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Chondracanthid copepods parasitic on flatfishes of Kerala, India

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Eight species of chondracanthid copepods (Poecilostomatoida) were recovered from nine species of flatfishes collected in Kerala, India. They are: *Acanthochondria zebriae* sp. nov. from *Zebrias synaturoides*; *Bactrochondria papilla* gen. et sp. nov. from *Cynoglossus dubius*; *B. hoi* (Pillai, 1985) from *C. lida*; *Heterochondria pillai* Ho, 1970 from *C. lida*, *Pseudorhombus arsius*, *P. elevatus*, *P. javanicus* and *P. triocellatus*; *H. petila* sp. nov. from *P. arsius*, *P. javanicus* and *P. triocellatus*; *H. similis* (Yü and Wu, 1932) from *C. azureus*; and both *Protochondracanthus alatus* (Heller, 1868) and *P. trilobatus* (Pillai, 1964) from *Psettodes erumi*.

KEYWORDS: Chondracanthidae, Copepoda, Flatfishes, India.

Introduction

Through the efforts of Prof. Dr N. Krishna Pillai and his students, more than 300 species of parasitic copepods have been recovered and reported from the fishes of Kerala on the southwest coast of India. Thus, Kerala is one of the few places in the world where the parasitic Copepoda of local fishes are relatively well known. Although several large and common families, such as Bomolochidae, Caligidae, Euryphoridae, Lernaeopodidae, Lernanthropidae, Pandaridae, Pennellidae and Taeniacanthidae, are well represented in the parasitic copepod fauna of Kerala (Pillai, 1985), only five species of Chondracanthidae are so far known from this area. They are: *Ceratochondria hoi* Pillai, 1985; *Heterochondria pillaii* Ho, 1970; *Medesicaste penetrans* Heller, 1868; *Protochondracanthus alatus* (Heller, 1868) and *P. trilobatus* (Pillai, 1964). Notably, *Acanthochondria* is absent.

Chondracanthidae is one of the major families of Copepoda, comprising more than 150 species. Among the 41 genera of this family, *Acanthochondria* is the largest one, containing 43 species distributed throughout the world oceans (Ho and Kim, 1995). Therefore, is the paucity of *Acanthochondria* in Kerala an artifact or simply

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a truth of nature? Since flatfishes are the most preferred hosts of chondracanthids (Ho, 1982) and about 70% of the flatfish landings in India are from Kerala State, we decided to search for an answer to the above question by examination of flatfishes caught in Kerala.

One of us (ABK) examined 21 species of flatfishes in Kerala from February 1994 to April 1995 and found nine species of them carried eight species of chondracanthids (table 1), with three of them being new to science. An *Acanthochondria* was among them. Therefore, a search on other demersal fishes from Kerala would be expected to yield more chondracanthid copepods.

In this report, a full description is given of all species regardless of whether they are new or already known, because the fine structures of the body parts and appendages, which are essential in the modern taxonomy of Copepoda, are incomplete in the original descriptions of the known species.

Materials and methods

Flatfishes were collected from trawlers and native boats in Kerala State, India. Individual species were separated, packed in separate plastic bags, and transported to the laboratory in ice buckets. In the laboratory, fishes were examined fresh and the parasites were removed and preserved in 5% buffered formalin. For microscopic examination of the parasites, the preserved specimens were first rinsed in water, transferred to and kept in 70% alcohol for 24 hours before clearing in 85% lactic acid. Measurements and dissections of the parasites were made in a drop of lactic acid on a wooden slide (Humes and Gooding, 1964). All drawings were made with the aid of a camera lucida.

Table 1. Flatfishes of Kerala, India infested by chondracanthid copepods. Number in parentheses indicates the number of parasites recovered from that host.

Flatfishes	Chondracanthid copepods
Bothidae	
Crossorhombus azureus (Alcock)	*Heterochondria similis* (Yü and Wu, 1932) (11)
Pseudorhombus arsius (Hamilton)	*Heterochondria petila* sp. nov. (135)
	Heterochondria pillaii Ho, 1970 (2)
Pseudorhombus elevatus Ogilby	*Heterochondria pillaii* Ho, 1970 (4)
Pseudorhombus javanicus (Bleeker)	*Heterochondria petila* sp. nov. (9)
	Heterochondria pillaii Ho, 1970 (1)
Pseudorhombus triocellatus (Bloch)	*Heterochondria petila* sp. nov. (3)
	Heterochondria pillaii Ho, 1970 (25)
Cynoglossidae	
Cynoglossus dubius (Regan)	*Bactrochondria papilla* sp. nov. (27)
	Heterochondria pillaii Ho, 1970 (1)
Cynoglossus lida (Bleeker)	*Bactrochondria hoi* (Pillai, 1952) (9)
	Heterochondria pillaii Ho, 1970 (1)
Psettodidae	
Psettodes erumi (Bleeker and Schneider)	*Protochondracanthus alatus* (Heller, 1868) (9)
	Protochondracanthus trilobatus (Pillai, 1964) (2)
Soleidae	
Zebrias synapturoides (Gilchrist)	*Acanthochondria zebriae* sp. nov. (27)

Descriptions

Acanthochondria zebriae sp. nov.
(figures 1–2)

Material examined. Twenty-four adult and three juvenile ♀♀ (19 with attached ♂) on gill filaments of *Zebrias synaturoides* (Gilchrist): four adults and three juveniles collected on 11 March 1994 and 20 adults collected on 26 December 1994. Holotype (USNM 285490) and eight paratypes (USNM 285491) have been deposited in the US National Museum of Natural History, Smithsonian Institution, Washington, DC and the remaining paratypes and other specimens kept in the junior authors' (IHK) collection.

Female. Body (figure 1A) elongated and cylindrical, measuring 1.69–1.94 mm long. Head (figure 1B) longer than wide, 403 × 273 μm (not including inflated antennule), with small rounded knob at each anterolateral corner and ventrally protruded oral region (figure 1C). First pediger narrower than head. Second pediger with remaining prosomal somites fused into a long, cylindrical trunk bearing a pair of posterolateral processes (figures 1D, E). Genital double somite slightly longer than wide, 135 × 123 μm, and abdomen distinctly wider than long, 37 × 65 μm. Caudal ramus (figure 1D) a spiniform, pointed process bearing four setae. Egg sac about as long as trunk.

Antennule (figure 1F) fleshy and inflated; armature being (from proximal to distal) 1-1-2-2-2-7. Antenna (figure 1G) two-segmented; terminal segment sharply curved and covered with minute tubercles on terminal area of basal half before bend. Labrum with smooth, straight posterior margin. Mandible (figure 1H) two-segmented; terminal blade with 31 to 33 teeth on convex (inner) side and 28 to 32 teeth on concave (outer) side. Paragnath (figure 1I) a small spinulose lobe. Maxillule (figure 1J) with two terminal elements. Maxilla (figure 1K) two-segmented; first segment robust and unarmed; second segment bearing one small, simple, basal seta, one large seta with hyaline tip and a row of 22 to 29 teeth on terminal process. Maxilliped (figure 2A) three-segmented; first segment largest but unarmed, second segment with long spines on greatly protruded inner distal corner, and terminal segment reduced to a small hook situated opposite to tuft of spinules on inner-distal corner of second segment. Both leg 1 (figure 2B) and leg 2 (figure C) nearly unilobate, with inflated, bluntly pointed exopod continuous with protopod and carrying a much reduced endopod tipped with a seta. Terminal region of exopod with six setae on leg 1 and four setae on leg 2.

Male. Body (figure 2D) 217 μm long, with swollen cephalosome and cylindrical metasome and urosome. Genital somite (figure 2E) with usual ventrolateral ridges. Abdomen (figure 2E) indistinguishably fused with genital segment. Caudal ramus as in female but naked. Antennule reduced to a simple seta (see figure 2D). Antenna (figure 2F) with small seta on basal segment and a conical process on basal part of terminal hook. Mandible (figure 2G) with fewer teeth on terminal blade, 17 on convex side and ten on concave side. Maxilla (figure 2H) with eight or nine teeth on inner side and single one on outside of terminal process. Maxilliped (figure 2I) essentially as in female, but terminal claw relatively larger. Leg 1 (figures 2D, J) reduced to a simple spiniform seta. Leg 2 absent.

Etymology. The specific name *zebriae* refers to the host of the present species.

Remarks. According to Ho and Kim's (1995) designation of the variable appendages useful in species identification in the genus *Acanthochondria*, the

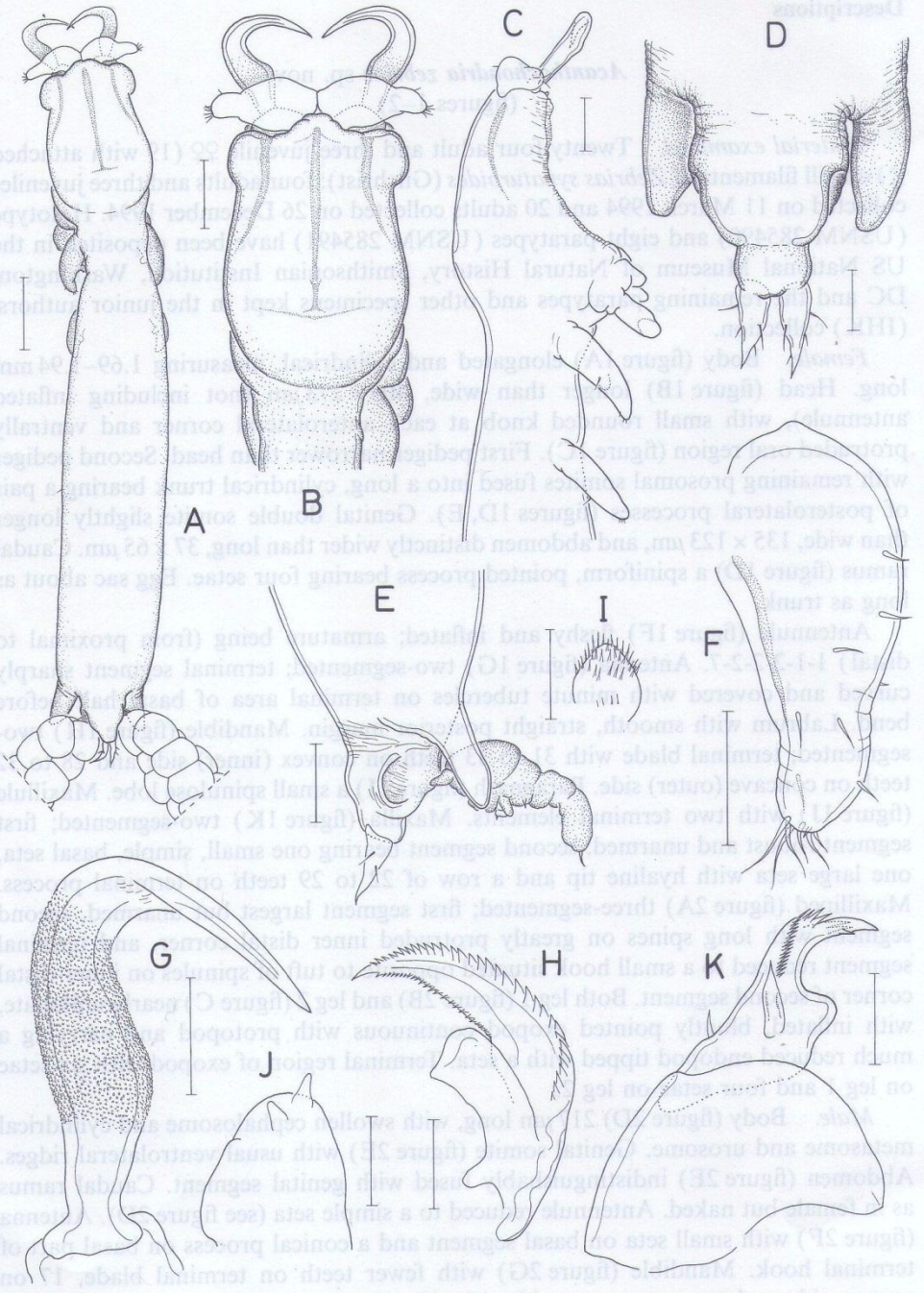

FIG. 1. *Acanthochondria zebriae* sp. nov. Female: (A) habitus of adult, dorsal; (B) head and neck, dorsal; (C) same, lateral; (D) posterior part of trunk, dorsal; (E) same with male, lateral; (F) antennule; (G) antenna; (H) mandible; (I) paragnath; (J) maxillule; (K) maxilla. Scale bars: 0.2 mm in (A); 0.1 mm in (B, C, E); 0.05 mm in (D, F, G); 0.02 mm in (H, I, J, K).

