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Six Species of the Lernanthropidae (Crustacea: Copepoda) Parasitic on Marine Fishes of Taiwan, with a Key to 18 Species of the Family Known from Taiwan

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Ju-shey Ho, Wei-Cheng Liu, and Ching-Long Lin (2011) Six species of the Lernanthropidae (Crustacea: Copepoda) parasitic on marine fishes of Taiwan, with a key to 18 species of the family known from Taiwan. *Zoological Studies* **50**(5): 611-635. Six species of copepods belonging to the Lernanthropidae Kabata, 1979 were found parasitic on the gill filaments of 6 species of marine fishes of Taiwan. They are: *Lernanthropodes chorinemi* Pillai, 1962 on *Scomberoides commersonnianus* Lacepède (Carangidae); *Lernanthropodes trachinoti* Pillai, 1962 on *Trachinotus blochii* (Lacepède) (Carangidae); *Lernanthropus incilis* sp. nov. on *Evoxymetopon poeyi* Günther (Trichiuridae); *Mitrapus heteropodus* (Yü 1933) on *Nematalosa nasus* (Bloch) (Clupeidae); *Sagum epinepheli* (Yamaguti et Yamasu, 1960) on *Epinephelus awoara* (Temminck et Schlegel) (Serranidae); and *Sagum folium* sp. nov. on *Paracaesio caerulea* (Katayama) (Lutjanidae). Aside from the 2 new species, the other 4 known species were recorded for the 1st time from Taiwan. A key to the 18 species of lernanthropids occurring on marine fishes of Taiwan is provided. In this paper we propose treating *Mitrapus rubiginosus* (Redkar, Rangnekar et Murti 1949) as a junior synonym of *M. heteropodus*.
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Key words: Lernanthropidae, Parasitic copepods, Taiwan, Marine fish.

Lernanthropidae Kabata, 1979 is a large family of siphonostomatoid copepods comprising over 150 species. They are exclusively parasitic on gill filaments of marine teleosts. They use their prehensile antennae and maxillipeds to attach tenaciously to a host's gill filaments. The attachment is assisted, in the case of the female, by leg 3 which is modified into a pair of large, folded lamellae designed for clamping onto a host's gill filaments. Thus, lernanthropids can often cause pathological effects like desquamation, erosion, and necrosis of the host's gill filaments (Manera and Dezfuli 2003) and, in cases of heavy infection, may lead to asphyxiation, anemia, and secondary bacterial infections (Tokşen et al. 2006).

Lernanthropids are largely parasites of warm-water fishes. Thus, while 44 species are known from India (Pillai 1985), only 9 species are known from Japan (Ho and Do 1985). So far, we have discovered and reported 12 species of lernanthropids from Taiwan (Ho et al. 2008, Liu et al. 2009a b). In this paper we add 6 more species, which means that 18 species of lernanthropids in 7 genera are known from Taiwan. Since we have examined about 20% of the marine fishes of Taiwan, we firmly believe there are more species of lernanthropids waiting to be discovered from Taiwan. Therefore, a key to the species of lernanthropids from Taiwan is provided at the end of this report to facilitate species identification of this group.

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MATERIALS AND METHODS

Fish caught and landed at various fishing ports in Taiwan in the last 10 yr were purchased and transferred in an icebox to the laboratory for examination of parasitic copepods. Parasites were carefully removed from the host's gill filaments under a dissection microscope, and preserved in 70% ethanol. Selected specimens were later cleared in 85% lactic acid overnight before dissection of the appendages and examination under a compound microscope with a series of magnifications up to 1500x. All drawings were made with the aid of a drawing tube attached to a compound microscope. Measurements of body parts were taken after specimens were soaked in lactic acid overnight. The mean value is given with the range following in parentheses.

Below, a full description is given of the female, and if the male is available, only sexually dimorphic characters are mentioned for the male.

RESULTS

Order Siphonostomatoida Thorell, 1859
Family Lernanthropidae Kabata, 1979
Genus *Lernanthropodes* Bere, 1936
Lernanthropodes chorinemi Pillai, 1962
(Figs. 1, 2)

Material examined: 2♀♀ on 1 (of 9) talang queenfish, *Scomberoides commersonnianus* Lacepsède, 1801, landed at Dong-shi Fishing Port on 13 Jan. 2000.

Female: Body (Fig. 1A-C) cylindrical, 3.56 (3.50-3.62) mm long (from anterior rim of head to tip of caudal ramus), comprising a subtriangular head, cylindrical trunk, and small urosome. Head 0.98 (0.88-1.08) mm long and 0.95 (0.92-0.98) mm wide, with broadly protruding posterolateral corners and narrowed anterior end. Trunk cylindrical, narrower than head, only 0.82 (0.80-0.84) mm wide, and without a dorsal plate. Posterior part of trunk with ventrally fused lamellae of leg 3 appearing wider than head, 1.28 (1.24-1.32) mm wide. Genital complex (Fig. 1D) longer than wide, 401 (324-478) × 324 (316-332) μm, with a laterally protruding egg sac attachment area. Abdomen (Fig. 1D) also with laterally protruding sides, longer than wide, 223 (211-235) × 215 (194-235) μm, with distinct anal slit. Caudal ramus (Fig. 1D) a long distally attenuated process, 324 (284-365) × 97 (89-105) μm, carrying 2 dorsal setae in basal region and 2 setae at distal end. Egg sac long and straight.

Antennule (Fig. 1E) filiform and 7-segmented; armature formula: 0, 2, 1, 3, 1, 4, and 4. Parabasal process (Fig. 1E) present. Antenna (Fig. 1F) 2-segmented; corpus about 2.5-times longer than claw, bearing 1 broad basal seta on medial surface; claw bearing 2 similar basal setae and terminal striations. Mandible comprising 2 sections; with 8 teeth on terminal blade. Maxillule (Fig. 1G) bilobate, smaller outer lobe tipped with 1 spiniform element and larger inner lobe with 3 unequal elements. Maxilla (Fig. 1H) 2-segmented, lacertus unarmed; brachium with denticles scattered on medial surface and bearing 1 bifid spiniform element subterminally and 1 element distally; terminal claw fringed with row of larger denticles along both edges. Maxilliped (Fig. 2A) 2-segmented; corpus unarmed; shaft longer than claw, with broad seta on medial margin close to distal end; claw with striations as in antenna.

Ventral surface of leg 1 (Fig. 2B) ornamented with denticles; both outer and inner setae of protopod with large basal papilla; exopod 1-segmented, large, and tipped with 5 robust spines; endopod a smaller lobe with long terminal, blunt process. Leg 2 (Fig. 2C) with inconspicuous protopod carrying a short, blunt inner element and without outer seta; exopod tipped with 5 spiniform elements; endopod with 1 long, setiform element. Leg 3 with lamelliform rami completely fused to form a broad plate entirely covering urosome ventrally (Fig. 1B) and leaving narrow gap dorsally (Fig. 1A). Leg 4 a pair of long bilobate processes protruding out of ventral lamella formed by leg 3 (Fig. 1A-C). Leg 5 missing.

Male: Not collected.

Remarks: This is the 1st report of *Les. chorinemi* outside of India. The 1st report of this species was made by Pillai (1962) from gills of a doublespotted queenfish, *Scomberoides lysan* (Forsskål, 1775) [named *Chorinemus lysan* (Forsskål) in the original report], caught off Trivandrum, India. Although both specimens from Taiwan generally fit the description given by Pillai (1962 1985), some differences in fine structures were noticed. For instance, the brachium of the maxilla in the Indian specimen is equipped subterminally with a single (instead of double) seta, and leg 2 has an outer (instead of inner) seta. There is a remarkable difference in the size of the specimens from the 2 places; as the specimen from India is 8.2 mm long, while the one from

Fig. 1. *Lernanthropodes chorinemi* Pillai, 1962, female. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome with basal part of leg 4, dorsal view; (E) antennule and parabasal process, ventral view; (F) antenna, medial view; (G) maxillule, lateral view; (H) maxilla, medial view. Scale bars: A-C = 0.5 mm; D = 0.2 mm; E and G = 20 μm; F and H = 30 μm. p4: leg 4; cr: caudal ramus.

Taiwan is only 3.56 mm long on average.

Four species of *Lernanthropodes* are currently known, namely *Les. cucullus* Bere, 1936, *Les. natalensis* Kensley et Grindley, 1973, and *Les. trachinoti* Pillai, 1962, in addition to *Les. chorinemi*. Of these *Les. chorinemi* is most similar to *Les. natalensis* in having a triangular-shaped head and without a deep, central notch on the posterior margin of the fused leg 3 lamellae. Nevertheless, *Les. chorinemi* differs from this closest congener by possessing a well-developed parabasal process at the base of the antennules and the structures of the maxillule (inner lobe with 3, instead of 2, terminal setae) and maxilla (with denticles and bifid spiniform element on the brachium).

When Pillai (1985) gave the 2nd report of *Les. chorinemi* from India, the hosts were listed as *Chorinemus sanctipetri* and *C. lysan.* However, according to Froese and Pauly (2011), both of them are synonyms of *Scomberoides lysan*. In Pillai's (1985) 2nd report on *Les. chorinemi* from India, the male was described. It looks like the male of *Lernanthropinus sphyraenae* (Yamaguti et Yamasu 1959) previously reported by us from Taiwan (see Ho et al. 2008) in having both legs 3 and 4 comprising a single process.

Lernanthropodes trachinoti Pillai, 1962

(Figs. 3, 4)

Material examined: 1 ♀ on 1 (of 4) snubnose pompano, *Trachinotus blochii* (Lacepède, 1801), landed at Dong-shi Fishing Port on 19 Jan. 2008.

Female: Body (Fig. 3A-C) cylindrical, 5.46 mm long (from anterior rim of head to posterior margin of fused leg 3 lamellae), comprising head, trunk, and small urosome. Head squarish, 1.36 × 1.18 mm, with anterolateral corners protruding ventrally into rounded knob (Fig. 3C). Trunk cylindrical, slightly wider (1.26 mm wide) than head, without dorsal plate. Posterior part of trunk with ventrally fused lamellae of leg 3 appearing wider (2.02 mm wide) than head. Genital complex (Fig. 3D) slightly wider than long, 478 × 494 μm, with laterally protruding egg sac attachment area. Abdomen (Fig. 3D) also with laterally protruding sides and wider than long, 267 × 308 μm. Caudal ramus (Fig. 3D) elongate, 356 × 162 μm, carrying 2 dorsal setae in basal region and 2 setae at distal end. Egg sac long and straight (not illustrated).

Antennule (Fig. 3E, F) filiform and indistinctly 7-segmented; armature formula: 1, 2, 1, 2, 1, 3 +

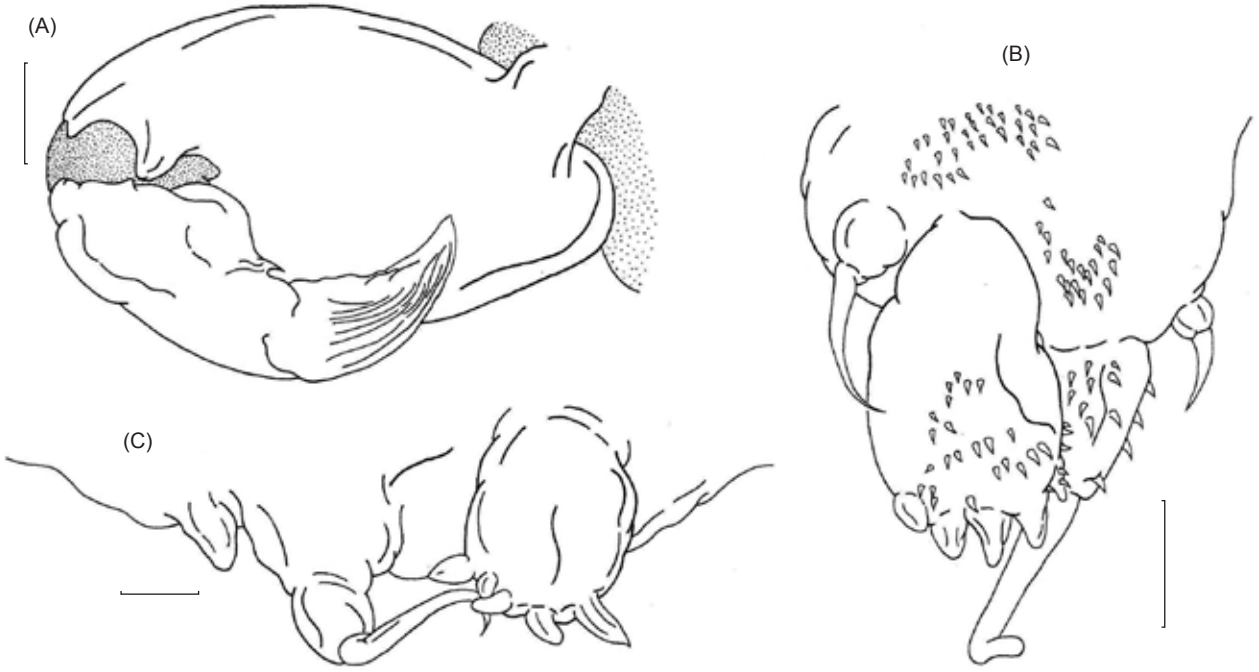

Fig. 2. *Lernanthropodes chorinemi* Pillai, 1962, female. (A) Maxilliped, medial view; (B) leg 1, ventral view; (C) leg 2, ventral view. Scale bars: A = 40 μm; B = 20 μm; C = 10 μm.

