

Solution to the Taxonomic Confusion Surrounding *Caligus epinepheli* Yamaguti, a Caligid Copepod (Siphonostomatoida) Parasitic on Marine Fishes

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(Accepted December 9, 2002)

Ju-shey Ho and Ching-Long Lin (2003) Solution to the taxonomic confusion surrounding *Caligus epinepheli* Yamaguti, a caligid copepod (Siphonostomatoida) parasitic on marine fishes. *Zoological Studies* 42(2): 268-283. Comparative studies of specimens of *Caligus* recovered from *Scolopsis vosmeri* (Bloch), *Lobotes surinamensis* (Bloch), and *Acanthopagrus schlegeli* Bleeker caught in the waters of Taiwan revealed that *Caligus pagrosomi* Yamaguti, 1939 is a valid species, not synonymous with *C. epinepheli* Yamaguti, 1936 as proposed by T. Byrnes in 1987. Furthermore, *C. epinepheli* is restricted to the temperate waters of Asia and Oceania. Those specimens reported as *C. epinepheli* from the Caribbean Sea by R. F. Cressey in 1991 belong to a separate species, which is proposed to be called *Caligus cresseyi* nom. nov. Moreover, a new subspecies, *Caligus pagrosomi schlegeli* subsp. nov., is described based on the specimens obtained from Taiwan. <http://www.sinica.edu.tw/zool/zoolstud/42.2/268.pdf>

Key words: *Caligus epinepheli*, Sea lice, Taiwan, Marine fish.

Caligus epinepheli Yamaguti, 1936 has a fairly wide distribution. It was first reported from Japan (Yamaguti 1936) and then intermittently from India (Pillai 1963, Rangnekar and Murti 1963), Sri Lanka (Kirtisinghe 1964), Australia (Kabata 1965), Malaysia (Leong 1984), the Caribbean Sea (Cressey 1991), Persian Gulf (Ho and Sey 1996), and Taiwan (Ho et al. 2000). On the other hand, the distribution of its close ally, *Caligus pagrosomi* Yamaguti, 1939, is restricted. It has been sighted only once in Australia by Roubal (1981) since its original report from Japan by Yamaguti (1939). According to Yamaguti's (1939) original report, *C. pagrosomi* differs from *C. epinepheli* chiefly in the presence of "a small sub-terminal seta" on the posterior margin of the terminal segment of leg 1 and "a mammiferous projection" on each side of the sternal furca. However, in his work on the caligid parasites of the sea breams (*Acanthopagrus* spp.) of Australia,

Byrnes (1987) considered otherwise, alleging that "the furcal projections mentioned by Yamaguti are only visible in some specimens" and "the minute spine of the first exopod is very easily missed behind the pectinate base of the apical seta contiguous to it." There upon, he argued that the 2 distinguishing characteristics enumerated by Yamaguti (1939) were "insufficient reason for establishing a separate species" and proposed to relegate *C. pagrosomi* to a junior synonym of *C. epinepheli*.

In our survey of the sea lice of the fishes of Taiwan, we encountered certain specimens that are clearly identifiable with *C. epinepheli* and some other specimens, definitely attributable to *C. pagrosomi* in accordance with Yamaguti's (1939) notation. Comparative studies on these 2 forms of *Caligus* have also revealed that there are additional differences between them than those mentioned by Yamaguti (1939). Furthermore, a 3rd taxon,

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i.e., a new subspecies was identified. Therefore, in this paper, in addition to providing an account of these 3 taxa based on the specimens collected on Taiwanese fishes, a detailed discussion is given on the taxonomic confusion and complexity of this species group.

MATERIALS AND METHODS

The fishes caught in the Strait of Taiwan and landed at Makung Fishing Port in Penghu County and Dongshih Fishing Port in Chiayi County were purchased and transferred in an icebox to National Chiayi University where the laboratory examination of the copepod parasites was carried out. The copepod parasites removed from the fish were preserved in 70% ethanol. In studying the parasites, the specimens were cleared in 85% lactic acid for 1 to 2 h before dissection in a drop of lactic acid. The hanging-drop method devised by Humes and Gooding (1964) was employed to examine the dissected parts and appendages on a wooden slide under a compound microscope. All drawings were made with the aid of a camera lucida. Measurements of the body and body parts were taken from 10 randomly selected specimens, or all available specimens if the obtained number of specimens was less than 10. The various measurements given in the description are the average with the range given in parentheses. To show certain intricate morphological differences that are difficult to express fully with words, a complete set of illustrations is provided for each taxon in the following account.

RESULTS

Caligus epinepheli Yamaguti, 1936

(Figs. 1, 2)

Caligus epinepheli Yamaguti, 1936: 4; Shiino, 1952: 80; Yamaguti, 1963: 53; Kirtisinghe, 1964: 57; Kabata, 1965: 112; Leong, 1984: 166; Pillai, 1985: 287; Ho and Sey, 1996: 64; Ho et al., 2000: 164.

Caligus cossackii Rangnekar and Murti, 1959: 78 (not Bassett-Smith, 1898).

Materials examined: 4 ovigerous ♀♀ from gill filaments of 3 whitecheek monocle bream, *Scolopsis vosmeri* (Bloch), landed at Makung Fishing Port in Penghu County on 18 June 1998.

Female: Body (Fig. 1A) 2.26 (2.20-2.32) mm long, excluding setae on caudal rami. Cephalo-

thoracic shield 1.01 (0.98-1.03) mm long and 0.94 (0.93-0.94) mm wide, excluding lateral hyaline membranes. Genital complex 0.74 (0.72-0.74) mm long and 0.69 (0.68-0.69) mm wide. Abdomen about twice as long as wide, 0.41 (0.38-0.44) x 0.21 (0.20-0.23) mm. Caudal ramus (Fig. 2H) slightly longer than wide (65 x 45 μ), armed with 3 short and 3 long setae. Egg sac short, about 1/2 of body length, containing 15 eggs.

Antennule (Fig. 1B) 2-segmented; proximal segment slightly longer than distal segment, with 27 plumose setae on anterodistal surface; distal segment rod-shaped, armed with 1 subterminal seta on posterior margin and 11 setae plus 2 aesthetascs on distal margin. Antenna (Fig. 1C) 3-segmented; proximal segment armed with a bluntly tipped posteromedial spine bearing a serrated membrane; middle segment subrectangular, heavily sclerotized; distal segment a strongly curved claw bearing 1 basal and 1 marginal setae. Postantennal process (Fig. 1C) hook like, carrying 2 basal papillae with one bearing 4 setules and the other one, two setules. Another similar 4-setule-bearing papilla located nearby on sternum. A small sclerotized protrusion on sternum between antenna and postantennal process. Mandible (Fig. 1D) 4-segmented, with 12 teeth on medial margin of distal blade. Maxillule (Fig. 1C) a bluntly pointed process bearing a serrated membrane and a basal papilla with 3 unequal setae. Maxilla (Fig. 1E) 2-segmented and brachiform; proximal segment (lacertus) large and unarmed; slender distal segment (brachium) with a small subterminal hyaline membrane on outer edge and 2 unequal elements (calamus and canna) at terminal end. Maxilliped (Fig. 1F) 3-segmented; proximal segment (corpus) stout and unarmed; middle and distal segments fused to form a strong claw, with 1 medial seta. Tines of sternal furca (Fig. 1G) curved inward like a horseshoe, serrated hyaline membrane on outer margin extending around tip to distal portion of medial margin.

