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A new species of *Procolobomatus* Castro Romero, 1994 (Copepoda: Philichthyidae) endoparasitic in a deepwater longtail red snapper (Actinopterygii: Lutjanidae) off Ishigaki Island, Japan, with records of philichthyid copepods reported from Asian waters

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Abstract A new species of the Philichthyidae Vogt, 1877 (Copepoda: Poecilostomatoida), *Procolobomatus hoi* n. sp., is described based on adult female specimens recovered from the cephalic sensory canals of *Etelis coruscans* Valenciennes (Actinopterygii: Lutjanidae) caught off Ishigaki Island, the Ryukyu Islands, southern Japan. The new species differs from its congeners by having the following combination of characters: a long medial cephalic lobe about one-third the length of the body; an armature of five spines on the distal exopodal segment of leg 2; one long apical seta on the papillose leg 4; a caudal ramus armed with one medial and four terminal setae (two middle setae are inflated); and spinulose ornamentation covering the body. *Procolobomatus hoi* n. sp. is the first member of the genus reported from the western Pacific Ocean and from a host of the family Lutjanidae. Previous records of philichthyid copepods from Asian waters are also reported.

Introduction

Members of the family Philichthyidae Vogt, 1877 (Copepoda: Poecilostomatoida) are highly modified endoparasitic copepods, which occupy spaces associated with the sensory canals of the lateral line and skull bones of marine actinopterygian fishes (West, 1992). Currently, the family comprises about 79 species belonging to nine genera: *Colobomatoides* Essafi & Raibaut, 1980; *Colobomatus* Hesse, 1873; *Ichthyotaces* Shiino, 1932; *Leposphilus* Hesse, 1866; *Lernaescus* Claus, 1886; *Philichthys* Steenstrup, 1862; *Procolobomatus* Castro Romero, 1994; *Sarcotaces* Olsson, 1872; and *Sphaerifer* Richardi, 1874 (Castro Romero, 1994; Walter & Boxshall, 2010). Of the nine genera, *Procolobomatus* is the most recently erected genus, and its members resemble species of *Colobomatus*. However, females of *Procolobomatus* can be differentiated from those of *Colobomatus* by the possession of more primitive characters, i.e. a pair of unmodified antennae, a buccal apparatus typical of the Poecilostomatoida, three pairs of biramous legs and a vestigial or absent leg 4 (Castro Romero, 1994).

To date, there are only two reports of *Procolobomatus*, both from the eastern Pacific Ocean: *P. kyphosus* (Sekerak, 1970) collected from the cephalic sensory canals of *Sebastes alutus* (Gilbert) [as *Sebastodes alutus*] (Sebastidae) caught off Vancouver Island, British Columbia, Canada (Sekerak, 1970); and *P. hemilutjani* Castro Romero, 1994 collected from the mandibular canals of *Hemilutjanus macrophthalmos*

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(Tschudi) [as *H. macrophtalmus*] (Serranidae) captured in the coastal waters of Antofagasta, Chile (Castro Romero, 1994).

This study provides a detailed description of a new species of *Procolobomatus* based on adult females recovered from the cephalic sensory canals of a lutjanid finfish species caught off Ishigaki Island, the Ryukyu Islands, southern Japan. This finding constitutes the first record of a species of *Procolobomatus* from the western Pacific Ocean and the first report of a member of this genus parasitic in finfishes of the family Lutjanidae. In addition, previous records of philichthyid copepods from Asian waters are included herein.

Materials and methods

Procolobomatus samples were collected from the cephalic sensory canals of a deepwater longtail red snapper *Etelis coruscans* Valenciennes caught off Ishigaki Island, the Ryukyu Islands, southern Japan. Philichthyid copepods were recovered from the above host by applying double-netting (Madinabeitia & Nagasawa, 2012) to dissected head washings. Collected copepods were preserved in 70% ethanol and cleared in a drop of 85% lactic acid or lactophenol prior to examination using a microscope with phase contrast. Selected specimens were measured intact using an ocular micrometer and/or dissected and examined according to the wooden slide procedure of Humes & Gooding (1964). Measurements given are the mean followed by the range in parentheses. Drawings were made with the aid of a drawing tube. The descriptive terminology follows Boxshall & Halsey (2004). The common and scientific names of host fishes follow Froese & Pauly (2012). Voucher specimens are deposited at the National Museum of Nature and Science, Tokyo (NSMT), Japan.

