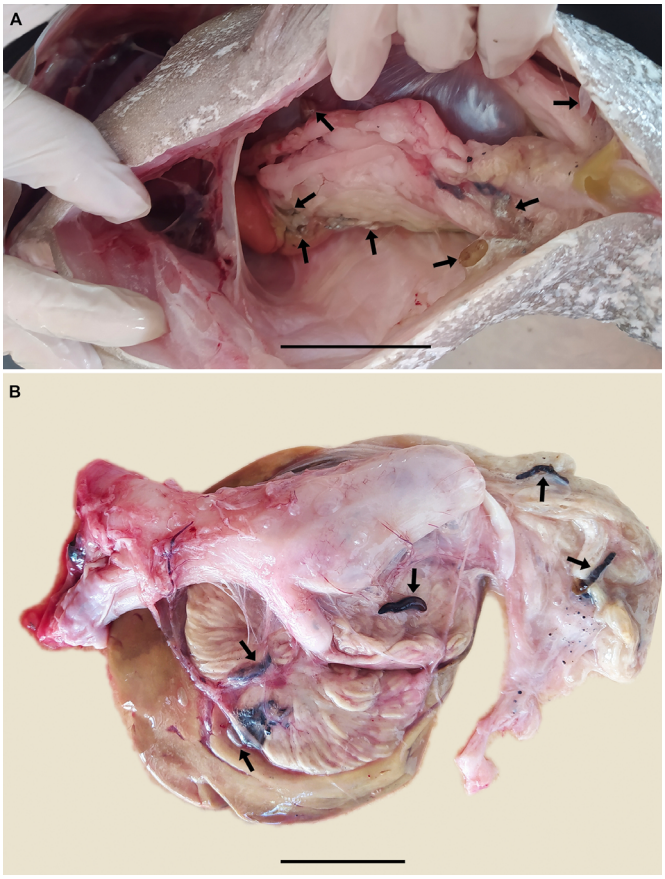

Figure 1. *Hyporthodus niveatus* with abdominal cavity opened showing (A) cestode blastocysts (arrows) in the visceral serosa and (B) cestode blastocysts (arrows) in the visceral serosa, all visible to the naked eye. Scale bars: A and B = 4 cm.

cavity opened, showing cestode blastocysts parasitizing the visceral serosa.

The specimens of cestodes were taxonomically identified as follows:

Platyhelminthes Minot, 1876, Rhabditophora Ehlers, 1985, Neodermata Ehlers, 1985, Cestoidea Rudolphi, 1808, Eucestoda Southwell, 1930, Trypanorhyncha Diesing, 1863, Trypanoselachoida *sensu* Beveridge, Haseli, Ivanov, Menoret and Schaeffner, 2017, Gymnorhynchoidea Dollfus, 1935, Rhopalothylacidae Guiart, 1935

Pintneriella Yamaguti, 1934

Pintneriella gymnorhynchoides (Guiart, 1935) Beveridge and Campbell, 2003. Figure 2.

One specimen of *P. gymnorhynchoides* was obtained from the stomach of one individual of *H. niveatus*. The parasitic indices were indicated as follows: prevalence 5%, intensity 1, and abundance 0.05. A voucher specimen was deposited in CHIOC under the number 39791.

