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Two Species of Caligidae (Copepoda) Parasitic on Cultured Rabbit Fish (*Siganus fuscescens*) in Taiwan

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Two species of caligid copepods, *Lepeophtheirus atypicus* n. sp. and *Caligus oviceps* Shiino, 1952, are described based on the specimens obtained from moribund rabbit fish (*Siganus fuscescens*) cultured in a cage-net at the Penghus Hatchery Station on Pescadores Island, Taiwan. The new species bears close resemblance to *L. goniistii* Yamaguti, 1936, but can be easily distinguished from it by the armature on leg 3. The antennule, sternal furca, and leg 4 of these two species also exhibit difference. *Lepeophtheirus* species from rabbit fish in Japan reported as *L. goniistii* by Shiino (1952) is reidentified as *L. atypicus* n. sp. *Caligus truncatogenitalis* Roubal, 1981 is proposed to be relegated to the synonym of *C. oviceps*.

Key words: *Caligus*, *Lepeophtheirus*, Caligidae, *Siganus*, Taiwan, rabbit fish, *Lepeophtheirus atypicus*, *Caligus oviceps*

In May 1995, a heavy mortality occurred on the rabbit fish, *Siganus fuscescens* (Houttuyn) cultured in a cage-net at a hatchery in Taiwan. Moribund fishes swimming at the edge of the cate-net appeared black and thin, and showing lesion on many parts of the body. A close inspection of the fish disclosed that the wounds on its body surface were invariably accompanied by parasitic copepods. Subsequent studies of those copepods revealed that two species were involved: a species of *Lepeophtheirus* and a species of *Caligus*. With this preliminary identification of the parasities, it was confirmed that the lesion observed on the skin of those moribund rabbit fishes was caused by the feeding action of those caligid copepods. Caligid copepods are known to feed on the skin of their hosts by rasping, scraping and sucking. They are known to cause heavy loss in salmon farming in Europe and Canada (Boxshall and Defaye, 1993).

According to Shiino (1952), the rabbit fish occurring in the waters of Japan carries two species of caligids, namely, *Lepeophtheirus goniistii* Yamaguti and *Caligus oviceps* Shiino. In order to confirm the identity of those two caligid species found on the same host from Taiwan, we examined the specimens collected and studied by the late Dr. Sueo M. Shiino and kept in Mie university in Tsu City, Japan. In that reexamination, we discovered unexpectedly that the specimens from the rabbit fish collected near Yamada, Mie Prefecture and identified by Dr. Shiino (1952) as *L. goniistii* are actually belonging to a new species. Thus, it prompted us to describe the new species and also redescribe *C. oviceps*, which is so far known only from Mie Prefecture, Japan.

Materials and Methods

On May 15, 1995, 10 moribund rabbit fish *Siganus fuscescens* (6 to 9 cm long) swimming at the edge of the cage-net, at Penghus Hatchery Station in Shih-Li of Makung City on the Pescadores Island of the southwestern coast of Taiwan, were collected and brought to the laboratory for examination. All together, 146 parasitic copepods were recovered. The parasites were immediately preserved in 70% alcohol. In making microscopical study, the alcoholized specimens were cleared in 85% lactic acid for at least 24 h before taking measurements and making dissection. All drawings were made with the aid of a camera lucida. In this paper, a full description is

given of the female and only the sexual dimorphic characteristics are mentioned for the male. All measurements are given in mm unless specified otherwise.

Descriptions

Lepeophtheirus atypicus n. sp. (Figs. 1–3)

Material examined—8 ovigerous females, 6 males and 3 juveniles recovered from the body surface of rabbit fish. Three females and 3 males from Shiino's Collection No. 102 kept in Mie University (collected from *Siganus fuscescens* in June, 1950 near Yamada, Mie Prefecture, Japan and labeled as "*Lepeophtheirus goniistii*").

Holotype (USNM 278200), allotype (USNM 278201) and 6 paratypes (4 females and 2 males) (USNM 278202) have been deposited in the Division of Crustacea, National Museum of Natural History, Smithsonian Institution.

Female—Body (Fig. 1A) with typical appearance of *Lepeophtheirus*, measuring 2.05 (1.99–2.11) long, excluding setae on caudal rami, based on 8 specimens. Carapace 1.36 (1.30–1.40) long and 1.30 (1.23–1.39) wide, excluding lateral hyaline membrane. Fourth pediger wider than long, 0.10×0.35. Genital complex wider than long, 0.43×0.69 and fused with fourth pediger. Abdomen short, 1-segmented and slightly wider than long, 0.11×0.14. Caudal ramus (Fig. 3B) much longer than wide, 0.11 ×0.04, armed with 6 plumose setae as in most congeners. Egg sac (Fig. 1A) 0.96 to 1.21 long, containing 9 to 12 eggs.

Frontal plate (Fig. 1A) with 1 setule on anterior margin near center. Antennule (Fig. 1B) 2-segmented, proximal segment trapezoid, much broader than distal segment, carrying 14 large, stout, marginal plumose setae, another 11 short, plumose setae on ventral surface, and 2 short, plumose setae on dorsal surface. Distal segment short, rod-shaped, about twice as long as wide, armed terminally with 11 setae and 2 aesthetes and subterminally on posterior margin with 1 seta. Antenna (Fig. 1C) 3-segmented; proximal segment smallest, with short, bluntly pointed medial process; middle segment largest, robust; and terminal segment a strongly curved hook bearing a basal seta and a marginal seta. Post antennary process (Fig. 1C) hook-like, carrying 2 basal papillae with each bearing 5 long setules. Another similar papilla located nearby on sternum.

