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Records of *Caligus* (Crustacea: Copepoda: Caligidae) from Marine Fish Cultured in Floating Cages in Malaysia with a Redescription of the Male of *Caligus longipedis* Bassett-Smith, 1898

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B. A. Venmathi Maran, Leong Tak Seng, Susumu Ohtsuka, and Kazuya Nagasawa (2009) Records of *Caligus* (Crustacea: Copepoda: Caligidae) from marine fish cultured in floating cages in Malaysia with a redescription of the male of *Caligus longipedis* Bassett-Smith, 1898. *Zoological Studies* **48**(6): 797-807. Five species of the copepod genus *Caligus* were found on 7 species of marine fish cultured at Penang and the Langkawi Is., Malaysia: *C. chiastos* Lin and Ho, 2003 from *Lutjanus johni* (Bloch, 1792); *C. epidemicus* Hewitt, 1971 from *Lates calcarifer* (Bloch, 1790) and *Epinephelus coioides* (Hamilton, 1822); *C. longipedis* Bassett-Smith, 1898 from *Gnathonodon speciosus* (Forsskål, 1775); *C. punctatus* Shiino, 1955 from *L. calcarifer*; and *C. rotundigenitalis* Yü, 1933 from *Lutjanus erythropterus* (Bloch, 1790), *E. bleekeri* (Vaillant, 1878), *E. fuscoguttatus* (Forsskål, 1775), and *G. speciosus*. Attachment sites of these copepods were the body surface and gill cavities of the fish. These findings constitute new host and country records for all identified caligids, and this is also the first record of *C. chiastos* from cultured fish. The male of *C. longipedis* is redescribed herein.
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Key words: *Caligus*, Cultured fish, Gill filaments, Malaysia, New hosts.

The decline in ocean fisheries and the rise in the global demand for fish have initiated rapid increases in aquaculture facilities (Rosenberg 2008). This has led to the development of semi-intensive and intensive brackish-water and marine aquaculture around the world. In turn, the importance of parasitic copepods as disease-causing agents in aquaculture has become evident (Johnson et al. 2004).

Sea lice such as *Caligus* Müller, 1785 and *Lepeophtheirus* Nordmann, 1832 are causing serious problems in aquaculture farms (Boxshall and Defaye 1993, Ho 2000). In Europe and North America, *Caligus elongatus* (Nordmann, 1832) and *Lepeophtheirus salmonis* (Krøyer, 1837) are considered to be important pathogens, since they induce heavy infections in caged fish (Boxshall and Defaye 1993).

In marine cultured fish, 54% of copepod infestations are caligids, and their impacts range from mild skin damage to stress-induced mortality of the fish (Costello 2006). In Asia, aquaculture farms are facing severe challenges due to parasitic copepods (Ho 2000). There are 90 species of *Caligus* and 33 species of *Lepeophtheirus* so far reported from cultured and wild marine fish (Ho and Lin 2004). In India and Taiwan alone, more than 50 species of sea lice are known from marine

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fish (Pillai 1985, Ho and Lin 2004), and in Japan, more than 28 species of *Caligus* and 17 species of *Lepeophtheirus* are known from cultured and wild fish (Ho 2000). Ho et al. (2004a) reported on the *Caligus* and *Lepeophtheirus* menace to marine fish cultured in Japan. Likewise, in the Philippines, caligids have been found from marine cultured and wild fish (Ho et al. 2004b, Venmathi Maran 2007). Recently in Indonesia, some parasitic copepods were reported from wild fish (Yuniar et al. 2007), and they were reported from both wild and cultured groupers in Vietnam (Vo et al. 2008).

In Southeast Asia, floating net cage-culture is extensively used and is rapidly expanding, especially in Malaysia (Leong et al. 2006). However, with the exception of Taiwan, parasitic copepods from cultured and wild fish in all other Asian countries are poorly documented (Ho 2004). In Malaysia, only 14 species of parasitic copepods including 10 caligids and 6 *Caligus* spp. (Table 1) were identified from wild fish (Leong 1984 1985 1986). We tried to further close this gap by revealing the taxonomy of caligids from marine fish cultured in floating cages in Malaysia.

