

THREE NEW SPECIES OF PARASITIC COPEPODS (COPEPODA,
CYCLOPOIDA, SHIINOIDAE) INFECTING THE NASAL LAMELLAE OF
JAPANESE ACTINOPTERYGIAN FISHES

BY

KUNIHICO IZAWA¹⁾

Izawa Marine Biological Laboratory, 795-16 Kannonji, Tsu, Mie 514-0062, Japan

ABSTRACT

Three new species of the family Shiinoidae, *Shiinoa japonica*, *S. purionura*, and *Parashiinoa cookeola* are described based on specimens recovered from the nasal lamellae of Japanese actinopterygian fishes, *Kyphosus vaigiensis* (Quoy & Gaimard, 1825), *Prionurus scalprum* Valenciennes, 1835, and *Cookeolus japonicus* (Cuvier, 1829), respectively. The male of *S. japonica* and the male copepodid II of *P. cookeola* are described. All host fishes named above represent new host families for the Shiinoidae. The phylogenetic affinity of this family with the Philichthyidae is discussed.

RÉSUMÉ

Trois espèces nouvelles de la famille des Shiinoidae, *Shiinoa japonica*, *S. purionura*, et *Parashiinoa cookeola* sont décrites à partir de spécimens prélevés sur les lamelles nasales des poissons actinoptérygiens japonais, *Kyphosus vaigiensis* (Quoy & Gaimard, 1825), *Prionurus scalprum* Valenciennes, 1835, et *Cookeolus japonicus* (Cuvier, 1829), respectivement. Le mâle de *S. japonica* et le copépodite II mâle de *P. cookeola* sont décrits. Tous les poissons-hôtes nommés ci-dessus représentent de nouvelles familles-hôtes pour les Shiinoidae. L'affinité phylogénétique de cette famille avec celle des Philichthyidae est discutée.

INTRODUCTION

Shiinoid copepods are exclusively parasitic on the nasal lamellae of acanthopterygian fishes, with the exception of *Parashiinoa mackayi* West, 1986 recovered from the dorsal fin groove of two species of Australian haemulid fishes. Shiinoidae was erected as a family by Cressey (1975) to accommodate *Shiinoa oculusa* Kabata, 1968 and *S. inauris* Cressey, 1975. Additionally, Cressey (1976)

¹⁾ e-mail: izawafam@ztv.ne.jp

described a third species, *S. elagata* Cressey, 1976 from a carangid fish. A second genus, *Parashiinoa* was described in the family to accommodate a new species, *P. mackayi* by West (1986). In that same year, *S. bakeri* was described by Cressey & Cressey (1986), the authors presumably being unaware of West's (1986) paper. This apparent oversight, which led Cressey & Cressey (1986) to include *S. bakeri* in the type genus *Shiinoa*, was later rectified by Boxshall & Halsey (2004), who transferred it to *Parashiinoa*. Currently, the Shiinoidea include two genera and five species.

In this paper, three new species of Shiinoidea, *Shiinoa japonica*, *S. purionura*, and *Parashiinoa cookeola* are described based on specimens recovered from the nasal lamellae of the sea chub, *Kyphosus vaigiensis* (Quoy & Gaimard, 1825) (Pisces, Kyphosidae), the surgeonfish, *Prionurus scalprum* Valenciennes, 1835 (Acanthuridae), and the bigeye, *Cookeolus japonicus* (Cuvier, 1829) (Priacanthidae), respectively.

A review of the host groups and a discussion of the phylogenetic affinities of the family are provided.

MATERIAL AND METHODS

Specimens were fixed in formalin-sea water and preserved in alcohol. The specimens were stained with chlorazol black E in lactic acid and examined with a differential interference contrast microscope using the wooden slide method of Humes & Gooding (1964). Drawings were made with the aid of a drawing tube. The terminology is based on Kabata (1979) and Huys & Boxshall (1991). The higher categories of Actinopterygii follow Nelson (2006). The specimens will be retained in the Izawa Marine Biological laboratory (IMBL), Tsu, Mie Prefecture, Japan, until final deposition in the National Science Museum, Tokyo.

DESCRIPTIONS

***Shiinoa japonica* nov. sp. (figs. 1-3)**

Material examined. — Sixteen females and 9 males from the nasal lamellae of 6 individuals of *Kyphosus vaigiensis* (Quoy & Gaimard, 1825) (Pisces, Kyphosidae) captured in Tanabe Bay, Wakayama Prefecture, 28 Nov. 1971-17 Jun. 1972 (IMBL K-319).

Etymology. — The specific name refers to the type locality of the species. It is an adjective agreeing in gender with the (feminine) generic name.