Family Philichthyidae Vogt, 1877

Genus *Procolobomatus* Castro Romero, 1994

Procolobomatus hoi n. sp.

Type-host: *Etelis coruscans* Valenciennes (Lutjanidae).

Type-locality: Western North Pacific Ocean, off Ishigaki Island, the Ryukyu Islands, southern Japan.

Type-material: Holotype female (NSMT-Cr 22170) and 2 paratype females (NSMT-Cr 22171) from one *E. coruscans* (standard length = 29.5 cm) caught on 23 October, 2011 off Ishigaki Island and subsequently purchased at Yaeyama Fisheries Cooperative on Ishigaki Island.

Site of infection: Interorbital canals associated with the lateral line system.

Prevalence: Not determined

Intensity: Three copepods per host.

Etymology: The specific name is for Prof. Ju-shey Ho in recognition of his numerous contributions on symbiotic copepods.

Description

Adult female (Figs. 1, 2)

Body 7.54 (7.35–7.75) mm long (including anteromedian cephalic process, but excluding caudal rami) and 1.18 (1.16–1.21) wide (n = 3) (Fig. 1A,B). Pre-oral area of cephalosome (Fig. 1A,B) carrying 1 median and 2 ventrolateral processes on anterior region; median process long, about 1/3 length of body, and tapering toward apical end; ventrolateral processes about 1/3 length of median process, blunt and anterolaterally directed. Cephalosome widest posteriorly and demarcated from body by slight transverse constriction. First to fourth pedigerous somites fused to form cylindrical trunk, slightly swollen at mid-length and with 2 pairs of blunt, posterolaterally directed processes; anterior pair of processes robust, arising from dorsomedian surface; posterior pair of processes slightly shorter than anterior pair, arising from ventromedian surface. First to fourth pairs of legs located ventrolaterally. Fifth pedigerous somite narrower posteriorly. Genital somite (Fig. 1A,B) bearing pair of lateral swellings with acuminate processes (Fig. 1C) and single spine (Fig. 1D). Abdomen (Fig. 1A,B) 3-segmented and gradually tapering towards caudal rami. Caudal ramus (Fig. 1A,B) fused to last abdominal somite, slender, and tapering to rounded tip. Tip of caudal ramus (Fig. 1E) bearing 4 apical, naked setae (2 middle setae inflated) and 1 medial naked seta. Body (including processes and caudal rami) covered with spinulose ornamentation (Fig. 1F).

Antennule (Fig. 1G) laterally directed, situated posterior to base of anteromedian cephalic process, apparently 7-segmented, with armature formula 1, 8,