MATERIALS AND METHODS

Parasitic copepods were collected from the body surface and gill cavities of marine fish cultured in Penang and the Langkawi Is., Malaysia such as the crimson snapper *Lutjanus erythropterus* (Bloch, 1790), seabass *Lates calcarifer* (Bloch, 1790), and golden trevally *Gnathonodon specious* (Forsskål, 1775) in May 2003; and John's snapper *Lutjanus johni* (Bloch, 1792), *L. calcarifer*, *G. specious*, dusky-tail grouper *Epinephelus bleekeri* (Vaillant, 1878), brown-marbled grouper *E. fuscoguttatus* (Forsskål, 1775), and orange-spotted grouper *E. coioides* (Hamilton, 1822) in Apr. 2006. The copepods were preserved in 70% ethanol after removal from the fish hosts. Specimens were later cleared in lactophenol for 1-2 h and dissected. The dissected body parts and appendages were examined using a differential interference contrast microscope at magnifications of up to 1000x (Olympus BX50T, Tokyo, Japan). All drawings were made with the aid of a drawing tube. Terminology basically followed Ho and Lin (2004). Measurements are shown as the mean with the range in parentheses. Scientific names of the host fish follow Froese and Pauly (2008).

Specimens are deposited in the National Museum of Nature and Science, Tokyo (NSMT-Cr).

Table 1. Siphonostomatoid copepods collected from wild marine fish in Malaysian waters (after Leong 1984 1985 1986)

Copepod	Host
Caligidae	
Caligus eleutheronema Shen 1957	*Eleutheronema tetradactylum* (Shaw, 1804)
Caligus epinepheli Yamaguti 1936	*Nemipterus japonicus* (Bloch, 1791)
	Sillago sihama (Forsskål, 1775)
Caligus kanagurta Pillai 1961	*Rastrelliger kanagurta* (Cuvier, 1816)
Caligus laticaudus Shiino 1960	*Formio niger* (Bloch, 1795)
Caligus malabaricus Pillai 1961	*Lutjanus malabaricus* (Bloch and Schneider, 1801)
Caligus multispinosus Shen 1957	*Pampus chinensis* (Euphrasen, 1788)
Hermilius longicornis (Bassett-Smith, 1898)	*Arius thallassinus* (Rüppel, 1837)
Hermilius pyriventris Heller 1865	*Arius thallassinus* (Rüppel, 1837)
Parapetalus hirsutus (Bassett-Smith, 1898)	*Eleutheronema tetradactylum* (Shaw, 1804)
Synestius caliginus (Steenstrup and Lütken, 1861)	*Formio niger* (Bloch, 1795)
Lernanthropidae	
Lernanthropus corniger Yamaguti 1954	*Megalaspis cordyla* (Linnaeus, 1758)
Lernanthropus trifoliatus (Bassett-Smith, 1898)	*Eleutheronema tetradactylum* (Shaw, 1804)
Lernaeopodidae	
Neobrachiella stellifera Heegard 1962	*Arius thallassinus* (Rüppel, 1837)
Thysanote appendiculata (Steenstrup and Lütken, 1861)	*Formio niger* (Bloch, 1795)

RESULTS AND DISCUSSION

Five species of *Caligus* were identified from marine fishes cultured in floating cages in Malaysia, and all were found to be new host and country records.

Family Caligidae Burmeister, 1835

Caligus chiastos Lin and Ho, 2003
(Figs. 1A-L, 2A)

Material examined: 6 ♀♀ (NSMT-Cr 20391) and 1 ♂ (NSMT-Cr 20392) from the body surface and gill cavities of *L. johni* cultured at Langkawi, Malaysia in Apr. 2006.

Description: *Female* (*n* = 6). Body (Fig. 1A) 3.52 (3.48-3.56) mm long excluding setae on caudal rami. Cephalothoracic shield slightly longer than wide, 1.81 (1.78-1.84) × 1.52 (1.48-1.56) mm, excluding marginal hyaline membranes. Fourth pediger wider than long, 0.19 (0.16-0.22) × 0.28 (0.25-0.31) mm. Genital complex suborbicular, as long as wide, 1.01 (1.00-1.02) × 1.03 (1.01 -1.05) mm. Abdomen small, 0.55 (0.52-0.58) × 0.32 (0.28-0.34) mm, longer than wide. Caudal ramus (Fig. 1B) longer than wide, armed with 3 short and 3 long plumose setae.