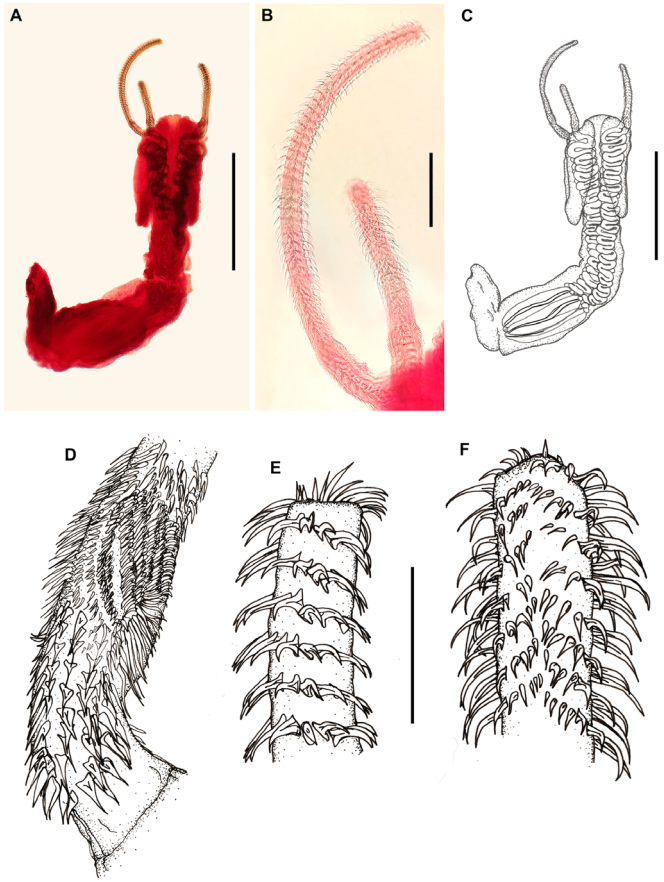

Figure 2. Plerocercus of *Pintneriella gymnorhynchoides* obtained from *Hyporthodus niveatus*. (A and C) Scolex, latero-ventral view showing extroverted tentacles, pars bothrialis, pars vaginalis, pars bulbosa, and pars postbulbosa. (B) Metabasal and basal tentacular armature, internal surface of the right side of tentacle and external surface of the left side of tentacle. (D) Basal tentacular armature, internal surface. (E) Metabasal tentacular armature, internal surface. (F) Metasal tentacular armature, external surface. Scale bars: A and C = 1 mm; B = 0.2 mm; D–F = 0.1 mm.

The main characteristics of the single plerocercus obtained were as follows. Plerocercus with blastocyst; elongated scolex; acraspedote; 3.10 long by 0.55 wide with a 9.12 long by 1.12 wide appendix; two oval bothria were arranged opposite to one another with no thickened rims and free edges; bothrial pits were absent; pars vaginalis was longer than pars bothrialis; pars postbulbosa were present; four elongated slender tentacles with basal swelling emerging from elongated bulbs were present; retractor muscles originating at the base of the bulbs were present; prebulbar organs and gland cells inside bulbs were absent; sinuous tentacle sheaths; metabasal tentacular armature heteroacanthous and typically heteromorphous, in ascending half spirals of 11 hooks with divergent hook files 1(1') which did not abut on the external surface and did not overlap; and the hooks were hollow. Hooks 1(1') were robust and uncinate with a distinctive keel; hooks 2(2') became broadly uncinate; hooks 3(3') became uncinate; hooks 4(4') became falcate; hooks 5(5') became falcate with a narrower base; hooks 6(6') became falcate; hooks 7(7') became slender and falcate; hooks 8(8') became smaller and falcate; hooks 9(9') became falcate with a narrow base; hooks 10(10') became falcate; and hooks 11(11') became falcate to filiform. The characteristic of the basal armature included hollow hooks and the first six rows of hooks were deltoid in shape, becoming filiform on the external surface. On the antibothrial surface, the ninth row of hooks contained five enlarged, unciform hooks. A quadrangular array of bill hooks with a total of six rows and four to eight hooks per row was present.

Lacistorhynchoidea Guiart, 1927, Grillotiidae Dollfus, 1969

Grillotia Guiart, 1927

Grillotia (*Christianella*) *carvajalregorum* (Carvajal & Rego, 1983) Menoret and Ivanov, 2009. Figure 3.

Two specimens of *G.* (*C.*) *carvajalregorum* were obtained from the visceral serosa of one individual of *H. niveatus*. The parasitic indices were indicated as follows: prevalence 5%, intensity 2, abundance 0.10, and a voucher specimen was deposited in the CHIOC under the number 39792.

The main characteristics observed in the two plerocerci obtained were as follows. Plerocercus with a pyriform blastocyst; specimens with a scolex with 1.97 long by 0.52 wide and an appendix with 0.85 long by 0.20 wide; elongated, acraspedote scolex; two sub-cordiform bothria, each with a slight indentation on the posterior edge; surfaces of the scolex and pars bothrialis covered by microtriches; long pars bothrialis with sinuous sheaths; elongated pars vaginalis with the sheaths coiled at the proximal portion of the bulb insertion and sinuous at the distal portion; elongated bulbs; the retractor muscle was originated from the last third of the bulbs; the pars postbulbosa represented one-fourth of the body length; the tentacles were elongated and tapered with no basal swelling; the armature heteracanthous and atypical with hollow, heteromorphous hooks; the distinct basal armature consisted of 1–2 rows of uncinate hooks with different shapes and sizes; the bothrial surface had uncinate hooks with