Armature on rami of legs 1-4 as follows (Roman numerals indicating spines and Arabic numerals indicating setae):

	Exopod	Endopod
Leg 1	1-0; III,1	(rudimentary)
Leg 2	I-1; I-1; I,II,5	0-1; 0-2; 6
Leg 3	I-0; 1-1; 3,4	0-1; 6
Leg 4	I-0; I,III	(missing)

Leg 1 (Fig. 2A) protopod with basal patch of spinules in addition to 1 long outer seta, one short

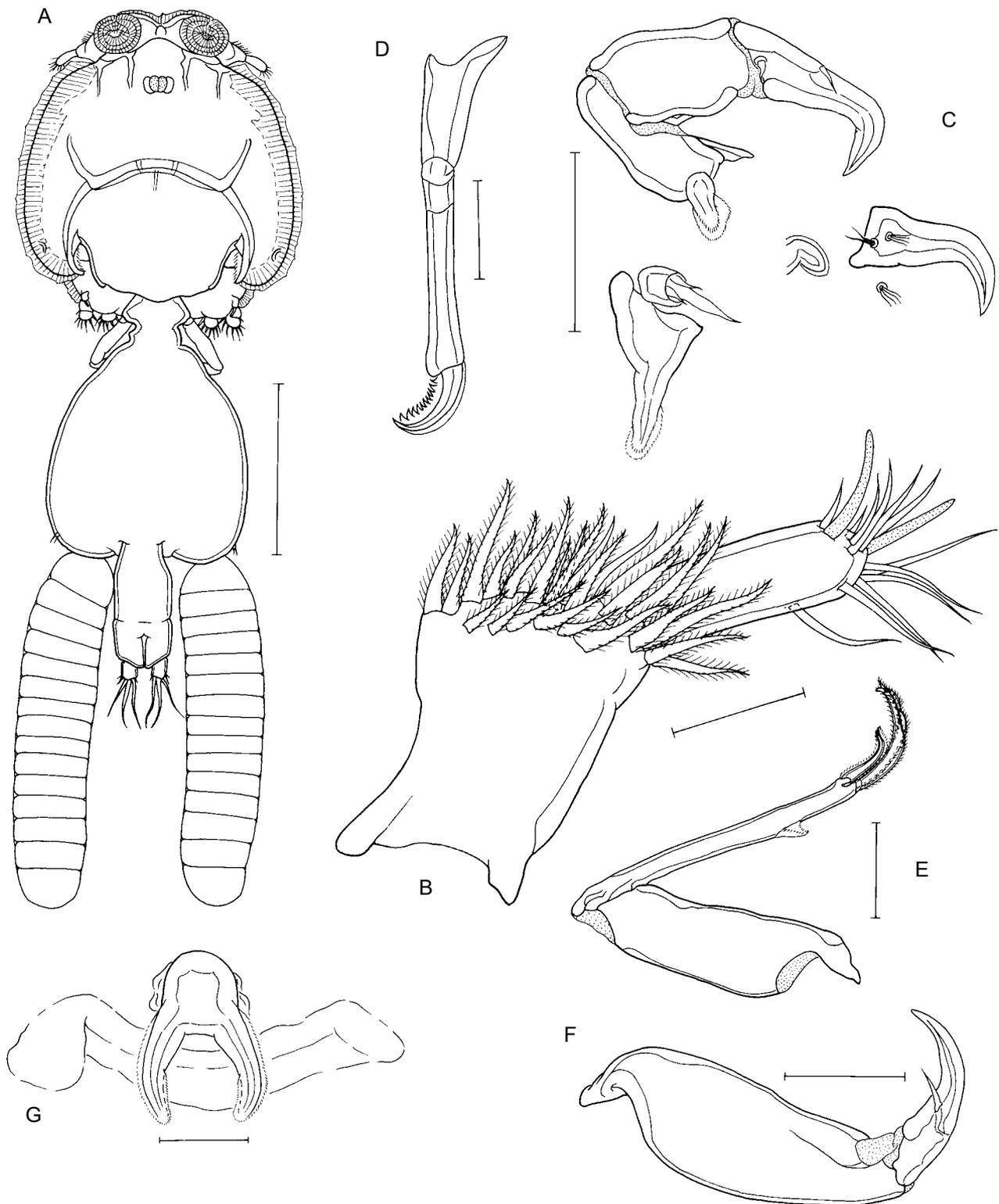


Fig. 1. *Caligus epinepheli* Yamaguti, 1936, ♀. A: Habitus, dorsal; B: antennule, ventral; C: antenna, postantennary process, and maxillule; D: mandible; E: maxilla; F: maxilliped; G: sternal area with sternal furca. Scale bars: 0.6 mm in A, G; 50 μ in B; 0.1 mm in C, F; 30 μ in D; 70 μ in E.

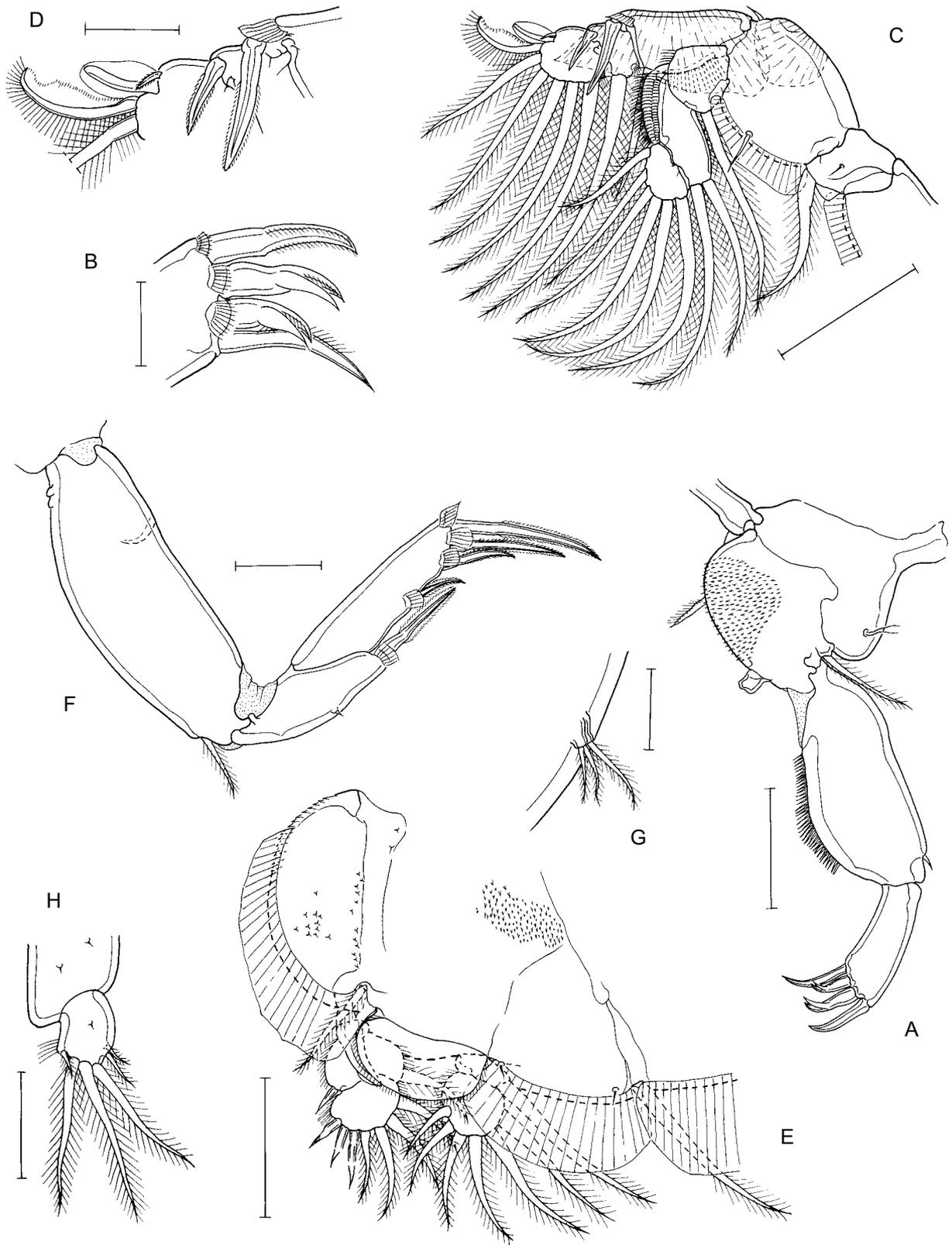


Fig. 2. *Caligus epinepheli* Yamaguti, 1936, ♀. A: Leg 1; B: tip of leg 1 exopod; C: leg 2; D: spines on outer margin of leg 2 exopod; E: leg 3, ventral; F: leg 4; G: leg 5, ventral; H: caudal ramus. Scale bars: 70 μ in A; 20 μ in B; 0.15 mm in C; 50 μ in D, F; 0.1 mm in E, H; 40 μ in G.

inner seta, and outer papilla bearing 2 setules; endopod a small knob; 1st segment of exopod with prominent row of setules on posterior edge and 1 small seta at outer distal corner; middle 2 of 4 terminal elements on last segment of exopod (Fig. 2B) each with an accessory process; pecten at base of each of 3 outer terminal elements (Fig. 2B). Leg 2 (Fig. 2C) coxa small, with 1 large plumose seta on posterior edge and long setule on ventral surface; basis with 1 small seta on outer edge and a setule on posterior edge by base of marginal membrane; external spines on 3 exopod segments unequally constructed as shown in figure 2C. First segment of endopod with short row of setules on outer distal corner, 2nd segment with long rows of setules on outer margin. Leg 3 (Fig. 2E) apron (fused, expanded protopod) with outer and medial patches of spinules in addition to row of marginal serrations anterior to outer marginal hyaline membrane; another marginal hyaline membrane medial to velum; both medial coxal seta and outer basal seta long and plumose. Leg 4 (Fig. 2F) protopod with single short plumose outer seta; setule-bearing papilla on outer margin of 1st segment of exopod; pecten on both segments of exopod at base of each outer spine. Leg 5 (Fig. 2G) located on posterolateral margin of genital complex, represented by 2 papillae, anterior one tipped with 1 plumose seta and posterior one with 2 plumose setae.