Antennule (Fig. 1C) 2 segmented; proximal segment distinctly longer than distal segment and armed with 27 setae on anterodistal surface; distal segment armed with subterminal seta on posterior margin and 11 setae plus 2 aesthetascs on distal margin. Antenna (Fig. 1D) 3 segmented; proximal segment small, with dentiform process on posteromedial surface, unarmed; middle segment unarmed; distal segment with claw bearing 2 small setae at both basal and middle regions. Postantennal process (Fig. 1D) large, bearing 2 basal papillae each with 2 setules, another similar papilla located nearby sternum. Maxillule (Fig. 1D) comprising large, sharply pointed dentiform process and papilla bearing 3 short setae anteriorly. Distal part of mandible (Fig. 1E) comprised of 12 teeth. Maxilla (Fig. 1F) 2 segmented, distal segment with 2 spinulate elements with hyaline membrane. Maxilliped (Fig. 1G) indistinctly 3 segmented; proximal segment largest, but unarmed; distal 2 segments incompletely fused to form claw and carrying small, medial seta at midlength. Sternal furca (Fig. 1H) with proximal subquadrate box and bluntly pointed tines.

Armature on rami of legs 1-4 as follows: (Roman and Arabic numerals indicate spines and setae, respectively).

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

Leg 1 (Fig. 1I) bearing coxa with papilla on outer margin carrying 2 setules; basis with long plumose outer and short plumose inner setae; vestigial endopod tipped with 2 setules; middle two of 4 terminal elements on last segment of exopod with accessory process. Leg 2 (Fig. 1J) ornamented with spinule on anterior surface and large, plumose, inner seta on posterodistal corner; basis with small, naked, outer seta and medial papilla bearing long setule; both outer and medial edges of basis fringed with large marginal membrane; similar membrane on outer margin of 1st segment of exopod; proximal outer spine on distal segment of exopod longer than succeeding spine and crossing over posteriorly. All 5 outer spines of exopod leg 4 (Fig. 1K) bearing pecten at base. Leg 5 (Fig. 2L) possessing 3 setae separated as 1 and 2 and adjacent on posterolateral margin of genital complex.

Male (*n* = 1). Body (Fig. 2A) 2.82 mm long excluding setae on caudal rami. Cephalothoracic shield longer than wide, 1.60 × 1.20 mm. Fourth pediger wider than long, 0.24 × 0.36 mm. Genital complex longer than wide, 0.51 × 0.46 mm. Abdomen 2 segmented, 0.52 × 0.45 mm, longer than wide. Caudal ramus longer than wide and armed as in female.

Remarks: The present specimens of *C. chiastos* do not differ from the original descriptions based on Taiwanese specimens (Lin and Ho 2003). However, the reason why this species was identified as *C. chiastos* are its characteristic features of legs 2 and 4: the proximal outer spine on the exopod of leg 2 is longer than the subsequent spine, which is unusual in *Caligus*; and the exopod of leg 4 is armed with elements I-IV.

Caligus chiastos seems to be a rare species. It was first found in Australia (Roubal et al. 1983) followed by Taiwan (Lin and Ho 2003). In Australia, only 1 female was found on a wild reef-associated snapper *Chrysophrys auratus* (Forster, 1801) (Sparidae), and in Taiwan, 1 male and female