Mandible (Fig. 1E) with 12 teeth on mediodistal margin. Maxillule (Fig. 1D) bifid terminally and basal papilla with 3 setae. Maxilla (Fig. 1G) 2-segmented and brachi form; proximal segment (lacertus) unarmed; slender distal segment (brachium) with fin-like membranous structures midway on outer margin (Fig. 2A) and 2 unequal terminal elements (calamus and canna). Canna with serrated medial margin (Fig. 1H). Maxilliped (Fig. 1I) 3-segmented; proximal segment (corpus) largest but unarmed; middle segment (subchela) short and unarmed; and distal segment (claw) with a basal seta. Base of sternal furca (Fig. 1F) wider than long, with diverged and bluntly pointed tines.

Armature on rami of legs 1–4 as follows (Roman numeral indicating spines and Arabic numeral, setae):

Leg 1	Exp 1–0; III, I, 3	Enp (rudimentary)
Leg 2	Exp I–1; I–1; I, II, 5	Enp 0–1; 0–2; 6
Leg 3	Exp I–1; 1–1; 3, 3	Enp 0–1; 4
Leg 4	Exp I–0; I–0; III	Enp (missing)

Fine ornamentations on legs 1–4 (Figs. 2B–H) as in most congeners. Protopod of leg 1 (Fig. 2B) carrying 1 outer and 1 inner short, plumose seta. Inner most element at tip of leg 1 exopod appeared differently from other 3 (Fig. 2C). Leg 2 (Fig. 2D) armed with a large, plumose, inner seta on coxa and a small, simple, outer seta on basis. First 3 external spines on exopod of leg 2 similarly constructed as shown in Fig. 2E, but next 2 spines differing with membranous outer membrane (Fig. 2D). Leg 3 with an adhesive pad on anteroventral surface of coxa and lacking a usual, plumose, inner seta on basis (Fig. 2F). Further, basal spine of exopod bifid and terminal segment of endopod carrying only 4 setae (Fig. 2G). Leg 4 exopod (Fig. 2H) long and slender; outer spine on proximal segment small and recurved; inner 2 terminal elements on third segment about equal in length. Basal part of all elements covered by a hyaline membrane. Leg 5 (Fig. 3A) represented by a plumose seta on posterolateral corner of genital double somite and a slender process armed with 3 plumose setae.

Male—Body (Fig. 3C) smaller than female, 1.48 (1.43–1.52) long, excluding setae on caudal rami, based on 6 specimens. Carapace 1.04 (0.99–1.09) long and 0.94 (0.92–0.99) wide, excluding hyaline lateral membranes. Fourth pediger wider than long, 0.10×0.18. Genital complex subquadrate, 0.22