Male: Unknown from Taiwan, but has been reported from Japan (Shiino 1952), India (Pillai 1963), and Malaysia (Leong 1984).

***Caligus pagrosomi pagrosomi* (Yamaguti, 1939)**
(Figs. 3-5)

Caligus pagrosomi Yamaguti, 1939: 445; Roubal, 1981: 25.
Caligus epinepheli Rangnekar and Murti, 1963: 87; Byrnes, 1987: 384 (in part) (not Yamaguti, 1936).

Materials examined: All specimens found on gills of the following 6 species of fish landed at Dongshih Fishing Port: 56 ♀♀ and 25 ♂♂ from 16 spotted catfish *Arius maculatus* (Lacepede) collected on 20 Mar. 1999; 2 ♀♀ from 2 barramundi *Lates calcarifer* (Bloch) collected on 3 June 1999; 14 ♀♀ from Atlantic tripletail *Lobotes surinamensis* (Bloch); 9 ♀♀, 3 ♂♂ and 1 larva from 5 hosts collected on 19 Nov. 1999, 14 ♀♀ from 9 hosts collected on 3 Dec. 1999, 1 ♀ collected on 13 Jan. 2000, 1 ♂ collected on 3 Mar. 2000, 1 ♂ collected on 21 Apr. 2000, and 21 ♀♀ and 2 ♂♂ from 5 hosts collected on 10 Nov. 2000; 1 ♀ and 1 ♂ from 2 Russell's snapper *Lutjanus russelli*

(Bleeker) collected on 23 June 2000; 4 ♀♀ and 1 ♂ from 2 miiuy croaker *Miichthys miiuy* (Basilewsky) collected on 6 Oct. 2000; 1 ♀ from a giant travelly *Caranx ignobilis* (Forsskål) collected on 10 Nov. 2000; and 1 ♀ from a snubnose pompano *Trachinotus blochii* (Lacépède) collected on 10 Nov. 2000.

Female: Body (Fig. 3A) 4.83 (3.94-5.30) mm long, excluding setae on caudal rami. Cephalothoracic shield slightly longer than wide, 1.76 (1.54-2.00) mm long and 1.57 (1.40-1.80) mm wide, excluding lateral hyaline membranes. Fourth pediger distinctly wider than long, 0.13 (0.10-0.18) x 0.41 (0.30-0.40) mm. Genital complex bottle-shaped with prominent neck, 1.54 (1.30-1.72) mm long and 1.09 (0.90-1.30) mm wide. Abdomen club like, more than 3 times longer than wide, 1.23 (0.94-1.42) x 0.34 (0.28-0.40) mm. Caudal ramus (Fig. 3B) slightly longer than wide, 111 (97-146) x 100 (81-130) μ, fringed with setules on median distal edge and armed with 3 short and 3 long plumose setae. Egg sac 3.68 mm long and carrying 55 eggs.

Antennule (Fig. 3C) 2-segmented; proximal segment longer than distal segment, with 27 plumose setae on anterodistal surface; distal segment rod-shaped, armed with 1 subterminal seta on posterior margin and 11 setae plus 2 aesthetascs on distal margin. Antenna (Fig. 3D) 3-segmented; bluntly tipped, posteromedial spine on proximal segment fringed with a serrated hyaline membrane; middle segment unarmed; distal segment a curved claw bearing 1 basal and 1 marginal setae. Postantennal process (Fig. 3D) hook like and nearly as large as antennal claw, with 2 basal papillae each bearing 4 setules. Another similar setule-bearing papilla located nearby on sternum. A well-sclerotized protrusion on sternum between antenna and postantennal process (Fig. 3D). Mandible (Fig. 3E) 4-segmented, with 12 teeth on medial margin of distal blade. Maxillule (Fig. 3D) a bluntly pointed process fringed with a hyaline membrane as in posteromedial spine of antenna and a prominent basal paila bearing 1 long and 2 short setae. Maxilla (Fig. 3F) 2-segmented and brachiform; proximal segment (lacertus) large and unarmed; slender, distal segment (brachium) with a small subterminal, hyaline membrane on outer edge and 2 unequal elements (calamus and canna) at terminal end. Maxilliped (Fig. 3G) 3-segmented; proximal segment (corpus) stout and unarmed; middle (shaft) and distal (claw) segments fused to form strong subchelum, with a knob like element on distal part of shaft and 1

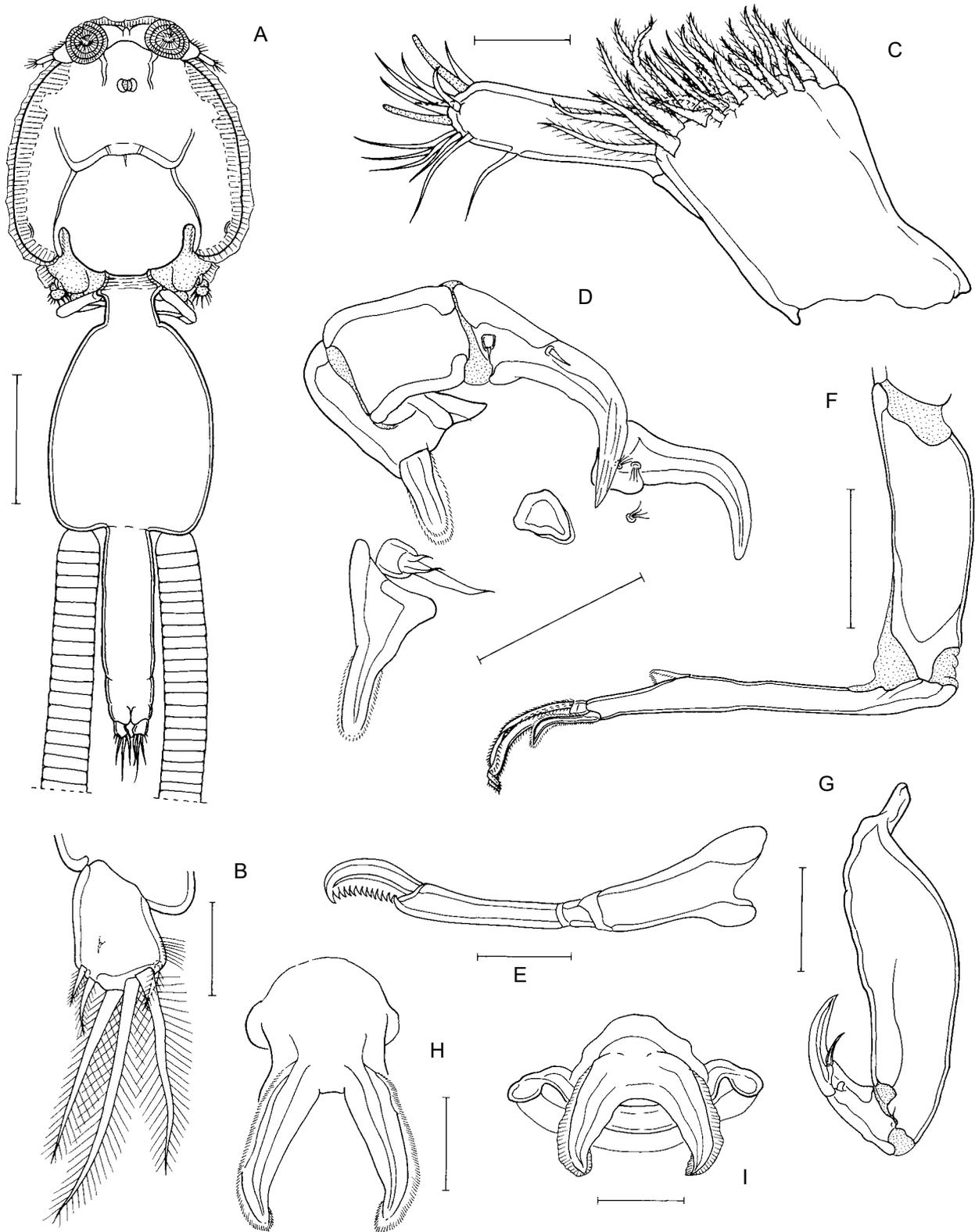


Fig. 3. *Caligus pagrosomi pagrosomi* (Yamaguti, 1939), ♀. A: Habitus, dorsal; B: caudal ramus, ventral; C: antennule, ventral; D: antenna, postantennal process and maxillule, ventral; E: mandible; F: maxilla; G: maxilliped; H: sternal furca; I: sternal area with sternal furca. Scale bars: 1 mm in A; 0.1 mm in B, C, H, I; 0.2 mm in D; 50 μ in E; 0.15 mm in F, G.