Female (figs. 1, 2). — Body (fig. 1A, B) pale yellow, including three prominent body portions, with silvery red ocelli of the nauplius eye embedded ventrally near mouth. Body length except caudal rami 3.29-4.23 mm (mean 3.87 mm,

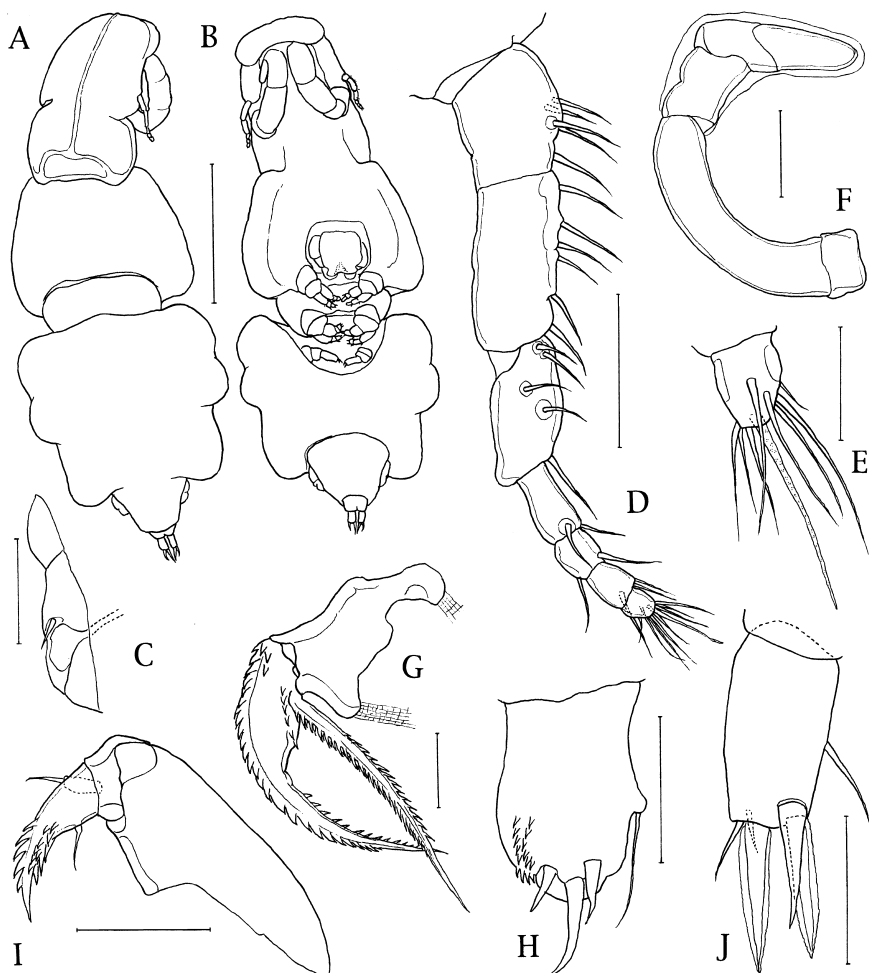


Fig. 1. *Shiinoa japonica* nov. sp., female. A, habitus, dorsal; B, same, ventral; C, genital area, dorsal; D, antennule, lateral; E, terminal antennular segment, medial; F, antenna, lateral; G, mandible, dorsal; H, maxillule, ventral; I, maxilla, ventral; J, caudal ramus, ventral. Scale bars: 1 mm for A, B; 0.3 mm for F; 0.1 mm for C, D, I, J; 0.05 mm for G, H; 0.03 mm for E.

n = 16), width 1.39-1.57 mm (mean 1.47 mm, n = 4). Antennal portion including quadrangular rostrum, longer than wide, occupying about one-third of body length, with lateral constriction posterior to antennal bases. Succeeding oral portion wider than long, broadened distally, bearing mouthparts and legs 1 ventrodistally. Oral portion followed by narrow 2nd pediger, then a broad thoracic portion. Thoracic portion roughly quadrangular, wider than long, with 2 lateral protuberances and posterolateral protuberances, bearing leg 3 in anteroventral pit. Small, conical genito-abdomen ending in free anal somite. Genital aperture (fig. 1C) dorsolateral, accompanied by a seta on genital operculum. Caudal ramus (fig. 1J) longer than

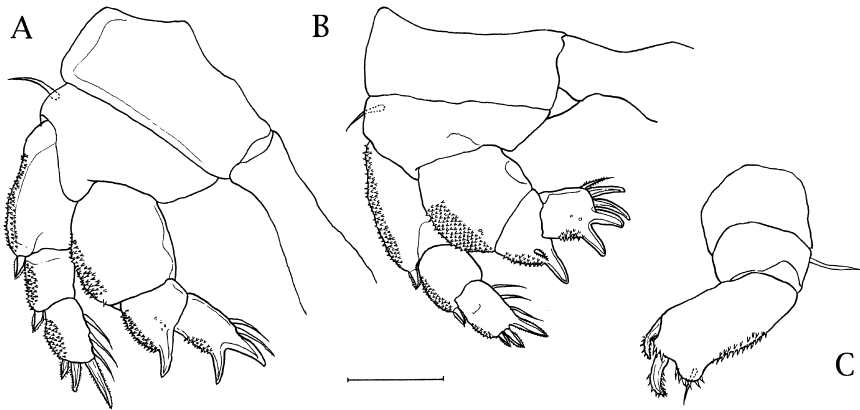


Fig. 2. *Shiinoa japonica* nov. sp., female. A–C, legs 1–3, respectively, ventral. Scale bar: 0.1 mm for A–C.