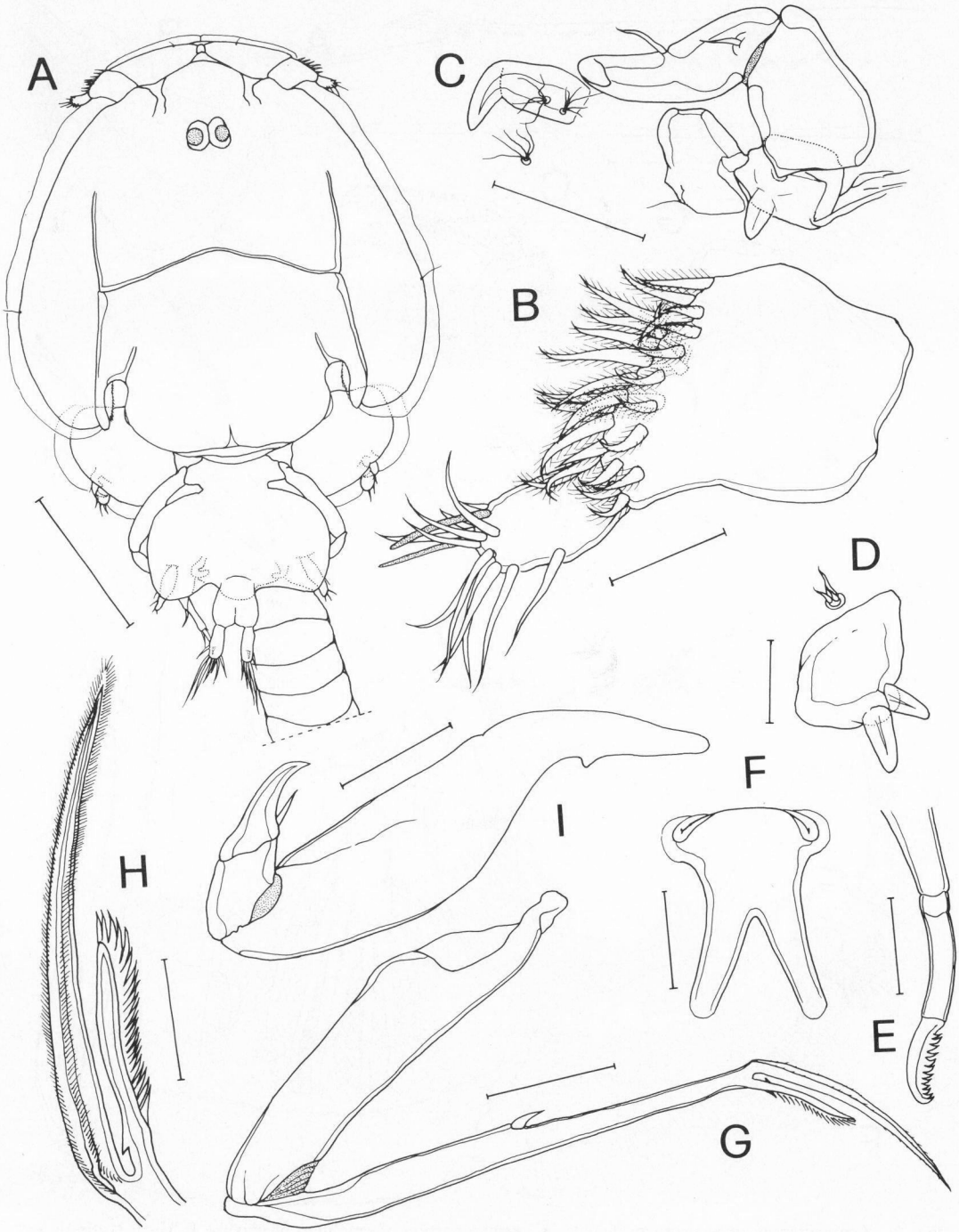

Fig. 1. *Lepeophtheirus atypicus* n. sp., female: A. habitus, dorsal; B. antennule, ventral; C. antenna and postantennary process; D. maxillule; E. mandible; F. sternal furca; G. maxilla; H. tip of maxilla; I. maxilliped. Scale bars: 0.5 mm in A; 0.05 mm in B, D; 0.1 mm in C; 0.04 mm in E, F; 0.075 mm in G; 0.03 mm in H; 0.07 mm in I.

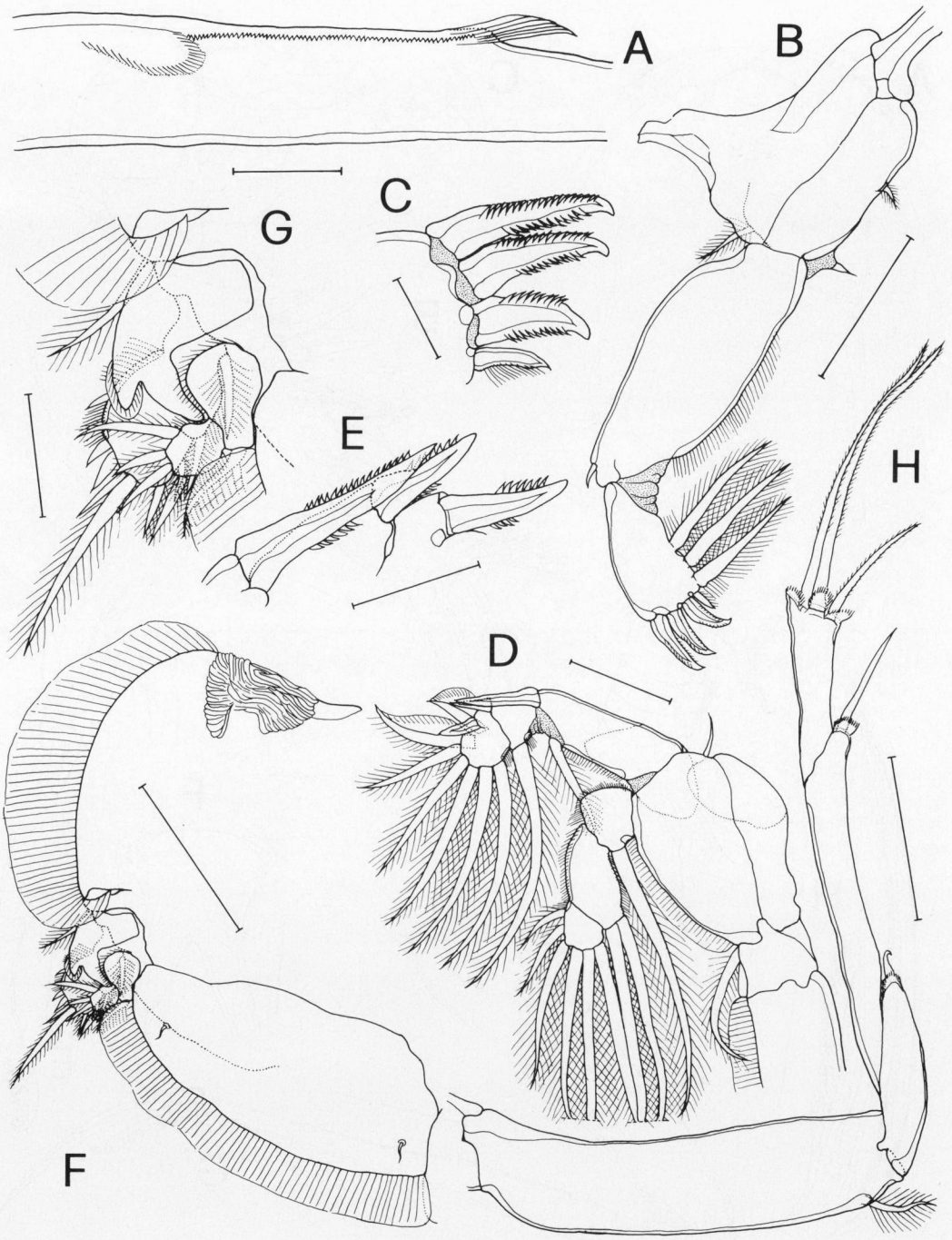

Fig. 2. *Lepeophtheirus atypicus* n. sp., female: A. median portion of brachium of maxilla; B. leg 1; C. tip of leg 1 exopod; D. leg 2; E. spines on outer margin of three segments of leg 2 exopod; F. leg 3; G. rami of leg 3; H. leg 4. Scale bars: 0.02 mm in A; 0.1 mm in B, D, H; 0.04 mm in C, E; 0.15 mm in F; 0.05 mm in G.

