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A New Species of Hatschekiid Copepod (Crustacea: Hatschekiidae) Parasitic on the Porkfish *Anisotremus virginicus* (Linnaeus, 1758) (Actinopterygii: Haemulidae), with Notes on Previously Known Species of *Hatschekia* Poche, 1902 Collected from Actinopterygians off Brazil

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Received: 14 January 2022 / Accepted: 4 April 2022

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Abstract

Introduction Copepods of the genus *Hatschekia* Poche, 1902 are parasitic on the gills of marine actinopterygians. Currently, about 151 species of this genus have been reported in marine ecosystems and only few occur in South Atlantic Ocean.

Methods Fifty specimens of *A. virginicus* from Angra dos Reis, off the State of Rio de Janeiro, Brazil, were parasitized by copepods on the gills. Parasites were fixed and preserved in 70% ethanol. Morphological observations were based on light and scanning electron microscopy.

Results *Hatschekia nagasawai* n. sp. can be distinguished from all congeners by the combination of the following characters: (1) presence of two pointed processes on the proximal (first) segment of antennule, (2) cephalothorax octagonal to ovoid, (3) absence of processes on the intercoxal sclerite of legs 1 and 2, (4) trunk without lobes at the postero-lateral margins. Other species of *Hatschekia* and their hosts previously collected off Brazil were analysed and discussed.

Conclusions This is the first report of a representative of the family Hatschekiidae Kabata, 1979 parasitizing a species of *Anisotremus*. The number of species of *Hatschekia* reported in the South Atlantic Ocean was increased to five, including the new species; however, the diversity of hatschekiid copepods in this oceanographic region is still underestimated, most likely being higher than what is currently known.

Keywords Parasitic copepod · Siphonostomatoida · Marine fish · Perciformes · South Atlantic Ocean

Introduction

Siphonostomatoid copepods of the family Hatschekiidae Kabata, 1979 represent one of the most diverse groups of crustacean parasites, found on the gills of marine actinopterygian fish [1, 2]. Currently, this family comprises about

170 species, belonging to nine genera namely, *Bassettithia* Wilson, 1922, *Brachihatschekia* Castro-Romero & Baeza-Kuroki, 1989, *Congericola* Beneden, 1854, *Hatschekia* Poche, 1902, *Laminohatschekia* Boxshall, 1989; *Mihbaicola* Uyeno, 2013, *Prohatschekia* Nunes-Ruivo, 1954, *Pseudocongericola* Yü, 1933 and *Wynnoweria* Boxshall, 1987 [1–3]. *Hatschekia* is the most diverse genus and since the last systematic revision by Jones [4] that reduced the number of valid species from 100 to 68, 83 other species were described worldwide [1, 2, 5–9].

Surveys on hatschekiid copepods from marine fish in the Southwestern Atlantic are scarce and, similarly, the related taxonomic knowledge is fragmentary [10]. In this sense, only two species of *Hatschekia* have been reported so far in this region, parasitizing gills of their hosts, i.e., *H. conifera* Yamaguti, 1939 from the Atlantic pomfret *Brama brama* (Bonnerterre), off Mar del Plata and San Matías gulf, Argentina and *H. quadrabdominalis* Yü, 1933 from the Atlantic