wide, with a slender lateral seta at midlength, 2 small mediodistal setae, and 3 large distal setae, 2 of 3 distal setae fringed with membrane.

Antennule (fig. 1D, E) 7-segmented, number of setae per segment (base to apex) as follows: 5, 6, 5, 2, 2, 3, 8 + aesthetasc. Antenna (fig. 1F) 5-segmented, distal 3 segments, as well as anteroventral portion of rostrum, coated with mucus.

Labrum with distolateral sinuses. Mandible (fig. 1G) usual shiinoïd type, consisting of unarmed basal segment with distal portion tapered into denticulate flagellum and bearing denticulate accessory flagellum dorsoproximally. Maxillule (fig. 1H) unimerous, flattened dorsoventrally, with slender lateral seta, 3 stout distal setae, and mediodistal spinulose area. Maxilla (fig. 1I) 3-segmented; basal segment flanks labrum; second segment short, with jointed dorsodistal setae; distal segment tapering into denticulate claw, with medioproximal seta.

Legs 1 and 2 (fig. 2A, B) with intercoxal bar, consisting of 2-segmented protopod and 3-segmented rami. Leg 3 (fig. 2C) without intercoxal bar, consisting of 2-segmented protopod and unimerous exopod. Basis of all legs with lateral seta. Rami of all legs with spinulose lateral margin. Exopod of leg 3 with distolateral expansion covered with spinules. Formula for spines (Roman numerals) and setae (Arabic numerals) on legs 1–3 as follows:

	Exopod			Endopod		
	1	2	3	1	2	3
Leg 1	I-0	I-0	III,3	0-0	I-0	II,2
Leg 2	I-0	I-0	III,3	0-0	I-0	IV,1
Leg 3	1,II					

Exopodal spines of all legs fringed with serrated membrane.

Male (fig. 3). — Body (fig. 3A) cyclopoid, comprised of cephalothorax and succeeding 10 free somites; pedigerous somites 2–4, limbless thoracic somites 5