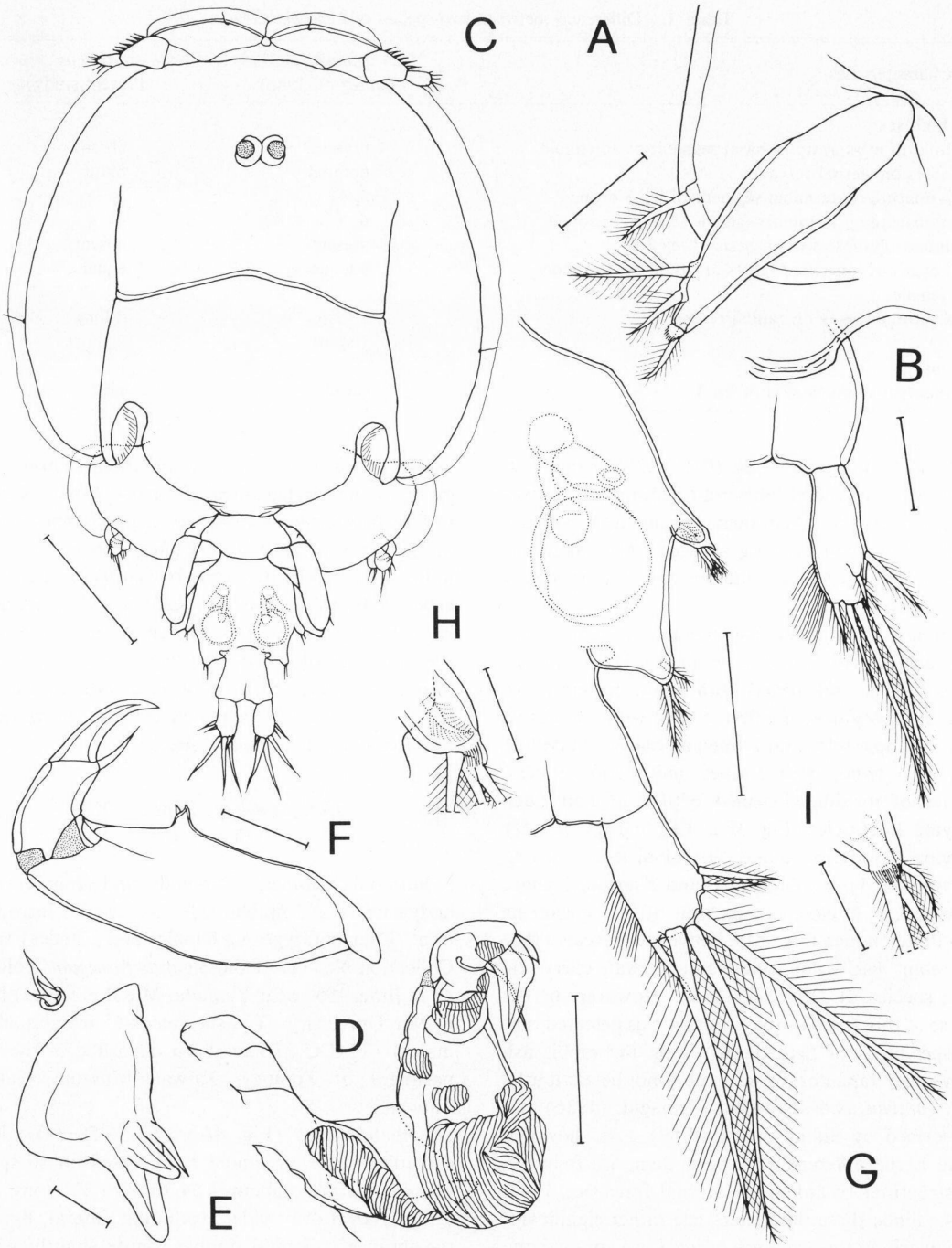

Fig. 3. *Lepeophtheirus atypicus* n. sp. Female: A. leg 5; B. caudal ramus. Male: C. habitus, dorsal; D. antenna; E. maxillule; F. maxilliped; G. left side of genital double somite, abdomen and caudal ramus; H. tip of leg 5; I. tip of leg 6. Scale bars: 0.05 mm in A, F; 0.075 mm in B; 0.3 mm in C; 0.08 mm in D; 0.025 mm in E; 0.1 mm in G; 0.02 mm in H, I.

Table 1. Differences between two species of *Lepeophtheirus*

Characteristics	*goniistii* (Yamaguti, 1936)	*atypicus* (Present study)
In both sexes:		
Bifid process at tip of basal segment of antennule	present	absent
Tines on sternal furca	pointed	blunt
Armature on terminal segment of leg 3 exopod	3, 4	3, 3
Armature on terminal segment of leg 3 endopod	6	4
Inner, plumose seta on basis of leg 3	present	absent
Length of inner two spines at tip of leg 4 exopod	unequal	equal
In female:		
4 terminal setae on caudal ramus	3 long	2 long
	1 short	2 short
In male:		
Basal spine on exopod of leg 3	simple	bifid

(0.19–0.24) long and 0.24 (0.21–0.26) wide, with posteriorly protruded lobes representing, respectively, legs 5 and 6. Abdomen 1-segmented, broader distally, but about as long as wide. Caudal ramus (Fig. 3G) longer than wide, bearing 3 short and 3 long plumose setae.