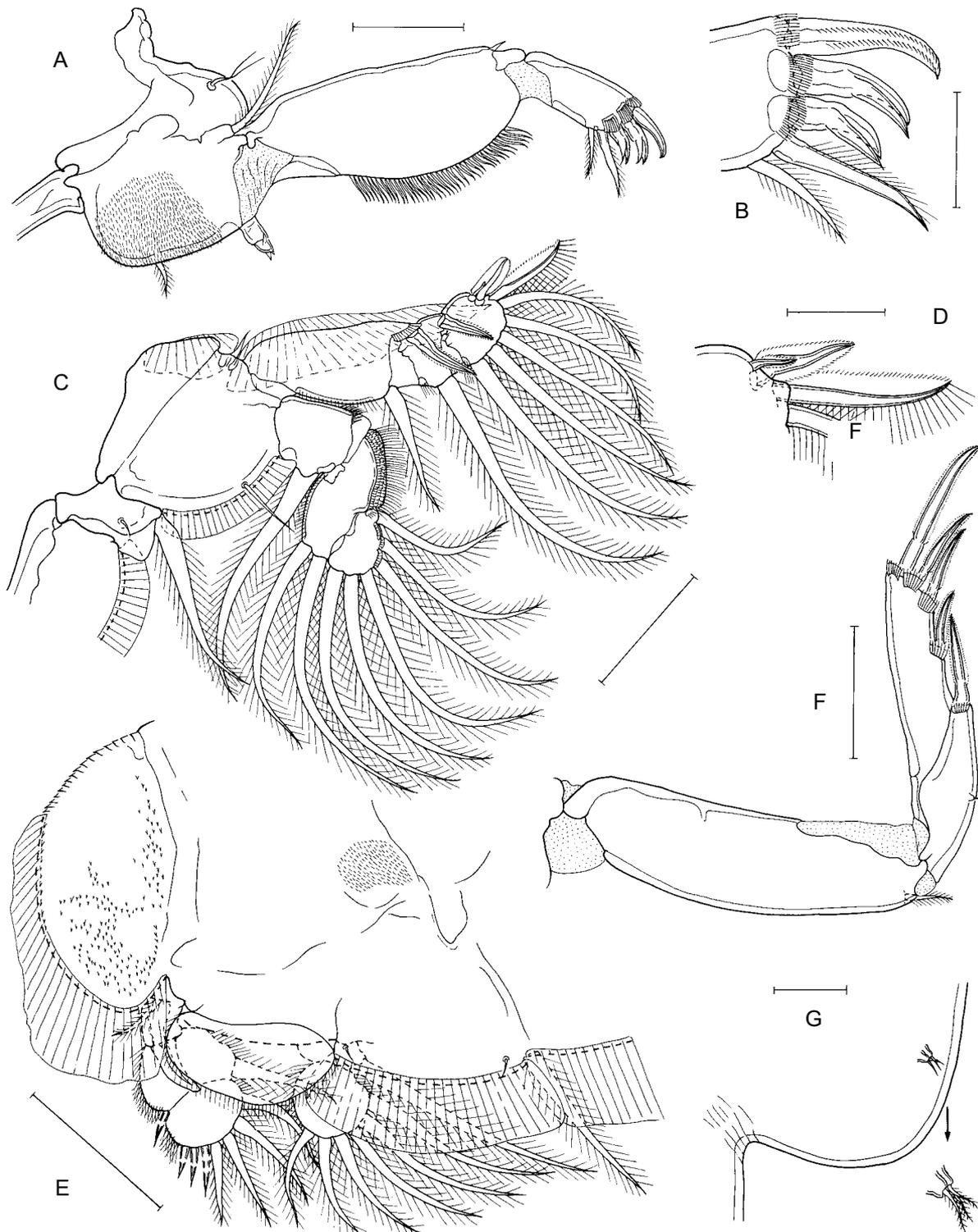


Fig. 4. *Caligus pagrosomi pagrosomi* (Yamaguti, 1939), ♀. A: Leg 1; B: tip of leg 1 exopod; C: leg 2; D: spines on outer margin of terminal segment of leg 2 exopod; E: leg 3, ventral; F: leg 4; G: posterolateral area of genital segment showing leg 5. Scale bars: 0.1 mm in A; 40 μ in B; 0.2 mm in C, E; 70 μ in D; 0.15 mm in F; 50 μ in G.

medial seta at base of claw. Tines of sternal furca (Fig. 3H) curved inward, serrated hyaline membrane on outer margin extending around tip to distal portion of medial margin. Bow like sclerite on sternum posterior to sternal furca with mammiferous projections at both ends (Fig. 3I).

Armature on rami of legs 1-4 as follows (Roman numerals indicating spines and Arabic numerals indicating setae):

	Exopod	Endopod
Leg 1	I-0; III,1,1	(rudimentary)
Leg 2	I-1; I-1; I,1,1,5	0-1; 0-2; 6
Leg 3	I-0; 1-1; 3,4	0-1; 6
Leg 4	I-0; I,III	(missing)

Leg 1 (Fig. 4A) protopod with large, basal patch of spinules in addition to 1 long outer seta, one short inner seta, and outer papilla bearing 2 setules; endopod indistinctly 2-segmented and tipped with 2 small elements; 1st segment of exopod with prominent row of setules on medial edge and 1 small seta on laterodistal corner; middle 2 of 4 terminal elements on last segment of exopod (Fig. 4B) each with an accessory process; medial margin of this segment with 1 small plumose seta; pecten at base of each of 3 outer terminal elements. Leg 2 (Fig. 4C) coxa small, with large plumose seta on posterior edge and setule on ventral surface; basis with 1 small seta on outer edge and 1 long setule on posterior edge by base of marginal membrane; external spines on terminal segment of exopod unequally constructed as shown in figure 4D. First segment of endopod with short row of setules on outer distal corner, 2nd segment with long rows of spinules on outer margin, and last segment with patches of setules at bases of outer 3 setae. Leg 3 (Fig. 4E) apron (fused, expanded protopod) with outer and medial patches of spinules in addition to row of serrations on outer margin anterior to marginal hyaline membrane; another hyaline marginal membrane medial to velum; both medial coxal seta and outer basal seta long and plumose. Leg 4 (Fig. 4F) protopod with single short plumose outer seta; setule-bearing papilla on outer margin of proximal segment of exopod; pecten on both segments of exopod at base of each outer spine. Leg 5 (Fig. 4G) located on posterolateral margin of genital complex, represented by 2 papillae tipped with 1 and 2 small plumose setae, respectively.

Male: Body (Fig. 5A) 3.04 (2.40-3.46) mm long, excluding setae on caudal rami. Cephalothoracic shield slightly longer than wide,

1.64 (1.32-1.84) x 1.45 (1.36-1.60) mm, excluding marginal hyaline membranes. Fourth pediger distinctly wider than long, 0.13 (0.08-0.18) x 0.35 (0.24-0.44) mm. Genital complex (Fig. 5F) flask-shaped and longer than wide, 0.62 (0.44-0.72) x 0.42 (0.36-0.54) mm. Abdomen 2-segmented; 1st segment slightly wider than long, 0.19 (0.14-0.22) x 0.26 (0.20-0.30) mm; but 2nd segment slightly longer than wide, 0.30 (0.22-0.36) x 0.28 (0.22-0.32) mm, and bearing a patch of spinules at distal outer corner (Fig. 5B). Caudal ramus (Fig. 5B) 1.39 times longer than wide, 157 (89-186) x 113 (89-154) μ , carrying 3 short and 3 long plumose setae in addition to 1 row of setules on inner edge and 1 setule-bearing papilla on both dorsal and ventral surfaces.

Antenna (Fig. 5C) 3-segmented; proximal segment small and unarmed; middle segment largest, with 2 corrugated pads in distal region; terminal segment smallest, with 2 subterminal setae on either side of terminal element composed of 4 or 5 pointed lamellae (Fig. 5D). Postantennal process as in female but maxillule differing in lack of a marginal membrane and by having 1 small subterminal seta on dentiform process (Fig. 5C). No sclerotized protrusion between bases of antenna and postantennal process (Fig. 5C). Maxilliped (Fig. 5E) 3-segmented; proximal segment (corpus) largest, with large, conical projection on medial surface; middle (shaft) and terminal (claw) segments united to form a hook and with 1 large inner spiniform seta (barb) in middle region. Leg 5 (Fig. 5G) located on posterolateral margin of genital complex and composed of 3 small, plumose setae on a bifid papilla. Leg 6 (Fig. 5G) represented by 1 naked seta on posterolateral ridge on ventral surface of genital complex.