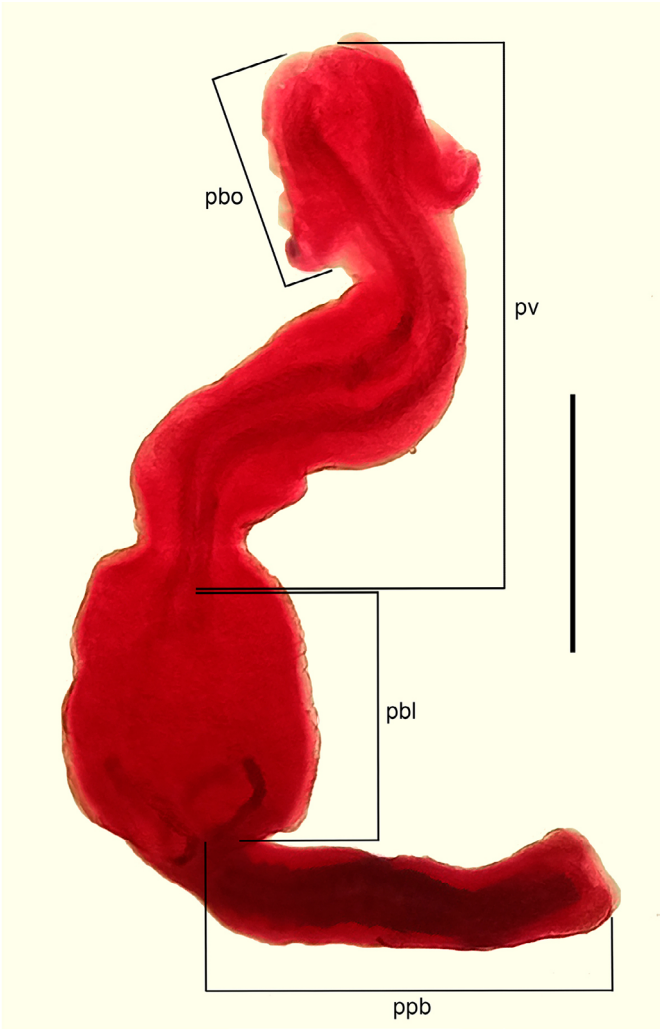

Figure 3. Plerocercus of *Grillotia* (*C.*) *carvajalregorum* obtained from *Hyporthodus niveatus* showing the pars bothrialis (pbo), pars vaginalis (pv), pars bulbosa (pbl), and pars postbulbosa (ppb). Scale bar: 0.5 mm.

recurved tips; the antibothrial surface had elongated falcate hooks; principal hooks began at rows 2–3; the band of hooklets on the external surface was restricted to the basal region of the tentacle, extending from the top of rows 1–2 of principal hooks up to rows 6–7; the width of hooklets 6–7 interrupted on the metabasal region; the metabasal armature with ascending rows with four large hooks beginning on the internal surface and terminating on the external surface; there was a prominent space between hooks 1 and 1' on the internal surface; and intercalary rows of 3–5 became uncinate to spiniform hooks between hooks 2(2') and 4(4').

Pterobothriidae Pintner, 1931 clade sensu Beveridge, Haseli, Ivanov, Menoret and Schaeffner, 2017

Pterobothrium Diesing, 1850

Pterobothrium crassicolle Diesing, 1850. Figure 4.

Two specimens of *P. crassicolle* were obtained from the visceral serosa of one individual of *H. niveatus*. The parasitic