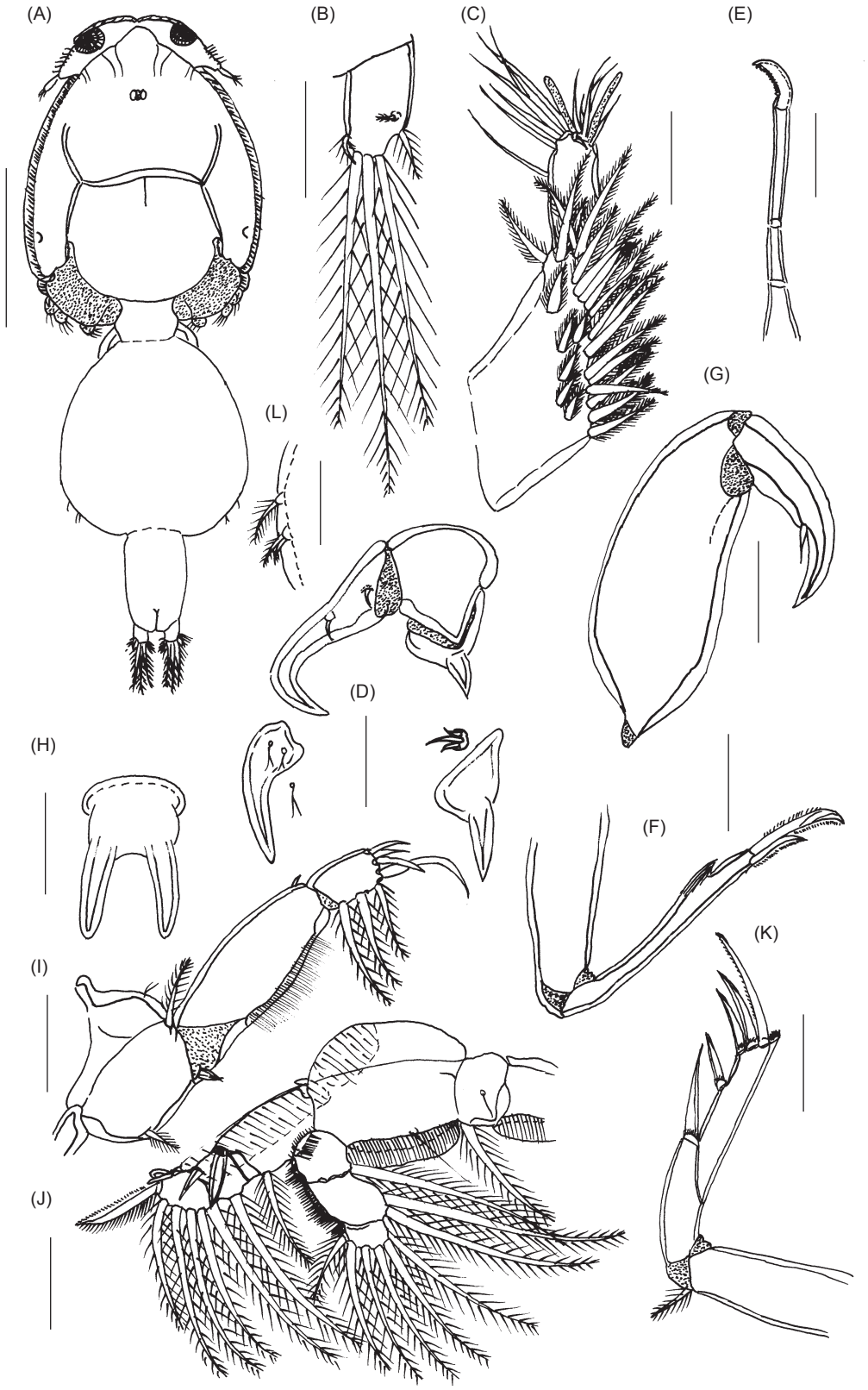

Fig. 1. *Caligus chiastos* Lin and Ho, 2003 female (A-F). (A) Habitus; (B) caudal ramus; (C) antennule; (D) antenna, post antennal process, and maxillule; (E) mandible; (F) maxilla; (G) maxilliped; (H) sternal furca; (I) leg 1; (J) leg 2; (K) leg 4; (L) leg 5. Scale: A = 1 mm; B-L = 0.1 mm.

pair was reported from the wild reef-associated crescent sweetlip *Plectorhynchus cinctus* (Temminck and Schlegel, 1843) (Haemulidae). However, 6 females and 1 male were found on marine cultured snappers in Malaysia. Recently it was reported that a large number of *C. chiastos* were found on the farmed southern bluefin tuna *Thunnus maccoyii* (Castelnau, 1872) in Australia (Hayward et al. 2008).

Caligus epidemicus **Hewitt, 1971**
(Figs. 2B-D)

Material examined: 5 ♀♀ (NSMT-Cr 20393) and 8 ♂♂ (NSMT-Cr 20394) from the body surface and gill cavities of *L. calcarifer* cultured at Penang in May 2003; 3 ♀♀ (NSMT-Cr 20395) from *L. calcarifer* and 2 ♀♀ (NSMT-Cr 20396) from *E. coioides* at Penang, Malaysia in Apr. 2006.