Antenna (Fig. 3D) 3-segmented; proximal segment armed with an adhesive pad; middle segment large, robust, and armed with 4 unequal adhesive pads; distal segment smallest, armed with 2 adhesive pads, 1 simple seta, and 2 unequal claws. Maxillule (Fig. 3E) trifid, with 2 tines and a soft process. Corpus of maxilliped armed with a median ridge carrying 2 denticles (Fig. 3F). Leg 5 (Figs. 3G, H) carrying 1 subterminal and 3 terminal setae and Leg 6 (Figs. 3G, I), 1 subterminal and 2 terminal setae.

Remarks—A close comparison of our specimens with those on loan from Mie University revealed that the rabbit fish from Japan and Taiwan carry the same species of *Lepeophtheirus*. However, in the course of this comparative study, it was detected that the specimens of *Lepeophtheirus* on the rabbit fish from either Japan or Taiwan could not be attributed to *L. goniistii* as described by Yamaguti (1936) and redescribed by Shiino (1952, 1959). As shown in Table 1, the differences between them are found in the structures of antennule, sternal furca, leg 3 and leg 4. Since these differences are rather significant, particularly in the armature of leg 3, we consider the specimens from rabbit fish represent a new species.

As of now, 109 species of caligids are classified under the genus *Lepeophtheirus*. It is interesting to point out that the armature of leg 3 has been considered as a stable feature of this genus without taxonomic significance. Thus, in his monumental work on the copepod parasites of British fishes, Kabata (1979) redescribed 7 species of *Lepeophtheirus* without giving a word or illustration for their leg 3, and in his work on the 10 species of *Lepeophtheirus* from fishes of British Columbia (Kabata, 1973), he dealt with the basal spine only for leg 3. However, with the discovery of *L. atypicus*, which is distinguished primarily by the armature of leg 3, attention to the structure of leg 3 is duely called for in the work on the taxonomy of *Lepeophtheirus*.

Caligus oviceps Shiino, 1952
(Figs. 4–6)

Material examined—47 females and 82 males from body surface of 10 rabbit fishes as given in Introduction. Four paratypes (2 females and 2 males) from Collection No. 117 (from *Siganus fuscescens* collected in June, 1950 near Yamada, Mie Prefecture) kept in Mie University. Ten specimens (5 females and 5 males) (TMCC 3) have been deposited in the Department of Zoology, Taiwan Museum, Taipei, Taiwan.

Female—Body (Fig. 4A) 2.62 (2.58–3.00) long excluding setae on caudal rami, based on 20 specimens. Carapace about 1.54 (1.40–1.82) long and 1.34 (1.16–1.48) wide, excluding lateral hyaline membranes. Genital double somite slightly wider than long, 0.61 (0.54–0.70)×0.73 (0.64–0.90), and inperceivably fused with fourth pediger. A lobate protrusion located medially to egg-sac attachment area (Fig. 5G). Abdomen short, 1-segmented and longer than wide (0.26×0.19). Caudal ramus (Fig.