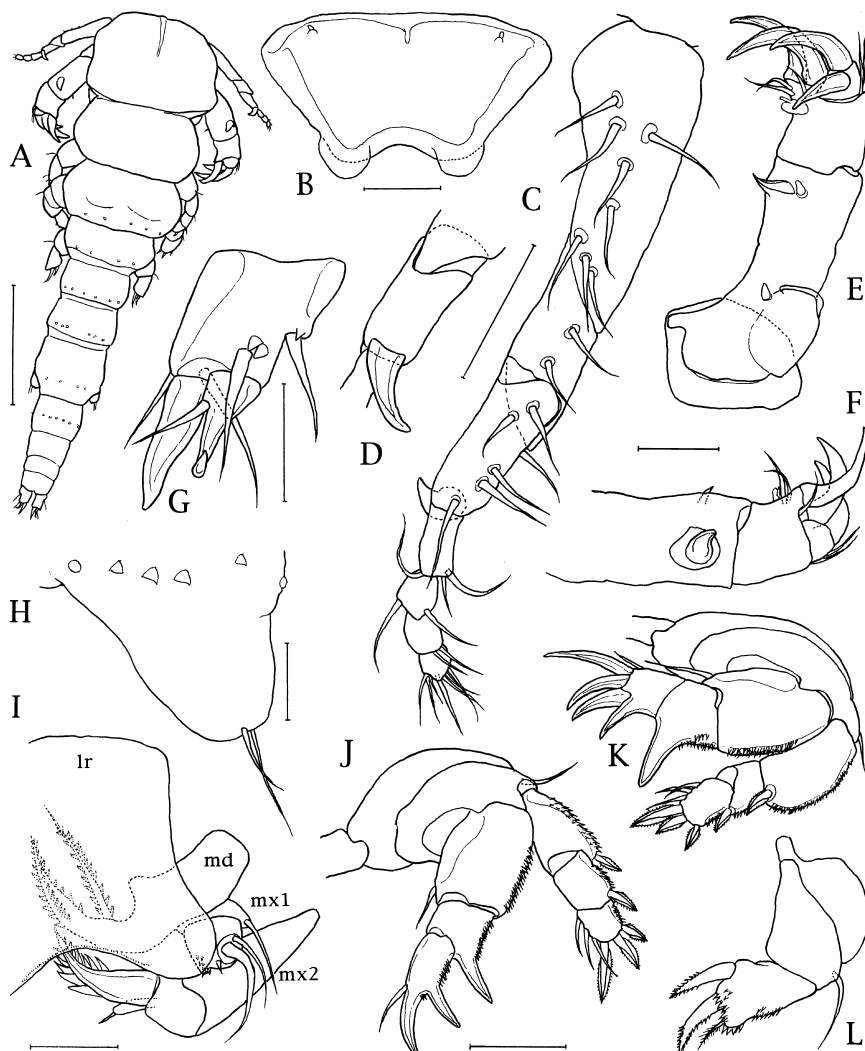


Fig. 3. *Shiinoa japonica* nov. sp., male. A, habitus, dorsal; B, rostrum, ventral; C, antennule, ventral; D, antennular segment 3, dorsal; E, antenna, ventral; F, distal portion of same, dorsal; G, caudal ramus, ventral; H, genital operculum, ventral; I, mouthparts, ventral; J-L, legs 1-3, respectively, ventral. Abbreviations: lr, labrum; md, mandible; mx1, maxillule; mx2, maxilla. Scale bars: 0.5 mm for A; 0.1 mm for B, C, D, E, F, J, K, L; 0.05 mm for G, H, I.

and 6, genital somite, and abdominal somites 1-4. Body length except caudal rami 1.67-2.07 mm (mean 1.86 mm, $n = 9$), width 0.50-0.59 mm (mean 0.54 mm, $n = 9$). Cephalothorax and all free somites wider than long; pediger 2 through first abdominal somite each with a transverse row of sensilla surrounding somite. Genital somite with 2 setae on genital operculum (fig. 3H). Caudal ramus (fig. 3G) slightly longer than wide, with lateral seta at midlength, subterminal ventral seta,

2 distal stout spines, mediodistal seta, and dorsodistal seta; lateral distal spine with accessory seta.

Rostrum (fig. 3B) trapezoidal, narrowed distally, with posterolateral protuberances and a pair of papillar sensilla anteroventrally. Antennule (fig. 3C, D) 7-segmented, with dorsodistal hook on segment 3, number of setae per segment (base to apex) as follows: 8, 2, 6, 3, 2, 2, 7. Antenna (fig. 3E, F) 4-segmented; short basal segment naked. Second segment long, formed presumably by original segments 2-3, with anterior basal protuberance and a set-off papillar sensillum plus membrane on distal margin of basal protuberance and on mediodistal portion, respectively, and armed with a hook-like process dorsodistally (fig. 3F). Third segment armed with 2 mediodistal claws, 3 setae and lamellar ornament on medio-subterminal portion, and 2 narrow outer distal setae. Fourth segment small, armed with 2 claws. Mouthparts (fig. 3I) as in female, except labrum without distolateral sinus.

Legs 1-3 (fig. 3J-L) similar to those in female except setal elements. Setal formula of legs 1-3 as follows:

	Exopod			Endopod		
	1	2	3	1	2	3
Leg 1	I-0	I-0	III,3	0-1	I-0	II,1
Leg 2	I-0	I-0	III,3	0-1	I-0	IV,1
Leg 3	1,II					

Remarks. — *Shiinoa japonica* nov. sp. is distinct from its congeners in having lateral protuberances on the thoracic portion. The host of this species is a representative of a new host group for the Shiinoidea.

***Shiinoa prionura* nov. sp. (fig. 4)**

Material examined. — Two females recovered from nasal lamellae of *Prionurus scalprum* Valenciennes, 1835 (Pisces, Acanthuridae) obtained at Seto, Tanabe Bay, Wakayama Prefecture on 23 Dec. 1971 (IMBL K-334).

Etymology. — The specific name refers to the generic name of the host. The name is an adjective agreeing in gender with the (feminine) generic name.

Female (fig. 4). — Body as in fig. 4A, B; body length except caudal rami 2.84-3.14 mm, width 1.0-1.04 mm. Antennal portion longer than wide, broadened in posterior two-thirds, with lateral constriction posterior to antennal bases. Oral portion wider than long, broadened distally, lateral margin swollen ventrally. Second pediger narrow and short. Thoracic portion elliptical, longer than wide, bearing leg 3 and rudiment of leg 4 in anteroventral pit. Genito-abdomen ending in free anal somite. Genital aperture accompanied by seta on genital operculum (fig. 4C). Caudal ramus (fig. 4D) longer than wide, with lateral seta at midlength, subterminal dorsal seta, and 4 unequal distal setae.

