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A new species of philichthyid copepod (Crustacea: Cyclopoida) parasitic on *Stellifer* spp. (Perciformes: Sciaenidae) from southeastern Brazil

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Abstract

A new species of copepod, *Colobomatus stelliferi* n. sp., belonging to the cyclopoid family Philichthyidae Vogt, 1877 is proposed based on female specimens collected from the mandibular canals of three species of sciaenid teleosts: *Stellifer brasiliensis* (Schultz) (type-host), *S. rastrifer* (Jordan) and *S. stellifer* (Bloch), collected in Caraguatubá Bay, State of São Paulo, Brazil. The new species can be distinguished from its closest congeners by the absence of lateral processes in the genital somite, the presence of one cephalic process in the cephalosome and one pair of dorso-lateral processes on the fused pedigerous somites. This is the first species of *Colobomatus* Hesse, 1873 described as parasites of species of the teleost genus *Stellifer*.

Key words: Copepoda, Philichthyidae, *Colobomatus*, marine fish, Actinopterygii, Neotropical region

Introduction

The cyclopoid family Philichthyidae Vogt, 1877 comprises highly modified and internal parasitic species, which are generally recorded in subcutaneous spaces associated with the sensory canals of the lateral line and skull bones of marine actinopterygians (Boxshall & Halsey 2004; Madinabeitia *et al.* 2013). This family comprises approximately 87 species belonging to nine genera: *Colobomatoides* Essafi & Raibaut, 1980; *Colobomatus* Hesse, 1873; *Ichthyotaces* Shiino, 1932; *Leposphilus* Hesse, 1866; *Lernaeascus* Claus, 1886; *Philichthys* Steenstrup, 1862; *Procolobomatus* Castro-Romero, 1994; *Sarcotaces* Olsson, 1872; and *Sphaerifer* Richiardi, 1874. *Colobomatus* is the most speciose genus with 70 valid species, followed by *Sarcotaces*, *Procolobomatus* and *Sphaerifer* with 7, 3 and 2 species, respectively (Walter & Boxshall 2014).

In the southeastern Atlantic, only three species of philichthyid copepods belonging to *Colobomatus* have been hitherto recorded, *C. belizensis* Cressey & Schotte, 1983 parasitizing *Haemulon steindachneri* (Jordan & Gilbert) and *Orthopristis ruber* (Cuvier), *C. sudatlanticus* Pereira, Timi, Lanfranchi & Luque, 2012 parasitizing *Mullus argentinae* (Hubbs & Marini), and an unidentified species found in the gills of *Micropogonias furnieri* (Quoy & Gaimard) (Luque & Tavares 2007; Pereira *et al.* 2012).

During a population study of sciaenid fishes from the coastal zone of the State of São Paulo, southwestern Atlantic, several philichthyid copepods were recovered. A detailed morphological study of these specimens, based on light and scanning electron microscopy (SEM), revealed that they represent a new species of *Colobomatus* that is described herein.

Material and methods

Philichthyid specimen samples were collected from the mandibular canals of sciaenid *Stellifer* spp., caught in Caraguatubá Bay (23° 37'–23° 44'S; 45° 24'–45° 26'W), State of São Paulo, Southeastern Brazilian coast. The copepods collected were fixed and preserved in 70% ethanol. For microscopic observation, specimens were cleared in 85% lactic acid and the appendages were dissected and examined following the wooden slide technique by Humes & Gooding (1964). For SEM analysis, specimens were critical point dried with CO₂ (Balzers CPD030) and sputter-coated with gold 50 mA for 300 s (Balzers SD050); scanning and photographs were performed using a Zeiss DSM 940™ SEM. Measurements are indicated in micrometers (μm) unless otherwise stated and the average values are followed by the range in parentheses. The descriptive terminology follows Boxshall & Halsey (2004). The common and scientific names of host fishes follow Froese & Pauly (2014). The term prevalence was used according to Bush *et al.* (1997). The holotype and some paratypes were deposited in the Museum of Zoology of the University of São Paulo (MZUSP), Brazil, and other paratype specimens are in the Crustacea Collection of the National Museum of Rio de Janeiro (MNRJ), Brazil.

Order Cyclopoida Burmeister, 1835

Family Philichthyidae Vogt, 1877

Genus *Colobomatus* Hesse, 1873

Colobomatus stelliferi n. sp.