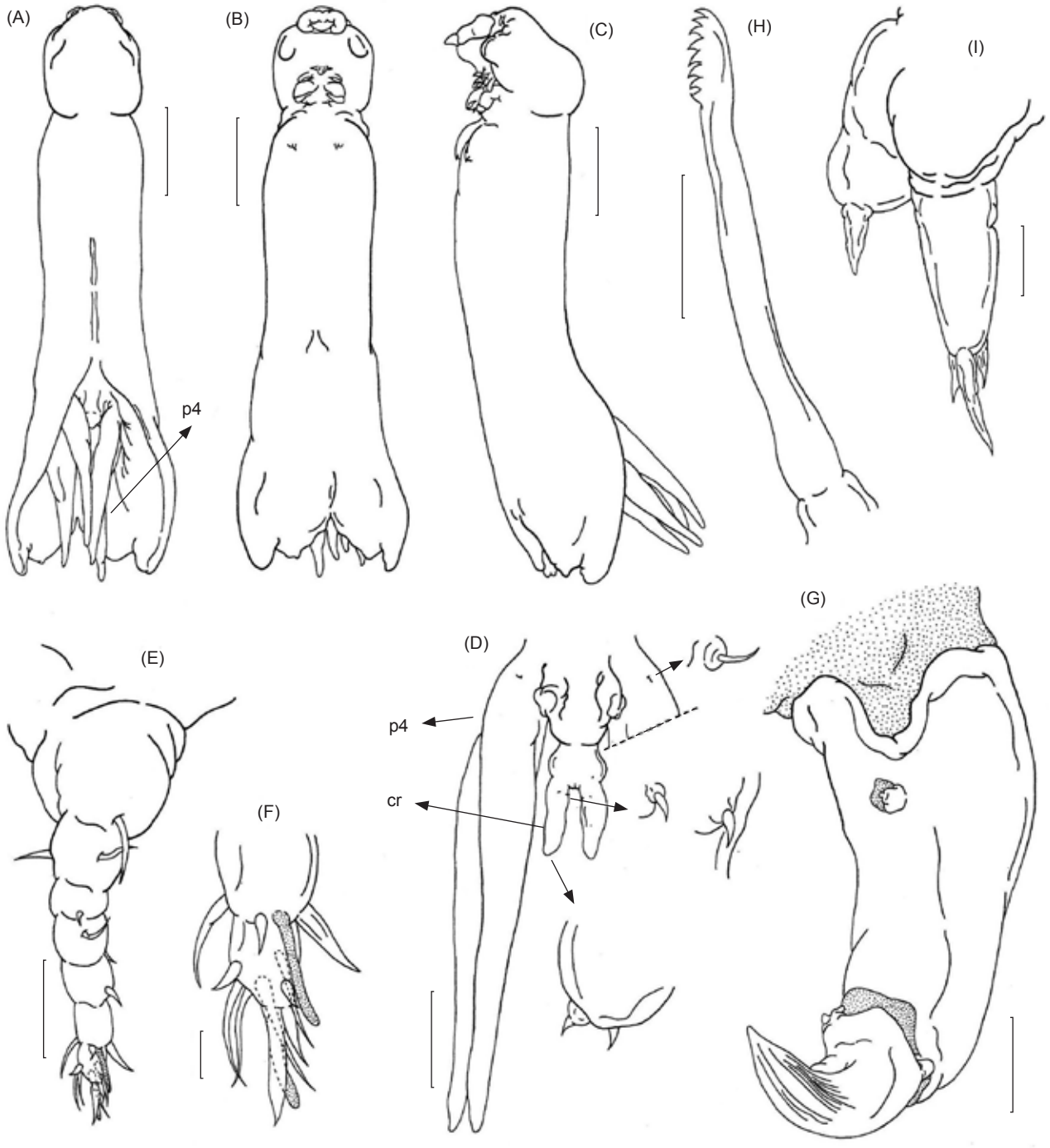

Fig. 3. *Lernanthropodes trachinoti* Pillai, 1962, female. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome and leg 4, dorsal view; (E) antennule, ventral view; (F) tip of antennule, ventral view; (G) antenna, medial view; (H) mandible; (I) maxillule, lateral view. Scale bars: A-C = 1 mm; D = 0.5 mm; E = 50 μm; F = 10 μm; G = 0.1 mm; H and I = 30 μm. p4: leg 4; cr: caudal ramus.

1 aesthetasc, and 8 + 1 aesthetasc. Parabasal process absent. Antenna (Fig. 3G) 2-segmented; corpus about twice as long as claw, former bearing 1 broad basal seta on medial surface; claw bearing similar basal seta and terminal striations. Mandible (Fig. 3H) and maxillule (Fig. 3I) essentially as in previous species. Maxilla (Fig. 4A, B) 2-segmented; lacertus unarmed; brachium bearing 1 subterminal seta on medial margin, 1 blunt, terminal element, and large patch of denticles on outer surface; terminal claw fringed with rows of denticles along both edges. Maxilliped (Fig. 4C) 2-segmented; corpus with fine denticles scattered in myxal region; shaft longer than claw, with 1 subterminal seta on medial margin; claw with striations as in antenna.

Ventral surface of leg 1 (Fig. 4D) with denticles scattered on protopod and endopod; outer protopodal seta simple and thin, but inner protopodal seta spiniform and arising from large papilla; exopod 1-segmented and large, tipped with 5 robust spines, inner 2 of which bear denticles on both sides; endopod smaller than exopod, carrying 1 long seta terminally. Leg 2 (Fig. 4E) protopod inconspicuous, without inner and outer setae; exopod armed as in leg 1, but seta on endopod bilaterally denticulate. Leg 3 with lamelliform rami completely fused to form a long plate completely covering urosome ventrally (Fig. 3B) and leaving large gap dorsally (Fig. 3A); posterior edge of ventral lamella with 3 indentations (Fig. 3B). Leg 4 a pair of long bilobate processes (Fig. 3A) arising

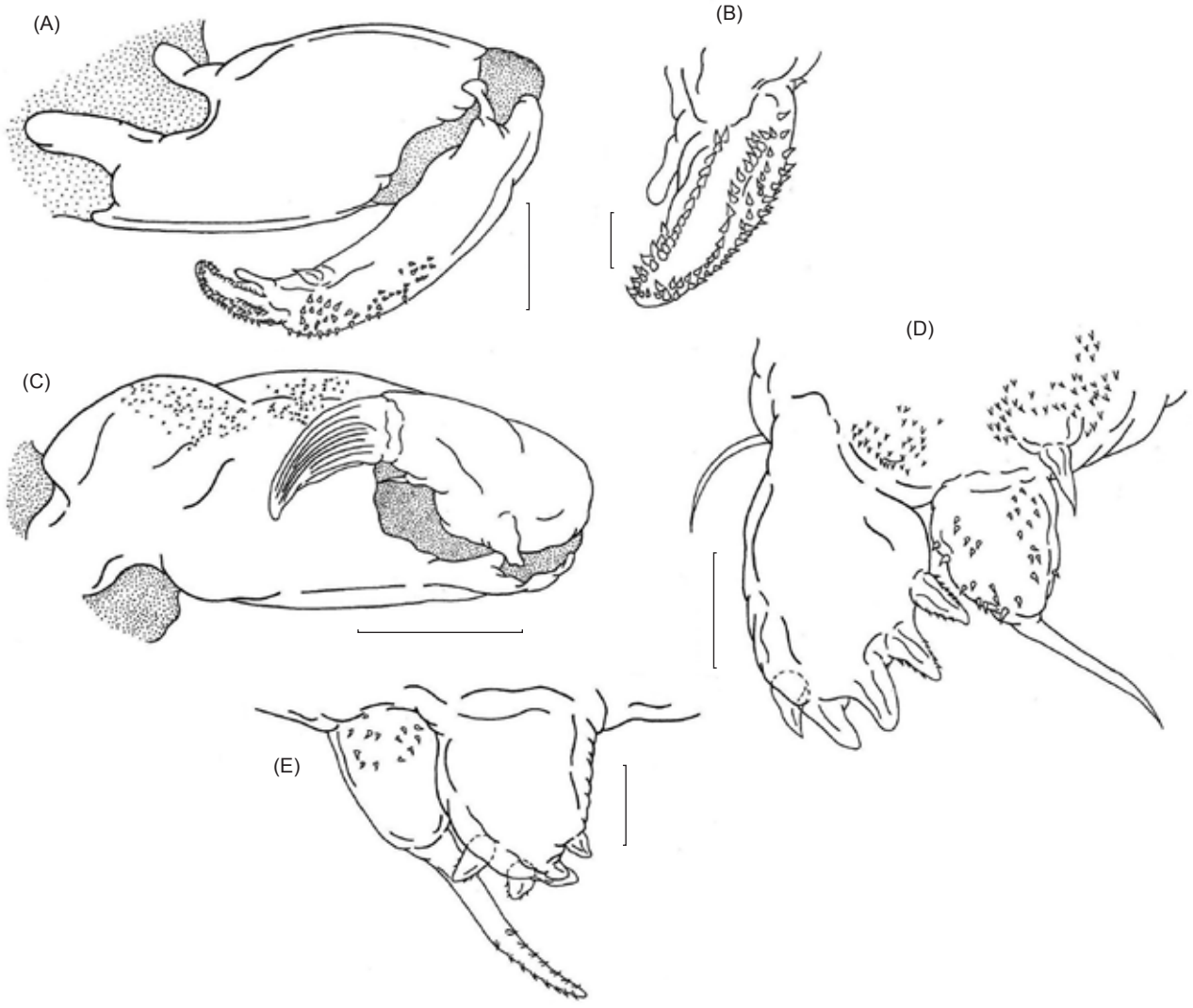

Fig. 4. *Lernanthropodes trachinoti* Pillai, 1962, female. (A) Maxilla, medial view; (B) tip of maxilla, medial view; (C) maxilliped, medial view; (D) leg 1, ventral view; (E) leg 2, ventral view. Scale bars: A = 50 μm; B = 10 μm; C = 0.1 mm; D = 30 μm; E = 20 μm.

from basal region of urosome (Fig. 3D). Leg 5 absent.

Male: Not collected.

Remarks: *Lernanthropodes trachinoti* is so far known to occur on pompanos (*Trachinotus*) from India and Australia. In India, like in Taiwan, it was taken from a snubnose pompano (Pillai 1962 1985), but in Australia, it was reported from another species of pompano, *Tra. botla* (Shaw, 1803) (see Kabata 1979b). It was intriguing to note the specimen of *Les. trachinoti* in Pillai's (1985) 2nd report differed from his original report (Pillai 1962) in having a triangular head (cephalothorax) and a large fused lamellae of leg 3 completely concealing the bifid leg 4 and urosome in ventral view of the animal. In other words, it may represent a different species of *Lernanthropodes*. In fact, Pillai (1985) remarked in his 2nd report of *Les. trachinoti* that "This species closely resembles *L. cuculus* Bere and distinguished by only minor differences. They may turn out to be the same." Inasmuch as the original description of *Les. cuculus* is sketchy, no further comment can be made at this point. Bere's (1936) specimens of *Les. cuculus* were found on *Tra. carolinus* (Linnaeus, 1766) and *Tra. falcatus* (Linnaeus, 1758) from the Gulf of Mexico.

Specimens of *Les. trachinoti* from Taiwan fit well with the original report of the species given by Pillai (1962). The male of this species is not known from India nor Taiwan, but Kabata (1979b) found it on *Tra. botla* from Australia.