***Caligus pagrosomi schelegeli* subsp. nov.**
(Figs. 6-8)

Caligus epinepheli Byren, 1987: 384 (in part) (not Yamaguti, 1936).

Materials examined: All specimens found in oral or gill cavities, operculum or body surface of the following 6 species of fish landed at Dongshih Fishing Port: from black porgy *Acanthopagrus schlegelii* (Bleeker): 123 ♀♀ and 8 ♂♂ on 25 hosts collected 25 Jan. 1999, 139 ♀♀ and 24 ♂♂ on 25 hosts collected 19 Nov. 1999, and 17 ♀♀ and 2 ♂♂ on 17 hosts collected 23 Feb. 2001; 1 ♀ from a flathead mullet *Mugil cephalus* Linnaeus collected 9 Feb. 1999; from spotted scat *Scatophagus argus* (Linnaeus): 5 ♀♀ and 2 ♂♂

on 3 hosts collected 3 June 1999, 2 ♀♀ on 2 hosts collected 23 June 2000, 1 ♂ collected 17 Aug. 2000; 1 ♀ from jarbua terapon *Terapon jarbua* (Forsskål) collected 23 June 2000; 1 ♂ from torpedo scad *Megalaspis cordyla* (Linnaeus) collected 23 Feb. 2001; and 1 ♂ from mottled spine-foot *Siganus fuscescens* (Houttuyn) collected 31 Mar. 2001. Holotype female, allotype male, and 20 paratypes (10 ♀♀ and 10 ♂♂) have been deposited in the National Museum of Natural History, Smithsonian Institution in Washington, DC.

Female: Body (Fig. 6A) 3.53 (3.10-3.88) mm long, excluding setae on caudal rami. Cephalothoracic shield slightly longer than wide, 1.39

(1.16-1.54) mm long and 1.27 (1.18-1.38) mm wide, excluding lateral hyaline membranes. Fourth pediger distinctly wider than long, 0.13 (0.06-0.18) x 0.34 (0.28-0.40) mm. Genital complex bottle-shaped with prominent neck, 1.22 (0.98-1.38) mm long and 1.01 (0.78-1.24) mm wide. Abdomen club like, length more than twice the width, 0.76 (0.58-0.84) x 0.30 (0.24-0.36) mm, dorsal surface of posterior somite with setule-bearing papillae (Fig. 6B). Caudal ramus (Fig. 6C) slightly longer than wide, 120 (100-150) x 90 (80-120) μ , fringed with setules on median distal edge and armed with 3 short and 3 long plumose setae. Egg sac shorter than body, 2.96 mm long and containing 36

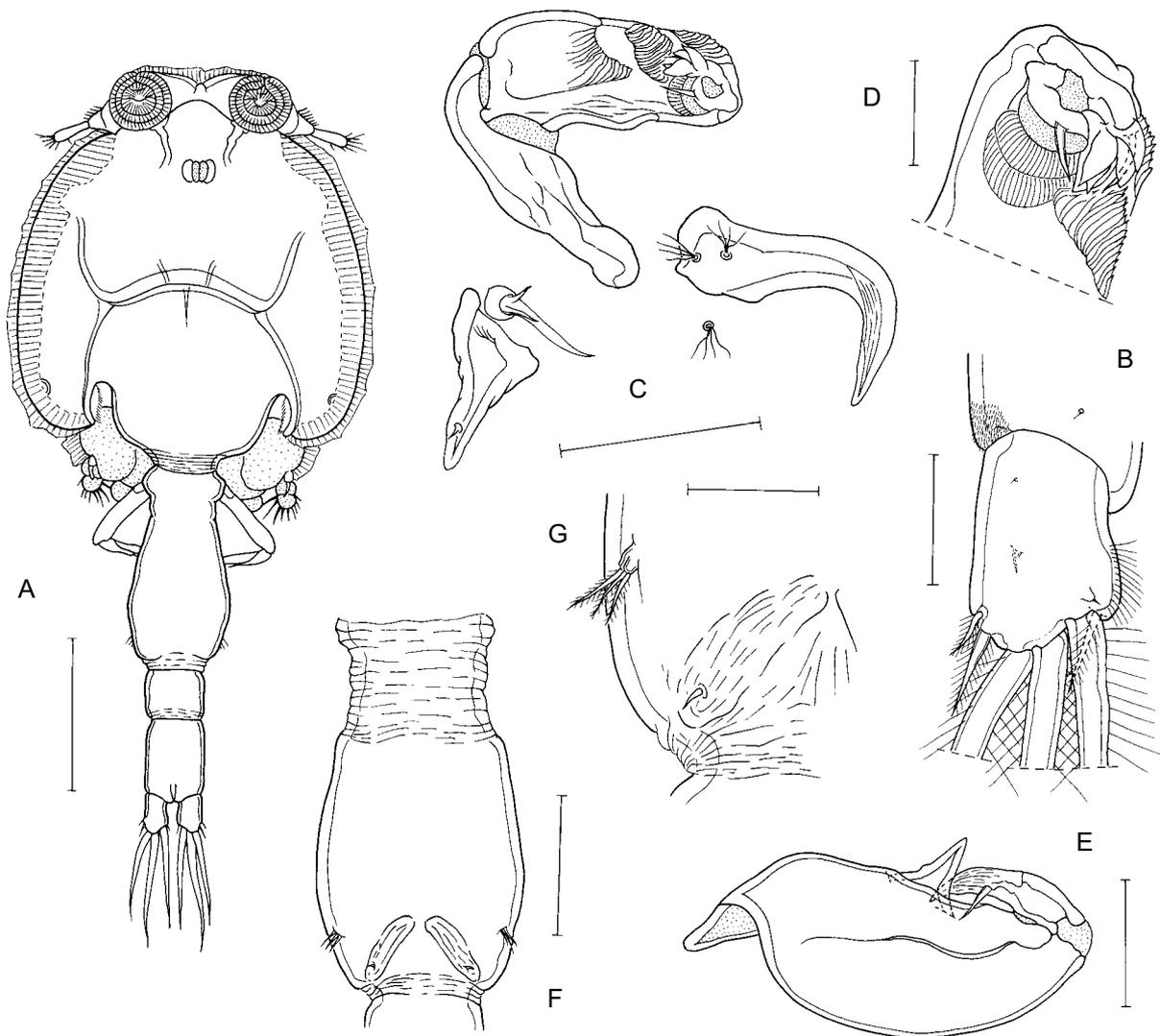


Fig. 5. *Caligus pagrosomi pagrosomi* (Yamaguti, 1939), ♂. A: Habitus, dorsal; B: caudal ramus, ventral; C: antenna, postantennal process, and maxillule, ventral; D: tip of antenna; E: maxilliped; F: genital complex, ventral; G: posterolateral area of genital complex, ventral. Scale bars: 0.7 mm in A; 0.1 mm in B, G; 0.2 mm in C, E; 50 μ in D; 0.3 mm in F.

eggs.

Antennule (Fig. 6D), antenna (Fig. 6E),
postantennal process (Fig. 6E), mandible (Fig. 6F),

maxillule (Fig. 6E), maxilla (Fig. 6G), and maxil-
liped (Fig. 6H) generally as in *P. pagrosomi*.
Sternal projection present between bases of