Figs 1–4

Material examined. Holotype female from *S. brasiliensis* (type-host) (MZUSP-32619) collected by A. Turra, April 2004; 3 female paratypes from *S. rastrifer* (MZUSP-32620) collected by A. Turra, April 2004; and 3 female paratypes (MNRJ-25206) from *S. stellifer* collected by A. Turra, April 2004. Additional material: 22 specimens females from the Brazilian stardrum *Stellifer brasiliensis* (357 necropsied individuals); 47 specimens females from the rake stardrum *S. rastrifer* (2,852 necropsied individuals); and six specimens females from the little croaker *S. stellifer* (116 necropsied individuals). These additional specimens are kept in the collection of the senior author.

Type-locality. Caraguatubá Bay, State of São Paulo, Southeastern Brazilian coast (23° 37' to 23° 44'S and 45° 24' to 45° 26'W).

Attachment site. Mandibular canals (figs. 4A, B).

Description of adult female. Based on 10 females, all measured. Body elongate (Figs. 1A, 2A, 4B), 3.31 mm (2.94–3.81) long. Pre-oral area of cephalosome (Fig. 2B) bearing one anterior, elongated process 264 μm (244–308) long and 231 μm (196–317) wide. Cephalosome trapezoidal (Figs 1A, 2A), wider than long, 412 μm (360–507) long and 563 μm (453–710) wide, and apparently larger in posterior margin. First to fourth pedigerous somites fused, octagonal to ovoid shaped 1.01 mm (0.88–1.22) long, representing about 30% of total body length, and 826 μm (583–990) wide, excluding dorso-lateral processes; bearing one pair of dorso-lateral processes (Figs. 1A, 2A,C) located at slightly above central region. Pair of dorso-lateral processes subequally long, right process 709 μm (521–912) long, left dorso-lateral process 708 μm (517–920) long. First to fourth pairs of legs inserted in ventro-lateral position of fused somites. Fifth pedigerous somite shorter than wide, 293 μm (224–350) long and 450 μm (240–554) wide. Genital somite (Figs. 1A, 3I) ovoid, 305 μm (230–385) long, 446 μm (340–498) wide, with pair of lateral genital orifices. Egg-sacs (Fig. 4B) attached near genital orifice, 788 μm (490–920) long ($n=4$). Abdomen four-segmented. Two first abdominal somites hexagonal, first somite 253 μm (220–291) long, 378 μm (264–495) wide; second somite 251 μm (210–280) long and 432 μm (354–543) wide. Third abdominal somite (Fig. 2D) with two robust lateral processes, similar to each other in size, right process 828 μm (694–946), left process 826 μm (698–940) long, longer than somite proper. Last abdominal somite short and gradually tapering towards caudal rami. Caudal ramus (Figs. 1A, 2D) 573 μm (457–730) long and 270 μm (248–289) wide, with two rounded lobes bearing 4 distal caudal setae (Fig. 2E).