Genus *Lernanthropus* de Blainville, 1822
Lernanthropus incilis sp. nov.
(Figs. 5-7)

Material examined: 4 ♀♀ and 2 ♂♂ found on gill filaments of Poey's scabbardfish, *Evoxymetopon poeyi* Günther, 1887, landed at Cheng-gong Fishing Port: 3 ♀♀ and 1 ♂ from 3 (of 3) *E. poeyi* on 11 Feb. 2009, and 1 ♀ and 1 ♂ from 1 (of 1) *E. poeyi* on 25 Mar. 2009. Female holotype (USNM 1131890) and male allotype (USNM 1131891) were deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Female: Body (Fig. 5A-C) large, 7.63 (7.50-7.76) mm long (from anterior rim of head to end of caudal ramus), divisible into head, neck, trunk, and urosome. Head nearly squarish, 1.95 (1.92-1.98) × 2.01 (1.80-2.22) mm, with narrowed antennal area. Neck (1st pediger) short and wide, bearing large dorsal lobe. Remaining pedigers fused into trunk, with pedigers 2 and 3 protruding out to form a lateral lobe and pediger 4 expanded posteriorly into a large subcircular dorsal plate that is deeply emarginated in center. Genital complex and abdomen (Fig. 5D) wider than long, 0.40 (0.38-0.42) × 0.89 (0.84-0.94) and 0.48 (0.46-0.50) × 0.62 (0.62-0.62) mm, respectively. Caudal ramus (Fig. 5D) transformed into a long process, 2.21 (2.04-2.38) × 0.42 (0.40-0.44) mm, bearing 2 basal setae on ventral surface (Fig. 5E), 1 subterminal seta on outer margin, and 2 small setae at tip. Egg sac long and straight.

Antennule (Fig. 5F, G) stocky, indistinctly 5-segmented; armature formula: 0, 0, 0, 0, and 9 + 2 aesthetascs. Parabasal process (Fig. 5F) short. Antenna (Fig. 5H) robust, 2-segmented; corpus unarmed; claw armed with basal seta. Mandible (Fig. 6A) and maxillule (Fig. 6B) essentially as in previous species. Maxilla (Fig. 6C) 2-segmented, with unarmed lacertus larger and longer than brachium; latter subterminally bearing 1 short, spiniform process and patch of denticles on medial surface (usual terminal seta missing); terminal claw (Fig. 6D) fringed with row of denticles on medial surface. Maxilliped (Fig. 6E) 2-segmented; corpus robust and unarmed; subchela comprising small, seta-bearing shaft and striated claw.

Leg 1 (Fig. 6F) with protopod protruding out into a process which carries an outer seta at its base; protopod also with inner conical process; exopod tipped with 5 stocky spines and endopod with 1 blunt seta (Fig. 6G). Leg 2 (Fig. 6H) more reduced than leg 1, with inconspicuous protopod and weakly armed exopod (Fig. 6I). Leg 3 (Fig. 5B) greatly modified, comprising large fleshy, folded lamella splayed ventrally at posterolateral corners of trunk (Fig. 5C). Leg 4 (Fig. 5B) a pair of long, bifid processes with round, blunt tip. Leg 5 (Fig. 5D) modified into a unilobate, long, obtuse process.

Male: Body (Fig. 7A, B) smaller than female and without dorsal plate on trunk, measuring 4.58 mm long (from tip of head to end of caudal ramus). Head (cephalosome) wider than long, 1.64 × 1.88 mm, with antennal region set apart from rest of head. First 2 pedigers identifiable by their lateral swellings, wider than long, measuring 0.24 × 1.00 and 0.40 × 1.08 mm, respectively. Genital complex indistinguishably fused to trunk. Caudal ramus (Fig. 7A, B) long, slender, 745 × 186 μm, and armed as in female.

Antennule (Fig. 7C) stocky as in female, but unsegmented and terminally armed with 3 more setae (Fig. 7D). Parabasal process with basal

papilla arising near base of antennule (Fig. 7C). Leg 1 (Fig. 7E) with rows of denticles on outer margin of protopod and medial margin of endopod. Leg 2 (Fig. 7F) carrying a process lateral to exopod, subterminally bearing 1 seta-bearing papilla and terminally 1 smaller seta-bearing papilla; exopod with dense patch of denticles terminally in addition to bearing 4 spiniform elements; endopod with dense patch of denticles on medial surface. Leg 3 (Fig. 7A) modified into pair of long, thin, bifid processes. Leg 4 (Fig. 7A) constructed as in leg 3, but longer and armed with bifid denticles on distal 1/2 of exopod. Leg 5 absent.

Etymology: The species name *incilis* means "cut in" in Latin. It alludes to the possession of a

Fig. 5. *Lernanthropus incilis* sp. nov., female paratype. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome and leg 5, ventral view; (E) basal part of caudal ramus circled in D; (F) antennule and parabasal process, dorsal view; (G) tip of antennule, ventral view; (H) antenna, medial view. Scale bars: A-C = 1 mm; D = 0.5 mm; E = 25 μm; F = 0.1 mm; G = 20 μm; H = 0.2 mm. p3: leg 3; p4: leg 4; p5: leg 5; cr: caudal ramus.

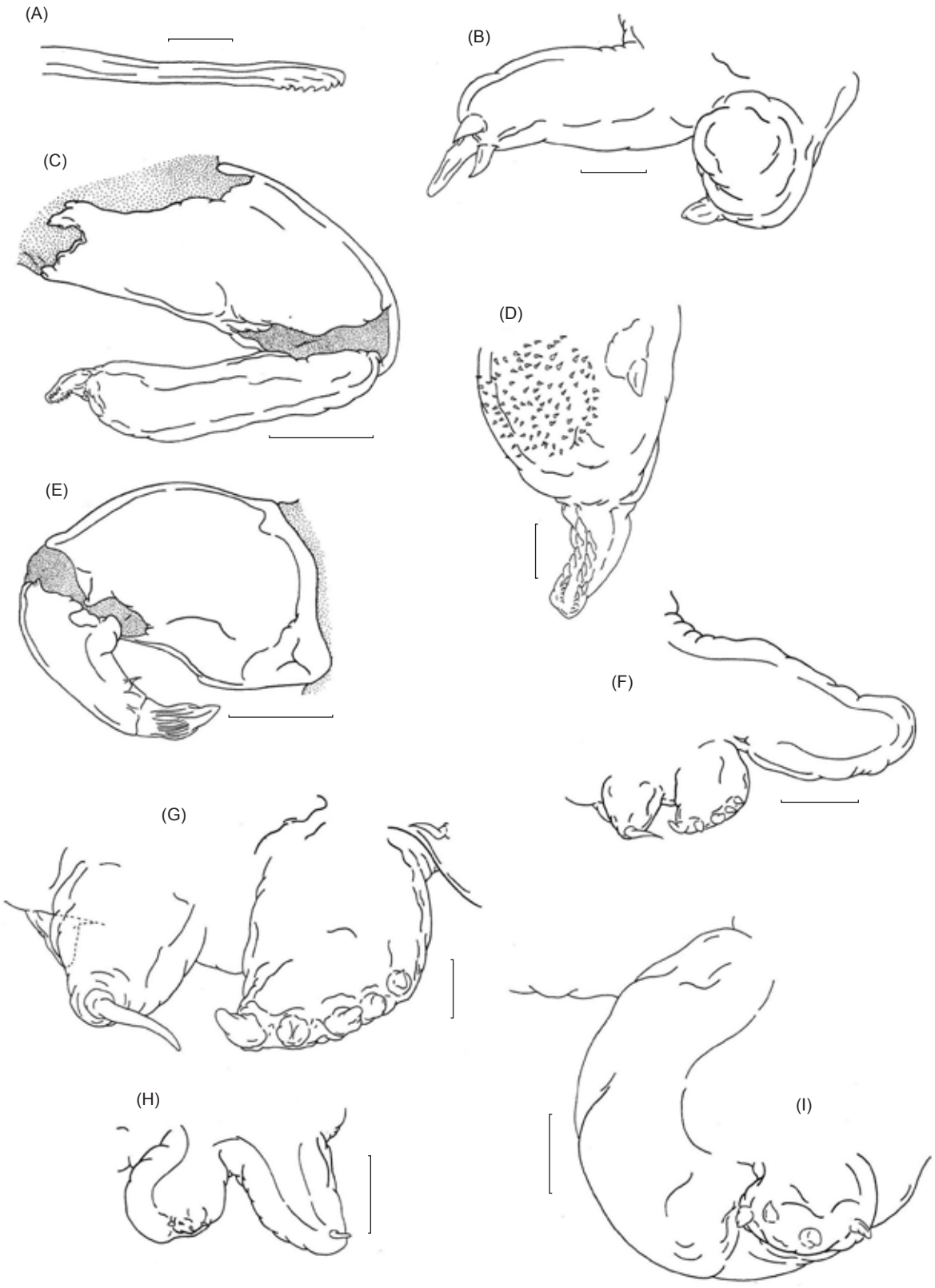

Fig. 6. *Lernanthropus incilis* sp. nov., female paratype. (A) Mandible; (B) maxillule, lateral view; (C) maxilla, medial view; (D) tip of maxilla, medial view; (E) maxilliped, medial view; (F) leg 1, ventral view; (G) rami of leg 1, ventral view; (H) leg 2, ventral view; (I) exopod of leg 2, ventral view. Scale bars: A and D = 20 μm; B = 50 μm; C, F, and H = 0.1 mm; E = 0.2 mm; G and I = 30 μm.

deep, central incision on the posterior rim of the dorsal plate.

Remarks: More than 100 species are currently classified under *Lernanthropus*. All of them are characteristic in having a large dorsal plate coming off the posterior border of the trunk. The posterior margin of this dorsal plate is entire (with even margin) in most cases. It is only in the following 3 species that we see, like *Lus. incilis* sp. nov., the presence of a deep, central incision in the posterior rim of the dorsal plate: *Lus. barnardi* Capart, 1959; *Lus. monodi* Delamare-Deboutteville et Nunes-Ruivo, 1954; and *Lus. obscurus* Wilson, 1913. Nevertheless, the new species from

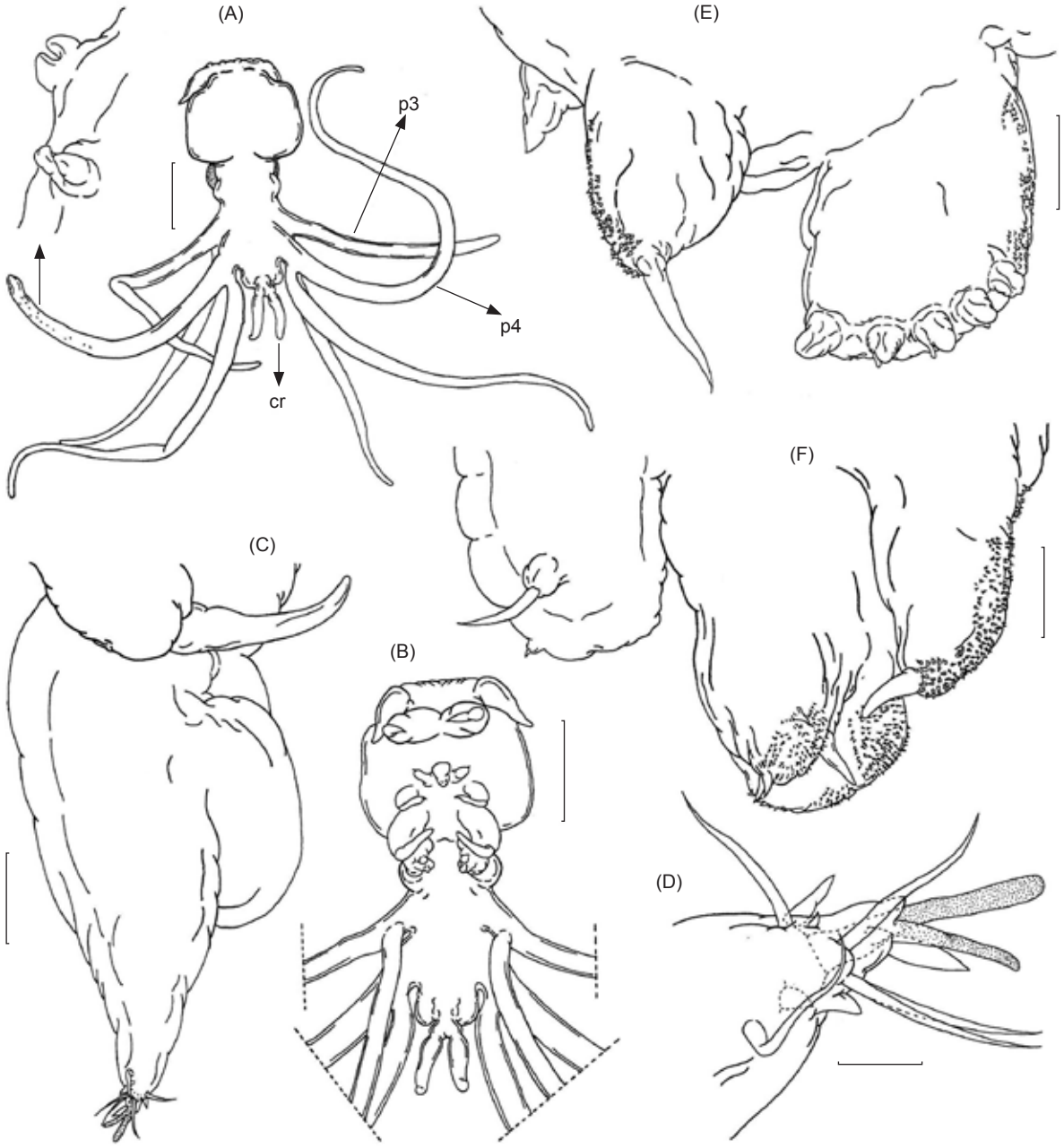

Fig. 7. *Lernanthropus incilis* sp. nov., male paratype. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) antennule and parabasal process, dorsal view; (D) tip of antennule, dorsal view; (E) leg 1, ventral view; (F) leg 2, dorsal view. Scale bars: A and B = 1 mm; C = 0.1 mm; D = 20 μm; E and F = 40 μm. p3: leg 3; p4: leg 4; cr: caudal ramus.