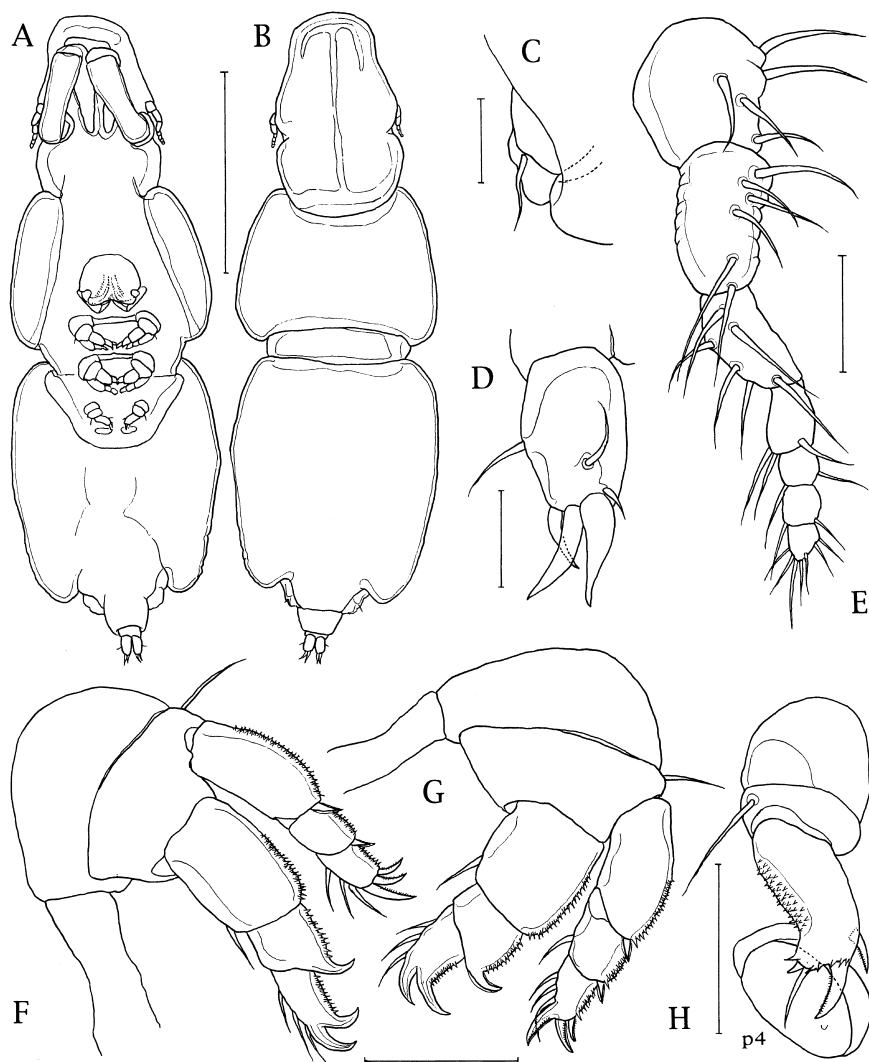


Fig. 4. *Shiinoa purionura* nov. sp., female. A, habitus, ventral; B, same, dorsal; C, genital area, dorsal; D, caudal ramus, dorsal; E, antennule, lateral; F, G, legs 1, 2, respectively, ventral; H, leg 3 and rudimentary leg 4, ventral. Additional abbreviation: p4, rudimentary leg 4. Scale bars: 1 mm for A, B; 0.1 mm for F–H; 0.05 mm for C, D, E.

Antennule (fig. 4E) 7-segmented, setae of segments as follows: 5, 6, 6, 3, 2, 2, 7. Antenna and mouthparts similar to those in female of *S. japonica* described above.

Legs 1 and 2 (fig. 4F, G) with intercoxal bar, consisting of 2-segmented protopod and 3-segmented rami. Leg 3 (fig. 4H) without intercoxal bar, consisting of 2-segmented protopod and unimerous exopod. Basis of all legs with lateral seta.

Rami of all legs with spinulose lateral margin. Exopod of leg 3 with dentate lateral expansion. Setal formula of legs 1-3 as follows:

	Exopod			Endopod		
	1	2	3	1	2	3
Leg 1	I-0	I-0	III,3	0-1	I-0	II,3
Leg 2	I-0	I-1	III,3	0-1	I-0	II,3
Leg 3	1,II					

Exopodal spines serrated. Rudiment of leg 4 represented by 2-segmented protopod without rami, situated posteriorly to leg 3 (fig. 4H, p4).

Male unknown.

Remarks. — *S. prionura* is unique in having a vestigial leg 4. This species resembles *S. elagata* Cressey, 1976 in having an oval thoracic portion (genital segment in Cressey, 1976), but the body is more slender in *S. prionura*, about 3.0×1.0 mm, than in *S. elagata*, 1.9×1.25 mm (Cressey, 1976). The host of *S. prionura* is a representative of a newly known host group for the family.