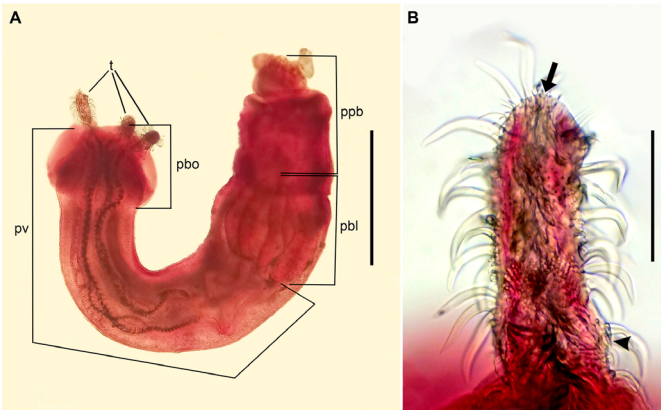

Figure 4. Plerocercus of *Pterobothrium crassicolle* obtained from *Hyporthodus niveatus*. (A) Entire plerocercus, tentacles partially extroverted (t), pars bothrialis (pbo), pars vaginalis (pv), pars bulbosa (pbl), and pars postbulbosa (ppb). (B) Details of the tentacle, showing external surface intercalar microhooks to principal hooks (arrow) and swelling present on the distinctive basal armature tentacle (arrowhead). Scale bar: A = 1 mm; B = 0.1 mm.

indices were indicated as follows: prevalence 5%, intensity 2, and mean abundance 0.10. A voucher specimen was deposited in the CHIOC under the number 39793.

The main characteristics observed in one of the two plerocerci obtained were as follows. Elongated acraspedote scolex with 2.85 long by 0.87 wide with a 1.00 long by 0.75 wide appendix; four pyriform bothria on mobile pedicels in a cruciform arrangement; and a subcylindrical pedunculus scolecis narrower than the pars bothrialis. The principal rows of metabasal armature formed alternating half-spirals of five large heteromorphous, hollow hooks with small, interpolated hooks between the principal rows on the bothrial and antibothrial surfaces. Tentacles with distinctive armature basal swelling, where the basal internal tentacle surface was armed with three rows of principal hooks and hooks 1(1') large hooks on the third row, and the basal external tentacle surface was armed with a band of compact patch of closely spaced microhooks. Hooks 1(1') were widely separated and became falciform in the proximal region, becoming smaller, stouter, and uncinate distally. Hooks 2(2') became falciform, decreasing in size in the distal metabasal region, the heel gradually enlarged, and the toe gradually disappeared. Hooks 3(3') became falciform with a short base and heel, gradually decreasing in size distally. Hooks 4(4') and 5(5') of the proximal 12 rows became digitiform, and hooks 4(4') became falciform at row 13. Hooks 5(5') remained digitiform throughout the entire file, markedly reducing in length in the apical region, heel and toe absent, and falcate with pointed tips. The intercalary rows present proximal to each principal row were extended onto the external surface to merge with the band of hooks occupying the midline of the external surface of the tentacle. Tentacle sheaths were sinuous. Bulbs were elongated, and the pars postbulbosa was present.

Lacistorhynchidae Guiart, 1927, Lacistorhynchinae Guiart, 1927,

Callitetrarhynchus Pintner, 1931,

Callitetrarhynchus gracilis (Rudolphi, 1819) Pintner, 1931. Figure 5.

A total of 42 specimens of *C. gracilis* were obtained from the visceral serosa, abdominal musculature, and intestine of eleven individuals of *H. niveatus*. The parasitic indices were indicated as follows: prevalence 55%, mean intensity 3.82, mean abundance 2.10, and range of infection of 1–10. Voucher specimens were deposited in CHIOC under the numbers 39794 and 39795.

The main characteristics observed in the 42 plerocerci obtained (30 whole mounts and 12 by SEM) and five measured were as follows. Plerocerci with blastocyst; scolex elongated, thin, and acraspedote; and plerocerci with remarkable size range within the same host. The specimens with scolex were 2.80–5.45 (4.36) long by 0.25–0.47 (0.33) wide and appendix 3.07–10.62 (7.16) long by 0.35–0.57 (0.46) wide. Two patelliform bothria with weakly notched posterior margins. Long pars vaginalis with regularly sinuous tentacle sheaths were less sinuous in the pars bothrialis region. Bulbs were elongated, and the retractor muscles originated in the anterior third of the bulbs. Pars postbulbosa was present, but small and absent in some cases. Metabasal armature was poeciloacanthous, atypical, and heteromorphous; hooks were hollow, spirals of eight principal hooks in ascending half, beginning on the internal surface. Hooks 1(1') were large and uncinate; hooks 2(2') were uncinate and long; hooks 3(3´) became falciform, large, and with large bases; hooks 4(4') and 5(5') became falciform; hooks 6(6') became spiniform and were located near the external surface; satellite hook 7(7') was larger than hook 8(8'), both with slender uncinate shape. A simple chainette was present.