Taiwan is distinguished from *Lus. barnardi* and *Lus. monodi* by the structure of the trunk (with 2 lateral indentations). It further differs from *Lus. barnardi* by the shape of the dorsal plate (large and comprising 2 subcircular plates) and from *Lus. monodi* by the short neck and structure of legs 3 and 4 (without pointed tip). Both *Lus. barnardi* and *Lus. monodi* were reported off the west coast of Africa (Delamare-Deboutteville and Nunes-Ruivo 1954, Capart 1959).

As far as the general appearance is concerned, *Lus. incilis* sp. nov. resembles *Lus. obscurus* the most. Both of them are also unusual for *Lernanthropus* in carrying a pair of plump antennules. However, *Lus. incilis* sp. nov. differs from *Lus. obscurus* in the structure of leg 5 (not foliaceous) and in bearing a large dorsal outgrowth in the neck region. *Lernanthropus obscurus* is so far known only from the West Indies (Wilson 1913).

Genus *Mitrapus* Song et Chen, 1976
Mitrapus heteropodus (Yü, 1933)
(Figs. 8-10)

Material examined: 4 ♀♀ and 1 ♂ on 3 (of 45) Bloch's gizzard shad, *Nematalosa nasus* (Bloch, 1795), landed at Sheng-dah Fishing Port on 14 Jan. 1999.

Female: Body (Fig. 8A-C) small, but short and broad, 1.87 (1.62-2.12) mm long (from anterior rim of head to end of caudal ramus), divisible into head, short neck, broad trunk, and small urosome; posterior part of trunk (4th pediger) carrying a large, semicircular dorsal plate. Head slightly longer than wide, 0.63 (0.58-0.68) × 0.61 (0.60-0.62) mm, with rounded sides. Trunk widest part of body, with forward protruding shoulders and another forward protrusion found in front of leg 2 (Fig. 8B). Genital complex and abdomen indistinguishably fused into 1 unit (Fig. 8D). Caudal ramus (Fig. 8D, E) longer than wide, 69 (65-73) × 45 (41-49) μm, bearing 3 subterminal and 2 terminal setae. Egg sac straight (not illustrated).

Antennule (Fig. 8F) filiform, indistinctly 6-segmented; armature formula: 3, 0, 2, 1, 4 + 1 aesthetasc, and 8 + 1 aesthetasc. Parabasal process absent. Antenna (Fig. 8G) robust, 2-segmented; corpus unarmed; claw long and sharply pointed, armed with 2 medial setae in basal region. Mandible (Fig. 8H) and maxillule (Fig. 8I) generally as in previous species. Maxilla (Fig. 9A) 2-segmented; lacertus larger than brachium but unarmed; latter armed subterminally with 2 short setae on medial surface in addition to 1 larger terminal seta; terminal claw fringed with row of denticles around medial margin. Maxilliped (Fig. 9B) 2-segmented; corpus robust, with 1 small papilla on myxal surface followed by row of denticles; subchela comprising small seta-bearing shaft and long, curved claw.

Leg 1 (Fig. 9C) protopod with simple outer seta and apically blunt, spiniform inner seta; 1-segmented exopod with 5 robust, denticulated terminal spines; endopod an inflated lobe bearing denticles on ventral surface and tipped with a short, spiniform seta. Leg 2 (Fig. 9D) protopod lacking outer and inner seta; 1-segmented exopod with 3 denticles scattered on ventral surface and armed with 4 terminal spines, of which only inner 2 are fringed with denticles; endopod armed generally as in leg 1. Leg 3 (Fig. 8A-C) greatly modified, comprising large fleshy, folded lamella splayed outward at posterolateral corners of trunk. Leg 4 (Fig. 8A, B) a pair of greatly unequal, bilobate processes, with exopod about 6 times as long as endopod. Leg 5 missing.

Male: Attached to basal region of female leg 4 exopod (see Fig. 8B, C). Body (Fig. 10A, B) 653 μm long (from tip of head to end of caudal ramus). Head (cephalosome) oblong, 338 × 207 μm, with narrowed antennal region. Trunk subrectangular, narrower than head; each of 4 pedigers identifiable by its lateral swellings. Genital complex wider than long, 72 × 80 μm, indistinguishably fused to trunk anteriorly and to abdomen posteriorly. Caudal ramus longer than wide, 34 × 19 μm, shaped and armed as in female.

Antennule (Fig. 10C, D) filiform, indistinctly 6-segmented; armature formula: 1, 3, 2, 1, 2 + 1 aesthetasc, and 9 + 1 aesthetasc. Legs 1 (Fig. 10E) and 2 (Fig. 10F) similar to those in female, except for carrying denticles on ventral surface of protopod and equipped with longer terminal seta on endopod. Legs 3 and 4 (Fig. 10A, B) each represented by 1 short outer seta in basal region of small knob on posterolateral corners of trunk. Leg 5 absent.

Remarks: When Song and Chen (1976) created *Mitrapus* to accommodate *Lus. heteropodus* Yü, 1933, 3 other species of *Lernanthropus* were included, namely *Lus. rubiginosus* Redkar, Rangnekar et Murti, 1949, *Lus. engraulis* Tripathi, 1962, and *Lus. oblongus* Pillai, 1964. Our specimens from Taiwan are identifiable with either *Lus. heteropodus* or *Lus. rubiginosus*. However, we formally consider *Lus.*

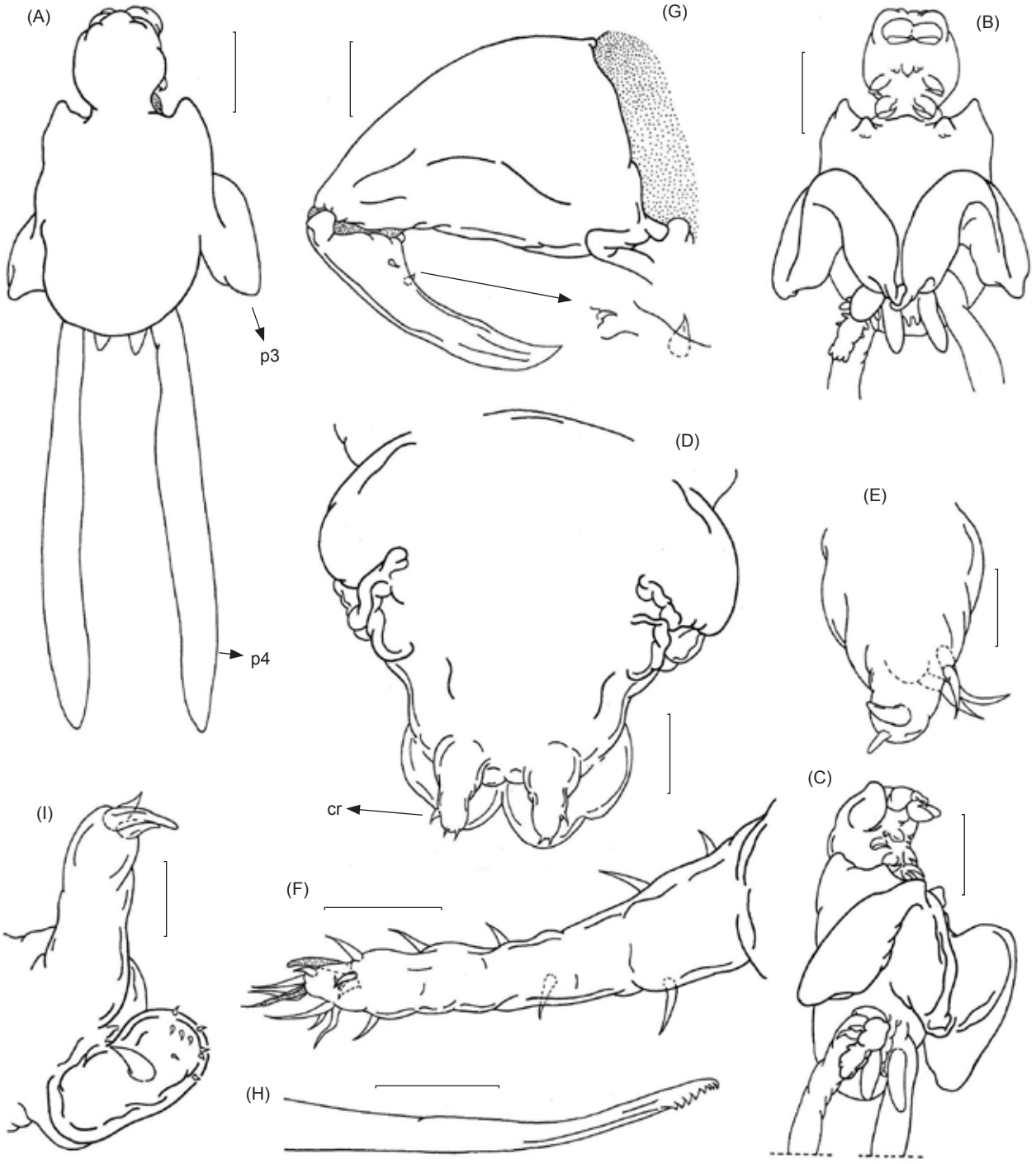

Fig. 8. *Mitrapus heteropodus* (Yü, 1933), female. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome, dorsal view; (E) caudal ramus, ventral view; (F) antennule, dorsal view; (G) antenna, ventral view; (H) mandible; (I) maxillule; lateral view. Scale bars: A-C = 0.5 mm; D and G = 50 μm; E, H, and I = 20 μm; F = 30 μm. p3: leg 3; p4: leg 4; cr: caudal ramus.

rubiginosus reported by Redkar et al. (1949) to be conspecific with *Lus. heteropodus* reported by Yü (1933), because of the resemblance between them in the gross morphology of both sexes and the general structure of the female appendages. Furthermore, according to Redkar et al. (1949) their specimens of *Lus. rubiginosus* (6 females and 6 males) were obtained from *Chatoessus nasus* Day [= *Nematalosa nasus* (Bloch)], the same species of gizzard shad from which we found our specimens of *M. heteropodus*.

The 3 species of *Mitrapus* show differences in the ratio of the endopod to the exopod in the female leg 4. It is about 1: 16 in *M. engraulis*, 1: 6 in *M. heteropodus*, and 1: 2 in *M. oblongus*. Another distinguishing point of these 3 species is seen in the structure of their shoulders. The shoulder of *M. engraulis* is rounded without an anterior protrusion, with a small anterior protrusion in *M. oblongus*, and bearing a large anterior protrusion in *M. heteropodus*. It is interesting to note that the species with the rounded shoulder (*M. engraulis*) is a parasite of the anchovy (Engraulidae), and the 2 other species with protruding shoulders (*M. heteropodus* and *M. oblongus*) are parasitic on herrings (Clupeidae).

Genus *Sagum* C. B. Wilson, 1913
Sagum epinepheli (Yamaguti et Yamasu 1960)

(Figs. 11, 12)

Material examined: 1 ♀ on 1 (of 27) yellow grouper, *Epinephelus awoara* (Temminck et Schlegel, 1842), landed at Dong-gang on 27 Dec. 2003.