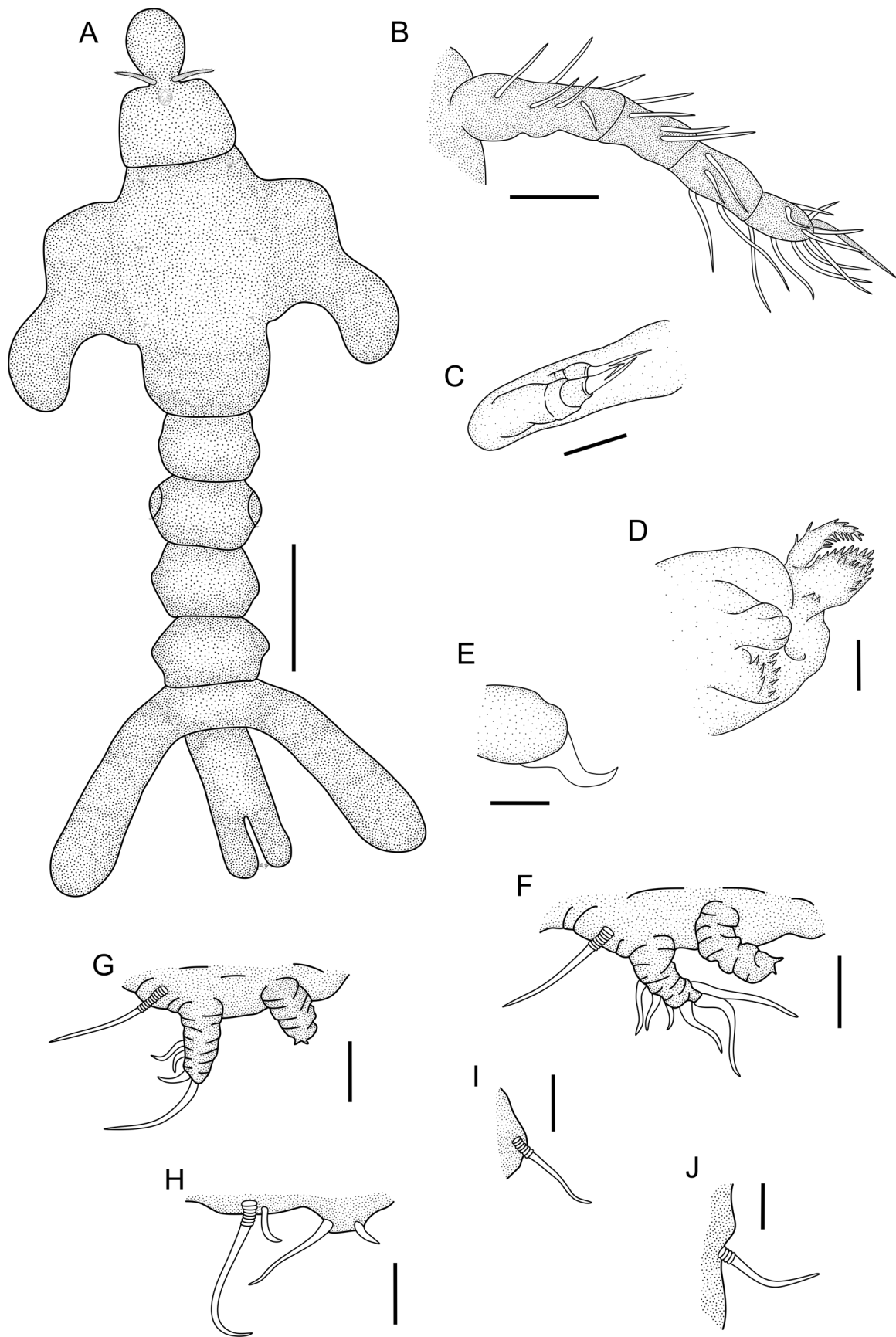


FIGURE 1. *Colobomatus stelliferi* n. sp. (female, ventral view). A, Habitus; B, Antennule; C, maxillule; D, maxilla; E, maxilliped; F, Leg 1; G, Leg 2; H, Leg 3; I, Leg 4; J, Leg 6. Scale bars: A, 500 μm ; B, 20 μm ; C–E and J, 5 μm ; F–H and I, 10 μm .