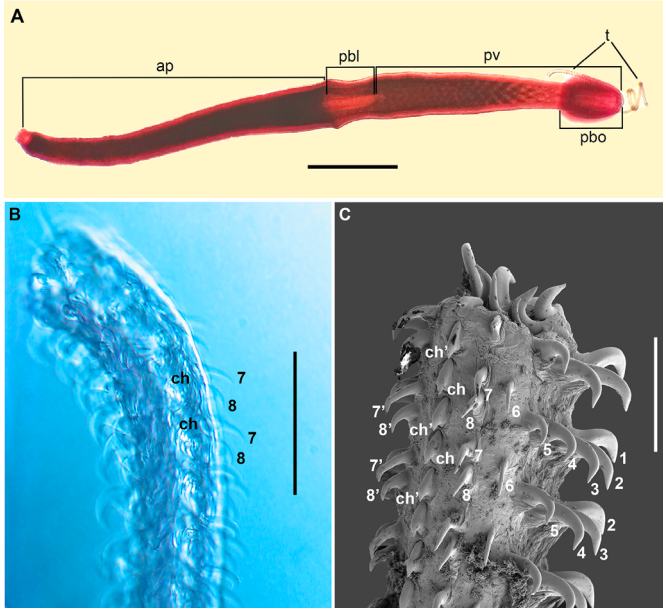

Figure 5. *Callitetrarhynchus gracilis* obtained from *Hyporthodus niveatus*. (A) Entire plerocercus, tentacles partially extroverted (t), pars bothrialis (pbo), pars vaginalis (pv), pars bulbosa (pbl), and appendix (ap). (B) Details of the bothrial surface hooks' arrangement of the metabasal armature tentacle, showing hooks 7 and 8 and the chainette (ch). (C) Details of the external face hooks' arrangement of the metabasal armature tentacle, showing hooks 1, 2, 3, 4, 5, 6, 7 (7'), and 8 (8') and the chainette (ch and ch') by SEM. Scale bar: A = 1.5 mm; B = 0.1 mm; C = 40 µm.

Callitetrarhynchus speciosus (Linton, 1897) Carvajal and Rego, 1985. Figure 6.

A total of 20 specimens of *C. speciosus* were obtained from the visceral serosa and abdominal musculature of 10 individuals of *H. niveatus*. The parasitic indices were indicated as follows: prevalence 50%, mean intensity 2, mean abundance 1, and range of infection of 1–5. Voucher specimens were deposited in CHIOC under the numbers 39796 and 39797.

The main characteristics observed in the 20 plerocerci obtained (16 whole mounts and 4 by SEM) and five measured were as follows. Plerocerci with blastocist present tail extension. Scolex was elongated, thin, and acraspedote, 3.75–6.70 (4.58) long by 0.45–1.2 (0.68) wide, with an appendix 4.92–9.35 (8.06) long by 0.70–1.1 (0.89) wide. Two patelliform bothria with weakly notched posterior margins were present. Pars vaginalis was long, and tentacle sheaths were regularly sinuous, enlarged anteriorly, and less sinuous on the pars bothrialis region. Bulbs