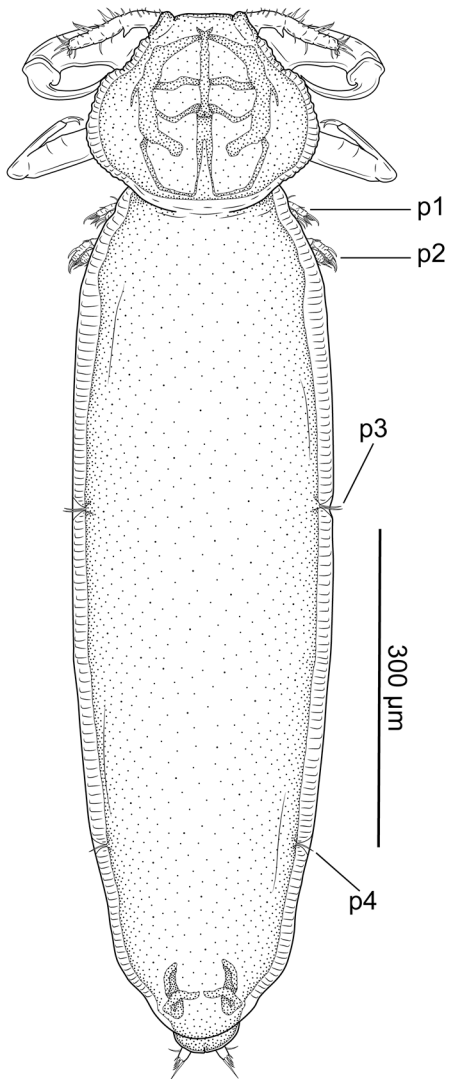
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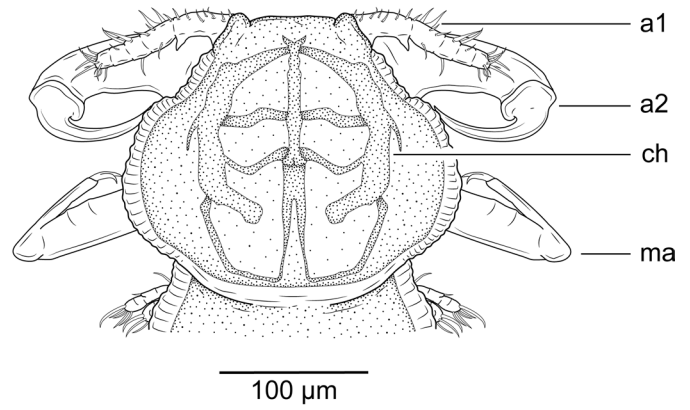
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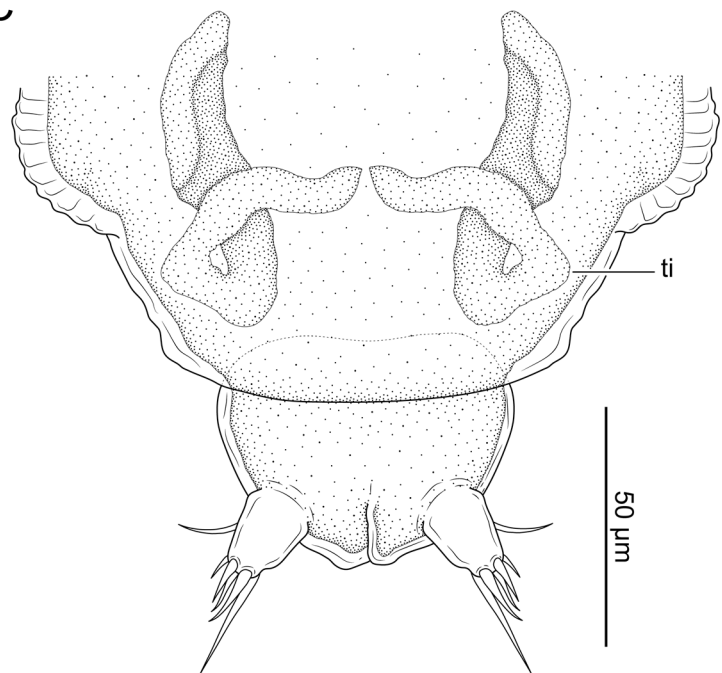
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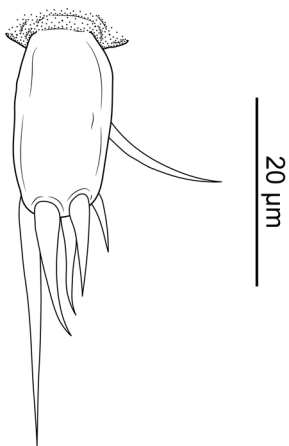
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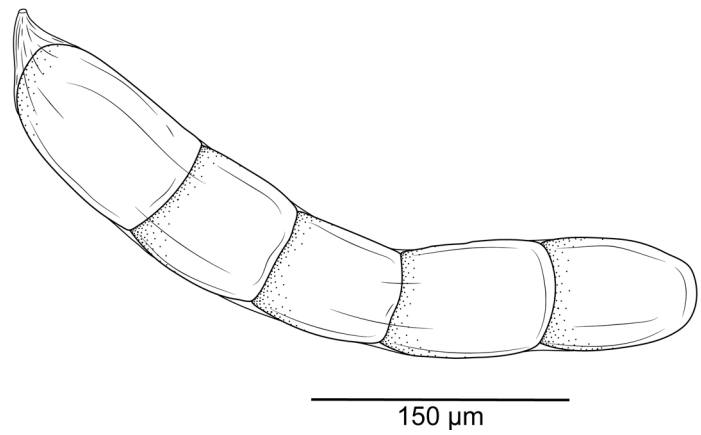


Fig. 1 *Hatschekia nagasawai* n. sp. (adult female). **A** Habitus, dorsal view, p1=leg 1, p2=leg 2, p3=leg 3, p4=leg 4; **B** details of cephalothorax, dorsal view, a1=antennule, a2=antenna, ch=dorsal chitinous markings, ma=maxilla; **C** posterior part of trunk, ventral view, ti=internal tissues; **D** caudal ramus, ventral view; **E** egg sacs, lateral view

bigeye *Priacanthus arenatus* (Cuvier), off Rio de Janeiro, Brazil [10, 11]. In addition, there are three undetermined species reports of *Hatschekia*, one on the Porkfish *Anisotremus virginicus* (Linnaeus), one on the Coney *Cephalopholis fulva* (Linnaeus) and one on the Bluewing searobin *Prionotus punctatus* (Bloch), off Rio de Janeiro, Brazil [10, 12].

Anisotremus virginicus (Perciformes: Haemulidae) is the most common species of the genus on the Brazilian coast [13]. This species occurs in coastal zones from USA to Brazil (including Gulf of Mexico and Caribbean Sea), commonly inhabiting reefs and rocky bottoms and feeding on a variety of invertebrates, mainly mollusks, echinoderms, annelids and crustaceans [13, 14]. To date, five species of copepods have been reported parasitizing *A. virginicus* in the Atlantic Ocean, namely, *Caligus atromaculatus* Wilson, 1913, *C. haemulonis* Krøyer, 1863, *C. longipedis* Bassett-Smith, 1898, *C. xystercus* Cressey, 1991 and *Lernanthropus amplitergum* Pearse, 1951, as well as an unidentified species of *Hatschekia* [12].

During parasitological studies on specimens of *A. virginicus* from the Brazilian coastal zone, some parasitic copepods were recovered from their gills. Detailed morphological analysis of these parasites revealed that they represented a new species of *Hatschekia*, which is described herein. In addition, other species of *Hatschekia* previously reported on actinopterygians in the Brazilian coast were re-examined and discussed.