***Parashiinoa cookeola* nov. sp. (figs. 5-6)**

Material examined. — One female accompanied by a juvenile male from the nasal lamellae of *Cookeolus japonicus* (Cuvier, 1829) (Pisces, Priacanthidae) obtained at Seto, Tanabe Bay, Wakayama Prefecture on 28 Nov. 1971 (IMBL K-322).

Etymology. — The specific name refers to the generic name of the host. It is an adjective agreeing in gender with the (feminine) generic name.

Female (fig. 5). — Body (fig. 5A, B) consisting of guitar-shaped antennal portion, broadest oral portion, 2-segmented thoracic portion, a small free thoracic somite, and a genito-abdomen ending in a free anal somite, with empty egg sacs, and accompanied by a juvenile male attached to the genito-abdomen. Body 2.72 mm long, and 1.03 mm wide. Oral portion and thoracic portion coalesced ventrally into one body section, with oral area and legs 1-3; 2 pairs of pit-like marks visible internally each on oral portion and on anterior half of thoracic portion ventrolaterally. Genital aperture (fig. 5C) accompanied by a seta and a tubercle on elongated genital operculum. Caudal ramus (fig. 5D) longer than wide, tapering distally, with lateral seta proximally, medial seta at about midlength, and 2 stout and 2 slender setae distally; medial distal stout setae with an accessory branch subterminally.

Rostrum (fig. 5F, r) narrowed in middle and thickened distally to form bulbous end. Antennule (fig. 5E) 6-segmented, number of setae for segments as follows: 5, 2, 4, 4, 2, 7. Antenna (fig. 5F, a2) 4-segmented, with inner seta on penultimate segment; terminal segment narrowed at base. Mandible (fig. 5G) usual shiinoid type. Maxillule (fig. 5H, mx1) with subterminal inner seta, 2 distal setae, and a

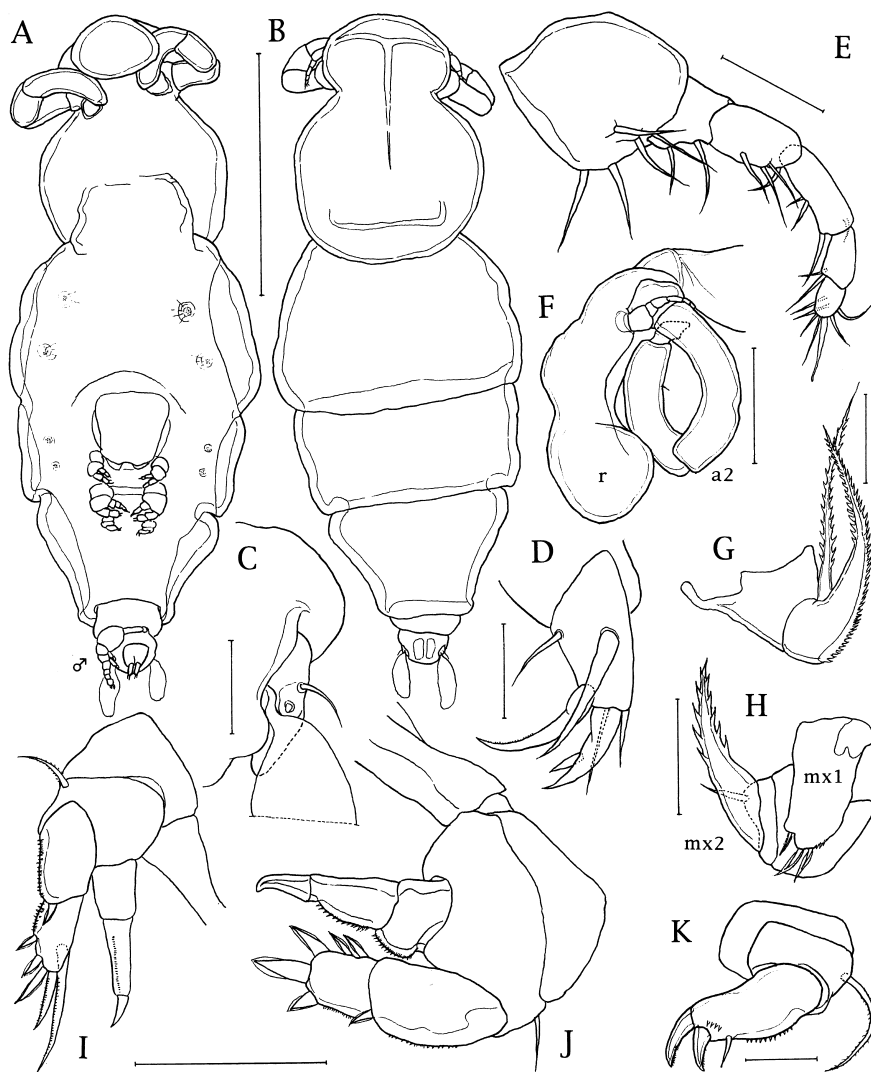


Fig. 5. *Parashiinoa cookeola* nov. sp., female. A, habitus with male attached, ventral; B, same, dorsal; C, genital area, dorsal; D, caudal ramus, ventral; E, antennule, lateral; F, rostrum, antennule and antenna, lateral; G, mandibule, ventral; H, maxillule and maxilla, ventral; I-K, legs 1-3, respectively, ventral. Additional abbreviations: a2, antenna; r, rostrum. Scale bars: 1 mm for A, B; 0.3 mm for F; 0.1 mm for I, J; 0.05 mm for C, E, G, H; 0.03 mm for D, K.