Female: Body (Fig. 11A, B) globular, covered with denticles on dorsal surface, 3.86 mm long

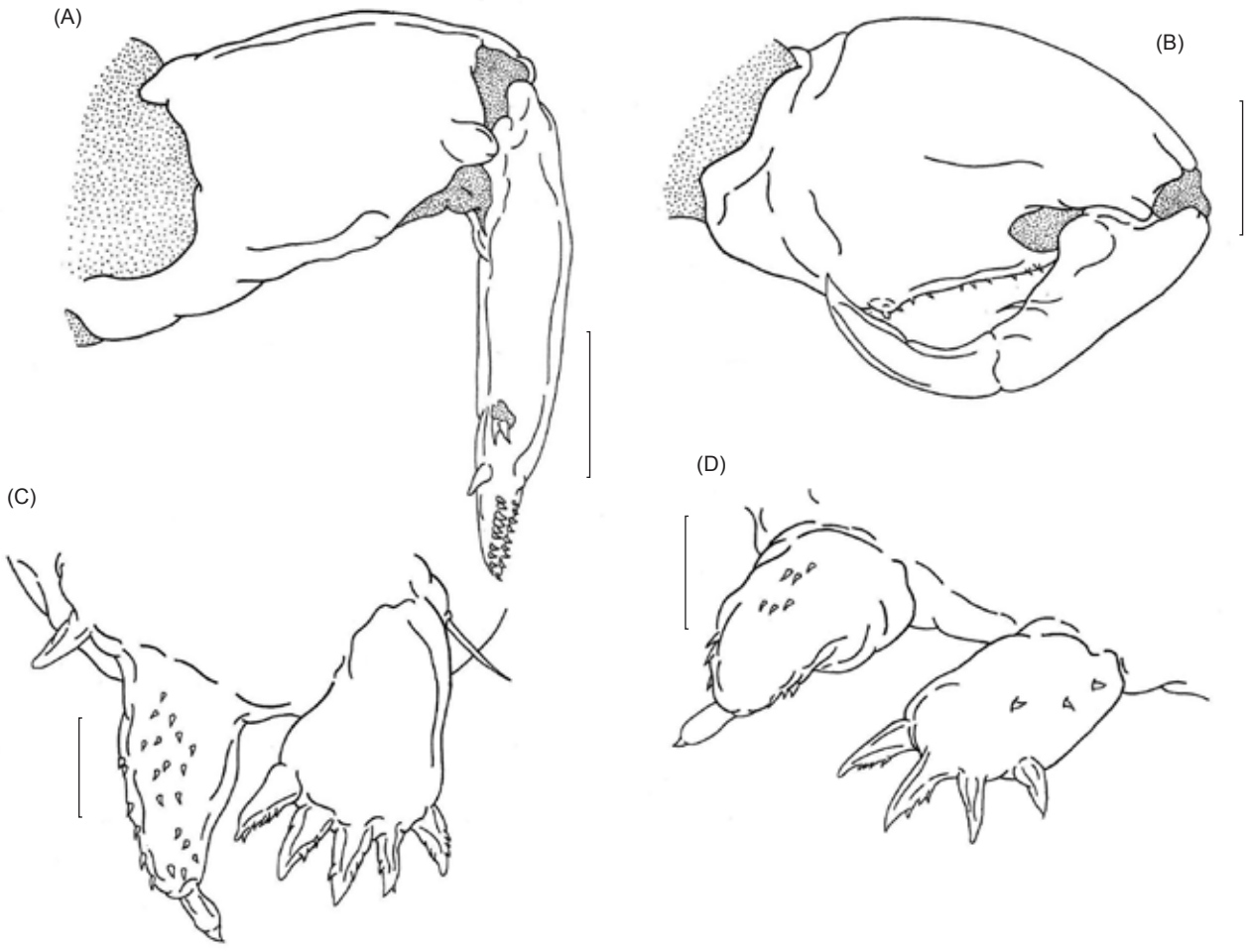

Fig. 9. *Mitrapus heteropodus* (Yü, 1933), female. (A) Maxilla, medial view; (B) maxilliped, medial view; (C) leg 1, ventral view; (D) leg 2, dorsal view. Scale bars: A = 40 μm; B = 50 μm; C and D = 20 μm.

(from tip of head to posterior margin of dorsal plate), comprising large head, short neck (1st pediger), rectangular trunk with a large subcircular dorsal plate, and minute, concealed urosome. Head bearing beak-like lateral protrusions, 1.24 × 1.82 mm, with both sides turned ventrally (Fig. 11C). Neck carrying globular swellings (Fig. 11B) on ventral surface lateral to leg 1 (Fig. 12D). Trunk (Fig. 11A, C) with smooth, shoulder-like anterolateral corners and posterolateral corners protruding to rear along lateral sides of dorsal plate. Components of urosome fused into 1 short unit (Fig. 11D) and entirely concealed under dorsal plate in dorsal view. Genital complex wider than long, 340 × 486 μm. Abdomen also wider than long, 146 × 186 μm. Caudal ramus (Fig. 11E) a long attenuated process carrying 1 seta and 2 knobs in swollen, basal region and 2 setae in distal region. Egg sac (not shown in Fig. 11) long and coiled underneath dorsal plate.

Antennule (Fig. 11F, G) indistinctly 7-segmented, with armature of 0, 0, 1, 1, 0, 2 and 10 + 2 aesthetascs. Antenna broken (see Fig. 11B). Mandible (Fig. 11H) as in previous species. Maxillule broken and lost during dissection. Maxilla (Fig. 12A) 2-segmented, with unarmed lacertus; brachium distally bearing 1 patch of denticles and 1 small, blunt element (Fig. 12B); terminal claw armed with row of denticles around margin. Maxilliped (Fig. 12C) indistinctly 3-segmented; corpus unarmed; subchela with 1 small subterminal seta on shaft; terminal claw with striations.

Leg 1 (Fig. 12D) protopod missing outer seta and with inner element appearing as a spiniform seta; exopod 1-segmented, tipped with 5 stocky spines; endopod reduced to a simple lobe. Leg 2 (Fig. 12E) protopod protruding laterally into

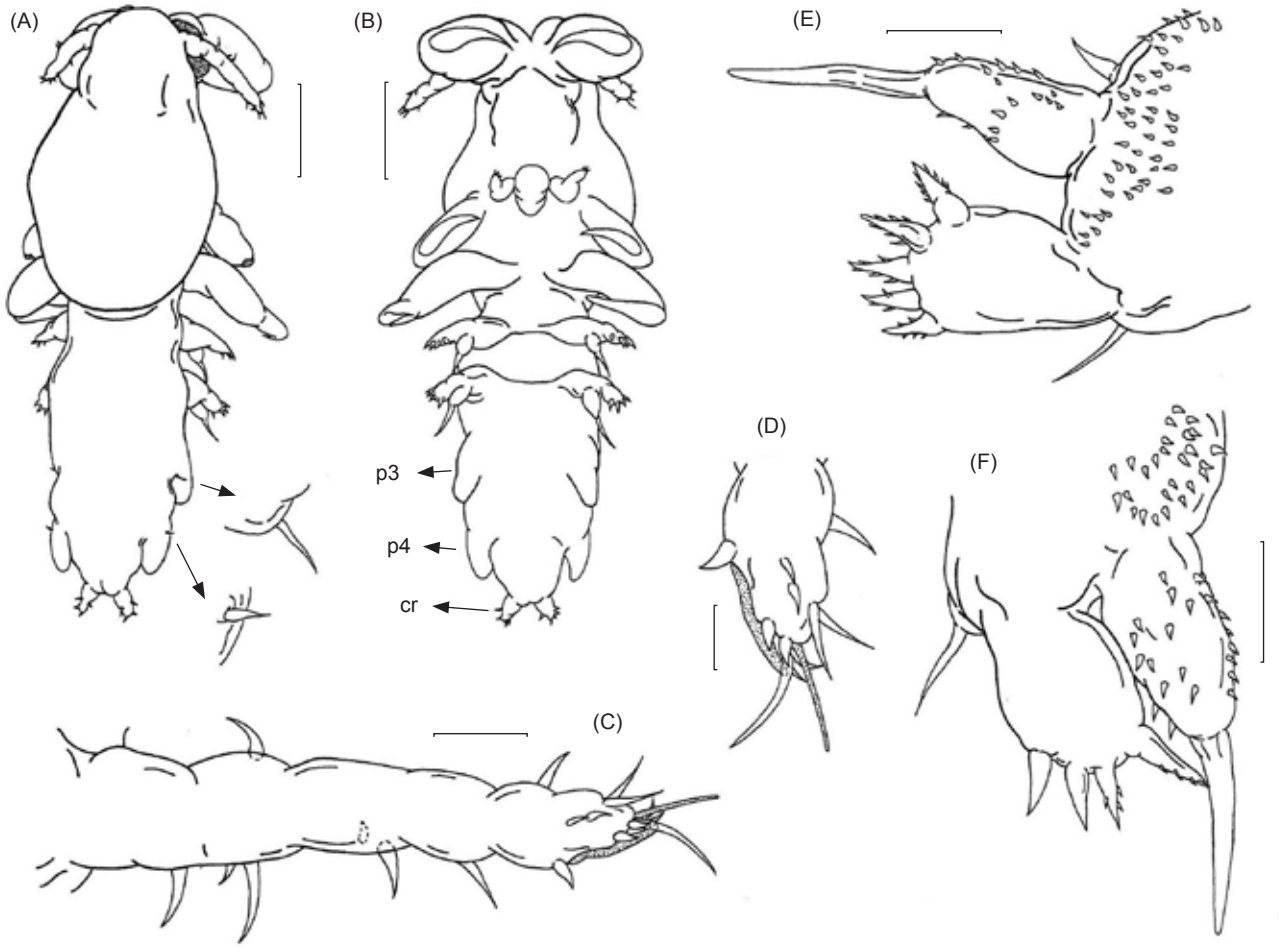

Fig. 10. *Mitrapus heteropodus* (Yü, 1933), male. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) antennule, dorsal view; (D) tip of antennule, dorsal view; (E) leg 1, ventral view; (F) leg 2, ventral view. Scale bars: A and B = 0.1 mm; C, E, and F = 20 μm; D = 10 μm. p3: leg 3; p4: leg 4; cr: caudal ramus.

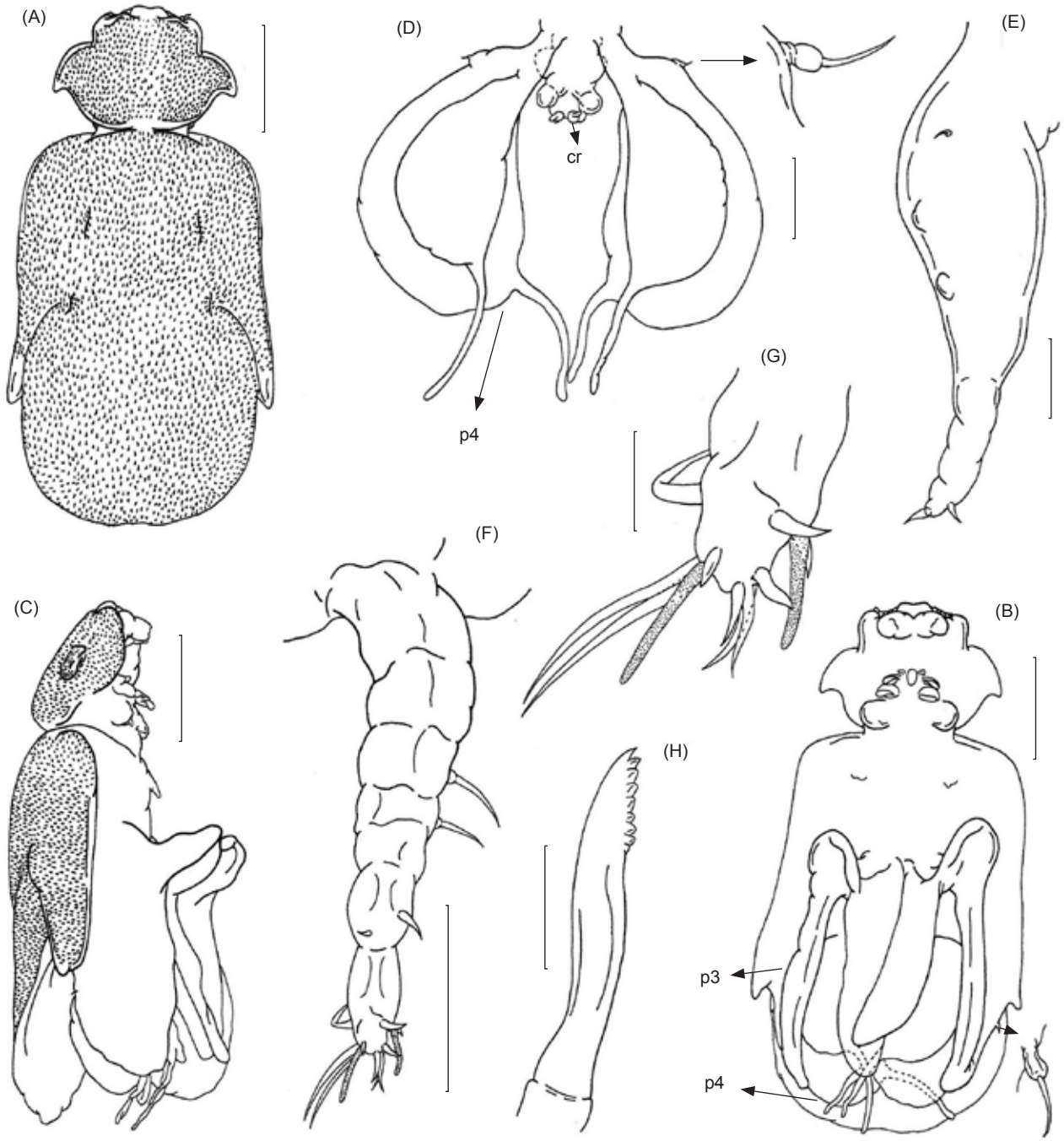

Fig. 11. *Sagum epinepheli* (Yamaguti et Yamasu, 1960), female. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome and leg 4, ventral view; (E) caudal ramus, dorsal view; (F) antennule, dorsal view; (G) tip of antennule, dorsal view; (H) mandible. Scale bars: A-C = 1 mm; D = 0.5 mm; E = 50 μm; F = 0.1 mm; G = 20 μm; H = 30 μm. p3: leg 3; p4: leg 4; cr: caudal ramus.

large, setulate process; exopod a lobe tipped with 3 small spiniform elements; endopod reduced to seta-bearing papilla. Leg 3 (Fig. 11B, C) greatly modified into fleshy, bent lamella; protopod folded and protruding ventrally (see Fig. 11C); exopod larger than endopod, expanded posteriorly into a large lamella with dorsal side fused to posteroventral protrusion of trunk (see Fig. 11C); endopod a long lamella concealing urosome in ventral view of animal (see Fig. 11B). Leg 4 (Fig. 11D) protopod with outer seta; exopod larger than endopod, but both rami with foliaceous basal part and long, filiform distal part. Leg 5 missing.