Materials and Methods

Fifty specimens of *A. virginicus* (total length 20.3–40.5; mean \pm standard deviation 27.2 ± 5.1 cm) from the coast of Angra dos Reis (23° 01' 21" S, 44° 19' 13" W), State of Rio de Janeiro, Southeastern Brazil, were purchased from local fishermen in April 2011 and July 2012. Copepods were collected from the host gills, fixed and preserved in 70% ethanol until morphological analysis. For microscopical observation, specimens were cleared in 85% lactic acid and the appendages were dissected and examined using the wooden slide procedure described by Humes and Gooding [15]. Drawings were made using an Olympus BX51 microscope (Olympus Corporation, Tokyo, Japan) with a drawing tube attached. For analysis using scanning electron microscopy (SEM), three female specimens were dehydrated through a graded ethanol series, dried in

hexamethyldisilazane, coated with gold and examined in a Jeol JSM 6510 LV scanning electron microscope, operating at 30 kV. Measurements were based on ten adult females, given as the ranges followed by mean and one standard deviation inside parentheses, all in micrometers. For identification and comparison purposes, the following specimens of *Hatschekia* deposited in the Coleção Helminológica do Instituto Oswaldo Cruz (acronym CHIOC) and in the Coleção de Crustacea do Museu Nacional do Rio de Janeiro (acronym MNRJ) were observed: *H. quadrabdominalis* (MNRJ15338; MNRJ 15339) from *P. arenatus* reported by Tavares *et al.* [16]; *Hatschekia* sp. (MNRJ-23992) from *A. virginicus* reported by Paschoal *et al.* [12]; *Hatschekia* sp. (CHIOC-35358) from *P. punctatus* reported by Bicudo *et al.* [17]. The morphological terminology used herein follows Huys and Boxshall [18], and the measurement were taken according to the methodology proposed by Uyeno and Nagasawa [19]. Ecological terminology adopted for parasites is according to Bush *et al.* [20]. Host identification was based on Menezes and Figueiredo [13], and nomenclature and classification were updated according to Froese and Pauly [14]. Type specimens were deposited in the collection of the Museu de Zoologia da Universidade de São Paulo (acronym MZUSP), Brazil.

Order Siphonostomatoida Burmeister, 1835

Family Hatschekiidae Kabata, 1979

Genus *Hatschekia* Poche, 1902

Hatschekia nagasawai n. sp.

Hatschekia sp. of Paschoal *et al.* [12]

Type host: The Porkfish *Anisotremus virginicus* (Linnaeus, 1758) (Perciformes: Haemulidae).

Site on host: Gill filaments.

Type locality: Angra dos Reis (23° 01' 21" S 44° 19' 13" W), State of Rio de Janeiro, Brazil.

Prevalence and intensity: 50% (25 infected fish out of 50 examined); mean of 6.3 copepods per infected fish (range 1–20).

Type material: Holotype female (MZUSP-42555) and nine paratype females (MZUSP-42556).

ZooBank registration: urn:lsid:zoobank.org:pub:A9112F17-667F-46BD-9E69-2205356EE7D5.

Etymology: The new species is named after Prof. Kazuya Nagasawa from Japan, for his contributions to our knowledge of parasitic copepods.

Description (Figs. 1, 2, 3, 4).

Adult Female

Body elongate (Fig. 1A), comprising distinct cephalothoracic head, short neck and long cylindrical trunk; external cuticular layer with grooves. Body length 929–1100 (977 ± 55.2) μm , excluding caudal rami. Cephalothorax forming octagonal to ovoid segment (Fig. 1A, B), shorter than wide 190–200 (194 ± 3.9) \times 210–264 (228 ± 16.2); its dorsal surface bearing chitinous marks resembling horseshoe outline, symmetrically divided in two sides by median longitudinal thick bar, with bifid extremities; each side with pointed process at anterior part and two median transversal slender bars connecting to median thick one; posterior part deep, with middle bar branching towards horseshoe outline (Fig. 1B). Trunk fusiform, longer than wide, 700–864 (759 ± 56.5) \times 203–258 (222 ± 17.1), lacking posterolateral lobes or processes, with anterior narrow and short “neck”;

expanding to maximum width at region slightly posterior to second legs level and gradually narrowing to posterior end; internal tissues separated from cuticle and apparently sheathed with cuticular membrane. Urosome (Fig. 1C) comprising fused genital complex and abdomen, wider than long 46–62 (52 ± 6.2) \times 57–67 (61 ± 4.3). Caudal ramus (Fig. 1D) fused to urosome, longer than wide 16–23 (20 ± 2.5) \times 12–20 (16 ± 2.9), with six naked setae: five distal and one lateral. Egg sacs (Fig. 1E) shorter than trunk, mean of 5.0 eggs per sac, range from three to six eggs per sac ($n=5$).

Rostrum absent. Antennule (Fig. 2A) indistinctly five segmented, 112–150 (134 ± 12.5) long; armature formula: 7, 6, 3, 1, 10+1 aesthetasc; proximal segment bearing two pointed processes (possibly modified setae) on posterior margin (Figs. 2A, 4A). Antenna (Figs. 2B, 4B) with three segments: proximal (coxa) unarmed, mid (basis) ornamented with surface pits and terminal claw large, without armature. Antenna 189–221 (197 ± 13.3) long; lengths of proximal, mid and terminal segments 30–36 (32 ± 2.1), 85–107 (94 ± 7.6) and 65–78 (70 ± 4.5), respectively. Parabasal papilla (Fig. 2B) blunt, thumb-like with annulated surface. Oral cone robust. Mandible (Fig. 2C) styliform,