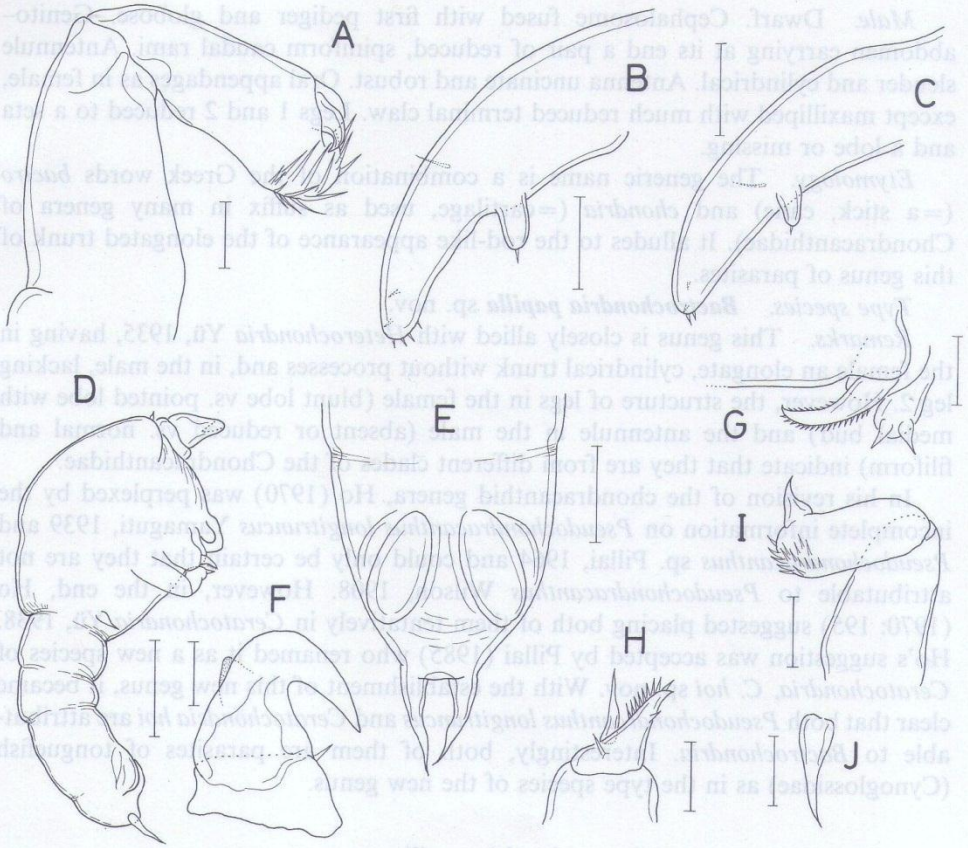

FIG. 2. *Acanthochondria zebriae* sp. nov. Female: (A) maxilliped; (B) leg 1; (C) leg 2. Male: (D) habitus of adult, lateral; (E) genito–abdomen, ventral; (F) antenna; (G) labrum, mandible and maxillule; (H) maxilla; (I) maxilliped; (J) leg 1. Scale bars: 0.02 mm in (A, E); 0.05 mm in (B–D); 0.01 mm in (F–J).

antennule of the new species belongs, undoubtedly, to Type G–I, but its legs do not fit well to any of the five types. Basically, the legs of *A. zebriae* are attributable to Type A, but no species of *Acanthochondria* with Type A leg has its endopods on both legs 1 and 2 reduced to a small knob as in the present species. Furthermore, no species of *Acanthochondria* has the male with leg 2 missing and leg 1 reduced to a spiniform seta. The subchelate female maxilliped is another unusual feature of the present species.

Genus ***Bactrochondria*** gen. nov.

Female. Body elongate, cylindrical. Head consisting of cephalosome only. Neck region short, composed of first pediger. Remaining prosomal somites fused into a cylindrical trunk, without processes. Genito–abdomen and caudal ramus as usual form in family. Egg sac cylindrical, nearly as long as body. Antennule lobate. antenna uncinate. Oral appendages as in usual form, except with subchelate maxilliped. Two pairs of legs modified; leg 1 large, bilobate; leg 2 reduced to two rami without protopod.

Male. Dwarf. Cephalosome fused with first pediger and globose. Genito–abdomen carrying at its end a pair of reduced, spiniform caudal rami. Antennule slender and cylindrical. Antenna uncinate and robust. Oral appendages as in female, except maxilliped with much reduced terminal claw. Legs 1 and 2 reduced to a seta and a lobe or missing.

Etymology. The generic name is a combination of the Greek words *bactro* (=a stick, cane) and *chondria* (=cartilage, used as suffix in many genera of Chondracanthidae). It alludes to the rod-like appearance of the elongated trunk of this genus of parasites.

Type species. ***Bactrochondria papilla*** sp. nov.

Remarks. This genus is closely allied with *Heterochondria* Yü, 1935, having in the female an elongate, cylindrical trunk without processes and, in the male, lacking leg 2. However, the structure of legs in the female (blunt lobe vs. pointed lobe with medial bud) and the antennule in the male (absent or reduced vs. normal and filiform) indicate that they are from different clades of the Chondracanthidae.

In his revision of the chondracanthid genera, Ho (1970) was perplexed by the incomplete information on *Pseudochondracanthus longitruncus* Yamaguti, 1939 and *Pseudochondracanthus* sp. Pillai, 1964 and could only be certain that they are not attributable to *Pseudochondracanthus* Wilson, 1908. However, in the end, Ho (1970: 195) suggested placing both of them tentatively in *Ceratochondria* Yü, 1938. Ho's suggestion was accepted by Pillai (1985) who renamed it as a new species of *Ceratochondria, C. hoi* sp. nov. With the establishment of this new genus, it became clear that both *Pseudochondrcanthus longitruncus* and *Ceratochondria hoi* are attributable to *Bactrochondria*. Interestingly, both of them are parasites of tonguefish (Cynoglossidae) as in the type species of the new genus.

Bactrochondria papilla sp. nov.
(figures 3–4)

Material examined. Twenty-seven adult ♀♀ (each with attached ♂) found on gill filaments of *Cynoglossus dubius* (Regan): eight collected on 14.ii.1994 and 19 collected on 20 July 1994. Holotype (USNM 285492) and ten paratypes (USNM 285493) have been deposited in the US National Museum of Natural History, Smithsonian Institution, Washington, DC, and the remaining paratypes and other specimens kept in the author's (IHK) collection.

Female. Body (figure 3A) greatly elongated and cylindrical, 2.52–4.56 mm long and 0.37–0.52 mm wide. Head (figure 3B) longer than wide, 0.60 × 0.37 mm (not including inflated antennule), with prominent cephalic process (a swollen base tipped with a nipple-like protrusion) at each anterolateral corner (figures 3C, F). Neck region formed by first pediger, remaining prosomal somites fused into a long, cylindrical trunk. Genital double somite indistinguishably fused to trunk (figures 3A,D), carrying a central vermiform process on ventral side. Abdomen like a narrow ring attached to genital double somite (figure 3D). Caudal ramus (figure 3D) a pointed spiniform process carrying three setae and one tubercle. Longest egg sac 8.64 mm long, nearly twice as long as its body length.

Antennule (figure 3E) with inflated base and cylindrical tip; armature being (from proximal to distal) 1-1-2-1-7. Antenna (figure 3F) two-segmented; terminal segment an uncinate hook. Labrum (figure 3G) with smooth posterior margin. Mandible (figure 3H) two-segmented; terminal blade with 21 to 27 teeth on convex (inner)

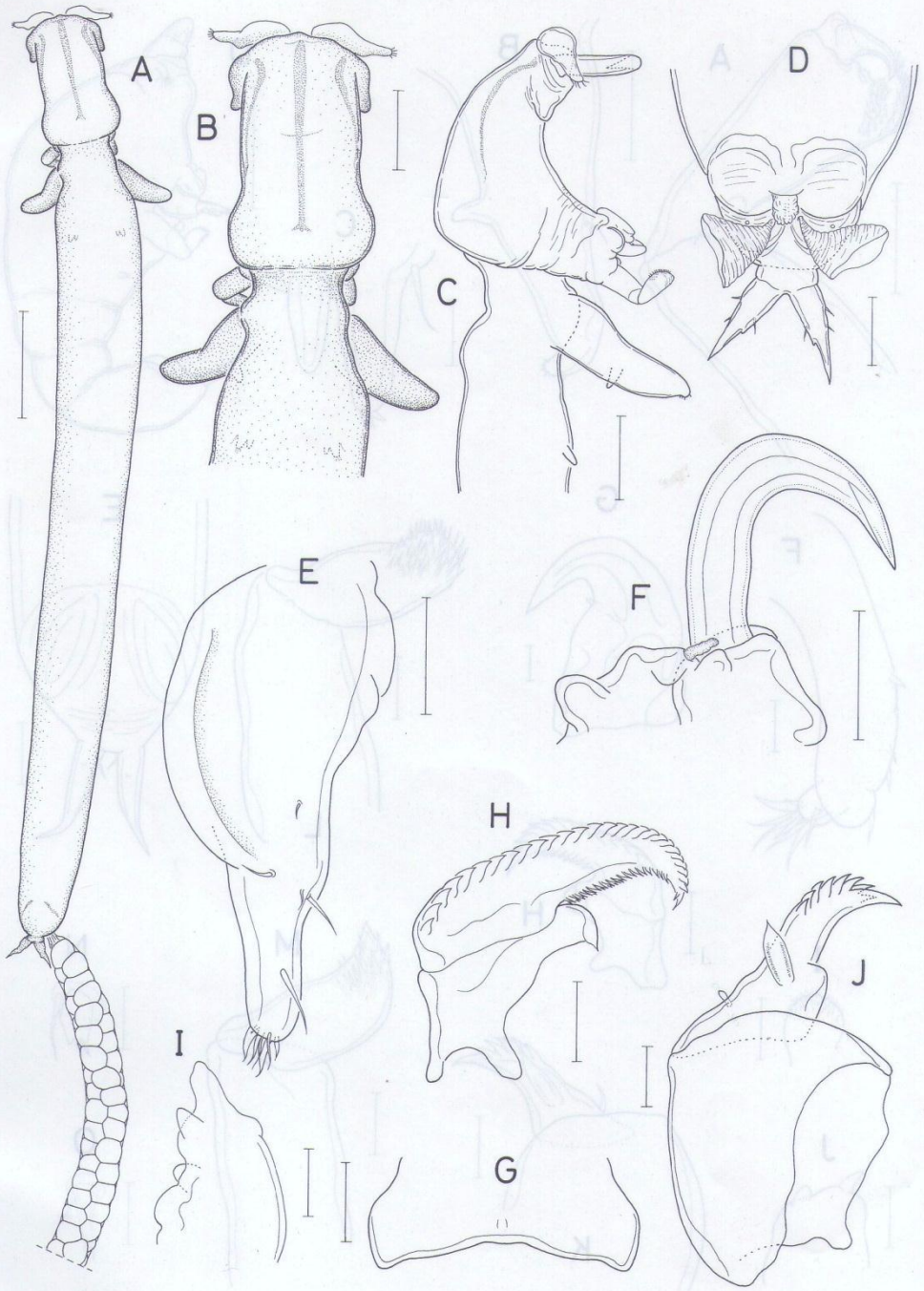

FIG. 3. *Bactrochondria papilla* gen. et sp. nov. Female: (A) habitus of adult, dorsal; (B) head and neck, dorsal; (C) same, lateral; (D) genito–abdomen, ventral; (E) antennule; (F) antenna; (G) labrum; (H) mandible; (I) manxillule; (J) maxilla. Scale bars: 0.2 mm in (A); 0.1 mm in (B–D); 0.05 mm in (E, F); 0.02 mm in (G–J).