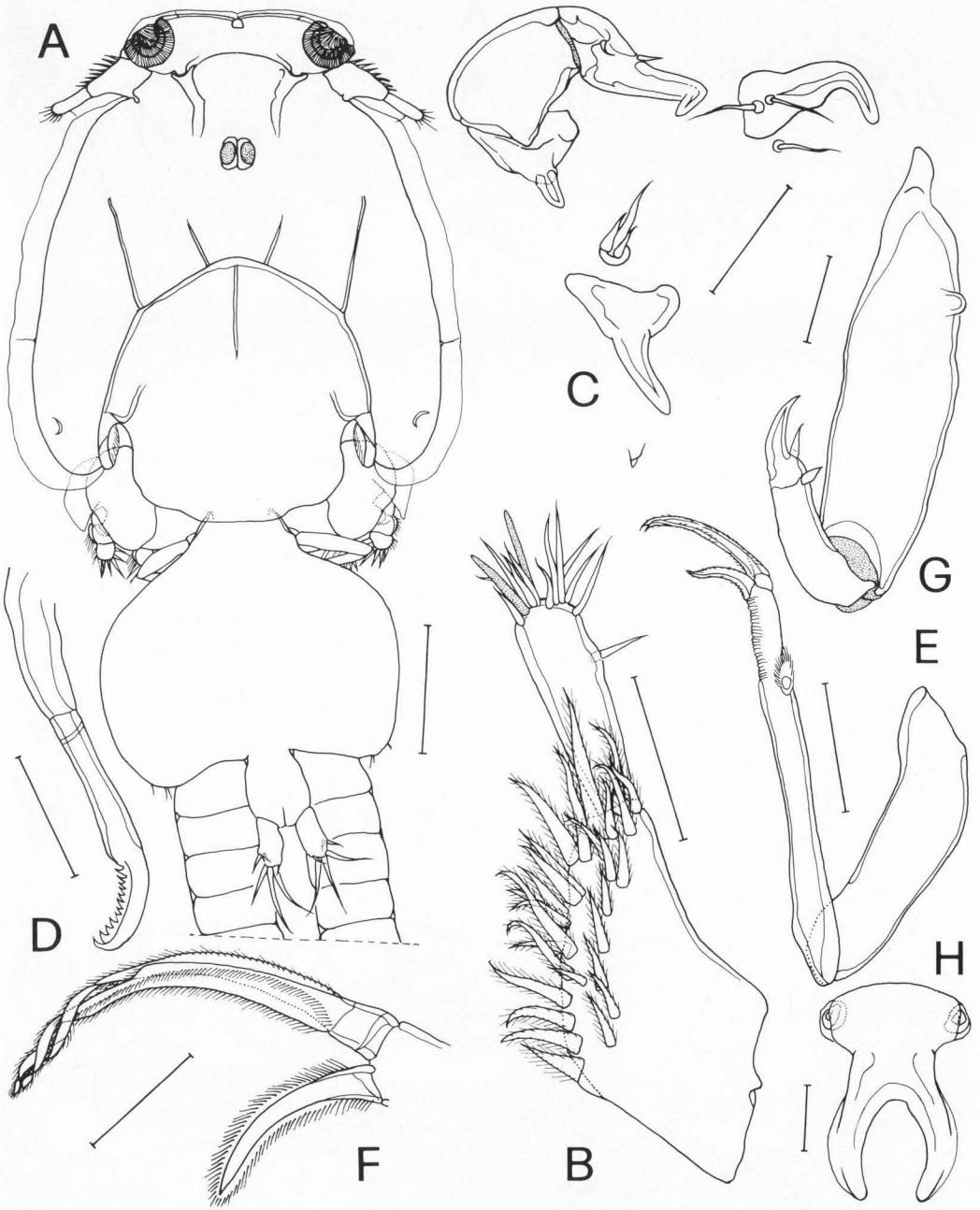

Fig. 4. *Caligus oviceps* Shiino, female: A. habitus, dorsal; B. antennule, ventral; C. antenna, post antennary process and maxillule; D. mandible; E. maxilla; F. tip of maxilla: G. maxilliped; H. sternal furca. Scale bars: 0.4 mm in A; 0.1 mm in B, C, D, E; 0.04 mm in F; 0.025 mm in G; 0.05 mm in H.

5G) longer than wide (0.15×0.08), armed with 6 usual setae. Egg sac length ranging from 1.20 to 1.98, containing 8 to 16 eggs.

Antennule (Fig. 4B) 2-segmented; proximal segment armed with 13 stout, subequal, plumose setae on anterior margin, another 13 short, plumose setae

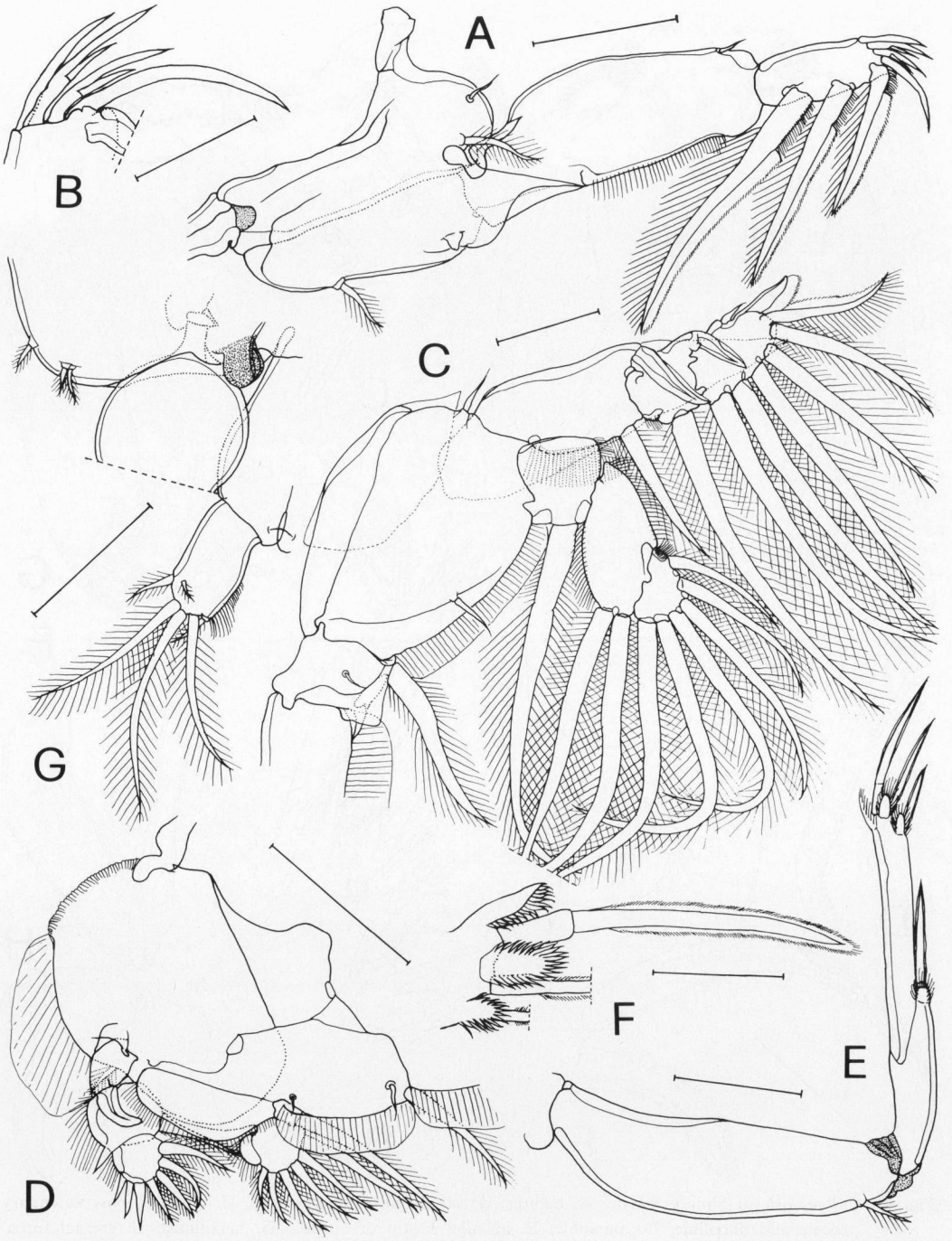

Fig. 5. *Caligus oviceps* Shiino, female: A. leg 1; B. tip of leg 1 exopod; C. leg 2; D. leg 3; E. leg 4; F. tip of leg 4 exopod; G. right side of egg sac attachment area, abdomen and caudal ramus, ventral. Scale bars: 0.1 mm in A, C, E; 0.04 mm in B, F; 0.2 mm in D, G.