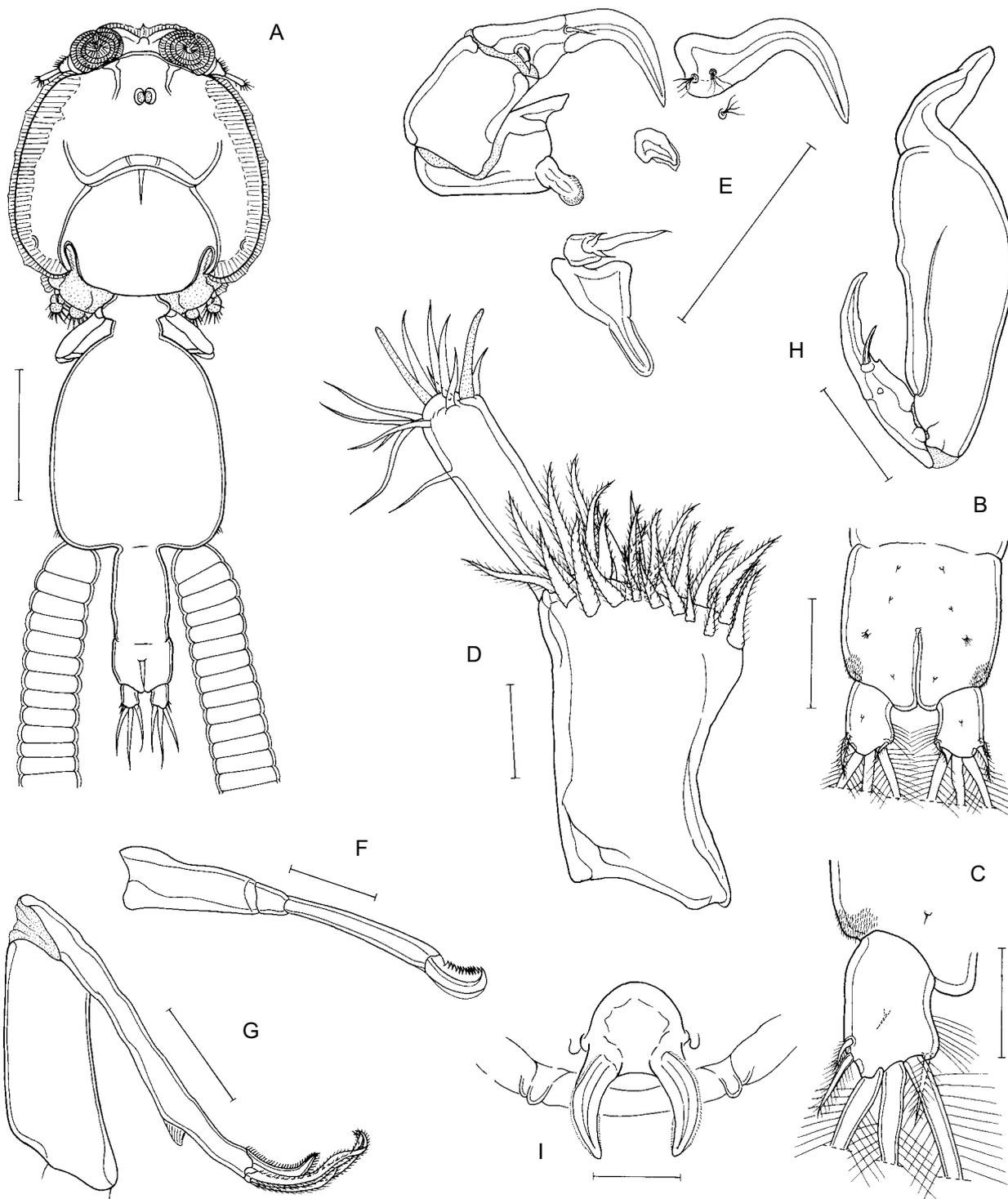


Fig. 6. *Caligus pagrosomi schlegeli* subsp. nov., ♀. A: Habitus, dorsal; B: distal part of abdomen and caudal rami, dorsal; C: caudal ramus, ventral; D: antennule, ventral; E: antenna, postantennal process, and maxillule, ventral; F: mandible; G: maxilla; H: maxilliped; I: sternal area with sternal furca. Scale bars: 0.7 mm in A; 0.2 mm in B, E; 0.1 mm in C, G, H; 50 μ in D; 40 μ in F; 80 μ in I.

antenna and postantennal process (Fig. 6E).
Tines of sternal furca (Fig. 6I) curved inward,
with narrow hyaline membrane on outer margin and

distal portion of medial margin. Pair of mammiferous
projections behind sternal furca (Fig. 6I).

Armature on rami of legs 1-4 generally as in

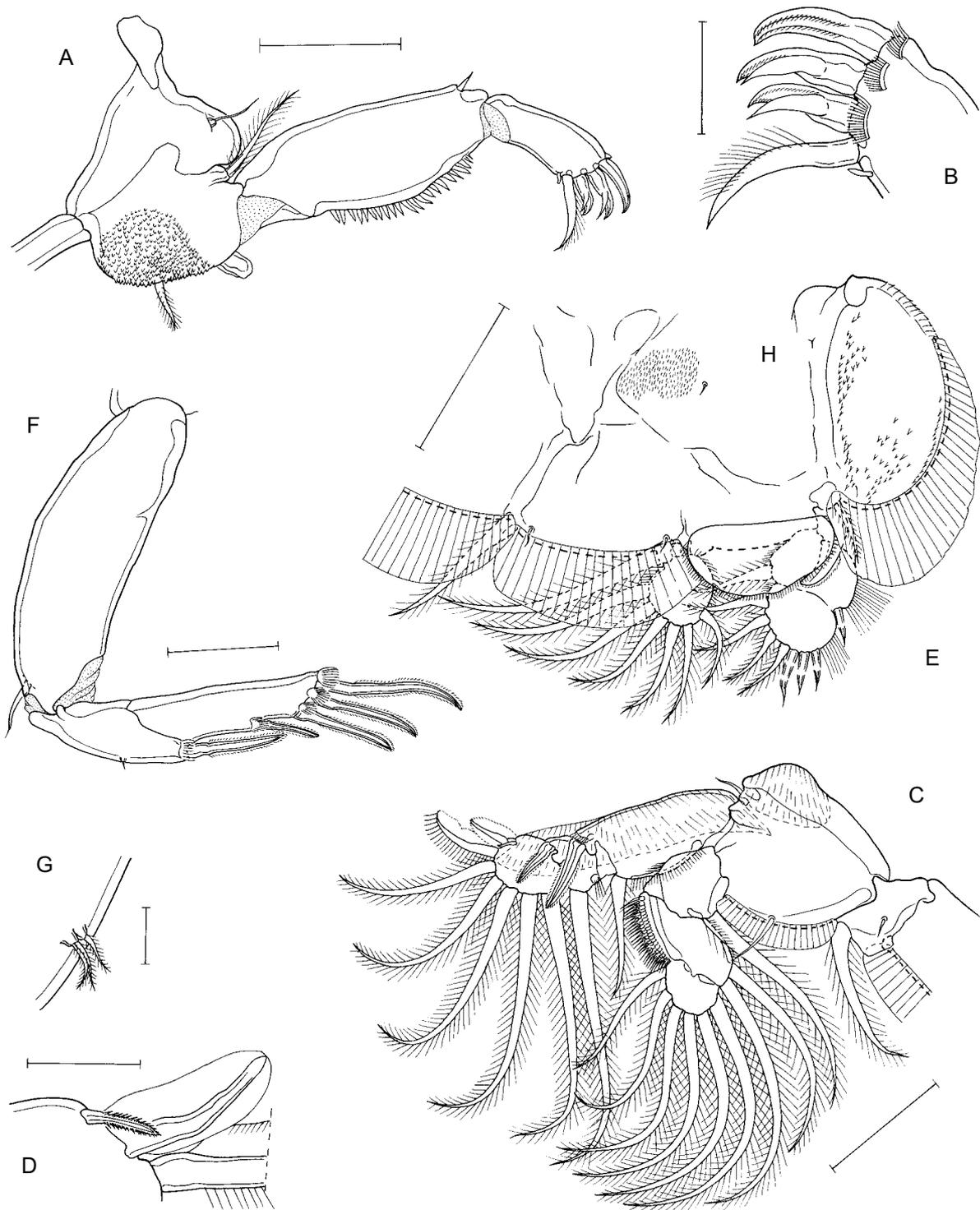


Fig. 7. *Caligus pagrosomi schlegeli* subsp. nov., ♀. A: Leg 1; B: tip of leg 1 exopod; C: leg 2; D: outer spines on terminal segment of leg 2 exopod; E: leg 3, ventral; F: leg 4; G: leg 5. Scale bars: 0.1 mm in A, F; 30 μ in B, D; 0.15 mm in C, E; 50 μ in G.

C. pagrosomi and differing chiefly in ornamentation and structural details of some elements. Ventral papilla near outer margin of leg 1 coxa tipped with single long setule (Fig. 7A); posterior margin of proximal segment of leg 1 exopod (Fig. 7A) fringed with a row of hyaline platelets resembling subterminal element on distal segment of the same rami (Fig. 7B). Proximal outer spine on terminal segment of exopod of leg 2 (Fig. 7C-D) spinulated and heavier. Leg 3 (Fig. 7E) bearing no particular difference from that of *C. pagrosomi* except that the relative lengths of the terminal 3 spines on leg 4 (Fig. 7F) differ. Leg 5 (Fig. 7G) generally as in *C. pagrosomi*.