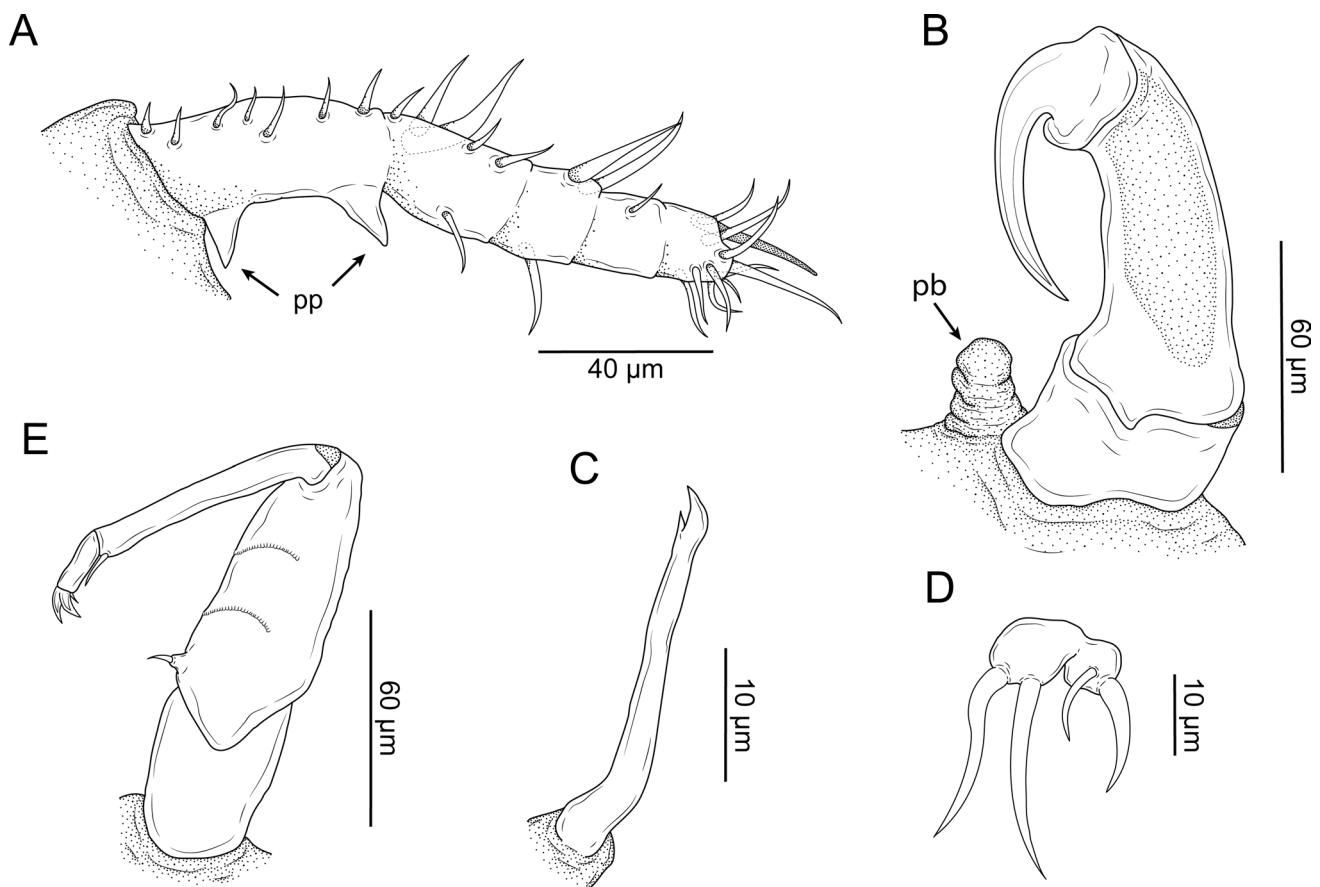


Fig. 2 *Hatschekia nagasawai* n. sp. (adult female). **A** Antennule, dorsal view, pp=pointed process; **B** antenna, ventral view, pb=parabasal papilla; **C** mandible, lateral view; **D** maxillule, ventral view; **E** maxilla, ventral view