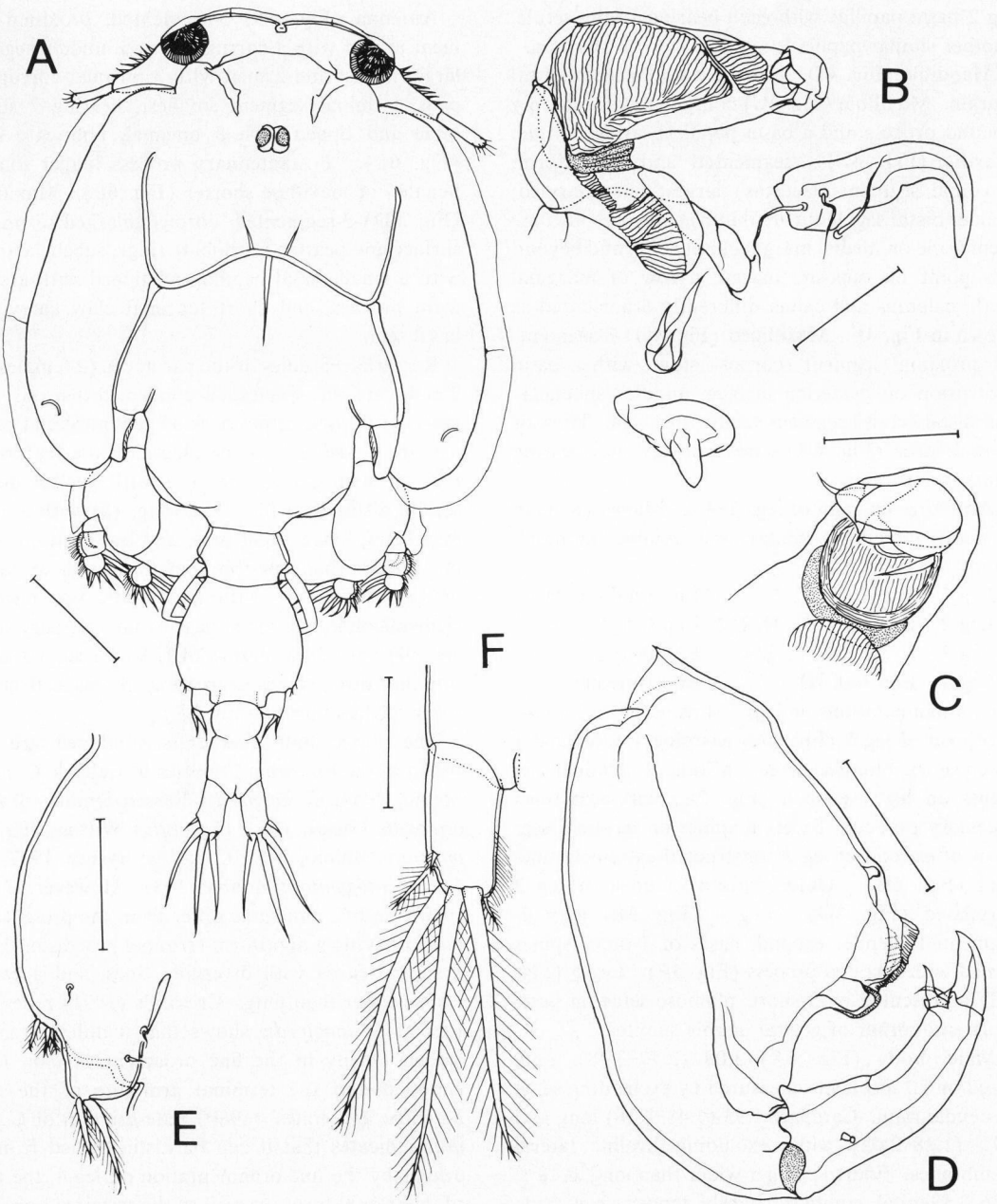

Fig. 6. *Caligus oviceps* Shiino, male: A. habitus, dorsal; B. antenna, postantennary process and maxillule; C. tip of antenna; D. maxilliped; E. right side of genital double somite, ventral; F. caudal ramus, ventral. Scale bars: 0.5 mm in A; 0.1 mm in B; 0.05 mm in C; 0.15 mm in D; 0.2 mm in E, F.

on ventral surface, and 2 short, plumose setae on dorsal surface; distal segment long and rod-shaped, 0.12×0.04, and carrying terminally 11 setae and 2 aesthetes and subterminally 1 seta on posterior margin. Antenna (Fig. 4C) 3-segmented and with a medial, basal spine; terminal segment a strongly curved hook bearing a basal and a marginal setae. Postantennary process (Fig. 4C) a stout hook carry-

ing 2 basal papillae with each bearing 1 long setule, another similar papilla located nearby on sternum.