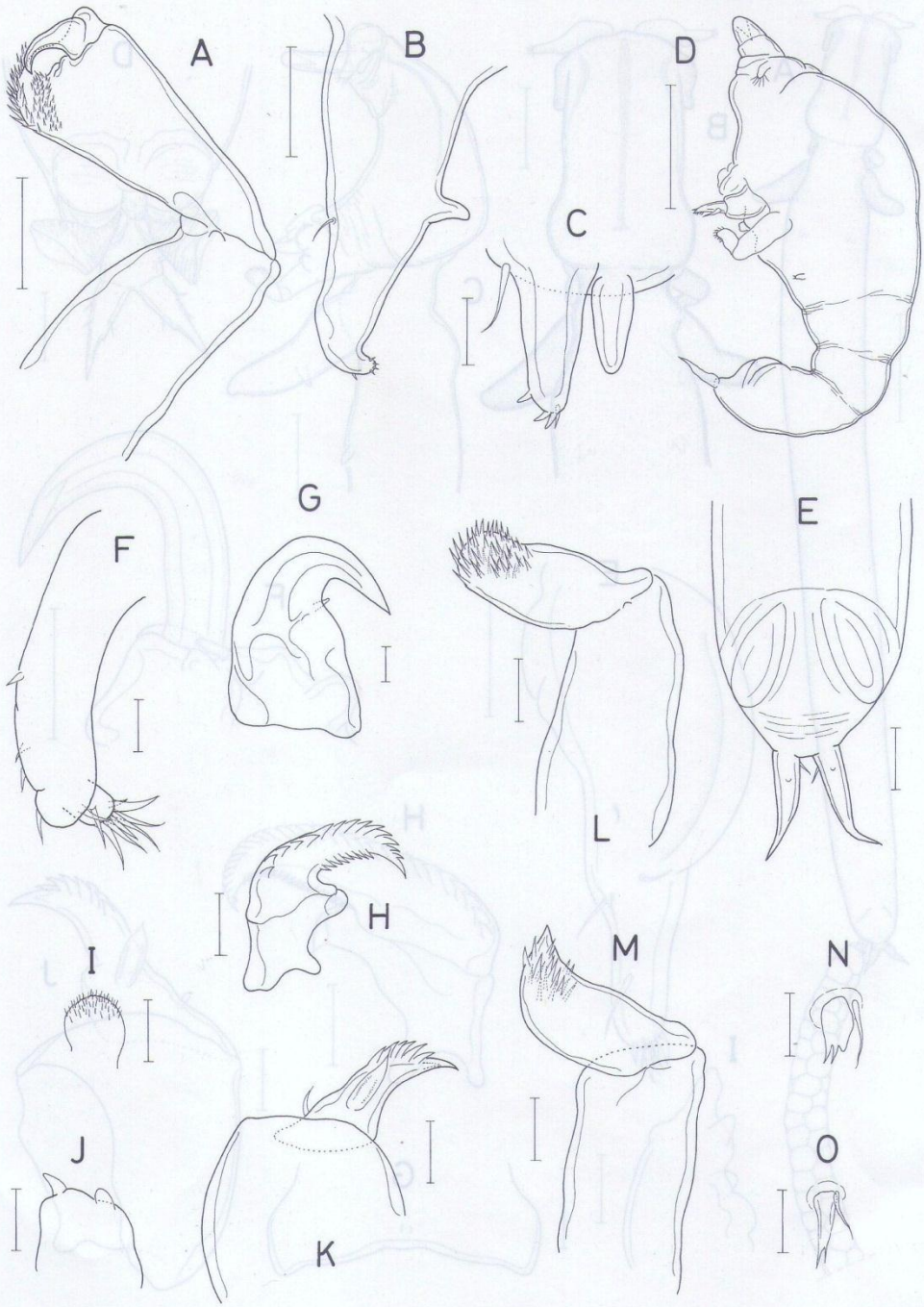

FIG. 4. *Bactrochondria papilla* gen. et sp. nov. Female: (A) maxilliped; (B) leg 1; (C) leg 2. Male: (D) habitus of adult, lateral; (E) genito–abdomen, ventral; (F) antennule; (G) antenna; (H) mandible; (I) paragnath; (J) maxillule; (K) maxilla; (L) maxilliped, posterior; (M) maxilliped, anterior; (N) leg 1; (O) leg 2. Scale bars: 0.05 mm in (A); 0.1 mm in (B, D); 0.02 mm in (C, E); 0.01 mm in (F–O).

side and 12 to 16 teeth on convex (outer) side. Maxillule (figure 3I) with three blunt, terminal setae. Maxilla (figure 3J) two-segmented; first segment robust but unarmed; second segment bearing one small, simple, basal seta, one large seta with hyaline tip and a row of seven to nine teeth along inner edge of terminal process. Maxilliped (figure 4A) three-segmented; first segment largest but unarmed, second segment expanded distally with enlarged inner corner armed with two patches of denticles, and terminal segment reduced to a small claw attached to non-swollen outer distal corner of second segment. Leg 1 (figure 4B) with greatly enlarged, process-like protopod carrying an outer basal seta and much reduced, knob-like rami. Endopod unarmed, but exopod tipped with five short setae, four terminal and one subterminal. Leg 2 (figure 4C) biramous; protopod largely fused to trunk and only identifiable by its outer, basal seta. Both rami rod-like, with exopod larger than endopod and tipped with four short setae, three terminal and one subterminal.

Male. Body (figure 4D) 388 μm long, cephalosome moderately swollen. Genital somite (figure 4E) with prominent ventrolateral ridges but abdomen small and indistinct. Caudal ramus (figure 4E) a spiniform process bearing a medial seta and a ventral tubercle at base. Antennule (figure 4F) elongate and cylindrical, with terminal portion set off in a posteroventrally directed knob; armature being 1-1-1-2-8. Antenna (figure 4G) a strongly recurved hook bearing an inner setule. Mandible (figure 4H) with fewer teeth on terminal blade, 14 on convex side and seven to eight or concave side. Paragnath (figure 4I) a spinulose lobe. Maxillule (figure 4J) with two terminal elements. Maxilla (figure 4K) with seven teeth on inner surface of terminal process. Maxilliped (figure 4L) with much reduced, terminal claw visible in lateral view only (figure 4M). Leg 1 (figure 4N) reduced to a seta and a tiny knob tipped with two setules and a small tubercle, or only two setules (figure 4O).

Etymology. The specific name *papilla* is Latin (=nipple, teat, bud), it refers to the reduction of the endopod on leg 2 to a bud-like structure.

Remarks. The new species can be distinguished from its two congeners by the following three characters:

Characters	*hoi*	*longitruncus*	*papilla*
ratio of female trunk (length/width)	4.7:1	5.8:1	8.9:1
annular sculptures on male antenna	present	present	absent
terminal claw of male maxilliped	absent	absent	present
leg 2 in male	absent	absent	present

Since Yamaguti (1939) failed to describe the fine structures of *B. longitruncus,* it is impossible to point out if there are further differences among these three species. However, more differences from *B. hoi* are given after the redescription of that species.

Bactrochondria hoi (Pillai, 1985)
(figures 5–6)

Material examined. Nine adult ♀♀ (seven with attached ♂) found on gill filaments of *Cynoglossus lida* (Bleeker): one collected on 11 March 1994 and eight on 20 July 1994.

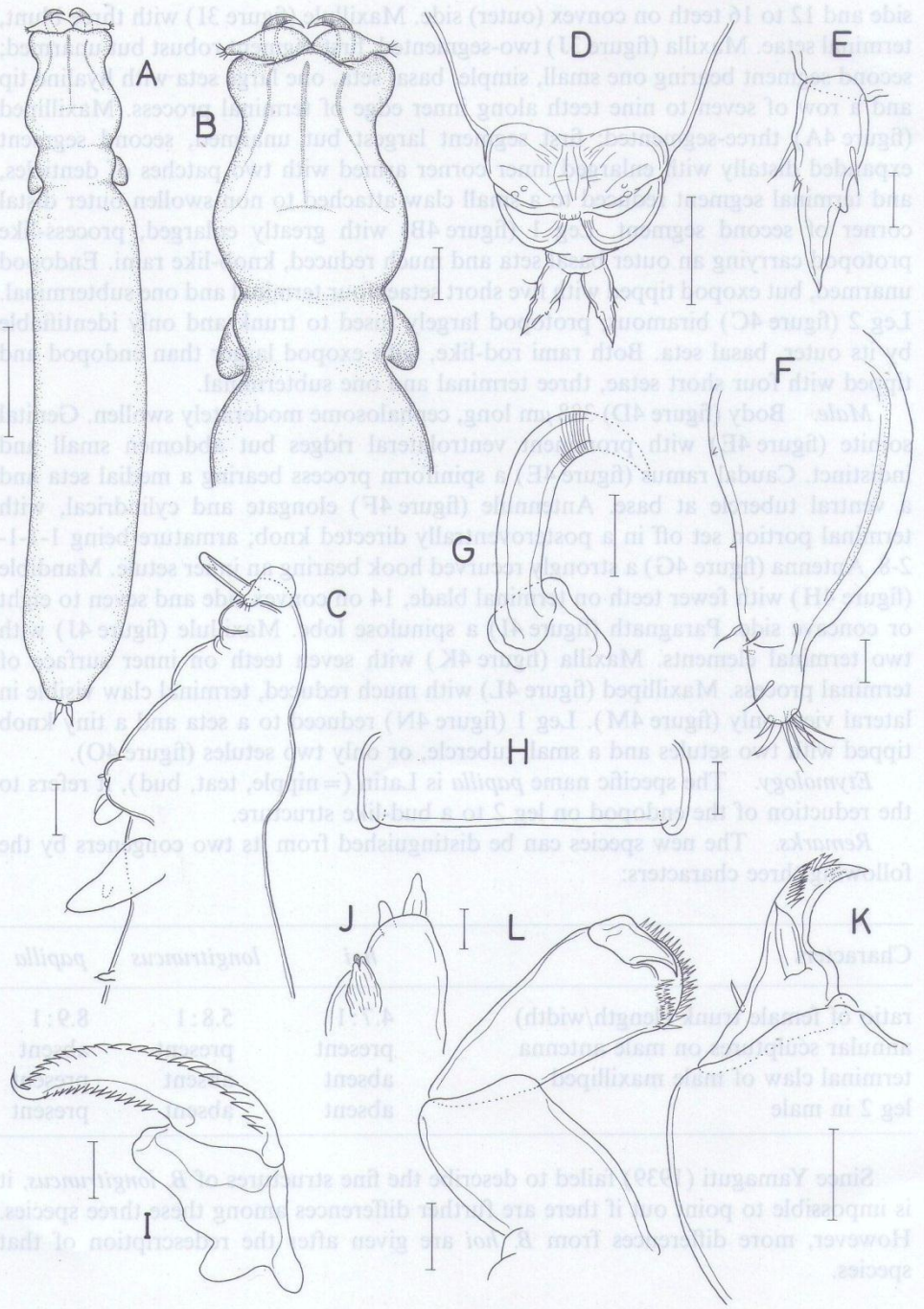

FIG. 5. *Bactrochondria hoi* (Pillai). Female: (A) habitus of adult, dorsal; (B) head and neck, dorsal; (C) same, lateral; (D) genito–abdomen, ventral; (E) caudal ramus; (F) antennule; (G) antenna; (H) labrum; (I) mandible; (J) maxillule; (K) maxilla; (L) maxilliped. Scale bars: 0.5 mm in (A); 0.1 mm in (B–D); 0.02 mm in (E, F, H, K, L); 0.05 mm in (G); 0.01 mm in (I, J).