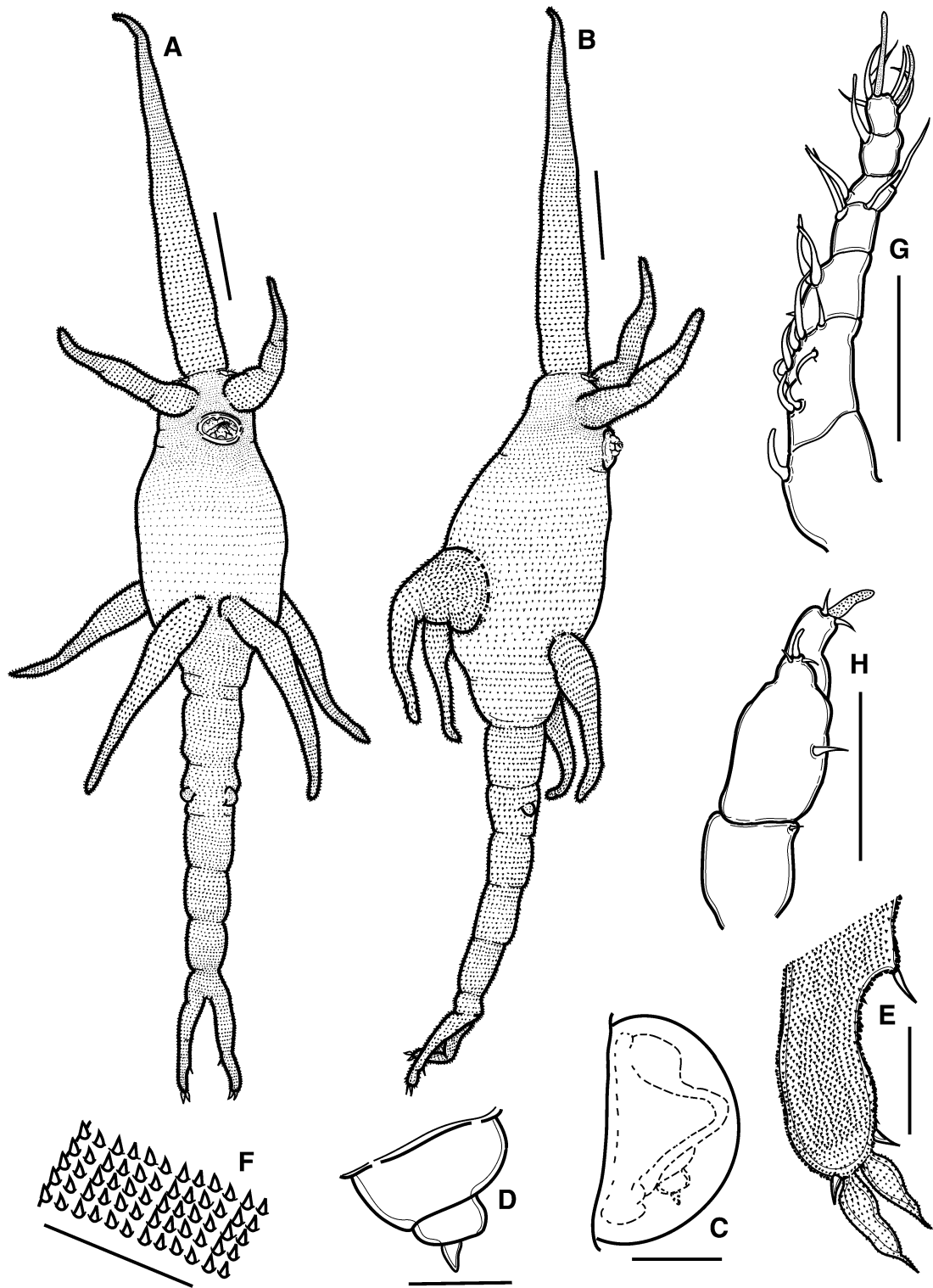


Fig. 1 *Procolobomatus hoi* n. sp., adult female. A, habitus, ventral; B, habitus, lateral; C, genital process, ventral; D, genital spine, ventral; E, tip of caudal ramus, ventral; F, spinulose ornamentation on body; G, antennule, ventral; H, antenna, ventral. Scale-bars: A,B, 700 µm; C, 200 µm; D,F,G, 100 µm; E,H, 50 µm