Male: Not collected.

Remarks: The present species was reported from Japan (Yamaguti and Yamasu 1960) and India (Pillai and Sebastian 1967). In all instances, just like from Taiwan, the parasites were found parasitic on gill filaments of groupers belonging to the genus *Epinephelus*.

Although 11 species of *Sagum* are listed in the *World of Copepods* by Walter (2010), many of them are so poorly known that a meaningful comparison of the morphology between congeners is impossible. Exceptions to this fact are the following 4 species: *S. flagellatum* Wilson, 1913; *S. foliaceum* (Richiardi, 1880); *S. petersi* (van Beneden, 1852); and *S. vespertilio* Kabata, 1979. *Sagum epinepheli* can easily be separated from *S. foliaceum* and *S. petersi* by the presence of

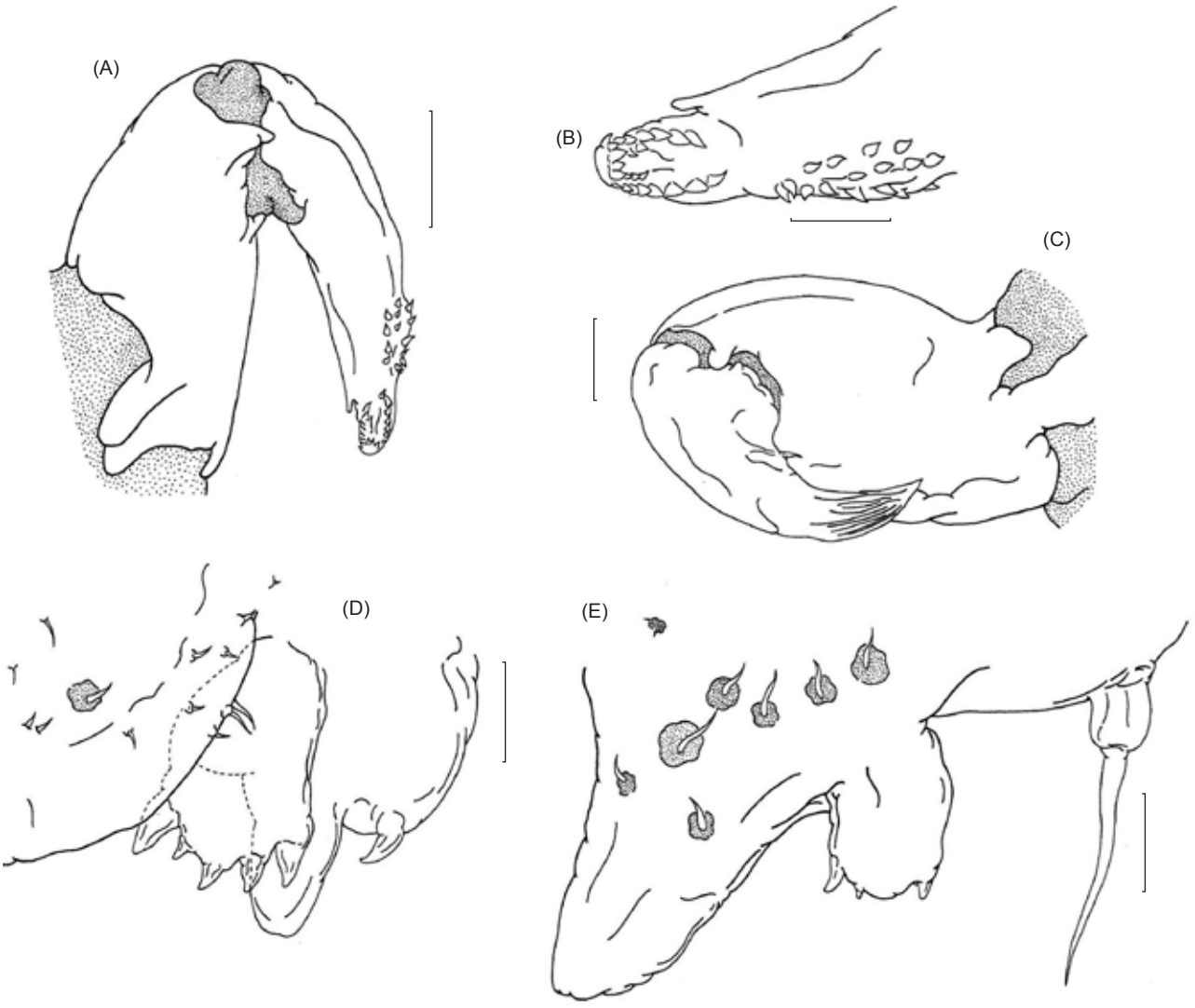

Fig. 12. *Sagum epinepheli* (Yamaguti et Yamasu, 1960), female. (A) Maxilla, medial view; (B) tip of maxilla, medial view; (C) maxilliped, medial view; (D) leg 1, ventral view; (E) leg 2, ventral view. Scale bars: A and C = 50 μm; B = 20 μm; D and E = 30 μm.

a pair of lateral horns on the head, and from *S. flagellatum* by not having posteroventral protrusions of the trunk "prolonged backward and outward like the skirts of a long military cloak" (Wilson 1913).

Ho et al. (2008) reported the occurrence of *S. vespertilio* on *Lethrinus nebulosus* (Forsskål) collected from Penghu, Taiwan. In that report *S. tuberculatum* Pillai, 1985 was proposed to be relegated to the synonym of *S. vespertilio*. *Sagum epinepheli* can be distinguished from *S. vespertilio* by having a pair of smaller lateral horns on the head, lacking a lateral process on the neck, carrying a relatively longer, terminal filament on each ramus of leg 4, and the absence of leg 5.

***Sagum folium* sp. nov.**
(Figs. 13-15)

Material examined: 15 ♀♀ and 3 ♂♂ found on gill filaments of Japanese snapper, *Paracaesio caerulea* (Katayama 1934): 2 ♀♀ on 1 (of 4) *P. caerulea*, landed at Dong-gang Fishing Port on 10 Oct. 2003; 13 ♀♀ and 3 ♂♂ on 5 (of 6) *P. caerulea* landed at Cheng-gong Fishing Port on 23 Sept. 2004. Female holotype (USNM 1131888) and male allotype (USNM 1131889) were deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Female: Body (Fig. 13A-C) globular, 4.13 (4.04-4.22) mm long (from tip of head to posterior margin of dorsal plate), comprising large head, short neck (1st pediger), semi-rectangular trunk with a large dorsal plate, and minute urosome. Head slightly longer than wide, 1.25 (1.06-1.44) × 1.19 (1.16-1.22) mm, with both sides turned ventrally. Trunk with sclerites on dorsal and lateral sides and anteriorly protruding shoulders. Urosomal somites fused into 1 short unit (Fig. 13D) and entirely concealed under dorsal plate in dorsal view. Genital complex wider than long, 316 (292-340) × 458 (446-470) μm. Abdomen also wider than long, 174 (162-186) × 279 (251-308) μm. Caudal ramus (Fig. 13E) leaf-like, inserted into posterolateral corner of abdomen, carrying 3 short, naked setae in distal 1/2 of dorsal surface and another 2 setae at distal end. Egg sac (not shown in Fig. 13) long and coiled underneath dorsal plate.

Antennule (Fig. 13F, G) indistinctly 7-segmented, with armature formula of 4, 1, 1, 0, 1, 2 and 8 + 2 aesthetascs. Antenna (Fig. 14A) 2-segmented; corpus carrying 1 small, basal papilliform element on medial surface; terminal claw stocky, also carrying similar basal element on medial surface and apical surface striations. Mandible (Fig. 14B) composed of 2 sections; with 8 teeth on terminal blade. Maxillule (Fig. 14C) bilobate; smaller outer lobe tipped with 1 element; larger inner lobe fringed with spinules on distal 1/2 of medial margin in addition to carrying 3 unequal, terminal elements. Maxilla (Fig. 14D, E) 2-segmented, with unarmed lacertus; brachium bearing 1 subterminal and 1 terminal blunt element and row of denticles around margin of terminal claw. Maxilliped (Fig. 14F) 2-segmented; corpus carrying 1 papilliform element in myxal area; subchela with 1 small subterminal seta on shaft and 1 basal blunt element, median row of minute denticles and apical striations on terminal claw.

Leg 1 (Fig. 14G) with inconspicuous protopod carrying 1 slender outer seta and 1 spiniform, pinnate inner element; exopod 1-segmented, fringed with setules on outer margin and tipped with 5 stocky spines; endopod reduced to a lobe tipped with a small, blunt element. Leg 2 (Fig. 14H) more reduced than leg 1, without protopod; exopod a lobe tipped with 5 blunt elements and endopod with1 blunt element. Leg 3 (Fig. 13B, C) with both rami greatly modified into foliaceous structure; exopod larger than endopod, occupying major portion of lateral part of trunk (see Fig. 13C). Leg 4 (Fig. 13B, D) rami subcylindrical, with setulate basal papilla on outer surface of protopod. Leg 5 (Fig. 14I) represented by a bent, blunt process near posterolateral corner of genital complex; carrying 1 setulate papilla subterminally on medial surface.

Male: Body (Fig. 15A, B) smaller than female, 1.81 (1.68-1.94) mm long (from tip of head to end of caudal ramus), without dorsal plate on trunk. Head (cephalosome) shaped like a piece of toast, slightly wider than long, 0.89 (0.86-0.92) × 0.91 (0.74-1.08) mm. First pediger forming a short neck and remaining pedigers fused to form a rectangular trunk with conical posterolateral protrusion. Genital complex and abdomen indistinguishably fused to each other. Caudal ramus (Fig. 15C) a lobe measuring 89 (81-97) μm long and 49 (41-57) μm wide, armed as in female.

Antennule (Fig. 15D, E) filiform and indistinctly 6-segmented, with armature formula of 1, 3, 2, 0, 1, and 11 + 2 aesthetascs. Leg 2 (Fig. 15F) protopod with simple outer seta; exopod armed in distal region with 4 stocky spines and 3 patches of spinules; endopod with single subterminal setule and tuft of terminal setules. Legs 3 and 4 (Fig. 15A, B) represented by pair of bifid cylindrical

processes coming off both sides of trunk. Leg 5 absent.

Etymology: The species name *folium* means "leaf" in Latin. It alludes to the unusual transformation of the caudal rami appearing like a pair of leaves at the end of the urosome.

Remarks: Without the presence of a pair of lateral horns on the head, the new species is closer to *S. foliaceum* and *S. petersi* than to the remaining 3 well-described congeners of *S. epinepheli*, *S. flagellatum*, and *S. vespertilio*. Nevertheless, *S. folium* sp. nov. can be easily separated from those 2 similar species by the structure of the caudal ramus (being leaf-like) and leg 5 (a bent, blunt, short process subterminally carrying a medial setulate papilla).

Among the 5 well-described species of *Sagum*, the male is known for 2 species, *S. epinepheli* and *S. foliaceum*. The male of the new species can be easily distinguished from that of *S. foliaceum* in having its leg 3 constructed of bilobate (vs. unilobate) cylindrical processes and from that of *S. epinepheli* in having its large head (cephalosome) shaped like a piece of toast and distinctly wider than the trunk (fused pedigerous somites and urosome).