small patch of spinules; setae fringed by membrane. Maxilla (fig. 5H, mx2) the usual shiinoid type.

Legs 1 and 2 (fig. 5I, J) with intercoxal bar, consisting of 2-segmented protopod and 2-segmented rami. Leg 3 (fig. 5K) without intercoxal bar, consisting of 2-segmented protopod and unimerous exopod. Basis of all legs with lateral seta.

Endopod of legs 1 and 2 tapering distally and tipped by claw to form hook. Exopodal segments of all legs and endopodal segments of leg 2 with spinulose lateral margin. Setal formula of legs 1-3 as follows:

	Exopod		Endopod	
	1	2	1	2
Leg 1	I-0	III,2	0-0	I
Leg 2	I-0	V	0-0	I
Leg 3	1,II			

All exopodal spines of legs 1 and 2 with membranes. Two medial setae of distal exopodal segment of leg 1 spine-like, with fine spinules on lateral margin. Exopodal spines of leg 3 with fine spinules on lateral margin.

Juvenile male (copepodid II) (fig. 6). — Body (fig. 6A) composed of cephalothorax, 3 free pedigerous thoracic somites, 2 free naked somites, and anal somite. Body, except caudal rami, 0.27 mm long and 0.11 mm wide. Any sign of reproductive system indiscernible in urosomal portion. Caudal ramus (fig. 6B) 2 times as long as wide, with lateral seta at about midlength, 2 subterminal lateral setae, and one stout and 2 slender terminal setae.

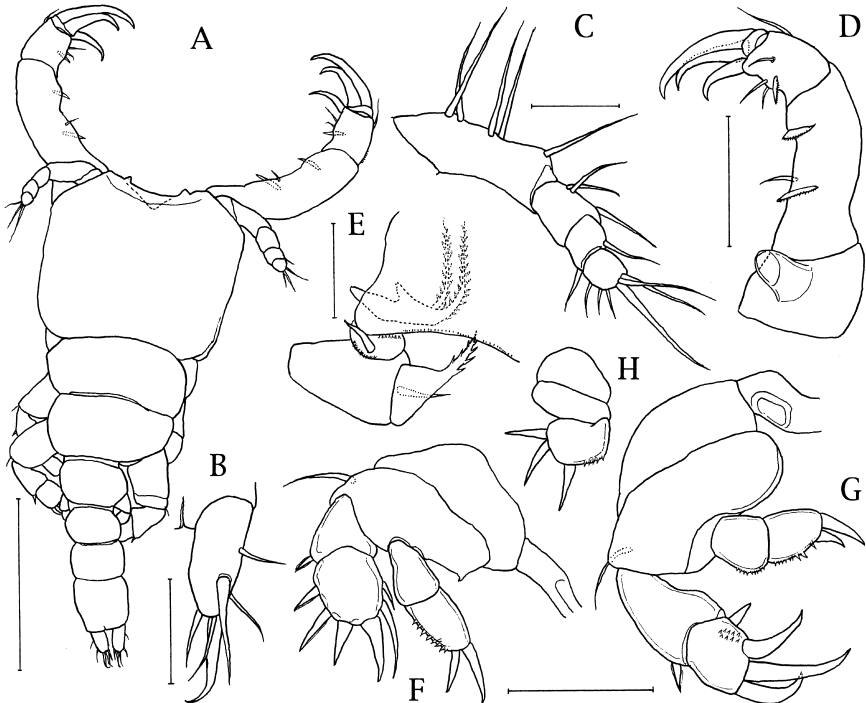


Fig. 6. *Parashiinoa cookeola* nov. sp., male copepodid II. A, habitus, dorsal; B, caudal ramus, ventral; C, antennule, ventral; D, antenna, ventral; E, mouthparts, ventral; F-H, legs 1-3, respectively, ventral.

Scale bars: 0.1 mm for A; 0.05 mm for D; 0.03 mm for F-H; 0.02 mm for B, C, E.