Mandible (Fig. 4D) with 12 teeth on mediodistal margin. Maxillule (Fig. 4C) comprising of a sharply pointed process and a basal papilla bearing 3 setae. Maxilla (Fig. 4E) 2-segmented and brachiform; proximal segment (lacertus) largest but unarmed; slender distal segment (brachium) carrying a hyaline membrane on medial margin closer to tip and beyond this point on opposite margin a row of marginal teeth; calamus and canna differently ornamented as shown in Fig. 4F. Maxilliped (Fig. 4G) 3-segmented; proximal segment (corpus) stout, with a basal protrusion on posterior surface; middle (subchela) and distal (claw) segment each with a seta. Tines of sternal furca (Fig. 4H) curved inward and bearing lateral sclerite.

Armature on rami of legs 1–4 as follows (Roman numeral indicating spines and Arabic numeral, setae):

Leg 1	Exp 1–0; IV, 3	Enp (rudimentary)
Leg 2	Exp I–1; I–1; II, I, 5	Enp 0–1; 0–2; 6
Leg 3	Exp I–0; 1–1; 3, 4	Enp 0–1; 6
Leg 4	Exp I–0; III	Enp (missing)

Fine ornamentations on legs 1–4 as usual in *Caligus*. Protopod of leg 1 (Fig. 5A) carrying 1 outer and 1 inner short, plumose setae. Middle 2 terminal elements on leg 1 exopod (Fig. 5B) with spiniform accessory process. External spines on terminal segment of exopod of leg 2 constructed extremely unequal (Fig. 5C). Outer margin of coxa of leg 3 corugated (Fig. 5D). Leg 4 (Fig. 5E) with 2-segmented, slender exopod; bases of 4 outer spines armed with serrated process (Fig. 5F). Leg 5 (Fig. 5G) represented by 3 short, plumose setae on posterolateral corner of genital double somite.

Male—body (Fig. 6A) 3.08 (2.72–3.48) long, based on 20 specimens measured by exclu7ding setae on caudal rami. Carapace 1.93 (1.48–2.18) long and 1.71 (1.28–2.02) wide, excluding hyaline lateral membranes. Fourth pediger wider than long, 0.18×0.36. Genital complex slightly longer than wide (0.52×0.48) and carrying a pair of blunt, posterior protrusions tipped with 2 plumose setae (Fig. 6E), representing rudimentary leg 6. Abdomen (Fig. 6A) indistinctly 2-segmented; proximal segment slightly wider than long (0.13×0.19) but anal segment about as long as wide (0.24×0.23). Caudal ramus (Fig. 6F) longer than wide (0.18×0.11), armature as in female.

Antenna (Fig. 6B) 3-segmented; proximal segment armed with a corrugated pad; middle segment large, robust and armed with 3 unequal corrugated pads; terminal segment smallest, bearing 2 simple setae and tipped with 3 unequal, imbricate lobes (Fig. 6C). Postantennary process longer than in female but maxillule shorter (Fig. 6B). Maxilliped (Fig. 6D) 3-segmented; corpus enlarged on medial surface and bearing a trilobate ridge; subchela armed with a small, basal papilla and tipped with a spiniform process; and short terminal claw carrying a basal seta.

Remarks—Studies of the paratypes (2 females and 2 males) of this species has confirmed that our specimens of *Caligus* removed from the moribund rabbit fish are *C. oviceps*. Some characteristic features of the present species are: (1) with genital double somite distinctly wider than long; (2) with a abdomen being longer than wide and less than one-half, but greater than one-third, of the length of genital double somite; (3) with the middle two terminal elements on leg 1 exopod bearing an accessory spine; and (4) with an armature of I, III on leg 4 and the terminal three spines decreasing in length from the inner to the outer margin.

The above four characters combined are also found in the following 7 species of Caligus: *C. brevis* Shiino, 1954; *C. longipedis* Bassett-Smith, 1898; *C. orientalis* Gusev, 1951; *C. patulus* Wilson, 1937; *C. punctatus* Shiino, 1955; *C. stokesi* Byrnes, 1987; and *C. truncatogenitalis* Roubal, 1981. However, *C. orientalis* and *C. punctatus* differ from the present species in having a digitiform terminal process on leg 4, a sternal furca with diverging tines, and a caudal ramus wider than long. Cressey's (1991) redescription of *C. longipedis* shows that it differs from *C. oviceps* chiefly in the fine ornamentation on leg 2 endopod and the terminal armature of the male antenna; and Jones' (1980) redescription of *C. patulus* indicates that it can be distinguished from *C. oviceps* by the fine ornamentation on leg 4, the tines of the sternal furca, as well as the terminal armature of the male antenna.

Combining Roubal's (1981) original description and Byrnes' (1987) redescription of *C. truncatogenitalis* from the Australian sea breams, it seems that they were dealing with *C. oviceps*. Our close comparison of their works with the paratypes of *C. oviceps* revealed that there is no significant discrepancy between them. Thus, we propose to relegate *C. trun-*

catogenitalis to the synonym of *C. oviceps*. Both Roubal (1981) and Byrnes (1987) failed to compare their materials with *C. oviceps*, thus a new taxon was recognized by them.

In his work on the original description of *C. brevis*, Shiino (1954) pointed out that it can be distinguished from *C. oviceps* "by the more powerful 2nd maxillipeds (=maxillipeds) of the female, by the simple terminal claw of the male 2nd antennae (=antennae), and by the different arrangement of spines on the male genital segment (=genital double somite)". Our reexamination of the paratypes of *C. oviceps* shows that only the third discrepancy enumerated by Shiino (1954) is significant. Thus, the distinction between *C. brevis* and *C. oviceps* is miniscule and lies in the male. The same situation is found between *C. orientalis* and *C. punctatus*, where the two species is also segregated by a recognizable but miniscule difference in the male.

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