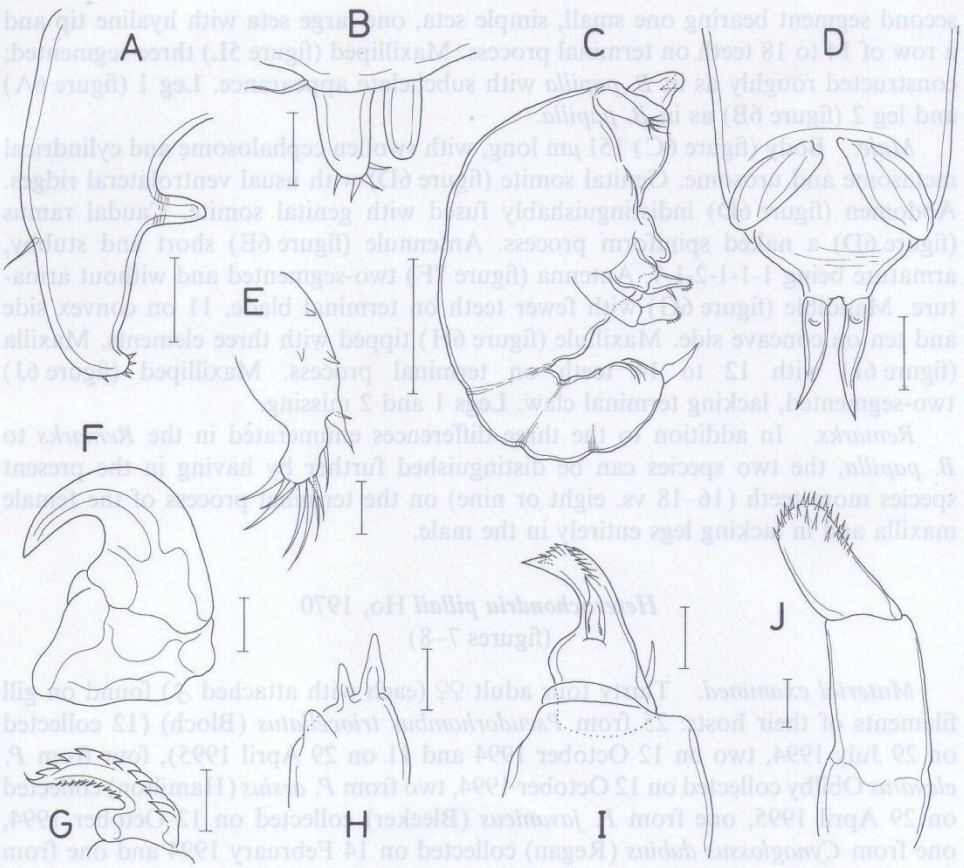

FIG. 6. *Bactrochondria hoi* (Pillai). Female: (A) leg 1; (B) leg 2. Male: (C) habitus of adult, lateral; (D) genito–abdomen, ventral; (E) antennule; (F) antenna; (G) mandible; (H) maxillule; (I) maxilla; (J) maxilliped. Scale bars: 0.05 mm in (A); 0.02 mm in (B, D); 0.1 mm in (C); 0.01 mm in (E–J).

Female. Body (figure 5A) elongated and cylindrical, measuring 2.26–3.02 mm long. Head (figure 5B) longer than wide, 495 × 385 μm (not including inflated antennule), with small rounded knob at each anterolateral corner and distinctly swollen oral region (figure 5C). First pediger forming neck region (figure 5C). Second pediger fused with remaining prosomal somites into a long, cylindrical trunk. Genital double somite (figure 5D) distinctly wider than long, with abdomen attaching to it like a narrow ring. Caudal ramus (figure 5E) a spiniform pointed process bearing three setae and a tubercle. Egg sac not seen.

Antennule (figure 5F) fleshy, with inflated base tipped with a short, setae-bearing process; armature being (from proximal to distal) 1-1-1-2-2-8. Antenna (figure 5G) two-segmented; terminal segment sharply curved (broken in dissected specimens), with annular sculptures in bent area. Labrum (figure 5H) with posterolateral knob and smooth posterior margin. Terminal blade of mandible (figure 5I) bearing 22 to 24 teeth on convex (inner) side and 13 to 16 teeth on concave (outer) side. Maxillule (figure 5J) with two terminal elements and a subterminal process tipped with three tubercles. Maxilla (figure 5K) two-segmented; first segment robust and unarmed;

second segment bearing one small, simple seta, one large seta with hyaline tip and a row of 14 to 18 teeth on terminal process. Maxilliped (figure 5L) three-segmented; constructed roughly as in *B. papilla* with subchelate appearance. Leg 1 (figure 6A) and leg 2 (figure 6B) as in *B. papilla*.

Male. Body (figure 6C) 151 μm long, with swollen cephalosome and cylindrical metasome and urosome. Genital somite (figure 6D) with usual ventrolateral ridges. Abdomen (figure 6D) indistinguishably fused with genital somite. Caudal ramus (figure 6D) a naked spiniform process. Antennule (figure 6E) short and stubby, armature being 1-1-1-2-1-7. Antenna (figure 7F) two-segmented and without armature. Mandible (figure 6G) with fewer teeth on terminal blade, 11 on convex side and ten on concave side. Maxillule (figure 6H) tipped with three elements. Maxilla (figure 6I) with 12 to 14 teeth on terminal process. Maxilliped (figure 6J) two-segmented, lacking terminal claw. Legs 1 and 2 missing.

Remarks. In addition to the three differences enumerated in the *Remarks* to *B. papilla*, the two species can be distinguished further by having in the present species more teeth (16–18 vs. eight or nine) on the terminal process of the female maxilla and in lacking legs entirely in the male.

Heterochondria pillaii Ho, 1970
(figures 7–8)

Material examined. Thirty four adult ♀♀ (each with attached ♂) found on gill filaments of their hosts: 25 from *Pseudorhombus triocellatus* (Bloch) (12 collected on 29 July 1994, two on 12 October 1994 and 11 on 29 April 1995), four from *P. elevatus* Obilby collected on 12 October 1994, two from *P. arsius* (Hamilton) collected on 29 April 1995, one from *P. javanicus* (Bleeker) collected on 12 October 1994, one from *Cynoglossus dubius* (Regan) collected on 14 February 1994 and one from *C. lida* collected on 26 December 1994.

Female. Body (figure 7A) elongated, cylindrical and measuring 2.52–5.71 mm long. Head (figure 7B) longer than wide, 910 × 482 μm (not including inflated antennule), with two lateral protrusions in front and one similar but smaller protrusion in rear. Neck region (first pediger) not marked off from trunk. Genital double somite (figure 7C) wider than long and bearing a lateral seta in egg sac attachment area. Abdomen (figure 7C) distinctly longer than wide. Caudal ramus (figure 7C) a spiniform, pointed process bearing three setae and a medial knob. Egg sac lengths variable, ranging from less than one-half of to more than twice body length.

Antennule (figure 7D) fleshy, inflated, with a subterminal, posteroventral protrusion; armature being 1-1-8 (figure 7E, from proximal to distal). Antenna (figure 7F) two-segmented; proximal segment small, bearing a sclerotized process at base of terminal segment, which is a slender claw with corrugated surface in the distal third. Labrum (figure 7G) with denticles on posterior margin. Mandible (figure 7H) two-segmented; terminal blade with a row of 22 to 26 teeth on convex (inner) side and two rows of about 25 teeth on concave (outer) side. Maxillule (figure 7I) a small fleshy lobe tipped with two short setae and a patch of spinules. Maxilla (figure 7J) two-segmented; first segment large but unarmed, second segment bearing in basal region one small, simple seta and one large seta with hyaline tip, and a row of about 30 teeth on terminal process. Maxilliped (figure 7K) three-segmented; first segment largest but unarmed, second segment expanded distally and bearing two rows of spines with terminal claw bending between them. Leg 1 (figure 8A) larger than leg

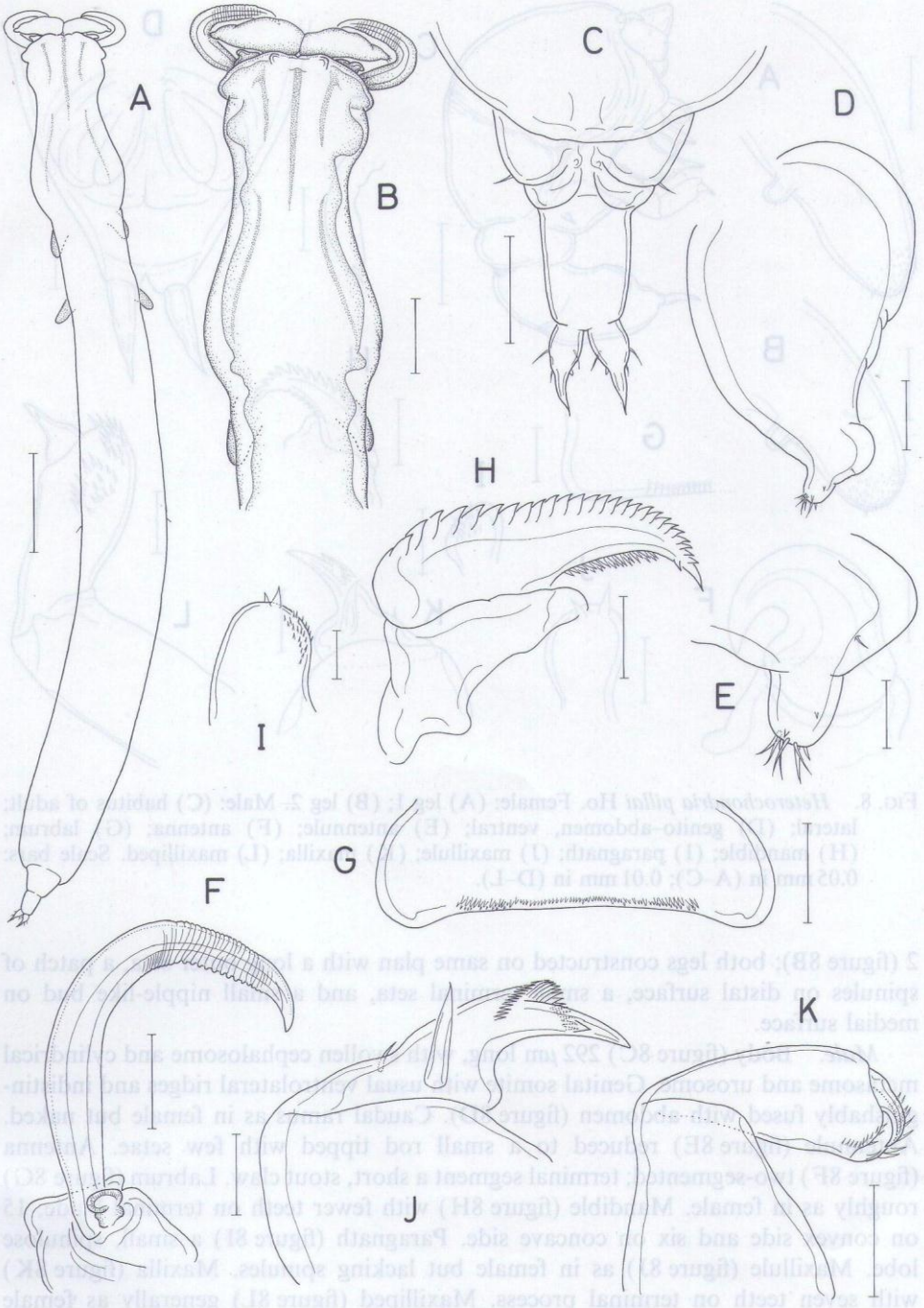

FIG. 7. *Heterochondria pillai* Ho. Female: (A) habitus of adult, dorsal; (B) head, dorsal; (C) genito–abdomen, ventral; (D) antennule; (E) terminal part of antennule; (F) antenna; (G) labrum; (H) mandible; (I) maxillule; (J) maxilla; (K) maxilliped. Scale bars: 0.5 mm in (A); 0.2 mm in (B); 0.1 mm in (C, F); 0.05 mm in (D, G, K); 0.02 mm in (E, H–J).