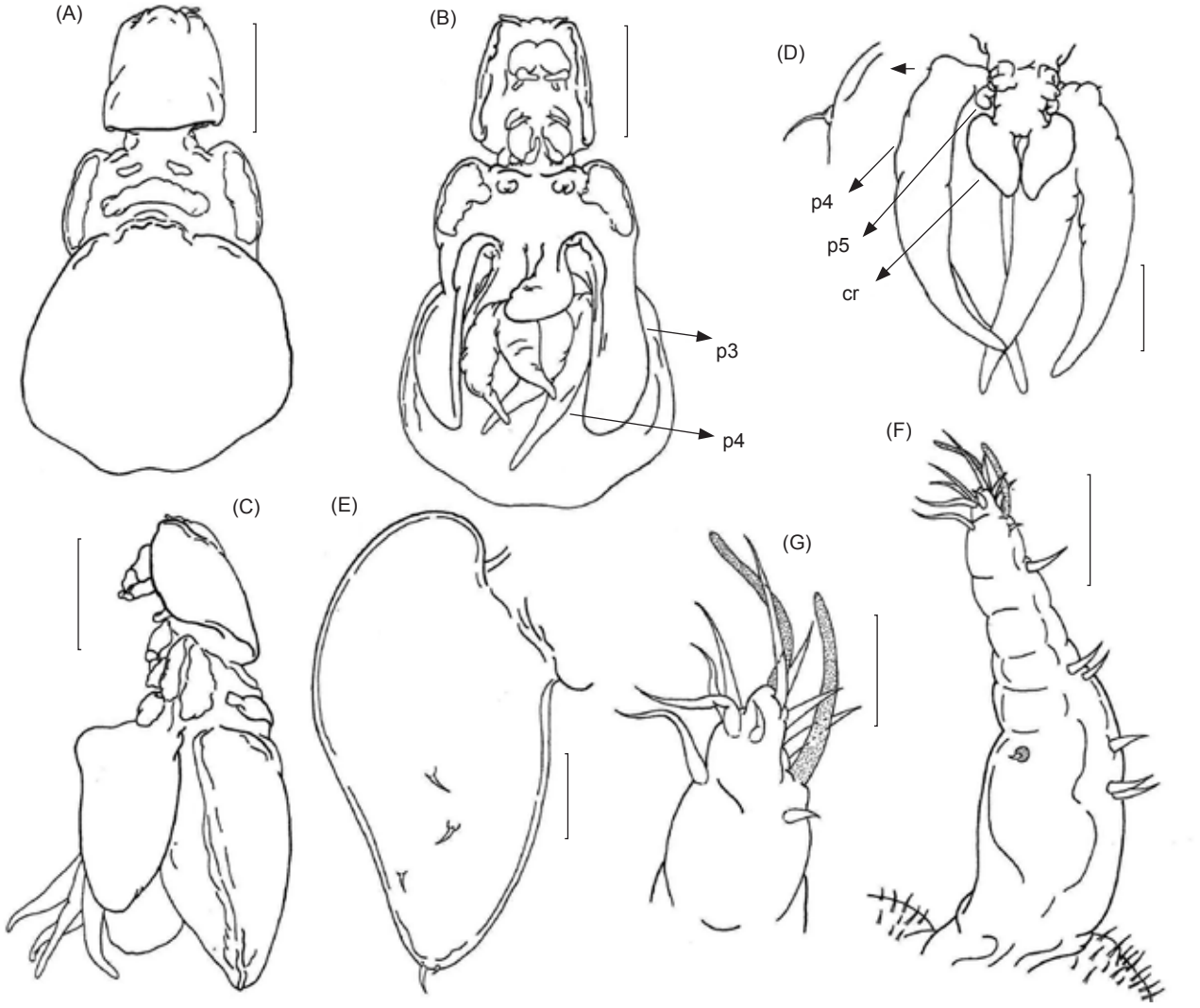

Fig. 13. *Sagum folium* sp. nov., female paratype. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus, lateral view; (D) urosome, showing leg 4, leg 5, and caudal rami, dorsal view; (E) caudal ramus, dorsal view; (F) antennule, ventral view; (G) tip of antennule, ventral view. Scale bars: A-C = 1 mm; D = 0.5 mm; E = 0.1 mm; F = 50 μm; G = 20 μm. p3: leg 3; p4: leg 4; p5: leg 5; cr: caudal ramus.

Fig. 14. *Sagum folium* sp. nov., female paratype. (A) Antenna, medial view; (B) mandible; (C) maxillule, lateral view; (D) maxilla, medial view; (E) tip of maxilla, medial view; (F) maxilliped, medial view; (G) leg 1, dorsal view; (H) leg 2, dorsal view; (I) leg 5. Scale bars: A = 0.2 mm; B and G = 40 μm; C and I = 50 μm; D and F = 0.1 mm; E = 20 μm; H = 30 μm.

DISCUSSION

The Lernanthropidae, following the Lernaeopodidae and Caligidae, is the 3rd-largest family of fish-parasitizing Siphonostomatoida. The family contains over 150 species, with a great majority of them occurring in tropical waters. Thus, in the 3 countries of India, Japan, and the UK, where the fauna of fish-parasitizing copepods are best known, we see that India stands out as having the most lernanthropid species, at 44 species (Pillai 1985), whereas Japan is surrounded by colder water and has only 8 species (Ho and Do 1985) as is the UK with only 5 species (Kabata 1979a). However, in consideration of the number of genera, Taiwan contains 7 genera of the Lernanthropidae (*Lernanthropinus* Do in Ho and Do, 1985, *Lernanthropodes*, *Lernanthropsis* Do in Ho and Do, 1985, *Lernanthropus*, *Mitrapus*, *Norion* von Nordmann, 1864, and *Sagum*). India is known to have representatives from 6 genera (*Aethon*, *Lernanthropinus*, *Lernanthropsis*, *Lernanthropodes*, *Lernanthropus*, and *Sagum*) and the other 2 aforementioned countries have 5 genera in each, namely *Lernanthropinus*, *Lernanthropsis*, *Lernanthropus*, *Mitrapus*, and *Sagum* in Japan (Ho and Do 1985) and *Aethon*, *Lernanthropodes*, *Lernanthropus*, *Norion*, and *Sagum* in the UK (Kabata 1979a).

According to the copepod database produced by Boxshall (2011), *Lernanthropus* is the largest genus of lernanthropids comprising 111 species. As a matter of fact, more than 3/4 (75.5% or 111/147) of lernanthropids belong to *Lernanthropus*. This striking uneven composition of species number is also evident in the

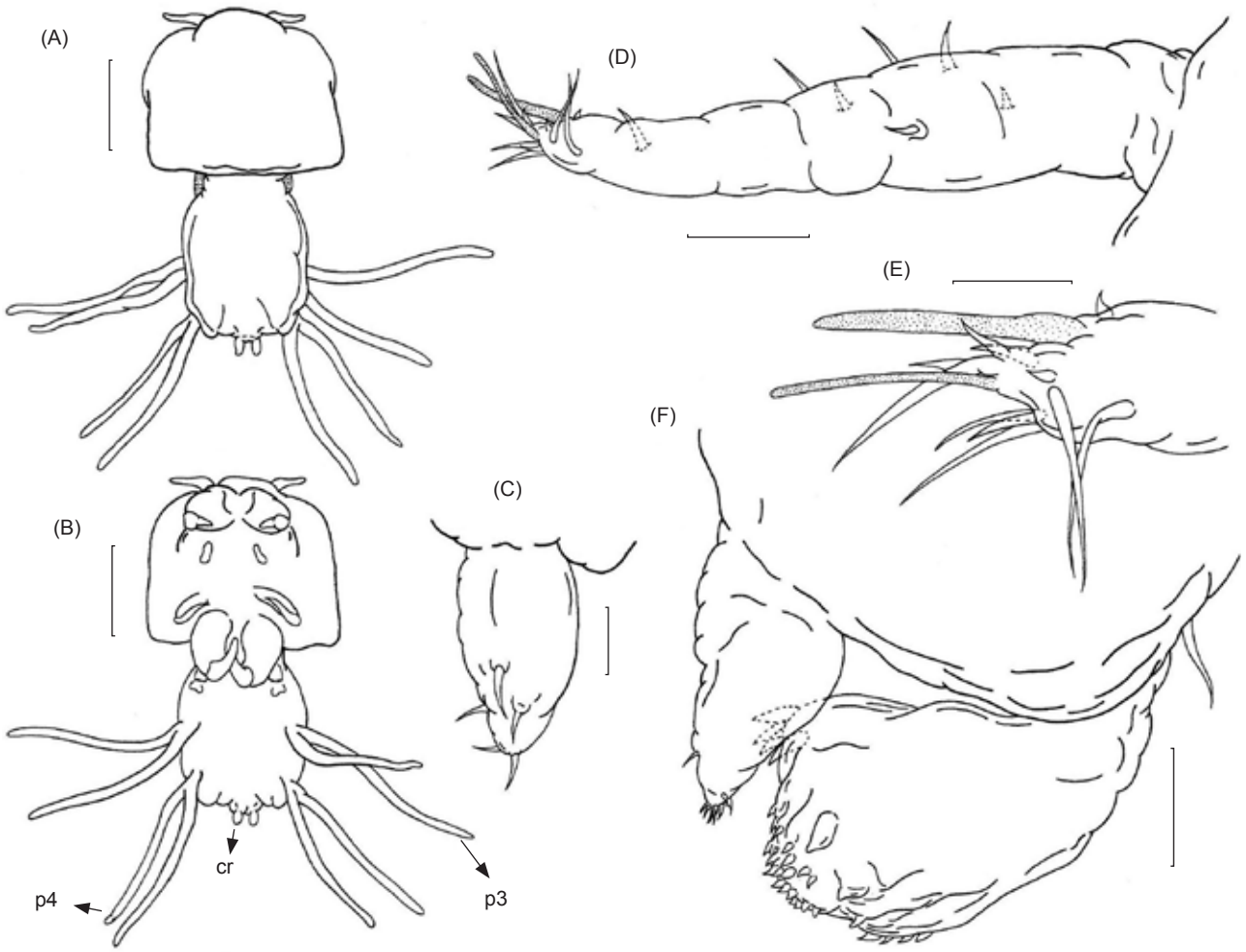

Fig. 15. *Sagum folium* sp. nov., male paratype. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) caudal ramus, dorsal view; (D) antennule, dorsal view; (E) tip of antennule, dorsal view; (F) leg 2, dorsal view. Scale bars: A and B = 0.5 mm; C = 25 μm; D = 50 μm; E = 20 μm; F = 30 μm. p3: leg 3; p4: leg 4; cr: caudal ramus.

Table 1. Hosts and localities of 18 species of the Lernanthropidae known from Taiwan. Data in this table are taken from Bassett-Smith (1898), Boxshall and Montú (1997), Byrnes (1988), Cressey and Collette (1970), Delamare-Deboutteville and Nunes-Ruivo (1954), Gusev (1951), Ho and Do (1985), Ho and Kim (2004), Ho and Sey (1996), Ho et al. (2008), Kabata (1962 1979b), Kensley and Grindley (1973), Kim (1998), Kirtisinghe (1937 1964), Krøyer (1863), Leong (1986), Liu et al. (2009a b), Pillai (1962 1963 1985), Pillai and Sebastian (1967), Shiino (1955), Shishido (1898), Tripathi (1962), Yamaguti (1936 1954), Yamaguti and Yamasu (1959 1960), and Yü (1933). The host names are valid ones following Froese and Pauly (2011). For those articles where a synonym was used for the host, they are identified with a number and noted at the bottom of the table

Parasite	Host	Locality
Lernanthropinus sphyraenae (Yamaguti et Yamasu, 1959)	*Mene maculata* (Bloch et Schneider)	Taiwan
	Sphyraena obtusata Cuvier	Sri Lanka
	Sphyraena pinguis Günther	Japan
Lernanthropodes chorinemi Pillai, 1962	*Scomberoides commersonnianus* Lacepéde	Taiwan
	Scomberoides lysan (Forsskål)	India
Lernanthropodes trachinoti Pillai, 1962	*Trachinotus blochii* (Lacepéde)	India, Taiwan
	Trachinotus botla (Shaw)	Australia
Lernanthropsis mugilii (Shishido, 1898)	*Acanthopagrus schlegelii schlegelii* (Bleeker)[2)]	India
	Mugil cephalus Linnaeus	Japan, India, Korea, Taiwan, Australia
	Mugil soiuy Basilewsky	China, Sri Lanka, Russia
	Pagrus major (Temminck et Schlegel)[3)]	India
Lernanthropus cadenati Delamare-Deboutteville et Nunes-Ruivo, 1954	*Acanthopagrus berda* (Forsskål)	Kuwait
	Elops machnata (Forsskål)	Taiwan
	Elops senegalensis Regan	Senegal
	Megalops cyprinoides (Broussonet)	India, Taiwan
	Sparidentex hasta (Valenciennes)[4)]	Kuwait
Lernanthropus chrysophrys Shishido, 1898	*Acanthopatrus australis* (Günther)	Australia
	Acanthopagrus berda (Forsskål)[5)]	Japan, India, Australia, Taiwan
	Acanthopagrus latus (Houttuyn)	Taiwan
	Acanthopagrus schlegelii schlegelii (Bleeker)[2)]	Japan, Taiwan
Lernanthropus corniger Yamaguti, 1954	*Alepes djedaba* (Forsskål)[6)]	South Africa
	Megalaspis cordyla (Linnaeus)	Indonesia, India, China, Malaysia, Thailand, Taiwan
	Mene maculata (Bloch et Schneider)	Taiwan
	Myripristis vittata Valenciennes	Taiwan
	Rastrelliger kanagurta (Cuvier)	India
Lernanthropus cornutus Kirtisinghe, 1937	*Ablennes hians* (Valenciennes)	US east coast, Haiti, Mexico, Panama, Brazil, Peru, Hawaii, Taiwan, Mauritius, the Philippines
	Platybelone argalus argalus (Lesueur)	Gulf of Guinea
	Strongylura anastomella (Valenciennes)[7)]	Japan, Korea
	Strongylura exilis (Girard)	Peru
	Strongylura incisa (Valenciennes)[8)]	Gilbert Is., Australia
	Strongylura leiura (Bleeker)[9)]	Sri Lanka, Taiwan, the Philippines
	Strongylura marina (Walbaum)	British Honduras
	Strongylura strongylura (Hasselt)	Malay Peninsula