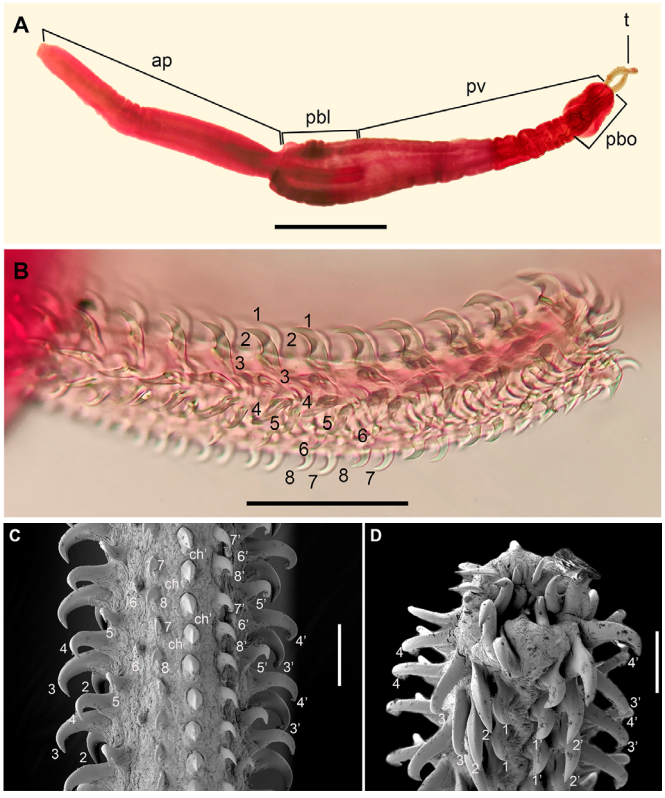

Figure 6. *Callitetrarhynchus speciosus* plerocercus obtained from *Hyporthodus niveatus*. (A) Entire plerocercus, tentacles partially extroverted (t), pars bothrialis (pbo), pars vaginalis (pv), pars bulbosa (pbl), and appendix (ap). (B) Details of the antibothrial face hooks' arrangement of the metabasal armature tentacle, showing hooks 1, 2, 3, 4, 5, 6, 7, and 8. (C) Details of the external face hooks' arrangement of the basal and metabasal armature tentacle, showing hooks 3(3'), 4(4'), 5(5'), 6(6'), 7(7'), and 8(8') and the chainette (ch and ch') by SEM. (D) Details of the internal face hooks' arrangement of the metabasal armature tentacle, showing hooks 1(1'), 2(2'), 3(3'), and 4(4') by SEM. Scale bar: A = 2 mm; B = 0.1 mm; C and D = 20 µm.

elongated. Retractor muscles originated in the anterior third of the bulbs. Pars postbulbosa were present, but small and absent in some cases. Metabasal armature was poeciloacanthous atypical and heteromorphous; hooks were hollow, in ascending half spirals of eight principal hooks, beginning on the internal surface. Hooks 1(1') were large and uncinate, hooks 2(2') were uncinate and long, hooks 3(3´) became falciform, large, and with large bases, hooks 4(4´) and 5(5´) became falciform, hooks 6(6´) became spiniform and were located near the external surface, and the satellite hooks 7(7') and 8(8') were of the same size with a slender uncinate shape. A simple chainette was present.

In this study, four hosts presented single infections, and nine presented co-infections with up to three trypanorhynch species.

Parasitism by *C. gracilis* was present in 85% of the infected hosts, this cestode being the most prevalent, with single infections in 30.8% of the infected hosts and the following co-infections: *C. gracilis* and *C. speciosus* (46%), *C. gracilis* and *P. gymnorhynchoides* sp. (8%), *C. gracilis*, *C. speciosus* and *P. crassicolle* (8%), and *C. gracilis*, *C. speciosus,* and *G. (C.) carvajalregorum* (8%). Parasitism by *C. speciosus* was present in 77% of the infected hosts, with single infections in 15% and co-infections as reported above.

4 DISCUSSION

The morphology and morphometry of the trypanorhynch cestode species obtained in the present study agreed with their descriptions and redescriptions by Beveridge and Campbell (2003) for the species *P. gymnorhynchoides*; by Campbell and Beveridge (1996), Carvajal and Rego (1983), Diniz et al. (2022), Menoret and Ivanov (2009) and Pereira Jr. and Boeger (2005) for *G.* (*C.*) *carvajalregorum*; by Diesing (1850), Oliveira et al. (2019), Palm (2004), Rego (1987), São Clemente (1986), and Zuchinalli et al. (2016), for *P. crassicolle*; by Carvajal and Rego (1985), Dollfus (1942), Leite et al. (2022), Menezes et al. (2018), Palm (2004), and São Clemente (1986), for *C. gracilis*, and by Carvajal and Rego (1985), Kuraiem et al. (2016), and Palm (2004) for *C. speciosus*.

Most of the plerocerci cestode species found in this study had been previously reported worldwide, parasitizing several marine teleost fish species and adults found in shark host species (Diniz et al., 2022; Eiras et al., 2016; Felizardo et al., 2010; Kuraiem et al., 2016; Leite et al., 2022; Lima, 2004; Menezes et al., 2018; Oliveira et al., 2019; Palm, 2004; Palm and Bray, 2014; Zuchinalli et al., 2016).