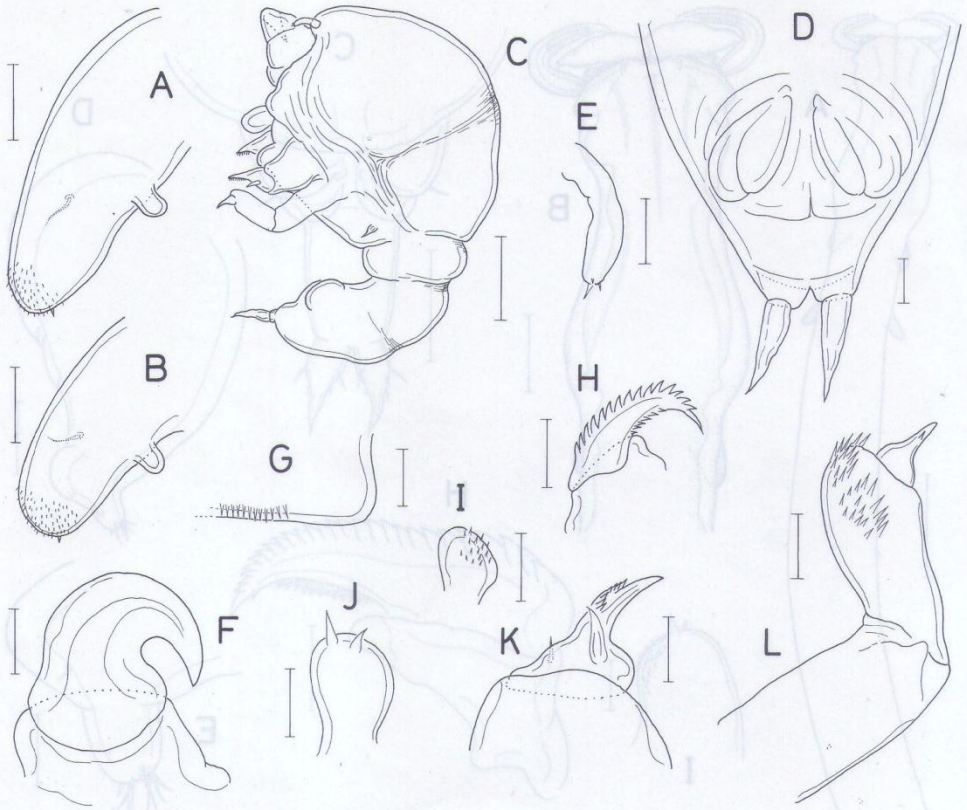

FIG. 8. *Heterochondria pillai* Ho. Female: (A) leg 1; (B) leg 2. Male: (C) habitus of adult; lateral; (D) genito–abdomen, ventral; (E) antennule; (F) antenna; (G) labrum; (H) mandible; (I) paragnath; (J) maxillule; (K) maxilla; (L) maxilliped. Scale bars: 0.05 mm in (A–C); 0.01 mm in (D–L).

2 (figure 8B); both legs constructed on same plan with a long outer seta, a patch of spinules on distal surface, a small terminal seta, and a small nipple-like bud on medial surface.

Male. Body (figure 8C) 292 μm long, with swollen cephalosome and cylindrical metasome and urosome. Genital somite with usual ventrolateral ridges and indistinguishably fused with abdomen (figure 8D). Caudal ramus as in female but naked. Antennule (figure 8E) reduced to a small rod tipped with few setae. Antenna (figure 8F) two-segmented; terminal segment a short, stout claw. Labrum (figure 8G) roughly as in female. Mandible (figure 8H) with fewer teeth on terminal blade, 15 on convex side and six on concave side. Paragnath (figure 8I) a small, spinulose lobe. Maxillule (figure 8J) as in female but lacking spinules. Maxilla (figure 8K) with seven teeth on terminal process. Maxilliped (figure 8L) generally as female except terminal teeth on second segment occurring in two patches rather than in two rows. Leg 1 (figure 8C) reduced to a simple spiniform seta as in *Acanthochondria zebriae* (see figure 2J). Leg 2 absent.

Remarks. The most characteristic feature of *H. pillaii* is the possession of a nipple-like bud on the medial surface of leg 1 in the female (see figure 8A) and a small, rod-like antennule in the male (figure 8E). Both of them are rather unusual

for the species of *Heterochondria*. If the nipple-like bud on the female leg 1 was considered to represent the modified, reduced endopod, then *H. pillaii* could have been placed in *Bactrochondria*. However, the structure of leg 2 in the female of *H. pillaii* will definitely preclude such consideration.

H. pillaii is the most common chondracanthid copepod parasitic on the six species of flatfishes in Kerala (table 1). Thus, it is not surprising to see it being reported on *Pseudorhombus arsius* (Hamilton) from the Persian Gulf by Ho and Sey (1996).

Heterochondria petila sp. nov.
(figures 9–10)

Material examined. One hundred and thirty-six adult ♀♀ (each with attached ♂) found on gill filaments of their hosts: 124 from *Pseudorhombus arsius* (four collected on 11 March 1994, five on 20 July 1994, 12 on 12 October 1994, 23 on 26 December 1994, 90 on 29 April 1995), nine from *P. javanicus* (five collected on 12 October 1995 and four on 25 December 1995) and three from *P. triocellatus* collected on 12 October 1994. Holotype (USNM 285486) and 30 paratypes (USNM 285486) have been deposited in the US National Museum of Natural History, Smithsonian Institution, Washington, DC and the remaining paratypes and other specimens in the author's (IHK) collection.

Female. Body (figure 9A) elongated and cylindrical, measuring 2.85–3.73 mm. Head (figure 9B) longer than wide, 610 × 360 μm (not including inflated antennule), with round, lateral protrusion in front and rear; in lateral view posterior (oral) region thicker than anterior (antennal) region (figure 9C). Neck region (first pediger) distinct. Trunk slightly wider in posterior region. Genital double somite (figure 9D) wider than long, carrying egg sacs on its ventral surface (figure 9E). Abdomen (figures 9D, E) globose. Caudal ramus (figures 9D, E) a spiniform, pointed process bearing three setae and a small, medial lobe. Egg sac (figure 9A) about as long as trunk.

Antennule (figure 9F) fleshy, with greatly inflated basal portion; armature being 1-1-1-2-8. Antenna (figure 9G) two-segmented; proximal segment small, with a round, distal protrusion; terminal segment a slender, uncinate hook bearing fine annuli in distal portion. Labrum (figure 9H) with denticles on posterior margin. Mandible (figure 10A) two-segmented; terminal blade with a row of about 80 teeth on convex (inner) side and two rows of about 40 teeth on concave (outer) side. Paragnath (figure 10B) a small lobe with spinules on distal surface. Maxillule (figure 10C) a spinulose lobe tipped with two small setae. Maxilla (figure 10D) two-segmented; first segment larger but unarmed, second segment bearing in basal region one small, simple seta and a large seta with hyaline tip, and a row of more than 30 teeth on terminal process. Maxilliped (figure 7K) three-segmented; first segment largest but unarmed, second segment expanded distally and bearing two groups of spines with terminal claw bending between them. Leg 1 (figure 10F) a large, fleshy process bearing a small medial, basal protrusion; outer surface with a regular, long seta and inner surface with two small setae near basal protrusion and five short setae on distal portion, of which the middle three are on a small knob. Leg 2 (figure 10G) small, less then one-half of leg 1, armed with a regular long, outer seta and two small, distal setae.

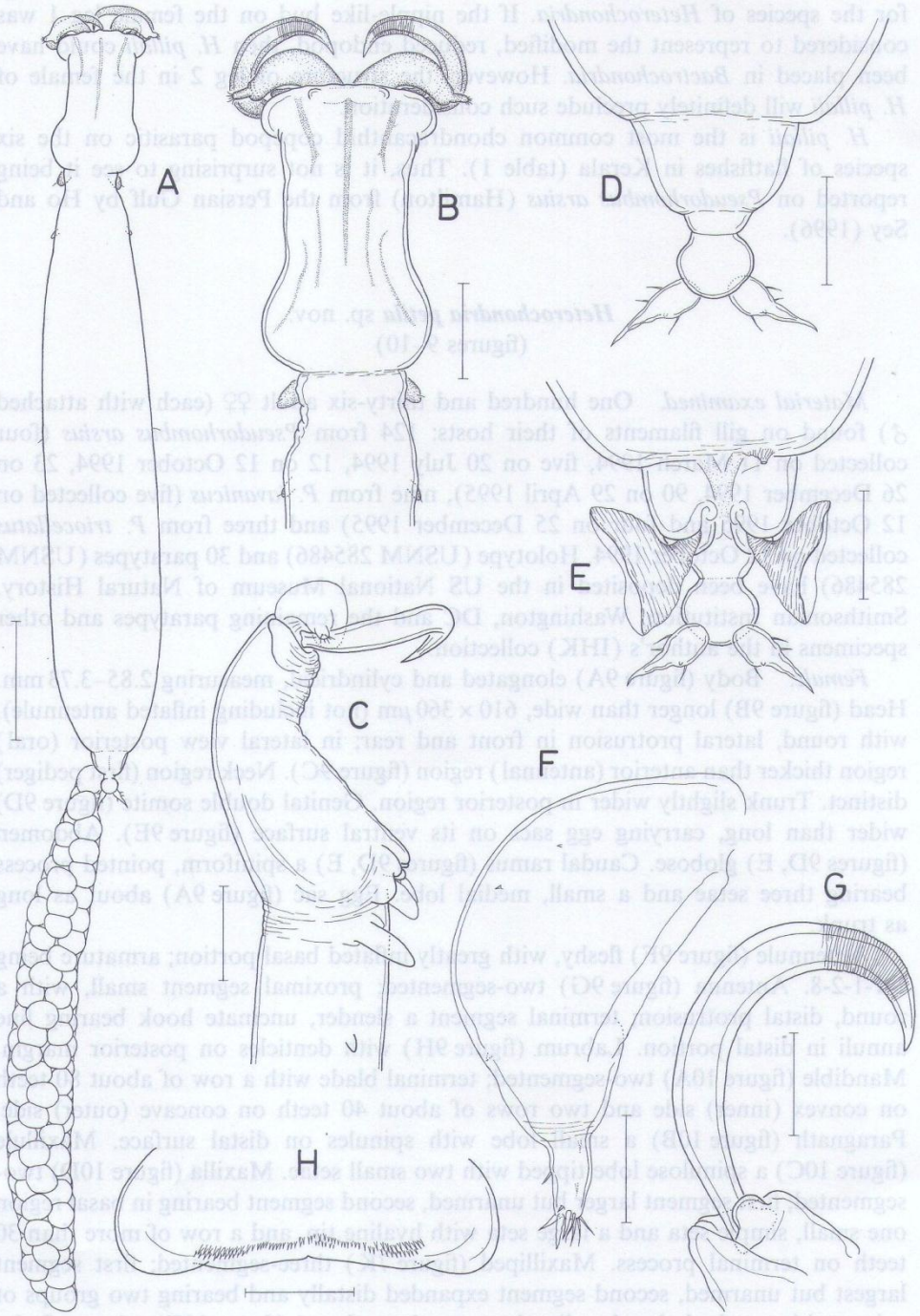

FIG. 9. *Heterochondria petila* sp. nov. Female: (A) habitus of adult, dorsal; (B) head and neck region, dorsal; (C) same, lateral; (D) genito–abdomen, dorsal; (E) same, ventral; (F) antennule; (G) antenna; (H) labrum. Scale bars: 0.5 mm in (A); 0.2 mm in (B, C); 0.1 mm in (D, E, G); 0.05 mm in (F, H).