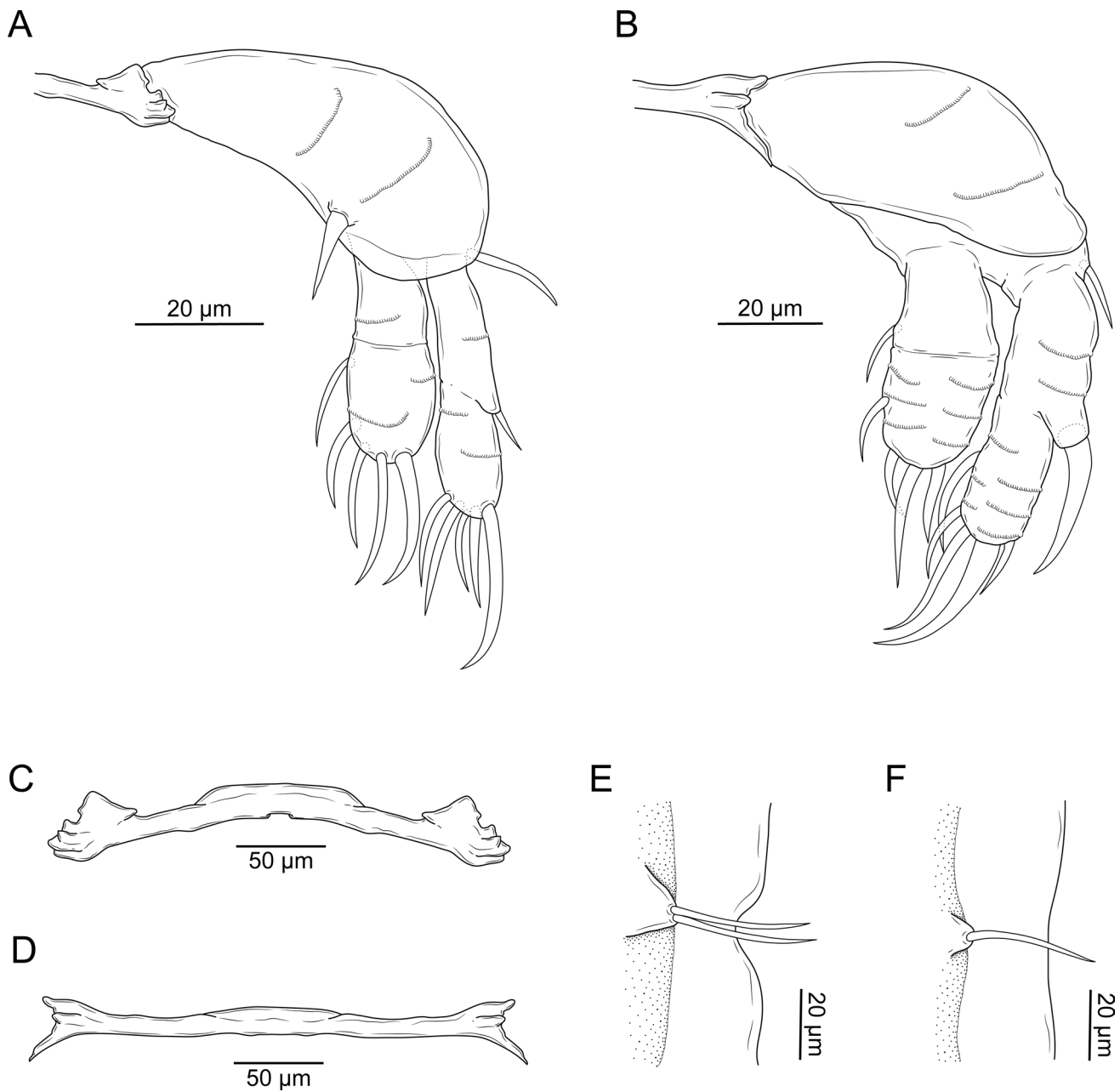


Fig. 3 *Hatschekia nagasawai* n. sp. (adult female). **A** Leg 1, ventral view; **B** leg 2, ventral view; **C** intercoxal sclerite of leg 1, ventral view; **D** intercoxal sclerite of leg 2, ventral view; **E** leg 3, ventral view; **F** leg 4, ventral view

with two sharp teeth. Maxillule (Figs. 2D, 4C) bilobate, both lobes armed with two tapering setae of unequal sizes. Maxilla (Figs. 2E, 4D) with four segments: proximal unarmed; second rod-like with one basal seta and two rows of blunt, fine spinules on anterior surface; third elongate with one distal seta. Terminal segment small, with one short seta and bifid claw. Maxilliped absent.

Legs 1 and 2 biramous, each joined by bar-like intercoxal sclerite. Exopods represented by two incompletely

fused segments and two-segmented endopods. All setae on rami naked and thick. Spine and seta formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1-1	1-0; 5	0-0; 5
Leg 2	1-0	1-0; 5	0-1; 4