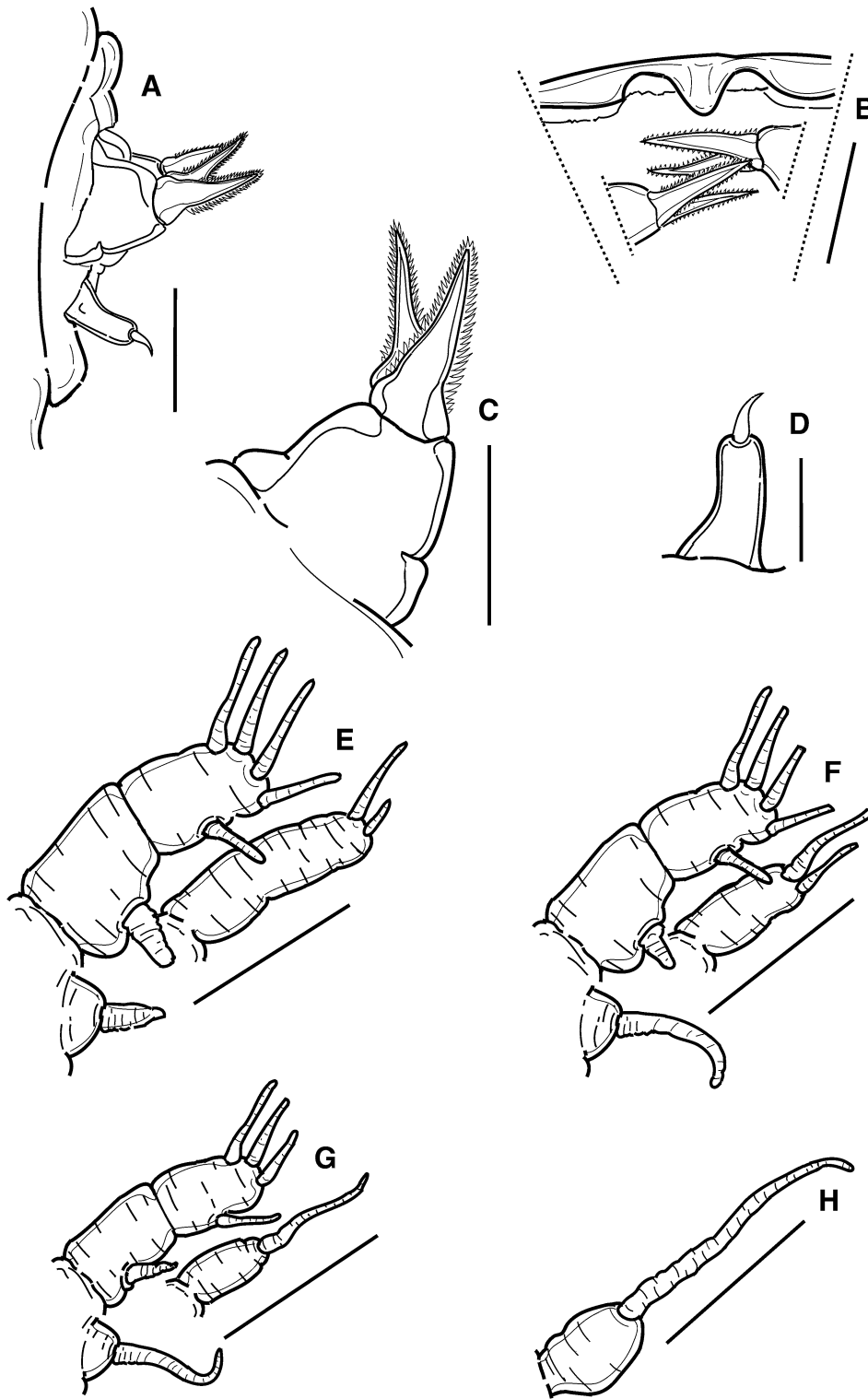


Fig. 2 *Procolobomatus hoi* n. sp., adult female. A, buccal apparatus, lateral; B, labrum and maxillae, ventral; C, maxilla, lateral; D, maxilliped, lateral; E, leg 1, ventrolateral; F, leg 2, ventrolateral; G, leg 3, ventrolateral; H, leg 4, ventrolateral. Scale-bars: A,B, 200 µm; C, 100 µm; D, 50 µm; E,F,G,H, 100 µm

Table 1 Records of philichthyid copepods parasitic in marine fishes from Asian waters