Male: Body (Fig. 8A) 2.59 (2.28-2.84) mm long, excluding setae on caudal rami. Cephalo-

thoracic shield longer than wide, 1.31 (1.22-1.42) x 1.18 (1.12-1.32) mm, excluding marginal hyaline membranes. Fourth pediger distinctly wider than long, 0.12 (0.10-0.17) x 0.35 (0.30-0.40) mm. Genital complex (Fig. 8F) flask-shaped and longer than wide, 0.69 (0.60-0.80) x 0.44 (0.36-0.49) mm. Abdomen 2-segmented; 1st segment wider than long, 0.19 (0.14-0.20) x 0.24 (0.22-0.26) mm, but 2nd segment nearly as long as wide, 0.26 (0.22-0.30) x 0.27 (0.23-0.28) mm, and bearing patch of spinules at distal outer area (Fig. 8B). Caudal ramus (Fig. 8C) only 1.55 times longer than wide, 0.17 (0.14-0.19) x 0.11 (0.10-0.12) mm, with 3 short and 3 long plumose setae in addition to 1 row of setules on inner edge and 1 setule-bearing papilla on dorsal surface.

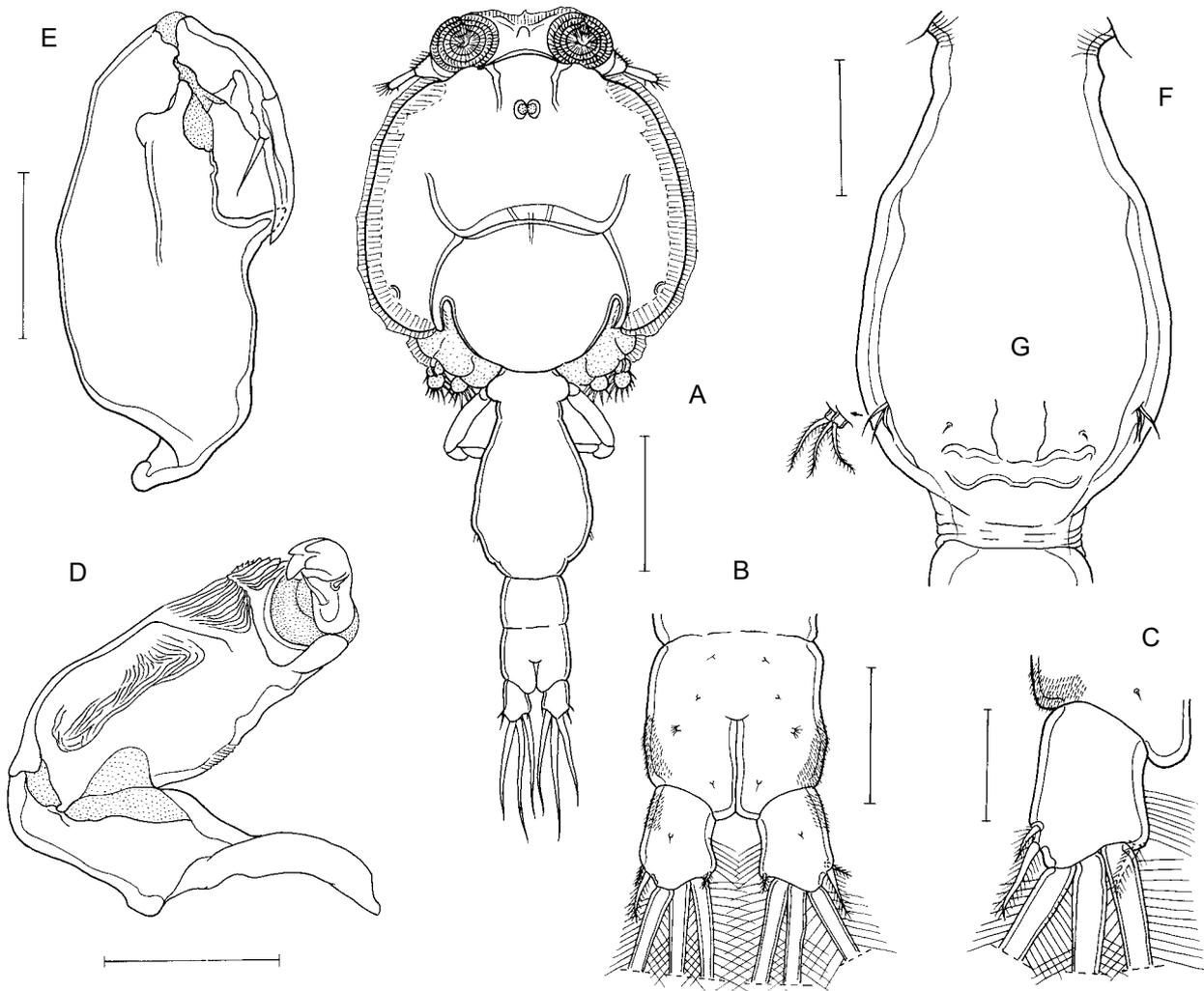


Fig. 8. *Caligus pagrosomi schlegeli* subsp. nov., ♂. A: Habitus, dorsal; B: distal part of abdomen and caudal rami, dorsal; C: caudal ramus, ventral; D: antenna; E: maxilliped; F: genital complex, ventral. Scale bars: 0.5 mm in A; 0.2 mm in B, F; 0.1 mm in C, D; 0.15 mm in E.

Antenna (Fig. 8D) 3-segmented; proximal segment small and unarmed; middle segment largest, with 1 large median and 2 distal corrugated pads; terminal segment smallest, with 2 basal setae on either side of terminal element, which is composed of 4 pointed lamellae. No sclerotized protrusion between bases of antenna and postantennal process. Maxilliped (Fig. 8E) 3-segmented; proximal segment (corpus) largest, with large conical projection on medial surface; middle (shaft) and terminal (claw) segments united to form a hook and carrying 1 large inner spiniform seta (barb) in middle region. Leg 5 (Fig. 8F) located on posterolateral margin of genital complex and composed of 1 bifid papilla with 3 small plumose setae. Leg 6 (Fig. 8F) represented by 1 small naked seta on ventral surface of genital complex.

DISCUSSION

Close comparison between specimens of *Caligus pagrosomi* from *Lobotes surinamensis* and those of *C. epinepheli* from *Scolopsis vosmeri* occurring in the Strait of Taiwan indicates that these 2 forms of sea lice are indeed closely affiliated; yet, they are still distinguishable by 6 of the 7 characters listed in table 1. The differences listed in table 1 are of taxonomic importance, except for the 1st character that indicates body size, which may show variation for conspecific specimens obtained from different species of host or from the same species of host occurring in allopatric locations. Accordingly, *C. pagrosomi* Yamaguti, 1939 is resurrected. In Taiwan, *C. pagrosomi* is more

common than *C. epinepheli*, for while the latter was found on only 1 species of fish, *C. pagrosomi* was collected from 8 species representing 7 families.

It is apparent from table 1 that the sea lice found on *A. schelegeli* is more closely related to those found on *L. surinamensis* than to those on *S. vosmeri*. The major differences between the first 2 taxa are found in the structure of the marginal fringe on the posterior border of the proximal segment of leg 1 (see Table 1, character 5) and the dentiform process of the male maxillules (see Table 1, character 7). Another apparent difference is the structure of the subterminal element on the posterior margin of the distal segment of the exopod of leg 1 (see Table 1, character 6). Since these morphological differences seem relatively minor, these 2 taxa are considered conspecific subspecies. Thus, the specimens found on *A. schelegeli* are named *Caligus pagrosomi schlegeli* and Yamaguti's (1939) *Caligus pagrosomi* becomes *Caligus pagrosomi pagrosomi*. It is intriguing to point out that these 2 subspecies show a clear distinction regarding host preference, for while the former was found on *Arius maculatus*, *Caranx ignobilis*, *Lateolabrax japonicus*, *Lates calcarifer*, *Lobotes surinamensis*, *Lutjanus russelli*, *Miichthys miiuy*, and *Trachinotus blochii*, the latter was restricted to *Acanthopagrus schlegeli*, *Megalaspis cordyla*, *Mugil cephalus*, *Scatophagus argus*, *Terapon jarbua*, and *Siganus fuscescens*.