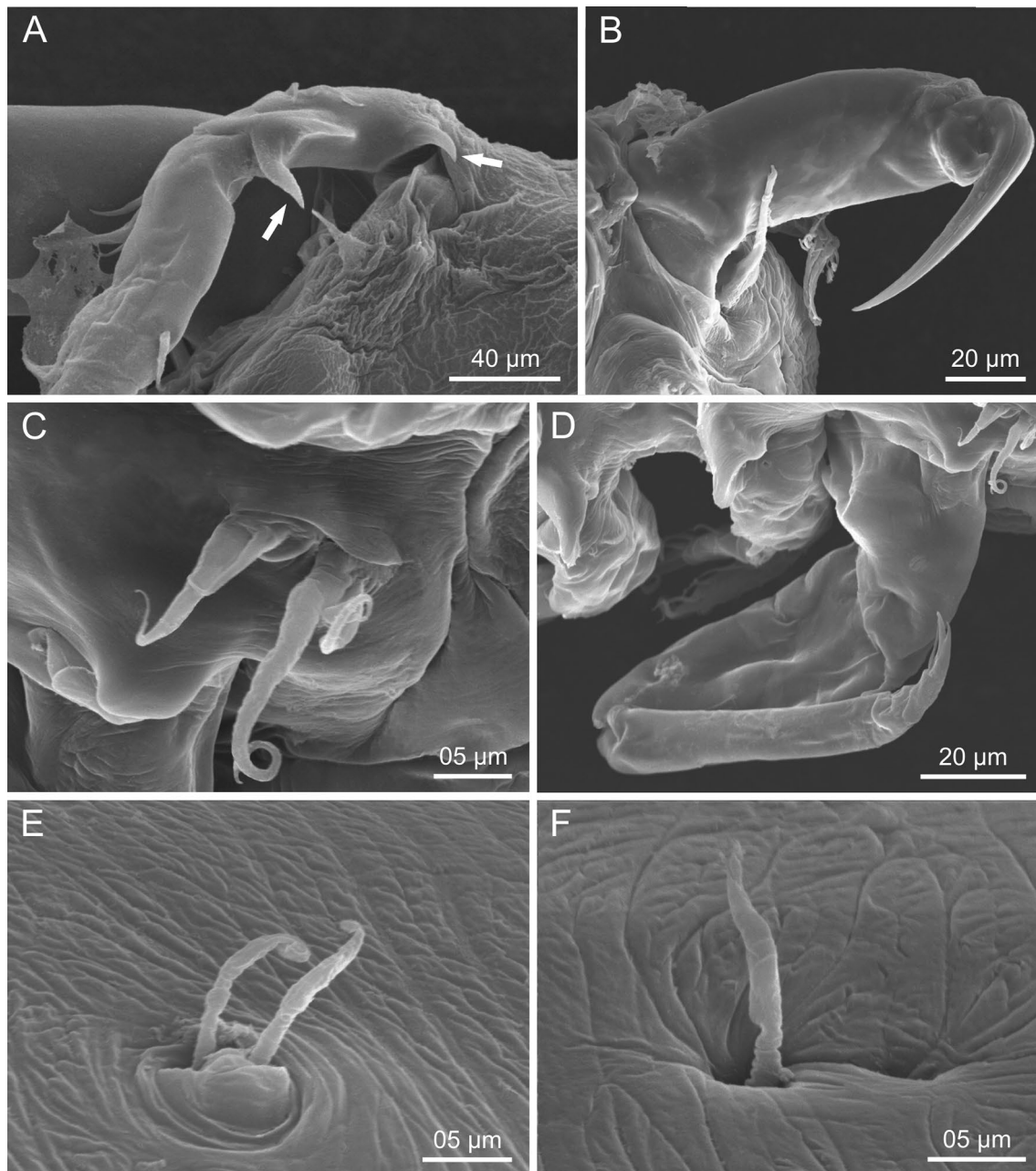


Fig. 4 *Hatschekia nagasawai* n. sp. (adult female), scanning electron micrographs. **A** First antennular segment, dorsal view, arrows indicate the pointed processes; **B** antenna, ventral view; **C** maxillule, ventral view; **D** maxilla, ventral view; **E** leg 3, lateral view; **F** leg 4, lateral view

Leg 1 (Fig. 3A) 80–96 (85 ± 7.3) long, with coxa and basis fused forming large protopod and retaining trace of suture. Protopod 40–56 (50 ± 6.5) long, with large inner seta and slender outer seta. Exopod longer than endopod, 37–41 (39 ± 1.8) and 27–32 (29 ± 2.2) long, respectively. Leg 2 (Fig. 3B) 111–130 (121 ± 8.1) long, with coxa and basis fused to form protopod, retaining trace of suture. Protopod 48–62 (56 ± 4.7) long, with slender basal outer seta. Exopod longer than endopod, 54–63 (57 ± 3.1) and

42–46 (43 ± 1.8) long, respectively. Intercoxal sclerites of legs 1 and 2 (Figs. 3C, D) slender, without processes. Protopods and rami of legs 1 and 2 ornamented with rows of blunt and fine spinules on anterior surface.

Leg 3 (Figs. 3E, 4E) represented by two simple naked setae, located at middle of trunk with slightly swollen base. Leg 4 (Figs. 3F, 4F) represented by small naked seta located at posterior 1/4 of trunk with slightly swollen base.

Adult Male

Unknown

Remarks The adult female specimens examined in the present study were assigned to *Hatschekia* based on the following features: (1) legs 1 and 2 biramous, (2) legs 3 and 4 represented by 1 or more setae and (3) egg-sacs uniseriate [1]. Of the 151 nominal species currently assigned to *Hatschekia*, *H. nagasawai* n. sp. can be clearly differentiated from 143 based on the presence of a pointed processes on the proximal (first) segment of antennule. The remaining eight species namely, *H. balistae* Nuñez-Ruivo, 1954, *H. bodiani* Nuñez-Ruivo, 1954, *H. cluthae* (Scott, 1902), *H. couardi* Nuñez-Ruivo, 1954, *H. gerro* Leigh-Sharpe, 1936, *H. labracis* (van Beneden, 1871), *H. pseudobalistesi* Uyeno & Nagasawa, 2010 and *H. pygmaea* Scott & Scott, 1913, can be easily differentiated from *H. nagasawai* n. sp. by the presence of one pointed process on the proximal segment of the antennule (vs. two in the new species) [4, 21–23]. Details on host and geographic occurrence of the previously mentioned eight species can be found in Table 1.

It should be observed that the absence of lobes in the postero-lateral margins of trunk in the new species is also a characteristic of *H. cluthae* and *H. pygmaea*. However, *H. nagasawai* n. sp. differs from *H. cluthae* by the maxillule with three setae and bifid tip (vs. four setae and bilobate in the new species) and by the presence of a tubercle with subapical conical outgrowth on Leg 3 (vs. lacking in the new species) [22]. Moreover, *H. nagasawai* n. sp. differs from *H. pygmaea* by the segmented neck region (vs. not segmented in the new species) [22].

In addition, the new species differs from *H. balistae* and *H. pseudobalistesi* by the absence of processes on the intercoxal sclerite of legs 1 and 2 [21, 23], as well as from *H. labracis*, *H. couardi* and *H. bodiani* by the cephalothorax

without protrusions [4, 21, 22]. Finally, it differs from *H. gerro* by the postero-lateral margins of trunk not extending beyond the abdomen [4].

Other Species of *Hatschekia* Collected from Actinopterygians off Brazil

Currently, there are more than 200 species of copepods reported parasitizing fish in Brazil, about 93 of them belong to the Order Siphonostomatoida, and the Perciformes is the most studied group of hosts [10, 26–29]. Regarding hatschekiid copepods, only four species are known from fish in Brazil, accounting for 4.3% of the total known siphonostomatoid copepods in the country. Unfortunately, these previous reports of hatschekiid in Brazil were based on non-taxonomic studies [10, 12, 16, 17], which may put the validity of these specific identifications in question. Therefore, in the present study, the material related to the reports of these four hatschekiid species from Brazil was taxonomically verified and the most important remarks are presented as follows:

- *Hatschekia quadrabdominalis* from *Priacanthus arenatus* (Priacanthidae): this copepod was originally described based on specimens from the Redcoat *Sargocentron rubrum* (Forskål) (Holocentriformes, Holocentridae) in China [30]. Subsequently, Jones [4] reported this species on *P. arenatus* from the coast of Venezuela and proposed that *H. curvata* Yamaguti & Yamasu, 1959 should be a synonym of *H. quadrabdominalis* based on the curved trunk, shared by both. Recently, Izawa [8] redescribed *H. curvata* and remarked that the specimens studied by Jones [4] were not conspecific to *H. quadrabdominalis*, since they had an intercoxal bar with prominent triangular processes in both legs 1 and 2, which are absent in