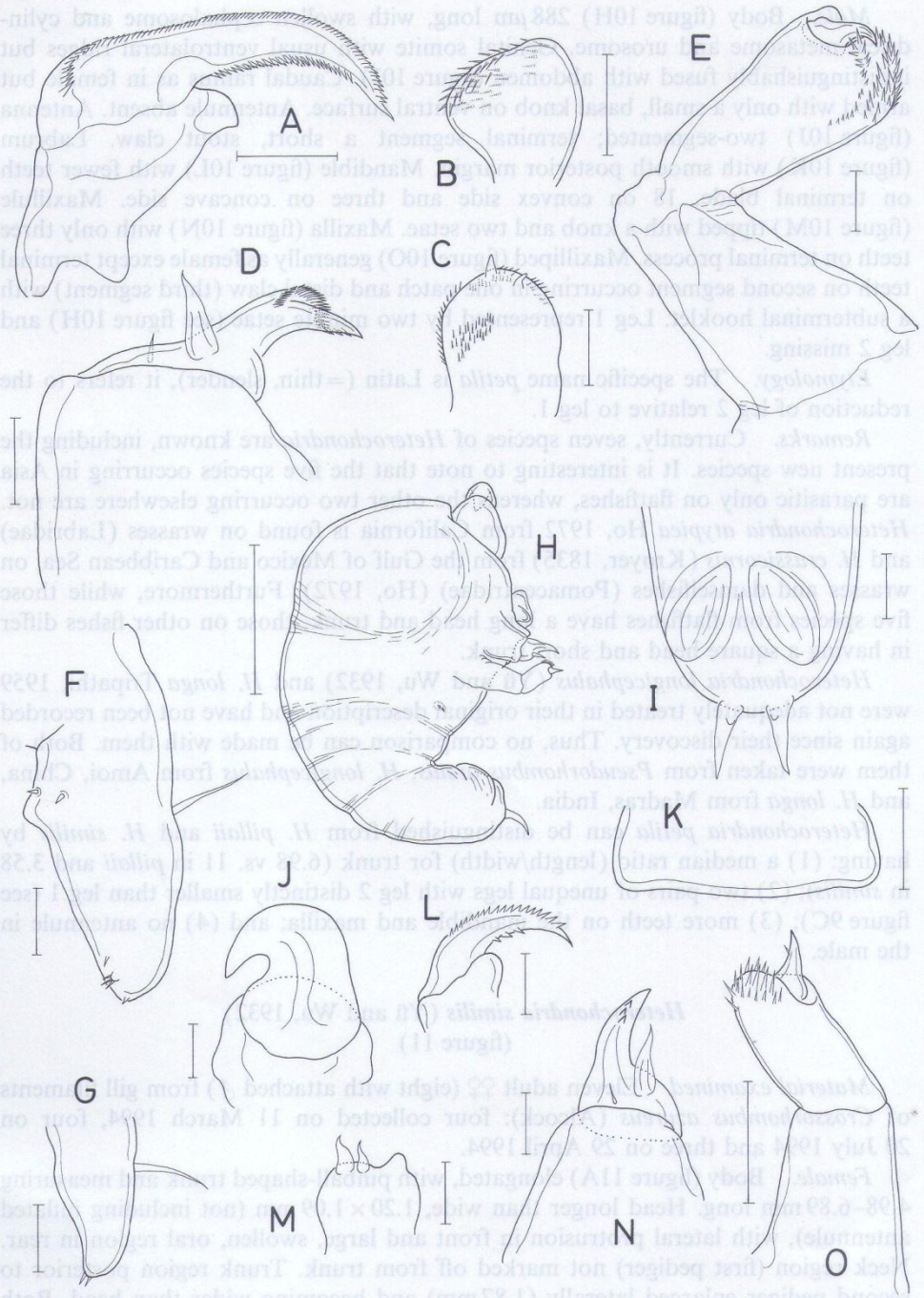

FIG. 10. *Heterochondria petila* sp. nov. Female: (A) mandible; (B) paragnath; (C) maxillule; (D) maxilla; (E) maxilliped; (F) leg 1; (G) leg 2. Male: (H) habitus of adult, lateral; (I) genito–abdomen, ventral; (J) antenna; (K) labrum; (L) mandible; (M) maxillule; (N) maxilla; (O) maxilliped. Scale bars: 0.02 mm in (A–E, I, K, O); 0.1 mm in (F–H); 0.01 mm in (J, L–N).

Male. Body (figure 10H) 288 μm long, with swollen cephalosome and cylindrical metasome and urosome. Genital somite with usual ventrolateral ridges but indistinguishably fused with abdomen (figure 10I). Caudal ramus as in female but armed with only a small, basal knob on ventral surface. Antennule absent. Antenna (figure 10J) two-segmented; terminal segment a short, stout claw. Labrum (figure 10K) with smooth posterior margin. Mandible (figure 10L) with fewer teeth on terminal blade, 18 on convex side and three on concave side. Maxillule (figure 10M) tipped with a knob and two setae. Maxilla (figure 10N) with only three teeth on terminal process. Maxilliped (figure 10O) generally as female except terminal teeth on second segment occurring in one patch and distal claw (third segment) with a subterminal hooklet. Leg 1 represented by two minute setae (see figure 10H) and leg 2 missing.

Etymology. The specific name *petila* is Latin (=thin, slender), it refers to the reduction of leg 2 relative to leg 1.

Remarks. Currently, seven species of *Heterochondria* are known, including the present new species. It is interesting to note that the five species occurring in Asia are parasitic only on flatfishes, whereas the other two occurring elsewhere are not. *Heterochondria atypica* Ho, 1972 from California is found on wrasses (Labridae) and *H. crassicornis* (Krøyer, 1835) from the Gulf of Mexico and Caribbean Sea, on wrasses and damselfishes (Pomacentridae) (Ho, 1972). Furthermore, while those five species from flatfishes have a long head and trunk, those on other fishes differ in having a square head and short trunk.

Heterochondria longicephalus (Yü and Wu, 1932) and *H. longa* Tripathi, 1959 were not adequately treated in their original description and have not been recorded again since their discovery. Thus, no comparison can be made with them. Both of them were taken from *Pseudorhombus arsius*, *H. longicephalus* from Amoi, China, and *H. longa* from Madras, India.

Heterochondria petila can be distinguished from *H. pillaii* and *H. similis* by having: (1) a median ratio (length/width) for trunk (6.98 vs. 11 in *pillaii* and 3.58 in *similis*); (2) two pairs of unequal legs with leg 2 distinctly smaller than leg 1 (see figure 9C); (3) more teeth on the mandible and maxilla; and (4) no antennule in the male.

Heterochondria similis (Yü and Wu, 1932)
(figure 11)

Material examined. Eleven adult ♀♀ (eight with attached ♂) from gill filaments of *Crossorhombus azureus* (Alcock): four collected on 11 March 1994, four on 20 July 1994 and three on 29 April 1994.

Female. Body (figure 11A) elongated, with pinball-shaped trunk and measuring 4.98–6.89 mm long. Head longer than wide, 1.20 × 1.09 mm (not including inflated antennule), with lateral protrusion in front and large, swollen, oral region in rear. Neck region (first pediger) not marked off from trunk. Trunk region posterior to second pediger enlarged laterally (1.87 mm) and becoming wider than head. Both genital double somite and abdomen (figure 11B) distinctly wider than long. Caudal ramus (figure 11C) a spiniform, pointed process bearing three setae. Egg sac about as long as body.

Antennule (figure 11D) fleshy, sausage-shaped, and tipped with seven setae. Antenna broken in all specimens examined. Labrum (figure 11E) with smooth posterior margin. Terminal blade of mandible (figure 11F) with a row of 45 teeth on

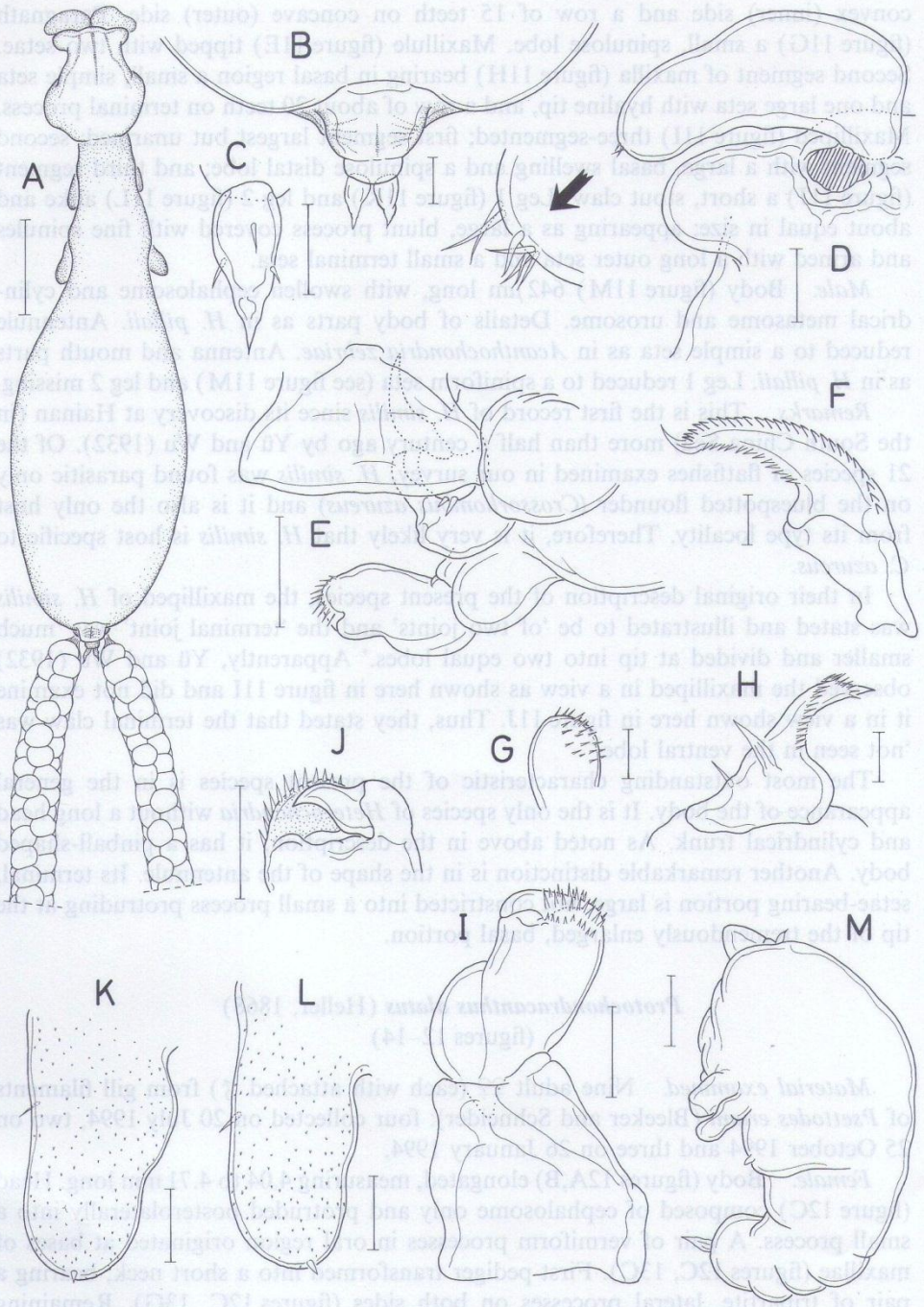

FIG. 11. *Heterochondria similis* (Yü and Wu). Female: (A) habitus of adult, dorsal; (B) genito-abdomen, dorsal; (C) caudal ramus; (D) right side of antennary region, ventral; (E) oral region, ventral; (F) mandible; (G) paragnath; (H) maxilla; (I) maxilliped; (J) terminal part of maxilliped; (K) leg 1; (L) leg 2. Male: (M) habitus of adult, lateral. Scale bars: 1 mm in (A); 0.1 mm in (B–E, K, L); 0.02 mm in (F–H); 0.05 mm in (I, J).

convex (inner) side and a row of 15 teeth on concave (outer) side. Paragnath (figure 11G) a small, spinulose lobe. Maxillule (figure 11E) tipped with two setae. Second segment of maxilla (figure 11H) bearing in basal region a small, simple seta and one large seta with hyaline tip, and a row of about 20 teeth on terminal process. Maxilliped (figure 11I) three-segmented; first segment largest but unarmed; second segment with a large, basal swelling and a spinulose distal lobe; and third segment (figure 11J) a short, stout claw. Leg 1 (figure 11K) and leg 2 (figure 11L) alike and about equal in size; appearing as a large, blunt process covered with fine spinules and armed with a long outer seta and a small terminal seta.