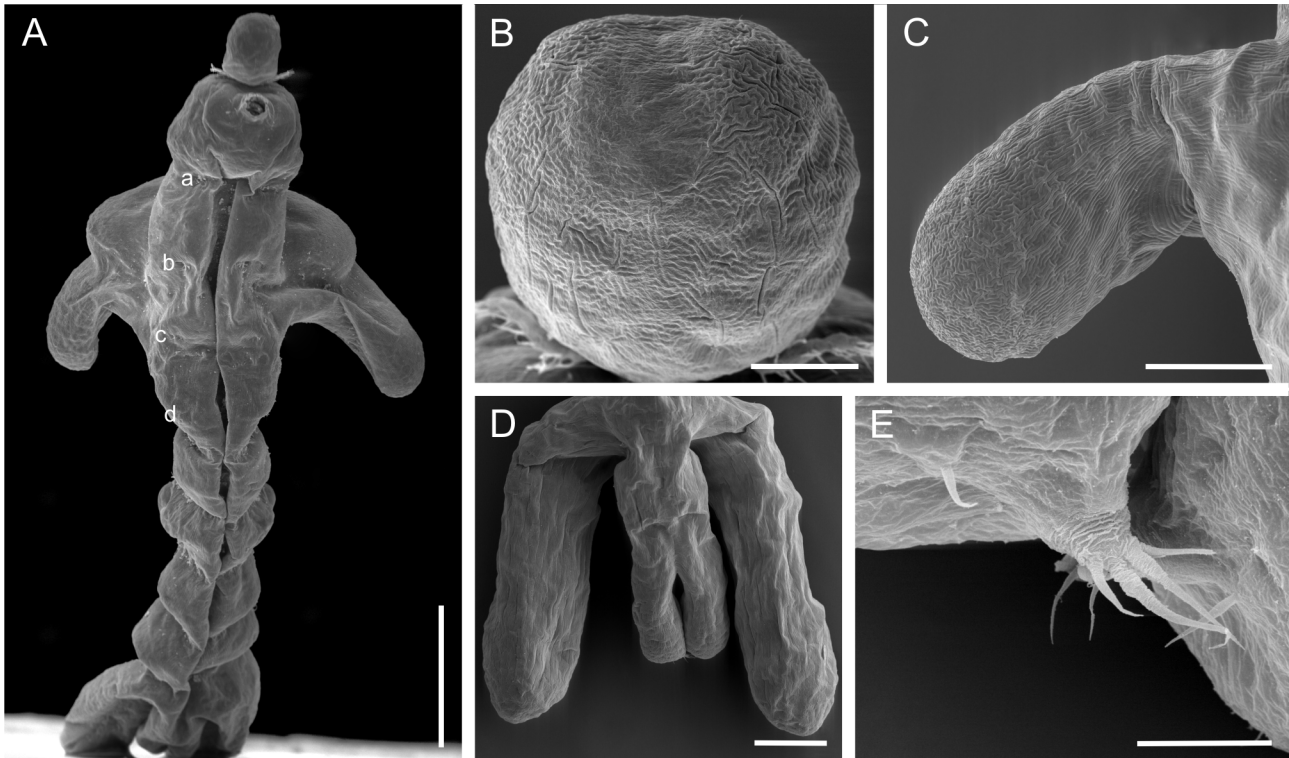


FIGURE 2. *Colobomatus stelliferi* n. sp. (female, ventral view). A, Habitus and distribution of legs in the fused pedigerous somites: Leg 1 (a), Leg 2 (b), Leg 3 (c) and Leg 4 (d); B, Cephalic processes; C, Detail of thoracic process; D, Detail of third and fourth abdominal somites and caudal rami; E, armature elements of the caudal rami. Scale bars: A, 500 μm ; B, 50 μm ; C and D, 200 μm ; E, 20 μm .

Antennule (Figs. 1B, 3A) apparently four-segmented, with armature formula 6, 4, 4 and 10 + 1 aesthetasc; all antennular setae naked. Oral area forming tube-like structure covered anteriorly by antennae and formed posteriorly by a simple, undivided labium. Antennae (Fig. 3B) modified, covering anterior region of siphon-like oral area. Labrum not seen. Maxillule (Figs. 1C, 3C) 1-segmented, located mid-laterally in oral area, with two apical spines. Maxilla (Figs. 1D, 3D) two-segmented, basal segment with two circular rows of spinules and one apical spine; distal segment ornamented with row of spinules and two distal spinules. Maxilliped (Figs. 1E, 3D) with naked basal segment and one distal spine.

Legs 1 and 2 inserted in rugose area. Leg 1 (Figs. 1F, 2A, 3E) biramous, located immediately posterior to junction of cephalosome and fused somites, protopod carrying 1 lateral seta irregularly annulated at base, apparently unsegmented unarmed endopod (vestigial) and indistinctly 2-segmented exopod, armed with 3 proximal-lateral and 3 distal setae. Leg 2 (Figs. 1G, 2A, 3F) biramous, located below the anterior leg, apparently in the second part of the fused somites, with protopod carrying 1 lateral seta irregularly annulated at base, apparently unsegmented unarmed endopod (vestigial) and indistinctly 2-segmented exopod, armed with 2 proximal lateral and 2 distal setae. Leg 3 (Figs. 1H, 2A, 3G), located apparently in the third part of the fused somites, and reduced to 4 setae of different size, largest seta with irregularly annulated at base. Leg 4 (Figs. 1I, 2A, 3H) reduced, located in the last part of the fused somites, and represented by single seta with irregularly annulated at base. Leg 5 absent. Leg 6 (Fig. 1J) near genital apertures, represented by minor seta.

Male: Unknown.

Etymology. The specific name refers to type-host of the species.

Prevalence. 60% in *S. brasiliensis*, 16% in *S. rastrifer*, and 7% in *S. stellifer*.