Antennule (fig. 6C) 4-segmented; number of setae per segment (base to apex) as follows: 5, 3, 2, 6. Antenna (fig. 6D) 4-segmented; first segment with lamellar sucker ventrally; second long, with 2 serrated membranes and a seta along medial surface; third segment furnished with inner distal claw, serrate membrane, and 3 setae on inner margin at about midlength, and outer distal seta; fourth segment small, with 2 distal claws. Mouthparts (fig. 6E) usual shiinoid type; maxillule tipped by a seta.

Legs 1 and 2 (fig. 6F, G) with intercoxal bar, consisting of 2-segmented protopod and 2-segmented rami; basis with lateral seta. Leg 3 (fig. 6H) consisting of 2-segmented protopod and unimerous exopod. Distal endopodal segment of leg 1 and endopodal segments of leg 2 with spinulose lateral margin. Distal exopodal segment of leg 2 with medial spinulose area. Formula for number of setal elements on legs 1-3 as follows:

	Exopod		Endopod	
	1	2	1	2
Leg 1	1-0	6	0-0	2
Leg 2	1-0	4	0-0	2
Leg 3	3			

Remarks. — The female of *P. cookeola* is distinct from those of its congeners, *P. mackayi* West, 1986, and *P. bakeri* (Cressey & Cressey, 1986), in habitus and morphological details. It is distinctly larger in size (2.72 mm long) compared to its congeners: 1.44 mm in *P. mackayi* (cf. West, 1986) and 1.5 mm in *P. bakeri* (cf. Cressey & Cressey, 1986).

The host of this species is a representative of a new host group for the family.

DISCUSSION

The hosts of the eight species of the family including the new species described herein, are restricted to fishes of the Perciformes, and belonging to three suborders and nine families of this order (table I).

Regarding phylogenetic affinity, Kabata (1968) suggested a relationship of *Shiinoa* with the Chondracanthidae, and the possibility of establishing a subfamily for *Shiinoa*. Subsequent to Kabata (1968), Cressey (1975) erected the Shiinoidea and mentioned that the family is most closely related to the Ergasilidae, and also suggested a possible affinity with the Philichthyidae. Boxshall & Halsey (2004) placed Shiinoidea in a group of families that included the Chondracanthidae, Lernaesoleidae, and Philichthyidae. Due to the close resemblance in the males, the present author supports the affinity between Shiinoidea and Philichthyidae: the cephalothorax does not include the first pedigerous somite and is followed by all 10 free somites as seen in *Shiinoa inauris* (cf. Cressey, 1975), *Parashiinoa*

TABLE I
Host diversity of the Shiinoidae (Copepoda, Cyclopoida)

Species	Suborder and family of host	References
<i>Shiinoa occlusa</i> Kabata, 1968	(Scombroidei) Scombridae	Kabata, 1968; Cressey, 1975
<i>S. inauris</i> Cressey, 1975	(Scombroidei) Scombridae	Cressey, 1975
<i>S. elagata</i> Cressey, 1976	(Percoidei) Carangidae	Cressey, 1976
	(Percoidei) Sphyraenidae	Cressey & Cressey, 1986
<i>S. japonica</i> nov. sp.	(Percoidei) Kyphosidae	present study
<i>S. purionura</i> nov. sp.	(Acanthuroidei) Acanthuridae	present study
<i>Parashiinoa mckayi</i> West, 1986	(Percoidei) Haemulidae	West, 1986
<i>P. bakeri</i> (Cressey & Cressey, 1986)	(Percoidei) Haemulidae, Carangidae, Lutjanidae, and Caesionidae	Cressey & Cressey, 1986
<i>P. cookeola</i> nov. sp.	(Percoidei) Priacanthidae	present study

mackayi (cf. West, 1986), and *S. japonica* described herein. This is the same in the Philichthyidae as shown in *Colobomatus pupa* Izawa, 1974 (cf. Izawa, 1974, fig. 9), although the number of somites was earlier misinterpreted. Other than Shiinoidae and Philichthyidae, no cyclopoid group parasitic on fishes exhibiting such a body form in males is known. The antenna is equipped with claws on the distal two endopodal segments in the shiinoid male as seen in *S. inauris*, *P. mackayi*, and *P. bakeri* (cf. Cressey & Cressey, 1986), and in *S. japonica* and *P. cookeola* here described. This feature closely resembles its counterpart as found in *C. pupa* of the Philichthyidae (cf. Izawa, 1974, fig. 11). In the Chondracanthidae, the distal segment of the antenna has degenerated, leaving an atrophied tip on the antenna in some genera (Boxshall & Halsey, 2004), and the prehensile function rests exclusively upon a strong claw on the penultimate segment. The body plan and antennal structure of the male and the absence of a maxilliped in both sexes set Shiinoidae and Philichthyidae apart from the Chondracanthidae-group. Furthermore, the claw-like spines of the leg usually found in both sexes of Shiinoidae bear close resemblance to those found in the male of *Colobomatus* (cf. Izawa, 1974, fig. 13).

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