Lima (2004) reported four species of trypanorhynch cestodes, namely, *G. carvajalregorum*, *P. crassicolle*, *C. gracilis,* and *C. speciosus* parasitizing *Epinephelus niveatus* (Valenciennes, 1828) (=*H. niveatus*), the same host obtained from the same fish market in Niterói, Rio de Janeiro State, Brazil. Palm (2004), in his "Parasite-host list," reported two species parasitizing the same host in Rio de Janeiro, Brazil, after visiting the Muséum National d'Histoire Naturelle (MNHN) in Paris, where he provided not-yet-published parasite-host records, *C. gracilis* MNHN BD 29 No. 16, 24 and *Pseudotobothrium dipsacum* (Linton, 1897), MNHN BD 29 No. 28. In this study, the same trypanorhynch species as Lima (2004) were found, with the addition of *P. gymnorhynchoides*. Compared with the report of Palm (2004), *C. gracilis* was the common species with the exception of *P. dipsacum*. The species *P. gymnorhynchoides* was reported in *Centroscymnus coelolepis* by Bocage and Capello, 1864, obtained from the Azores, off the coast of the East Atlantic Northern region (Beveridge and Campbell, 2003; Palm, 2004). Thus, the present report of *P. gymnorhynchoides* parasitizing *H. niveatus* is the first time this species has been reported in Brazil and Latin America and off the coast of the West Atlantic region.

Comparing the parasitic indices for the trypanorhynch species in *H. niveatus* obtained in this study with those reported by Lima (2004), who obtained them from 30 hosts (52–104 cm total length), *G. carvajalregorum*, *P. crassicolle*, *C. gracilis,* and *C. speciosus* were found with the following parasitic indices: prevalence 3.33%, 3.33%, 70%, and 56.66%; intensity or mean intensity of 1, 1, 54.7, and 3.8; and range of infection of 1, 1, 1–233, and 1–18, respectively. Considering the species obtained and concomitants in both studies, similarity was observed for prevalence and for intensity/mean intensity, with the exception of *C. gracilis* which presented a 10 times lower mean intensity.

Parasitic associations were found for six specimens obtained in this study, with four double infections, three by *C. gracilis* and *C. speciosus* and one by *C. gracilis* and *P. gymonrhynchoides*; and two triple infections, one by *C. gracilis*, *C. speciosus,* and *P. crassicolle*, and the other by *C. gracilis*, *C. speciosus,* and *G. carvajalregorum*. Comparing this kind of association of trypanorhych species with that found by Lima (2004), he recorded 14 host specimens with simultaneous infection by *C. gracilis* and *C. speciosus* and one host with concomitant infection by the following four trypanorhynch species: *G. carvajalregorum, P.crassicolle*, *C. gracilis,* and *C. speciosus*.

In this study, *P. gymnorhynchoides, G. carvajalregorum*, *P. crassicolle*, *C. gracilis,* and *C. speciosus* were found, showing some differences in the composition of the helminth larvae group in this host. The characteristics observed between and within ecoregions are known to influence fish parasite communities and explain the differences in the assemblages of the parasite species of teleost fish, as observed by Diniz et al. (2022). Current and previous studies in the same ecoregion seem to indicate that this fish species varies according to the trophic web, which determines the variability in richness and abundance of the helminth larvae.

The trypanorhynch plerocerci were visible to the naked eye, even when dead and with infection of up to 16 parasites per host. They were also sometimes found in the musculature, as can be seen in Figure 1, giving a repugnant aspect and making their marketing unfeasible. In a study with a murine model, Mattos et al. (2015) warned that the ingestion of fish infected with species of trypanorhynch metacestodes could cause allergic reactions in humans and that future studies should analyze this peculiarity.

5 CONCLUSION

Apart from the repugnance, the presence of cestode plerocerci is worrisome because of this risk of allergic reactions, thereby reinforcing the hygienic-sanitary significance of monitoring these parasites.

The intensification of fish-based food inspections and the implementation of health education programs are required. Hazard analysis and a critical control points plan should be applied at all points of the production chain in order to eliminate, prevent, or reduce risks and ensure a safe and quality product, as proposed by Diniz et al. (2022), Leite et al. (2022), Menezes et al. (2023), and Miguel et al. (2022). Furthermore, the evisceration on boards in warehouses, industries, or retailers should be examined, with the proper destination of the residues.

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