Remarks. Together with the Chondracanthidae Milne Edwards, 1840 and Shiinoidae Cressey, 1975, the Philichthyidae can be included within a group of families, characterized by the reduction of legs 4 and 5 and by the presence of 1 and 2 geniculate claws respectively on the second and third endopodal segments of the antenna in the first copepodid stage (Boxshall & Halsey 2004). However, philichthyids can be separated based on the body shape in the adult female, it can be elongate, flattened or highly irregular with numerous processes and also philichthyid

species dwell in mucous ducts of the host or form pouches in the body wall or viscera (Boxshall & Montú 1997). According to Boxshall & Halsey (2004), this family can be divided into two groups of genera: with a body bearing at least 1 pair of lateral processes (*Colobomatoides*, *Colobomatus*, *Philichthys*, *Procolobomatus*, *Sphaerifer* and *Ichtyotaces*) or forms without lateral processes on the body (*Lephosphilus*, *Lernaeascus* and *Sarcotaces*).

Currently, the genus *Colobomatus* is considered to show the highest morphological diversity and is the most speciose genus with 70 species recorded, parasitizing a wide range of perciform teleosts, but also some species of Anguilliformes, Myctophiformes, Characiformes, Beloniformes, Scorpaeniformes, and one species is known from an elasmobranch species of Lamniformes (Grabda & Linkowski 1978; West 1992; Hayward 1996; Madinabeitia *et al.* 2012).

Three species of *Colobomatus* have a single cephalic process only: *C. belizensis* from *Haemulon* spp. and *Orthopristis* spp. in the Neotropical Region, *C. muranae* (Richiardi, 1877) from *Muraena helena* Linnaeus in the Palearctic Region, and *C. springeri* Cressey, 1977 from *Cryptotrema corallinum* Gilbert in the Nearctic Region (Cressey 1977; Cressey & Schotte 1983; Walter & Boxshall 2014). The above mentioned species can be easily separated from *C. stelliferi* n. sp. by the possession of two pairs of dorso-lateral processes on the fused pedigerous somites and the presence of lateral processes in the genital somite, whereas the new species possesses one pair of dorso-lateral processes on the fused pedigerous somites and lateral processes are absent in the genital somite.