Copepod species	Host family	Host species	Site	Marine locality	Country	References
<i>Ichthyotaces pteroisicola</i> Shiino, 1932	Scorpaenidae	<i>Pterois lunulata</i> Temminck & Schlegel	Flesh	Tanabe Bay	Japan	Shiino, 1932
	Synodontidae	<i>Synodus variegatus</i> (Lacépède)	Gall on head canals	Unspecified	Vietnam	Cressey, 1984
<i>Colobomatus absens</i> Madinabeitia, Tang & Nagasawa, 2012	Caesionidae	<i>Pterocaesio digramma</i> (Bleeker)	Head canals	Ishigaki Island	Japan	Madinabeitia et al., 2012
<i>C. acanthuri</i> Madinabeitia, Tang & Nagasawa, 2012	Acanthuridae	<i>Acanthurus olivaceus</i> Bloch & Schneider	Head canals	Okinawa Island	Japan	Madinabeitia et al., 2012
<i>C. arabicus</i> Hayward, 1996	Sillaginidae	<i>Sillago attenuata</i> McKay	Pre-opercular canals	Tanjib Bay	Saudi Arabia	Hayward, 1996
		<i>S. arabica</i> McKay & Mc Carthy		Tanjib Bay Manifa Bay		
<i>C. asiaticus</i> Hayward, 1996	Sillaginidae	<i>Sillago asiatica</i> McKay	Pre-opercular canals	Bang Saen	Thailand	Hayward, 1996
		<i>S. chondropus</i> Bleeker		Phuket	Thailand	
		<i>S. sihama</i> (Forsskål)		Saikung	Hong Kong	
				Kuala Lumpur (market)	Malaysia	
				Cendering	Malaysia	
				Manifa Bay	Saudi Arabia	
<i>C. collettei</i> Cressey, 1977	Hemiramphidae	<i>Hemiramphus far</i> Forsskål	Head canals	Okinawa Island	Japan	Madinabeitia et al., 2012
<i>C. exilis</i> Izawa, 1974	Serranidae	<i>Caprodon schlegelii</i> (Günther) [as <i>C. schlegeli</i>]	Pre-opercular, supra-orbital and infra-orbital canals	Tanabe Bay	Japan	Izawa, 1974b
<i>C. fusiformis</i> Izawa, 1974	Chaetodontidae	<i>Heniochus monoceros</i> Cuvier & Valenciennes	Pre-opercular, supra-orbital and infra-orbital canals	Okinawa Island	Japan	Izawa, 1974b
<i>C. gymnocranii</i> Madinabeitia, Tang & Nagasawa, 2012	Lethrinidae	<i>Gymnocranus griseus</i> (Temminck & Schlegel)	Head canals	Okinawa Island	Japan	Madinabeitia et al., 2012
<i>C. mylionus</i> Fukui, 1965	Sparidae	<i>Acanthopagrus schlegelii</i> (Bleeker) [as <i>Mylio macrocephalus</i> (Basilewsky)]	Cavity associated with the frontal skull bone	Yokohama Bay	Japan	Fukui, 1965

Table 1 continued

Copepod species	Host family	Host species	Site	Marine locality	Country	References
<i>C. pterois</i> Madinabeitia, Tang & Nagasawa, 2012	Scorpaenidae	<i>Pterois volitans</i> Linnaeus	Head canals	Okinawa Island	Japan	Madinabeitia et al., 2012
<i>C. pupa</i> Izawa, 1974	Mullidae	<i>Parupeneus spilurus</i> (Bleeker) [as <i>Pseudupeneus spilurus</i>]	Pre-opercular, supra-orbital and infra- orbital canals	Tanabe Bay	Japan	Izawa, 1974b, 1975
		<i>P. ciliatus</i> Lacépède	Lateral line scales	Okinawa Island		Madinabeitia et al., 2012
		<i>P. multifasciatus</i> (Quoy & Gaimard)				
		<i>S. sihama</i>				
<i>C. sillaginis</i> West, 1983	Sillaginidae	<i>Sillago aeolus</i> Jordan & Everman	Pre-opercular canals	Samut Sakorn	Gulf of Thailand	Hayward, 1996
		<i>S. sihama</i>		Unspecified	Indonesia	
<i>C. similis</i> Kim, 1995	Sillaginae	<i>Ditrema temminckii</i> <i>temminckii</i> Bleeker	Unspecified	Off Chungmu	Korea Strait	Kim, 1995
<i>C. westi</i> Hayward, 1996	Sillaginidae	<i>Sillago japonica</i> Temminck & Schlegel	Enlarged tubes of lateral line	Ago Bay	Japan	Hayward, 1996
				Tsuyazaki, West Ishikawa		
		<i>S. japonica</i> Temminck & Schlegel	Enlarged tubes of lateral line	Kwangyang Bay	South Korea	
		<i>S. parvisquamis</i> Gill		Wanchai	Hong Kong	
		<i>S. sihama</i>		Sai Kung		
<i>Sarcotaces japonicus</i> Izawa, 1974	Muraenidae	<i>Gymnothorax kidako</i> (Temminck & Schlegel)	Encysted under the skin	Tanabe Bay	Japan	Izawa, 1974a
<i>S. komaii</i> Shiino, 1953	Peristediidae	<i>Satyrichthys amiscus</i> (Jordan & Starks) [as <i>Peristedion amiscus</i>]	Encysted under the skin	Tosa Bay	Japan	Shiino, 1953; Izawa, 1974a
	Scaridae	<i>Sparisoma rubripinne</i> (Valenciennes) [as <i>S.</i> <i>rubripinnis</i>]	Encysted under the skin	Sea of Kumano		
<i>S. pacificus</i> Komai, 1924	Antennariidae	<i>Antennarius striatus</i> (Shaw) [as <i>A. tridens</i> (Temminck & Schlegel)]	Encysted under the skin	Tanabe Bay	Japan	Komai, 1924; Izawa, 1973
<i>S. shiinoi</i> Izawa, 1974	Congridae	<i>Acromycter nezumi</i> (Asano) [as <i>Promyllantor nezumi</i>]	Encysted under the skin	Sea of Kumano	Japan	Izawa, 1974a