Male. Body (figure 11M) 642 μm long, with swollen cephalosome and cylindrical metasome and urosome. Details of body parts as in *H. pillaii*. Antennule reduced to a simple seta as in *Acanthochondria zebriae*. Antenna and mouth parts as in *H. pillaii*. Leg 1 reduced to a spiniform seta (see figure 11M) and leg 2 missing.

Remarks. This is the first record of *H. similis* since its discovery at Hainan (in the South China Sea) more than half a century ago by Yü and Wu (1932). Of the 21 species of flatfishes examined in our survey, *H. similis* was found parasitic only on the bluespotted flounder (*Crossorhombus azureus*) and it is also the only host from its type locality. Therefore, it is very likely that *H. similis* is host specific to *C. azureus*.

In their original description of the present species, the maxilliped of *H. similis* was stated and illustrated to be 'of two joints' and the 'terminal joint' was 'much smaller and divided at tip into two equal lobes.' Apparently, Yü and Wu (1932) observed the maxilliped in a view as shown here in figure 11I and did not examine it in a view shown here in figure 11J. Thus, they stated that the terminal claw was 'not seen in the ventral lobe.'

The most outstanding characteristic of the present species is in the general appearance of the body. It is the only species of *Heterochondria* without a long head and cylindrical trunk. As noted above in the description, it has a pinball-shaped body. Another remarkable distinction is in the shape of the antennule. Its terminal, setae-bearing portion is large, not constricted into a small process protruding at the tip of the tremendously enlarged, basal portion.

Protochondracanthus alatus (Heller, 1868)
(figures 12–14)

Material examined. Nine adult ♀♀ (each with attached ♂) from gill filaments of *Psettodes erumi* (Bleeker and Schneider): four collected on 20 July 1994, two on 25 October 1994 and three on 26 January 1994.

Female. Body (figures 12A,B) elongated, measuring 4.04 to 4.71 mm long. Head (figure 12C) composed of cephalosome only and protruded posterolaterally into a small process. A pair of vermiform processes in oral region originated at bases of maxillae (figures 12C, 13C). First pediger transformed into a short neck, bearing a pair of tripartite, lateral processes on both sides (figures 12C, 13G). Remaining pedigers fused into a long cylindrical trunk, bearing a pair of long, lateral processes in front, another pair of short posterior processes at end, and a vermiform process at midposterior end (figure 12D). Both genital double somite and abdomen (figure 12D) distinctly wider than long. Caudal ramus (figure 12D) a spiniform process armed with three setae and a small tubercle. Egg sac longer than body.

Antennule (figure 12E) with modified, fleshy basal portion bearing a vermiform

FIG. 12. *Protochondracanthus alatus* (Heller). Female: (A) habitus of adult, dorsal; (B) habitus of another adult, dorsal; (C) head and neck region, ventral; (D) posterior processes and genito–abdomen, ventral; (E) anennule; (F) antenna; (G) labrum. Scale bars: 1 mm in (A, B); 0.2 mm in (C, D); 0.05 mm in (E–G).

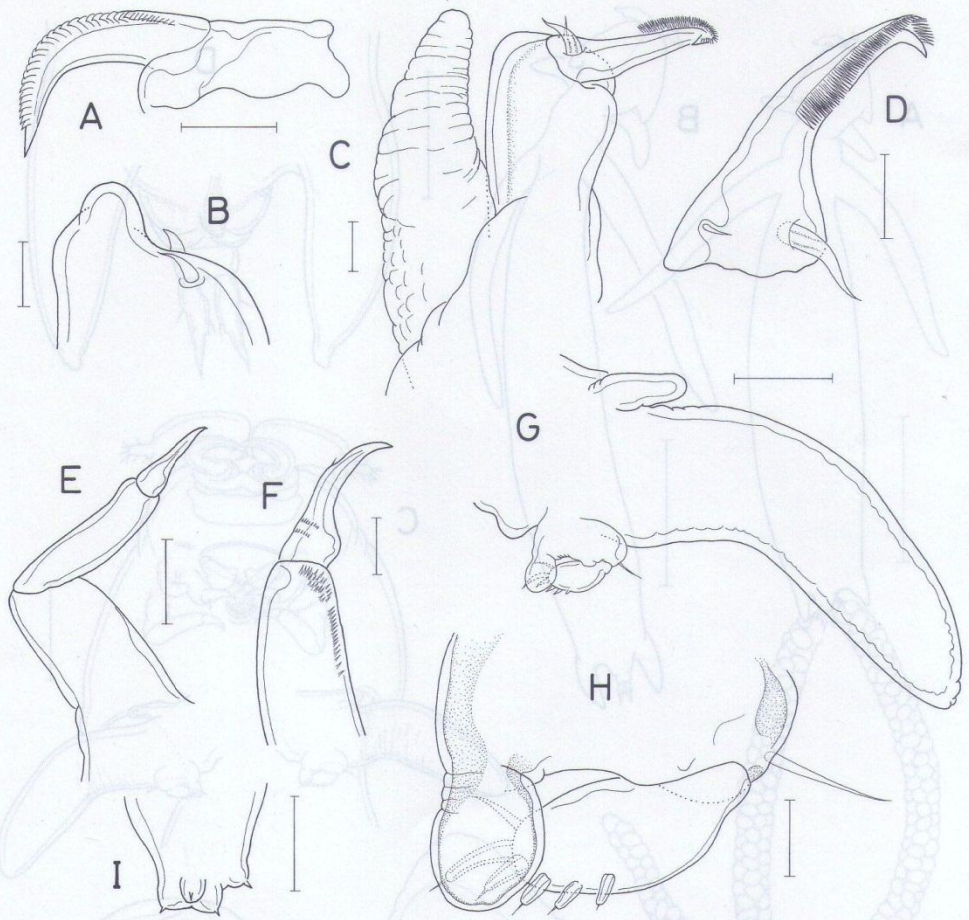

FIG. 13. *Protochondracanthus alatus* (Heller). Female: (A) mandible; (B) maxillule; (C) maxilla; (D) distal segment of maxilla; (E) maxilliped; (F) terminal part of maxilliped; (G) leg 1; (H) rami of leg 1; (I) distal part of trunk process. Scale bars: 0.02 mm in (A–D, F, H); 0.05 mm in (E, G, I).

posteroventral process and a small knob-like setiferous terminal process; armature being 11 on basal portion and ten on terminal process. Antenna (figure 12F) two-segmented; first segment small and unarmed, second segment a sharp, recurved hook with a small, medial knob in basal region. Labrum (figure 12G) with smooth posterior margin. Mandible (figure 13A) two-segmented; terminal blade with a row of 36 teeth on convex (inner) side. Maxillule (figure 13B) tipped with a lobe and two short setae. Maxilla (figure 13C) two-segmented; basal segment large but unarmed, distal segment (figure 13D) bearing one small, simple seta, one large seta with hyaline tip in basal region and a row of about 60 fine spinules on terminal process. Maxilliped (figure 13E) slender and three-segmented; first segment largest but unarmed, second segment with spinules in terminal and subterminal regions, and third segment drawn out into a pointed process with two rows of spinules in basal region in addition to a single, subterminal spinule (figure 13F). Leg 1 (figure 13G) located at base of tripartite, lateral process in neck region and consisting of a protopod carrying a long, outer seta, an exopod armed with five spines and

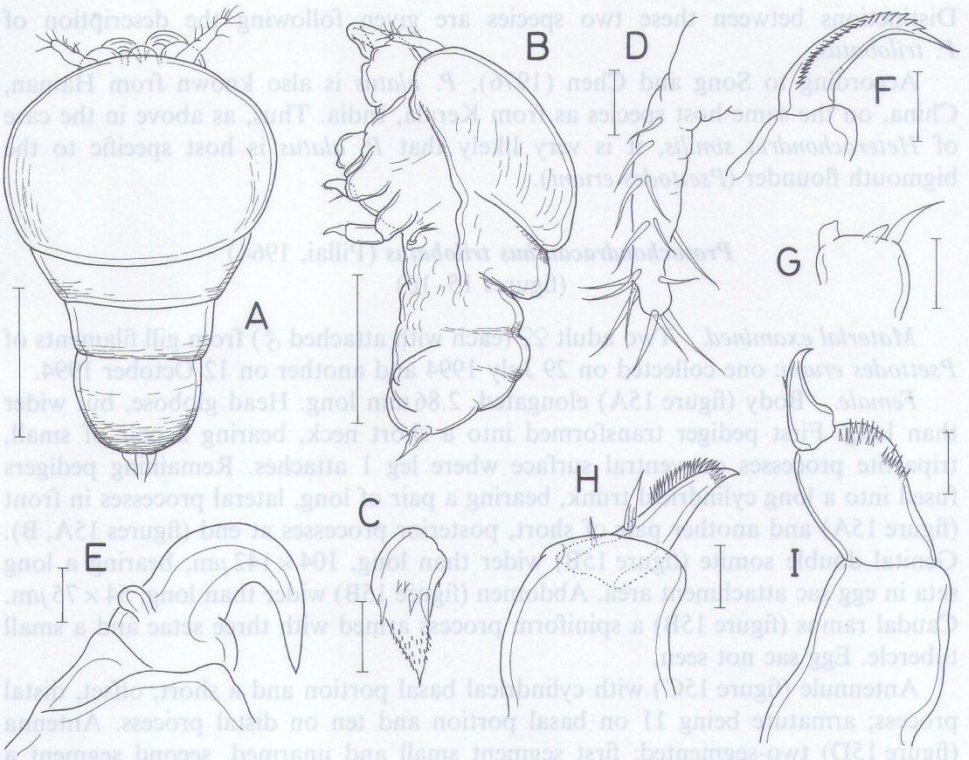

FIG. 14. *Protochondracanthus alatus* (Heller). Male: (A) habitus of adult, dorsal; (B) same, lateral; (C) caudal ramus; (D) antennule; (E) antenna; (F) mandible; (G) maxillule; (H) maxilla; (I) maxilliped. Scale bars: 0.1 mm in (A, B); 0.01 mm in (C–I).

one seta, and a naked endopod. Long, lateral process in anterior region of trunk tipped with four tubercles with each bearing a spinule at tip (figure 13I).

Male. Body (figure 14A) 269 μm long, with swollen cephalosome. First two pedigers separated, but remaining pedigers fused with genito–abdominal somites (figure 14A, B). Caudal ramus (figure 14C) a short, spiniform process with six short setae in basal region and spinules in distal region. Antennule (figure 14D) filiform, armature being 1-1-2-3-8. Antenna (figure 14E) two-segmented; terminal hook with a small outer knob in basal region. Mandible (figure 14F) with a row of about 25 teeth on convex margin of terminal blade. Maxillule (figure 14G) tipped with a blunt knob and two setae. Maxilla (figure 14H) as in female except for smaller number of teeth (about 25) on terminal process. Maxilliped (figure 14I) constructed as in female only stubbier. Leg 1 represented by a bifurcate seta (see figure 14B). Other legs missing.