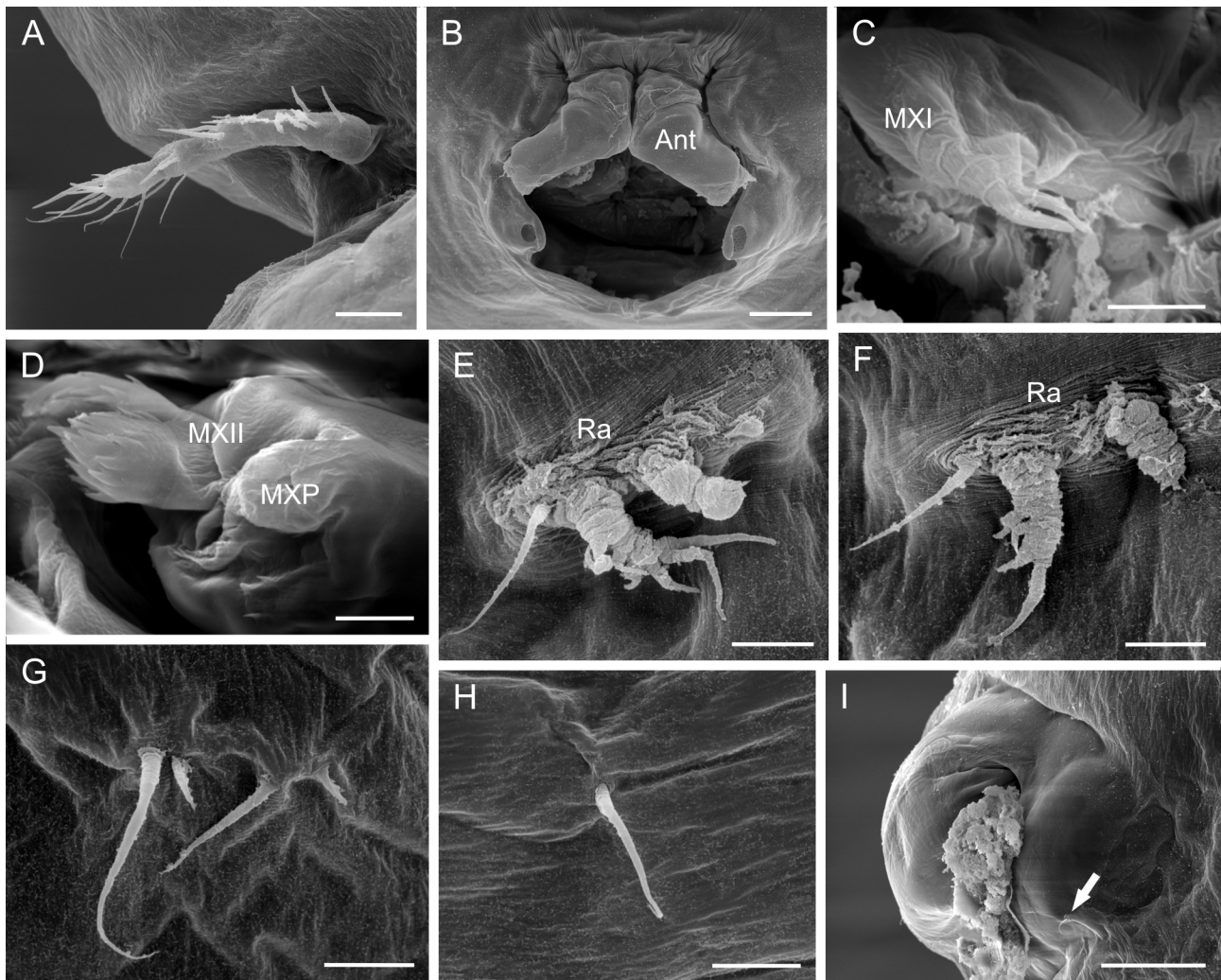


FIGURE 3. *Colobomatus stelliferi* n. sp. (female, ventral view). A, Antennule; B, Buccal area: detail of antenna (Ant); C, Detail of maxillule (MXI); D, Oral appendages: detail of maxilla (MXII) and maxilliped (MXP); E, Leg 1: detail of rugose area (Ra); F, Leg 2: detail of rugose area (Ra); G, Leg 3; H, Leg 4; I, Genital orifices: arrow showing the base of leg 6 (broken). Scale bars: A, B and E, 20 μ m; C and D, 5 μ m; F, G and H, 10 μ m; I, 40 μ m.

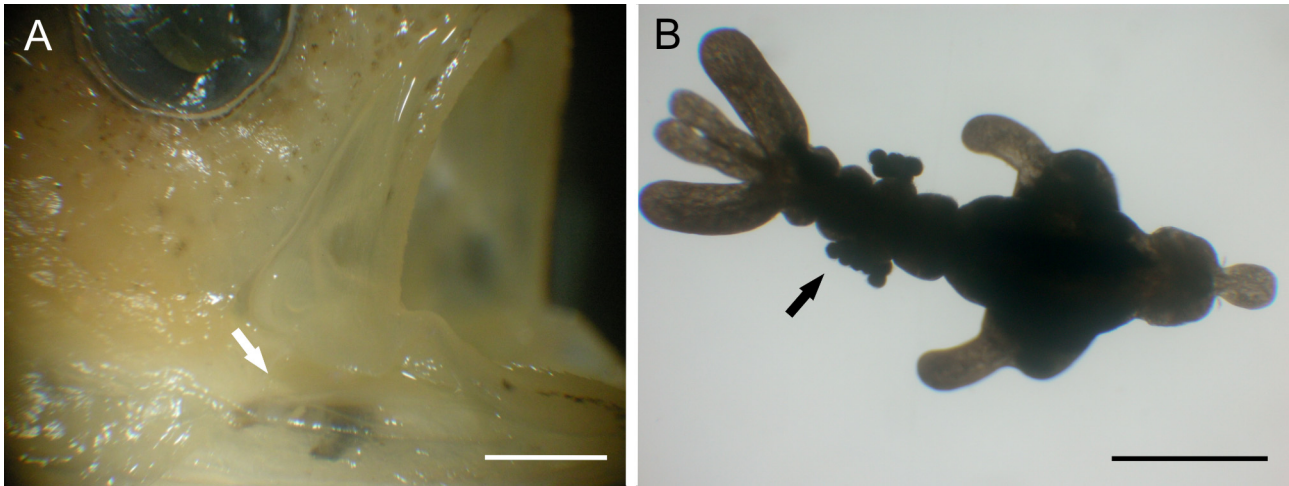


FIGURE 4. *Colobomatus stelliferi* n. sp. (female). A, Infection by female specimen in the mandibular canals; arrow showing the specimen; B, Specimen withdrawn, ventral view; arrow showing the egg-sacs. Scale bars: A, 2 mm; B, 3 mm.