Table 1 Species of *Hatschekia* with a pointed process on the first antennular segment associated with their hosts and geographic occurrence

Copepod species	Host species (family)	Geographic occurrence	References
<i>Hatschekia balistae</i>	<i>Balistes caprisicus</i> Gmelin (Balistidae)	Senegal (unspecified)	[4, 21]
<i>Hatschekia bodiani</i>	<i>Bodianus speciosus</i> (Bowdich) (Labridae)	Senegal (Gorée Island)	[4, 21]
<i>Hatschekia couardi</i>	<i>Gephyroberyx darwini</i> (Johnson) (Trachichthyidae)	Senegal (Dakar)	[4, 21]
<i>Hatschekia cluthae</i>	<i>Ctenolabrus rupestris</i> (Linnaeus); <i>Labrus bergylta</i> Ascanius (Labridae)	Great Britain (British waters)	[4, 22]
	<i>Symphodus rostratus</i> (Bloch) (Labridae)	Greece (Mediterranean Sea)	[4, 24]
<i>Hatschekia gerro</i>	<i>Labrus viridis</i> Linnaeus (Labridae)	Italy (Naples)	[4, 25]
<i>Hatschekia labracis</i>	<i>Labrus bergylta</i> ; <i>Labrus mixtus</i> Linnaeus (Labridae)	Great Britain (British waters)	[4, 22]
	<i>Labrus merula</i> Linnaeus; <i>Symphodus tinca</i> (Linnaeus) (Labridae)	Mediterranean Sea	[4]
<i>Hatschekia nagasawai</i> n. sp.	<i>Anisotremus virginicus</i> (Haemulidae)	Brazil (Rio de Janeiro)	Present study
<i>Hatschekia pseudobalistesi</i>	<i>Pseudobalistes fuscus</i> (Bloch & Schneider) (Balistidae)	Japan (Ryukyu Islands)	[23]
<i>Hatschekia pygmaea</i>	<i>Symphodus melops</i> (Linnaeus); <i>Ctenolabrus rupestris</i> (Labridae)	Great Britain (British waters)	[4, 22]

H. quadrabdominalis and, thus, revalidated *H. curvata* [8, 30]. According to Izawa [8], the material referred to as *H. quadrabdominalis* by Jones [4] is closely related to *H. curvata*, but differences in the intercoxal processes of legs 1 and 2 justified the proposal of a new taxon, namely *H. priacanthis*, to accommodate the specimens studied by Jones [4]. Therefore, only two species of *Hatschekia* are reported from Priacanthidae worldwide: *H. curvata* parasitizing the Glasseye *Heteropriacanthus cruentatus* (Lacepède) in Japan and *H. priacanthis* Izawa, 2016 from *P. arenatus* off Puerto la Cruz, Venezuela [8]. In Brazil, the presence of *H. quadrabdominalis* on *P. arenatus* off the State of Rio de Janeiro was reported by Tavares *et al.* [16], which was a possible taxonomic misidentification, based on the previous discussion. After observation of the specimens studied by Tavares *et al.* [16] (MNRJ15338; MNRJ 15,339), it was possible to conclude that they have curved trunk, intercoxal bar 1 and 2 with prominent triangular processes, and exopod and endopod of leg 1 with 3 + 2 setal elements, and leg 2 with 2 + 2 setal elements. On this evidence, *H. quadrabdominalis* does not occur in Brazil, and the species reported by Tavares *et al.* [16] is *H. priacanthis*.

- *Hatschekia* sp. from *Prionotus punctatus* (Triglidae): of the valid species of *Hatschekia*, only *H. prionoti* Pearse, 1947 was reported parasitizing a Triglidae fish, i.e., the Northern searobin *Prionotus carolinus* (Linnaeus) from North Carolina, USA [4]. Subsequently, Bicudo *et al.* [17] reported the presence of *Hatschekia* sp. on the gills of *P. punctatus* off Rio de Janeiro, Brazil. After analysis of the material studied by Bicudo *et al.* [17] (CHIOC-35358), we concluded that the specimens have an almost circular cephalothorax, trunk cylindrical, genital complex as wide as trunk and antenna with strongly recurved hook. These features are also present in *H. prionoti* [4], suggesting its conspecificity with the specimens found on *P. punctatus*, studied by Bicudo *et al.* [17]. However, the study of additional specimens is necessary to confirm this assertion, since it was not possible to observe some appendages (e.g., antennule; mandible; maxilla; legs) in the present analysis, due to the poor preservation of the deposited material.
- *Hatschekia* sp. from *Cephalopholis fulva* (Serranidae): currently, 17 species of *Hatschekia* have been reported parasitizing serranid fish worldwide [6, 8]. Of these, seven occur in the Atlantic Ocean namely, *H. albirubra* Wilson, 1913 from the Kelp bass *Paralabrax cf. clathratus* (Girard) in West Indies [4, 31]; *H. cadenati* Nuñez-Ruivo, 1954 from the Bluespotted seabass *Cephalopholis taeniops* (Valenciennes) and the Goldblotch grouper *Epinephelus costae* (Steindachner) in Senegal [21]; *H. cernae* Goggio, 1905 from *E. costae*, the White grouper *E. aeneus* (Geoffroy Saint-Hilaire) and the Dusky

grouper *E. marginatus* (Lowe) in the Mediterranean and Angola [4, 32]; *H. delamarei* Nuñez-Ruivo, 1954 from the Mottled grouper *Mycteroperca rubra* (Bloch) in Senegal [21]; *H. insolita* Wilson, 1913 from the Rock hind *E. adscensionis* (Osbeck) and the Black grouper *M. bonaci* (Poey) in Jamaica, Caribbean Islands, Venezuela and USA [4]; *H. petiti* Nuñez-Ruivo, 1954 from *E. aeneus* in Senegal [21]; and *H. uncata* Wilson, 1913 from *E. adscensionis* in West Indies [4, 31]. In Brazil, Luque and Tavares [9] reported *Hatschekia* sp. on the gills of *C. fulva* off Rio de Janeiro. Previously, only *H. cadenati* was reported in *Cephalopholis* serranids in the world. Unfortunately, the material studied by Luque and Tavares [9] in Brazilian could not be assessed since it was not deposited in any collection.