Table 1. (continued)

Parasite	Host	Locality
	Strongylura timucu (Walbaum)	Brazil
	Strongylura urvillii (Valenciennes)	the Philippines
	Tylosurus acus acus (Lacepède)	Puerto Rico, Angola, Panama, Mexico, Java, the Philippines
	Tylosurus acus melanotus (Bleeker)	Japan, Taiwan
	Tylosurus choram (Rüppell)	Red Sea
	Tylosurus crocodilus crocodilus (Péron et Lesueur)	US east coast, Venezuela, Mexico, Panama, Kenya, Zanzibar, Senegal, Madagascar, Red Sea, Mauritius, Seychelles, Gulf of Aden, Senegal, Java, Arabian Gulf, Gulf of Thailand, Borneo, Taiwan, the Philippines, Japan, Hawaii
	Tylosurus punctatus (Günther)	the Philippines
Lernanthropus giganteus Krøyer, 1863	*Carangoides ferdau* (Forsskål)	India
	Carangoides praecustus (Bennett)	China
	Caranx crysos (Mitchill)	Jamaica
	Caranx hippos (Linnaeus)[11]	Jamaica, Brazil
	Caranx ignobilis (Forsskål)	Sri Lanka, Taiwan
	Caranx leptolepis Cuvier	Kuwait
	Caranx melampygus Cuvier	Aden
	Caranx sansun (Forsskål)	Sri Lanka
	Caranx senegallus Cuvier	Senegal
	Caranx sexfasciatus Quoy et Gaimard	Taiwan
Lernanthropus incilis sp. nov.	*Evoxymetopon poeyi* Günther	Taiwan
Lernanthropus otolithi Pillai, 1963	*Otolithes ruber* (Bloch et Schneider)[12]	India
	Pennahia pawak (Lin)	Taiwan
	Pterotolithus maculatus (Cuvier)[13]	India
Lernanthropus pomadasysis Rangnekar and Murti, 1961	*Pomadasys kaakan* (Cuvier)	Taiwan
	Pomadasys maculatus (Bloch)	India
Lernanthropus pristipomoides Kirtisinghe, 1937	*Kyphosus vaigiensis* (Quoy et Gaimard)	Taiwan
Mitrapus heteropodus (Yü, 1933)	*Konosirus punctatus* (Temminck et Schlegel)	China, Japan
	Nematalosa nasus (Bloch)	Taiwan
Norion priacanthi (Kirtisinghe, 1956)	*Priacanthus macracanthus* Cuvier	Taiwan
Sagum epinepheli (Yamaguti et Yamasu, 1960)	*Epinephelus akaara* (Temminck et Schlegel)	Japan
	Epinephelus awoara (Temminck et Schlegel)	Taiwan
	Epinephelus sp.	India
Sagum folium sp. nov.	*Paracaesio caerulea* (Katayama)	Taiwan
Sagum vespertilio Kabata, 1979	*Lethrinus laticaudis* (Alleyne et Macleay)[14]	Australia
	Lethrinus nebulosus (Forsskål)	Taiwan

Synonyms used in the original publications are: 1) *Chorinemus lysan* in Pillai (1962); 2) *Sparus macrocephalus* in Shishido (1898), Shiino (1955), Song and Chen (1976), and Pillai (1985); 3) *Pagrosomus major* in Pillai (1985); 4) *Acanthopagrus cuvieri* in Ho and Sey (1996); 5) *Sparus longispinis* in Yamaguti (1936); 6) *Caranx djedaba* in Kensley and Grindley (1973); 7) *Ablennes anastomella* in Ho and Do (1985); 8) *Tylosurus incisus* in Kabata (1962); 9) *Tylosurus leisurus* in Kirtisinghe (1964); 10) *Strongylura crocodile* in Delamare-Deboutteville and Nunes-Ruivo (1954); 11) *Caranx carangus* in Krøyer (1863); 12) *Otolithus argenteus* in Pillai (1963); 13) *Otolithus maculates* in Pillai (1963); and 14) *Lethrinus fletus* in Kabata (1979b).

lernanthropids of Taiwan, where nine of the 18 known species are in *Lernanthropus* (see Table 1). As stated in the "Introduction", we believe that many more species of lernanthropids are yet to be discovered from the marine fishes of Taiwan, because so far fewer than 20% of the available species of marine fish from Taiwan have been examined for parasitic copepods. Another reason why we speculate that more species of lernanthropids will be found from Taiwan is the fact that a large number of lernanthropids reported from the Indo-West Pacific region are parasitic on fishes that are also known to occur in waters of Taiwan. As shown in table 2, as far as we are aware, as many as 25 species of such lernanthropids in 4 genera are yet to be found from the fishes of Taiwan.

To encourage future work on lernanthropids of Taiwan, a key to the 18 known species of the family in Taiwan is provided below. Since the male of many species of Lernanthropidae are unknown and the taxonomy of the family is largely based on the morphology of the female, the following key is, consequently, applicable only to female lernanthropids. The publication containing the best taxonomic description for each species is provided in parentheses following each species name in this key to facilitate a more-rapid verification of the species identification.

1. Fourth pediger without dorsal plate 2
- Fourth pediger with a single, large dorsal plate 4
- Fourth pediger with a pair of long, widely separated dorsal plates .... *Lernanthropinus sphyraenae* (Ho et al. 2008: 252-257)
2. Fourth pediger with a pair of round, dorsal knobs ....*Lernanthropsis mugilii* (Ho et al. 2008: 257-261)
- Fourth pediger without outgrowth; rami of leg 3 fused to form a ventral plate (*Lernanthropodes*) 3
3. Head triangular; parabasal process present .... *Lernanthropodes chorinemi* (present report: 612-614)
- Head rectangular; parabasal process absent .... *Lernanthropodes trachinoti* (present report: 614-617)
4. Egg strings coile 5

Table 2. Species of lernanthropids reported from the Indo-West Pacific region with hosts that also occur in waters of Taiwan

Parasite	Fish host	Locality, reported by
Lernanthropinus decapteri	*Decapterus russelli* (Carangidae)	India, Pillai (1985)
Lernanthropinus forficatus	*Lepturacanthus savala* (Trichiuridae)[a]	India, Pillai (1985)
Lernanthropinus gibbosus	*Saurida tumbil* (Synodontidae)	India, Pillai (1985)
Lernanthropinus sauridae	*Saurida elongata* (Synodontidae)	Japan, Ho and Do (1985)
Lernanthropus abitocephalus	*Pomadasys maculatus* (Haemulidae)	India, Pillai (1985)
Lernanthropus atrox	*Acanthopagrus schelegelii* (Sparidae)	Japan, Ho and Do (1985)
Lernanthropus brevicephalus	*Lutjanus malabaricus* (Lutjanidae)	India, Pillai (1985)
Lernanthropus breviculus	*Cheilinus chlorourus* (Labridae)	Australia, Kabata (1979b)
Lernanthropus chlamydotus	*Strongylura strongylura* (Belonidae)	India, Cressey and Collette (1970)
Lernanthropus chirocentrosus	*Chirocentrus dorab* (Chirocentridae)	India, Pillai (1985)
Lernanthropus dussumieri	*Dussumieria acuta* (Clupeidae)	India, Pillai (1985)
Lernanthropus gisleri	*Argyrosomus japonicus* (Sciaenidae)	Australia, Kabata (1979b)
Lernanthropus koenigii	*Parastromateus niger* (Carangidae)	India, Pillai (1985)
Lernanthropus latis	*Lates calcarifer* (Latida)	India, Pillai (1985)
Lernanthropus lappaceus	*Eleutheronema tetrad actylum* (Polynemiae)[b]	India, Pillai (1985)
Lernanthropus lativentris	*Lethrinus harak* (Lethrinidae)[c]	India, Pillai (1985)
Lernanthropus leiognathi	*Secutor ruconius* (Leiognathidae)	India, Pillai (1985)
Lernanthropus nemipteri	*Nemipterus furosus* (Nemipteridae)	Thailand, Ho and Kim (2004)
Lernanthropus opisthopteri	*Opisthopterus tardoore* (Clupeidae)	India, Pillai (1985)
Lernanthropus secutoris	*Secutor insidiator* (Leiognathidae)	India, Pillai (1985)
Lernanthropus sillaginis	*Sillago sihama* (Sillaginidae)	India, Pillai (1985)
Lernanthropus triangularis	*Gerres filamentosus* (Gerridae)	India, Pillai (1985)
Lernanthropus trifoliatus	*Polydactylus sextarius* (Polynemidae)[d]	Sri Lanka, Kirtisinghe (1964)
Mitrapus oblongus	*Sardinella fimbriata* (Clupeidae)	India, Pillai (1985)
Norion tayenus	*Priacanthus tayenus* (Priacanthidae)	Thailand, Ho and Kim (2004)

[a]Host was named *Trichiurus savala* in Pillai's report (1985: 550). [b]Host was named *Polynemus tetradactylum* in Pillai's report (1985: 565). [c]Host was named *Lethrinus rhodopterus* in Pillai's report (1985: 572). [d]Host was named *Polynemus sextarius* in Pillai's report (1985: 603).

- Egg strings linear 8
5. Leg 2 present (*Sagum*) 6
- Leg 2 absent ..... *Norion priacanthi* (Ho et al. 2008: 270-274)
6. Rami of leg 4 with lamelliform basal part and filiform distal part 7
- Rami of leg 4 subcylindrical ..... *Sagum folium* (present report: 627-630)
7. Neck region (1st pediger) smooth, without outgrowth; leg 5 missing ..... *Sagum epinepheli* (present report: 623-627)
- Neck region (1st pediger) with a pair of small lateral processes; leg 5 present ..... *Sagum vespertilio* (Ho et al. 2008: 274-278)
8. Endopod of leg 4 as long as, or longer than, exopod (*Lernanthropus*) 9
- Endopod of leg 4 shorter than exopod ..... *Mitrapus heteropodus* (present report: 621-624)
9. Posterolateral corner of head protruding out into a process. 10
- Head without such a process 11
10. Leg 4 concealed by dorsal plate in dorsal habitus view; caudal ramus a swollen process ..... *Lernanthropus cornutus* (Liu et al. 2009a: 40-45)
- Leg 4 exposed in dorsal habitus view; caudal ramus a cylindrical process ..... *Lernanthropus chrysophrys* (Liu et al. 2009a: 34-40)
11. Head with a pair of large, forwardly protruding horns ..... *Lernanthropus corniger* (Liu et al. 2009b: 120-124)
- Head without such outgrowths 12
12. Dorsal plate on 4th pediger with a deep, central incision ..... *Lernanthropus incilis* (present report: 617-621)
- Dorsal plate on 4th pediger entire, without such an incision 13
13. Head wider than long, triangular or trapezoidal 14
- Head longer than wide, not shaped as above 15
14. Antennule with parabasal process; caudal ramus cylindrical ..... *Lernanthropus pomadasysis* (Ho et al. 2008: 266-270)
- Antennule without parabasal process; caudal ramus with swollen base ..... *Lernanthropus pristipomoides* (Liu et al. 2009b: 128-131)
15. Dorsal plate large, concealing urosome entirely in dorsal habitus view ..... *Lernanthropus giganteus* (Liu et al. 2009b: 124-128)
- Dorsal plate not entirely covering urosome, at least exposing caudal rami in dorsal habitus view 16
16. Antennule with parabasal process; leg 5 long, reaching tip of caudal ramus ..... *Lernanthropus otolithi* (Ho et al. 2008: 261-266)
- Antennule without parabasal process; leg 5 absent ..... *Lernanthropus cadenati* (Liu et al. 2009a: 30-34)

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