At present only *C. mackayi* West, 1992 from *Pomadasyus striatus* (Gilchrist & Thompson) in the Oriental Region has been reported to possess one pair of dorso-lateral processes on the fused pedigerous somites. *C. stelliferi* n. sp. is differentiated from *C. mackayi* by having the following features: (1) a single elongated cephalic process (two simple cephalic processes with sharp tips in *C. mackayi*); (2) First to fourth pedigerous somites fused (second to fourth pedigerous somites fused in *C. mackayi*); (3) absence of lateral processes in the genital somite (presence of small circular lateral processes in the genital somite of *C. mackayi*); and (4) presence of lateral processes in the third abdominal somite (absent in *C. mackayi*) (West 1992).

The eight congeners that most resemble the new species are those with an absence of lateral processes in the genital somite, namely, *C. arabicus* Hayward, 1996 from *Sillago* spp. in the Palearctic Region; *C. asiaticus* Hayward, 1996 from *Sillago* spp. in the Oriental Region; *C. bergyltae* Hesse, 1873 from *Labrus bergylta* Ascanius in the Palearctic Region; *C. caribbei* Cressey & Schotte, 1983 from *Anisotremus surinamensis* (Bloch) in the Neotropical Region; *C. cribbi* West, 1992 from *Scolopsis taenioptera* (Cuvier) in the Australian Region; *C. pagelli* (Richiardi, 1877) from *Pagellus* spp. and *Lithognathus mormyrus* (Linnaeus) in the Palearctic Region; *C. quadrifarius* Cressey & Schotte, 1983 from *Anisotremus* spp., *Haemulon* spp. and *Orthopristsis* spp. in the Nearctic and Neotropical Regions; and *C. sieboldi* (Richiardi, 1877) from *Boops boops* (Linnaeus) in the Palearctic Region (Cressey & Schotte 1983; West 1992; Hayward 1996; Walter & Boxshall 2014). *Colobomatus stelliferi* n. sp. can be readily distinguished from all eight above mentioned congeners by the presence of a single cephalic process in the cephalosome and one pair of dorso-lateral processes on the fused pedigerous somites. Each of the other eight species possesses two cephalic processes in the cephalosome and two pairs of dorso-lateral processes on the fused pedigerous somites (Yamaguti 1963; Cressey & Schotte 1983; West 1992; Hayward 1996).

The majority of species of *Colobomatus* are parasites of perciforms fishes and three species have been recorded from sciaenid fishes. These species are *C. orientalis* Kim & Moon, 2013 from *Johnius grypotus* (Richardson); *C. sciaenae* (Richiardi, 1876) from *Argyrosomus regius* (Asso) and *Sciaena umbra* Linnaeus, both in the Palearctic Region; and *Colobomatus* sp. from *Micropogonias furnieri* in the Neotropical Region. The findings of this study reaffirming the status of sciaenid fishes as hosts for the genus *Colobomatus* and extend the host range to include members of genus *Stellifer*. However the family Sciaenidae are distributed in the Atlantic, Indian and Pacific oceans and possess an elevated number of species, approximately 283 spp. distributed in 66 genera, which probably indicate gaps in the real diversity of parasite copepods of the family Philichthyidae in these host group.

According to Grabda (1991) species of the genus *Colobomatus* possess highly specific by a single host species. However, based on the limited Grabda's data, Hayward (1996) proposed that most species are specific to genera or families host rather than to a single species. Recently, Madinabeitia *et al.* (2013) commented on the host-specificity of *C. pupa* Izawa, 1974 by members of the genus *Parupeneus* (i.e. *P. spilurus* (Bleeker), *P. ciliatus* (Lacépède) and *P. multifasciatus* (Quoy & Gaimard)). Consequently, we support Hayward's hypothesis of *Colobomatus* spp.

exhibiting a high host-specificity at the genus level, *C. stelliferi* n. sp. is probably specific to members of the genus *Stellifer* (i.e. *S. brasiliensis*, *S. rastrifer* and *S. stellifer*).

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