Remarks. Both Kirtisinghe (1950) and Pillai (1964) found both ovigerous and juvenile females of *P. alatus* occurring together on the same host taken respectively in Sri Lanka and at Trivandrum (in Kerala). However, while Pillai's illustration of the juvenile is readily identifiable with *P. alatus* (by the presence of a pair of posterolateral cephalic knobs), Kirtisinghe's illustration is not. Kirtisinghe's illustration (called *Protochondracanthus psettodis* and given in figure 50) of the immature specimen looks like a mirror copy of *P. trilobatus* given here in figure 15A.

Distinctions between these two species are given following the description of *P. trilobatus*.

According to Song and Chen (1976), *P. alatus* is also known from Hainan, China, on the same host species as from Kerala, India. Thus, as above in the case of *Heterochondria similis*, it is very likely that *P. alatus* is host specific to the bigmouth flounder (*Psettodes erumi*).

Protochondracanthus trilobatus (Pillai, 1964)
(figures 15–16)

Material examined. Two adult ♀♀ (each with attached ♂) from gill filaments of *Psettodes erumi*: one collected on 29 July 1994 and another on 12 October 1994.

Female. Body (figure 15A) elongated, 2.86 mm long. Head globose, but wider than long. First pediger transformed into a short neck, bearing a pair of small, tripartite processes on ventral surface where leg 1 attaches. Remaining pedigers fused into a long cylindrical trunk, bearing a pair of long, lateral processes in front (figure 15A) and another pair of short, posterior processes at end (figures 15A, B). Genital double somite (figure 15B) wider than long, $104 \times 142\,\mu$m, bearing a long seta in egg sac attachment area. Abdomen (figure 15B) wider than long, $54 \times 75\,\mu$m. Caudal ramus (figure 15B) a spiniform process armed with three setae and a small tubercle. Egg sac not seen.

Antennule (figure 15C) with cylindrical basal portion and a short, offset, distal process; armature being 11 on basal portion and ten on distal process. Antenna (figure 15D) two-segmented; first segment small and unarmed, second segment a sharp, recurved hook with a minute, medial tubercle in basal region. Labrum (figure 15E) with a small tubercle on lateral margin. Mandible (figure 15F) two-segmented; terminal blade with a row of 12 teeth on convex (inner) side. Maxillule (figure 15G) tipped with a lobe and two short setae. Maxillule (figure 15H) two-segmented; basal segment large but unarmed, distal segment bearing one small, simple seta, one large seta with hyaline tip in basal region and a row of about 25 teeth on terminal process. Maxilliped (figure 15I) three-segmented; first segment largest but unarmed, second segment with spinules in terminal and subterminal regions, and third segment drawn out into a pointed process with a subterminal setule (figure 15J). Leg 1 (figure 15K) located at base of tripartite, ventral process in neck region and consisting of a protopod carrying a long, outer seta, an exopod armed with six setae, and an endopod tipped with two setae. Long, lateral process in anterior region of trunk equipped with a subterminal seta and four or five terminal setae (figure 15L).

Male. Body (figure 16A) globose, with posterior portion strongly bent forward. Genital somite and abdomen indistinguishably fused (figure 16B). Caudal ramus (figure 16B) a short spinulose process. Antennule (figure 16C) filiform, armature being 1-1-1-7. Antenna (figure 16D) two-segmented; terminal hook short and stubby. Mandible (figure 16E) with a row of 13 teeth on convex margin of terminal blade. Maxillule (figure 16F) tipped with a blunt knob and 2 setae. Maxilla (figure 16G) as in female except for fewer teeth (about ten) on terminal process. Maxilliped (figure 16H) constructed as in female only stubbier. No traces of legs.

Remarks. Although *P. trilobatus* and *P. alatus* were often found occurring together on flatfishes, their appearances are quite different. The former, though smaller, can not be mistaken for the juvenile of the latter.

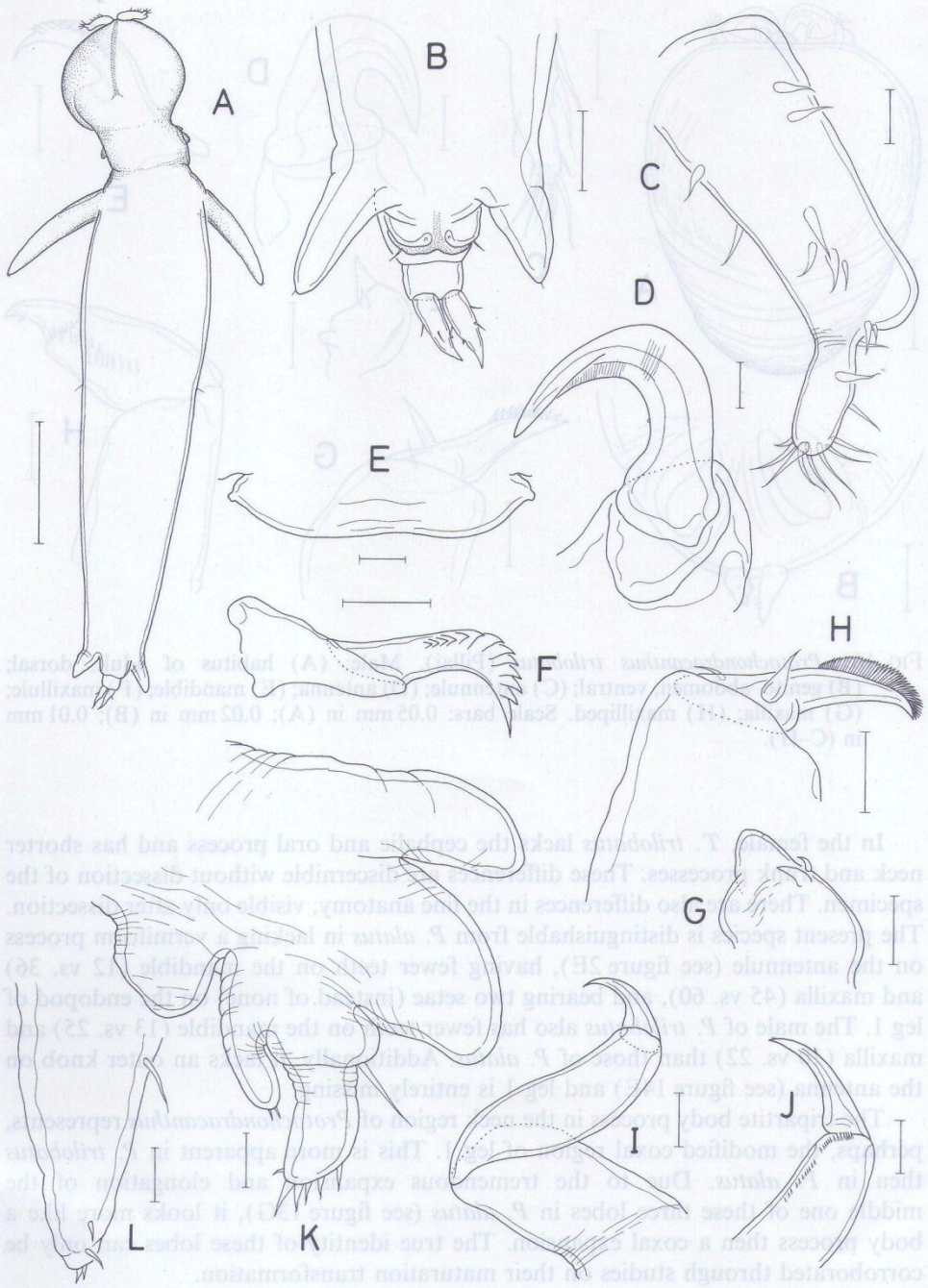

FIG. 15. *Protochondracanthus trilobatus* (Pillai). Female: (A) habitus of adult, dorsal; (B) genito–abdomen and posterior part of trunk, ventral; (C) antennule; (D) antenna; (E) labrum; (F) mandible; (G) maxillule; (H) maxilla; (I) maxilliped; (J) distal part of maxilliped; (K) leg 1; (L) distal part of trunk process. Scale bars: 0.5 mm in (A); 0.1 mm in (B); 0.02 mm in (C–L).

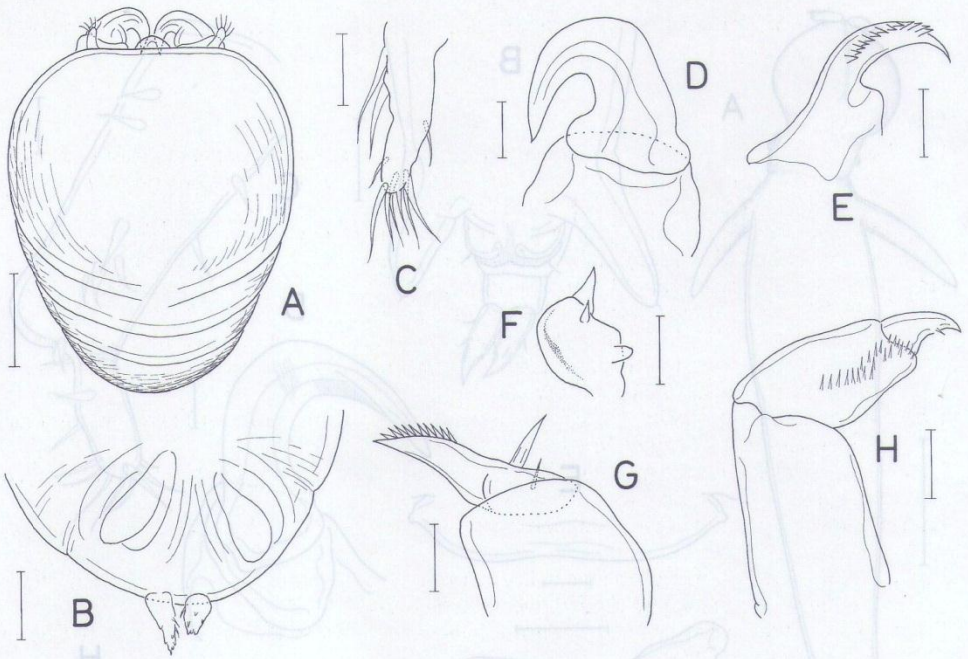

FIG. 16. *Protochondracanthus trilobatus* (Pillai). Male: (A) habitus of adult, dorsal; (B) genito–abdomen, ventral; (C) antennule; (D) antenna; (E) mandible; (F) maxillule; (G) maxilla; (H) maxilliped. Scale bars: 0.05 mm in (A); 0.02 mm in (B); 0.01 mm in (C–H).

In the female, *T. trilobatus* lacks the cephalic and oral process and has shorter neck and trunk processes. These differences are discernible without dissection of the specimen. There are also differences in the fine anatomy, visible only after dissection. The present species is distinguishable from *P. alatus* in lacking a vermiform process on the antennule (see figure 2E), having fewer teeth on the mandible (12 vs. 36) and maxilla (45 vs. 60), and bearing two setae (instead of none) on the endopod of leg 1. The male of *P. trilobatus* also has fewer teeth on the mandible (13 vs. 25) and maxilla (10 vs. 22) than those of *P. alatus*. Additionally, it lacks an outer knob on the antenna (see figure 14E) and leg 1 is entirely missing.

The tripartite body process in the neck region of *Protochondracanthus* represents, perhaps, the modified coxal region of leg 1. This is more apparent in *P. trilobatus* then in *P. alatus*. Due to the tremendous expansion and elongation of the middle one of these three lobes in *P. alatus* (see figure 13G), it looks more like a body process then a coxal expansion. The true identity of these lobes can only be corroborated through studies on their maturation transformation.

Acknowledgements

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