3, 2, 2, 1 and 4 + 3 aesthetascs; all setae naked. Antenna (Fig. 1H) unmodified, uniramous and 3-segmented; basal segment with distomedial naked seta; second segment with medial naked seta at mid-length of segment and 3 unequal, distomedial naked setae; distal segment short, dorsal to second segment, with 2

distomedial naked setae and 1 thin-walled, blunt element. Buccal apparatus (Fig. 1A) gaping, with small, triangular plate-like labrum (Fig. 2B) on anterior region. Mandibles and maxillules absent. Maxilla (Fig. 2A,C) 2-segmented; basal segment robust; distal segment bearing 2 serrated spines apically. Maxilliped

(Fig. 2A,D) unsegmented, with single, naked seta on apex.

Leg 1 (Fig. 2E) biramous; protopod fused to somite and carrying short, medial seta arising from basal protrusion; exopod 2-segmented, basal segment with 1 stout, medial seta and distal segment with 5 setae (1 lateral, 3 terminal and 1 medial); endopod unsegmented, with 2 terminal setae. Leg 2 (Fig. 2F) similar to leg 1, except with protopod carrying long, medial seta. Leg 3 (Fig. 2G) similar to leg 2, except terminal exopodal segment with 4 setae and endopod with 1 apical seta. Leg 4 (Fig. 2H) uniramous, papillose, carrying 1 long, apical seta.

Male. Not found.

Discussion

Procolobomatus hoi n. sp. resembles *P. kyphosus* (Sekerak, 1970) and *P. hemilutjani* Castro Romero, 1994 in the number and arrangement of the cephalic and thoracic processes [the two anterolateral processes on the body of *P. hemilutjani* are reinterpreted as pre-oral structures rather than thoracic in origin, as stated by Castro Romero (1994)], the structure of the maxilla and maxilliped, the absence of mandibles and the armature of the distal exopodal segment of leg 3 (4). In particular, the new species shares with *P. kyphosus* the segmentation of the antennule (7) and armature of the endopod of legs 1–3 (2, 2 and 1 setae, respectively); and with *P. hemilutjani* the armature of the antennule (24), the absence of the maxillule and the armature of the distal exopodal segment of legs 1 (5). However, *P. hoi* differs from its congeners by having the following combination of characters: a long medial cephalic lobe that is about one-third the length of the body; five setae on the distal exopodal segment of leg 2; one long apical seta on papillose leg 4; one medial and four terminal setae (the two middle setae are inflated) on the tip of the caudal ramus; and a spinulose ornamentation decorating the body.

Records of philichthyid copepods from Asian waters are scarce. So far, a total of 20 species (including *P. hoi* n. sp.) have been reported from Asia, accounting for less than 25% of the total (Table 1). Those species can be classified into three of the nine genera of philichthyid copepods, i.e. *Colobomatus* (14), *Sarcotaces* (4) and *Ichthyotaces* (1)

(Table 1). Copepods in the family Philichthyidae are usually overlooked during fish dissections, because they are endoparasitic in the subcutaneous spaces associated with the sensory canals of the skull bones and the lateral line (West, 1992). Therefore, this study corroborates the idea that this family is a still poorly-understood group of parasitic copepods and might be more abundant than previously thought. Our findings have demonstrated, once again, that double-netting (Madinabeitia & Nagasawa, 2012) is an efficient technique for the recovery of philichthyid copepods from marine fishes.

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