Of the 7 morphological characters listed in table 1, the 6th, defining the subterminal seta on the terminal segment of leg 1, is perhaps the most unusual feature for the 3 taxa of sea lice dealt with

Table 1. Differences between the 3 *Caligus* taxa parasitic on marine fishes of Taiwan

Character	<i>Caligus pagrosomi pagrosomi</i>	<i>Caligus pagrosomi schlegeli</i>	<i>Caligus epinepheli</i>
1. Female body length (mm)	long, 4.83 (3.94-5.30)	medium, 3.53 (3.10-3.88)	short, 2.26 (2.20-2.32)
2. Length of abdomen (in ratio to cephalothorax)	long (70%)	medium (55%)	short (44%)
3. Setules on basal papillae of postantennal process	4	4	3
4. Sternal projections	present	present	absent
5. Posterior margin of 1st segment of exopod of leg 1	row of setules	row of platelets	row of setules
6. Subterminal element on exopod of leg 1	plumose seta	hyaline element	absent
7. Setule on male maxillule dentiform process	present	absent	absent
Major host ^a	<i>Lobotes surinamensis</i>	<i>Acanthopagrus schlegeli</i>	<i>Scolopsis vosmeri</i>

^aThe species of fish found most frequently to carry the *Caligus* species in question.

in this paper. As far as we are aware, there is only 1 *Caligus* species, i.e., *C. alaihi* Lewis, 1968 parasitic on *Holocentrus sammara* (Forsskål) from Eniwetok Atoll, that shares with *C. pagrosomi* the character state of having 1 minute plumose seta on the posterior margin of the terminal segment of leg 1. According to Lewis (1968), *C. alaihi* can be readily distinguished from *C. pagrosomi* “by the presence of denticulations on the second segment of the endopodite of the second thoracic leg.” Another obvious difference is the possession of a short abdomen in the female of *C. alaihi*; it is only 22% of the length of its cephalothoracic shield.

The subterminal element on the posterior margin of leg 1 in *C. pagrosomi schlegeli* (Fig. 7B) is translucent and detachable. If it is detached, the parasite could be mistaken for *C. epinepheli* (Fig. 2B). Such an occurrence is suspected to have caused Byrnes (1987) to propose synonymization of *C. pagrosomi* with *C. epinepheli*. However, a close examination of the sternal area for the “mammiferous projections” should render an easy solution to this confusion. These projections (Fig. 3I) are present in both subspecies of *C. pagrosomi* (see Figs. 3I, 6I) but are absent from *C. epinepheli* (see Fig. 1G).

The most distinguishing feature of *C. epinepheli* is the complete absence of plumose setae, which are commonly found on the posterior margin of the terminal segment of the exopod of leg 1. Although more than 200 species of sea lice are contained in *Caligus*, this apomorphic character state is shared among only 13 congeners, i.e., *C. affinis* Heller, 1866; *C. annularis* Yamaguti, 1954; *C. ariicolus* Wilson, 1928; *C. (Subcaligus) bocki* Heegaard, 1943; *C. chiloscylli* (Pillai, 1963); *C. enormis* Wilson, 1913; *C. fugu* Yamaguti and Yamasu, 1959; *C. lagocephali* Pillai, 1961; *C. mauritanicus* Brian, 1924; *C. mirabilis* Leigh-Sharpe, 1934; *C. paxillifer* Yamaguti, 1954; *C. productus* Dana, 1852; and *C. sciaenae* Gnanamuthu, 1947. Some of these species can be easily distinguished from *C. epinepheli* but there are a few that are impossible to tell apart due to the unavailability of complete descriptive information.

Caligus (Subcaligus) bocki differs from the present species in having the tines of its sternal furca joined together to form a “lamelloid spine” (Heegaard 1943); *C. enormis* differs in the possession of a large genital complex carrying a greatly reduced abdomen (Wilson 1913); *C. fugu* differs by being equipped with a large sharp conical process on the corpus of the maxilliped (Yamaguti and Yamasu 1959); *C. lagocephali* also differs by

the structure of the maxilliped (Pillai 1961); and *C. productus* differs in having the distal corners of the genital complex enlarged and extending well beyond the insertion of the abdomen (Lin and Ho 2001). However, *C. mirabilis* and *C. sciaenae* cannot be distinguished from *C. epinepheli* because they were not adequately described by Leigh-Sharpe (1934) and Gnanamuthu (1947), respectively.

As to the remaining 6 similar species: *C. affinis*, *C. annularis*, *C. ariicolus*, *C. chiloscylli*, *C. mauritanicus*, and *C. paxillifer*, there seem to be no apparent structural differences between them and *C. epinepheli*. Based on the documented information, the only detectable differences among them are perhaps the size and shape of the genital complex. However, as it is generally well known that the size and shape of the genital complex vary with the maturity of the parasite, differences of this nature alone cannot usually be used for species discrimination.

Heller (1866) reported *C. affinis* from shi drum *Umbrina cirrosa* (Linnaeus) taken in the Adriatic Sea without providing an adequate description. Although the species was listed or briefly described by several authors dealing with the parasitic copepods of the Mediterranean (see Brian 1906), a decent account of the species was not available until 1935 when Brian (1935) reported *C. affinis* from the same host species at Genova, Italy. According to that account, *C. affinis* is characterized as lacking sternal projections as well as the 3 plumose setae on the posterior margin of the terminal segment of leg 1. It is essentially like what one would expect to find on *C. epinepheli*. However, when Kensley and Grindly (1973) reported *C. affinis* from the bluefish “*Pomatomus salator*” (= *Pomatomus salatrix* (L.)) taken at Durban, South Africa, the terminal segment of leg 1 was reported and illustrated with “one minute seta on posterior margin,” which is what we defined above for *C. pagrosomi schelegeli*. Similar confusion is found for *C. annularis* between the original and subsequent descriptions. Yamaguti (1954) reported on *C. annularis* from *Otolithes* sp. and *Caranx* sp. obtained in the Celebes; it was described as lacking setae on the posterior margin of the terminal segment of leg 1, but when Pillai (1963) reported *C. annularis* from the tiger-toothed croaker “*Otolithus maculatus*” (= *Pterotolithus maculatus* (Cuvier)) obtained in Trivandrum, India, the terminal segment of leg 1 was illustrated with a minute naked subterminal seta on the posterior margin. Since the presence or absence of sternal projec-

tions was not mentioned in these works, confirmation of these species will have to wait until reexaminations of the type specimens are made.

Although it is tempting to unify the 7 *Caligus* species mentioned above under the 1st reported name, *C. affinis*, such action is not considered appropriate before reexamination of the type material of each of these species. Furthermore, although *C. affinis*, *C. ariicolus*, and *C. mauritanicus* were reported before *C. epinepheli*, none of them were as well characterized as *C. epinepheli*; thus, specimens obtained from Taiwan are, for the time being, identified as *C. epinepheli*. It is perplexing to find that Yamaguti (1954) did not compare his material obtained from the Celebes with either *C. epinepheli* nor *C. pagrosomi* at the time when he was describing *C. annularis* and *C. paxillifer*, given that these species are so similar to one another.

It is interesting to point out that *C. epinepheli* and the 6 similar *Caligus* species are restricted to temperate waters of the Old World, namely, the Mediterranean (*C. affinis* by Brian 1934 1939), Thailand (*C. ariicolus* by Wilson 1928), Mauritania (*C. mauritanicus* by Brian 1924), Celebes (*C. annularis* and *C. paxillifer* by Yamaguti 1954), and India (*C. chiloscylli* by Pillai 1963 1967). This biogeographical information on the pattern of distribution would invoke doubt about Cressey's (1991) report of *C. epinepheli* from the "queenfish" collected from the temperate waters of the New World in Jamaica. Therefore, it is not surprising to discover that our close comparison of Cressey's work with the specimens of *C. epinepheli* from Taiwan revealed that "*Caligus epinepheli* Yamaguti, 1936" reported from the Caribbean Sea is in essence a separate species that differs from *C. epinepheli* (1) by the lacking of a sclerotized conical protrusion between the bases of the antenna and postantennal process; (2) by the slender (instead of stocky) and straight (instead of curved) tines on the sternal surca; (3) by the outermost terminal element on the distal segment of leg 1 having an accessory process; and (4) by possession of 3 terminal spines on leg 4 which are nearly equal (instead of varying) in length. Since these morphological differences are of taxonomic importance, Cressey's (1991) "*Caligus epinepheli* Yamaguti, 1936" becomes a junior homonym. Therefore, according to Article 60 of the International Code of Zoological Nomenclature, we propose to name the specimens from the Caribbean Sea "*Caligus cresseyi*" nom. n. in honor of its discoverer, Dr. Roger F. Cressey, who also redescribed many species of *Caligus*

known from the New World.

Acknowledgments: We thank Shian-Tian Hwang of Makung Fishing Port and Ching-Kuo Chang of Dongshih Fishing Port for their kindness and cooperation in making the necessary arrangements for us to purchase fish; and Yü-Feng Pai, Jia-Leng Hwang, Ping-Ju Wu, and Wei-Shen Tzeng of National Chiayi Univ. for their assistance in transportation and examination of fishes for copepod parasites. The field and laboratory portions of this project were made possible through grants (NSC 87-2313-B-021-012 and NSC 87-2313-B-021-18) from the National Science Council of Taiwan to CLL and a grant (NSC 90-2811-B-415-001) from the same agency to JSH. Completion of this manuscript was aided by a grant from the Paramitas Foundation to JSH.

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