- *Hatschekia* sp. from *Anisotremus virginicus* (Haemulidae): the new species described in the present study was previously reported as *Hatschekia* sp. by Paschoal *et al.* [12], parasitizing the gills of the present type host off Rio de Janeiro, Brazil. This conclusion was achieved after the analysis of the material studied by Paschoal *et al.* [12] (MNRJ-23992), which confirmed its morphological similarity with the new species. Therefore, the specimens deposited by Paschoal *et al.* [12] under accession number MNRJ-23992, at the Museu Nacional do Rio de Janeiro, Brazil, should be considered vouchers of *H. nagasawai* n. sp.

Discussion

The discovery of *H. nagasawai* n. sp. on *A. virginicus* represents the second report of a *Hatschekia* species parasitizing fish belonging to Haemulidae. In this sense, only the congener *Hatschekia linearis* Wilson, 1913 has been reported on gill filaments of the following haemulid fish: the barred grunt *Conodon nobilis* (Linnaeus), the white margate *Haemulon album* Cuvier, the Tomtate grunt *Haemulon aurolineatum* Cuvier, the bluestriped grunt *Haemulon sciurus* (Shaw) and the white grunt *Haemulon plumierii* (Lacepède), all from the Caribbean Sea [4, 12]. According to Jones [4], *H. linearis* has a unique combination of features that separate it from all congeners (obviously including *H. nagasawai* n. sp.). This combination consists of the following characteristics: (1) trunk seven to nine times long than the cephalothorax, narrowing anteriorly to form a neck; (2) bases of legs 1 and 2 swollen laterally and exceeding the trunk margins; and (3) lack of lobes on the postero-lateral trunk margins. Suárez-Morales *et al.* [33] also reported *Hatschekia* parasitizing the gills of *Haemulon sciurus* and *Haemulon plumierii* in the Mexican Caribbean, but the report refers to unidentified species. Even though only few species of *Hatschekia* have been reported as parasites of haemulid

fish, the real biodiversity of such copepods on the referred host taxa would probably be much higher, since Haemulidae represents one of the most diverse families within the Perciformes [34] and the present findings now include the genus *Anisotremus* as potential host for these parasites. In fact, the efforts related to taxonomic studies on *Hatschekia* parasitizing haemulids are still underdeveloped, contributing to the previously depicted scenario.

According to Lee *et al.* [6], some species of *Hatschekia* remain poorly described, mainly as a consequence of featureless bodies and small vestigial appendages. However, a series of interspecific differences that is useful for taxonomic diagnosis have been found in these small appendages, e.g., segmentation and armature formula of antennule, presence/absence of parabasal papilla, ornamentation of mandible and maxillule, as well as structure and ornamentation of legs [4, 6, 35]. In addition to these morphological features, the morphometry of female body and of some appendages are strongly recommended to be used in *Hatschekia* spp. descriptions [2, 6, 19, 35]. In the present study, it was observed that the presence of one or two setal elements modified as pointed processes, on the proximal segment of the antennule, was shared by only eight *Hatschekia* congeners (see Table 1), reiterating the taxonomic importance of these small appendages within the genus, as well as the need of descriptions including these minute details.

Most of the *Hatschekia* spp. are reported in the North Pacific Ocean and, according to Uyeno and Nagasawa [36], this taxon achieves high biodiversity in Japanese waters, where 37% of the total known species occur. The Japanese Archipelago, located in East Asia, is surrounded by four sea regions (Northwestern Pacific Ocean, East China Sea, Sea of Japan, and Sea of Okhotsk) extending over an area of 3,000 km [37], and supporting 3,875 species of fish [14]. Such high biodiversity of potential hosts well justifies the also high species richness of *Hatschekia* along the Japanese marine territory, as asserted by Uyeno and Nagasawa [36]. In contrast, in the Atlantic coast of South America that includes Brazil, Argentina and Uruguay extends for more than 10,000 km and supports 2,184 species of fish [14], only 5 species of *Hatschekia* have been reported, accounting for only 3.3% of the global generic diversity. These data emphasize that much more effort should be directed to the study of fish-parasitic copepods in South Atlantic, since the biodiversity of hatschekiids in this area is still neglected and most likely higher than that currently known.

Acknowledgements We are thankful to Dra. Cristiana Serejo and Dra. Irene Cardoso, Curators at the Museu Nacional do Rio de Janeiro, Brazil, and Dr. Marcelo Knoff, Curator at the Coleção Helmintológica do Instituto Oswaldo Cruz, Brazil, for lending vouchers of *Hatschekia* spp. Thanks are also due to Dr. Daysuke Uyeno from Kagoshima University, Japan, for providing literature. Fabiano Paschoal was supported by Universidade Castelo Branco Rio de Janeiro (Brazil). José L. Luque

was supported by a research fellowship from the Conselho Nacional de Desenvolvimento Científico e Tecnológico do Brazil (CNPq).

Funding No funding was received for conducting this study.

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. The authors declare that the animals used in the work were acquired dead in fish markets and there is no need for approval by the Research Ethics Committee.

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