Description: *Female* (*n* = 10). Body (Fig. 2B) 2.28 (2.23-2.33) mm long excluding setae on caudal rami. Cephalothoracic shield suborbicular, 1.70 (1.67-1.74) × 1.64 (1.61-1.66) mm in size. Genital complex 0.74 (0.71-0.77) × 1.04 (1.00-1.07) mm, wider than long with rounded edges. Fourth pediger wider than long. Abdomen small, 0.14 (0.11-0.15) × 0.17 (0.15-0.20) mm. Caudal ramus 0.04 (0.03-0.05) × 0.06 (0.05-0.08) mm, short, box-shaped, and armed with 3 long and 3 short setae. Egg sac with 15-26 eggs. Protopod of leg 4 (Fig. 2C) long with plumose seta at outer distal corner; exopod 2 segmented; terminal segment of exopod with 2 spines; 1 long inner spine with pecten at base and outer spine without pecten.

Male (*n* = 8). Body (Fig. 2D) 1.62 (1.58-1.65) mm long (excluding setae on caudal rami). Cepahlothoracic shield suborbicular, 1.22 (1.18-1.25) × 1.17 (1.13-1.21) mm. Genital complex subrectangular 0.37 (0.33-0.39) × 0.35 (0.32-0.38) mm. Abdomen small, subquadrate 0.10 (0.08-0.12) × 0.15 (0.12-0.18) mm. Caudal ramus slightly wider than long, 0.02 (0.01-0.03) × 0.05 (0.04-0.06) mm with 3 long and 3 short setae.

Remarks: The most distinguished feature of *C. epidemicus* among its congeners is leg 4 with a long exopodal spine. This species is a common parasite of fish farms in the western Pacific. It was reported from different parts of the region on many fish hosts, including 8 fish species from Australia (Hewitt 1971, Byrnes 1987) 2 fish from the Philippines, and 10 from Taiwan (Ho and Lin 2004). It was also found on shrimp in Thailand (Ruangpan and Kabata 1984). Recently, a single surgeon fish *Acanthurus mata* (Cuvier, 1829) was found to be infected by 5000 individuals of *C. epidemicus* in the Philippines (Ho et al. 2004b). In Taiwan, heavy infections of *C. epidemicus* led to the mass mortality of cultured fish (Lin et al. 1996). The life history of this species is peculiar, because this species has the longest series of developmental stages comprising 2 naupliar, 1 copepodid, 6 chalimus, and the adult, in contrast to 2, 1, and 4 larval and juvenile stages in most species of *Caligus* (Lin et al. 1996, Ho and Lin 2004).

Caligus epidemicus is very frequently reported, and it provides the predominant threat to aquaculture in Australian and Asian waters due to its abundant existence and low host specificity (Ho 2000, Hutson et al. 2007). Ho et al. (2004b) reported that 10 host species, especially cultured sea bass, snappers, and groupers, were found with heavy infections of *C. epidemicus* in the Philippines. In Vietnam both wild and cultured groupers *E. bleekeri* and *E. coioides* were infected with *C. epidemicus* (Vo et al. 2008). This species is also known to cause mass mortality of mullet (Mugilidae) and porgies (Sparidae) in Australia (Hewitt 1971) and Taiwan (Lin 1996).

Caligus longipedis **Bassett-Smith, 1898**
(Figs. 2E-G, 3A-I)

Material examined: 3 ♀♀ (NSMT-Cr 20397) and 5 ♂♂ (NSMT-Cr 20398) from the body surface and gill cavities of *G. specious* cultured at Penang in May 2003; 10 ♀♀ (NSMT-Cr 20399) from the same host *G. specious*, Penang, Malaysia in May 2006.

Description: *Female* (*n* = 13). Body (Fig. 2E) 3.78 (3.76-3.79) mm long excluding setae on caudal rami. Cepahlothoracic shield suborbicular, 2.16 (2.14-2.17) × 1.90 (1.88-1.92) mm, more than 1/2 body length. Genital complex 1.20 (1.18-1.24) × 1.09 (1.07-1.10) mm, slightly longer than wide but larger than abdomen. Abdomen 0.32 (0.29-0.33) × 0.30 (0.27-0.31) mm, subrectangular, 1 segmented. Caudal ramus 0.14 × 0.11 mm slightly lengthy, with 3 long and 3 short setae. Egg sac with 20-26 eggs. Sternal furca (Fig. 2F) broad with robust tines. Protopod of leg 4 (Fig. 2G) long and slender, with plumose seta at outer corner; exopod spines with pecten basally.

Male (*n* = 5). Body (Fig. 3A) 4.38 (4.23-4.41) mm long excluding setae on caudal rami. Cephalothoracic shield suborbicular, 2.83

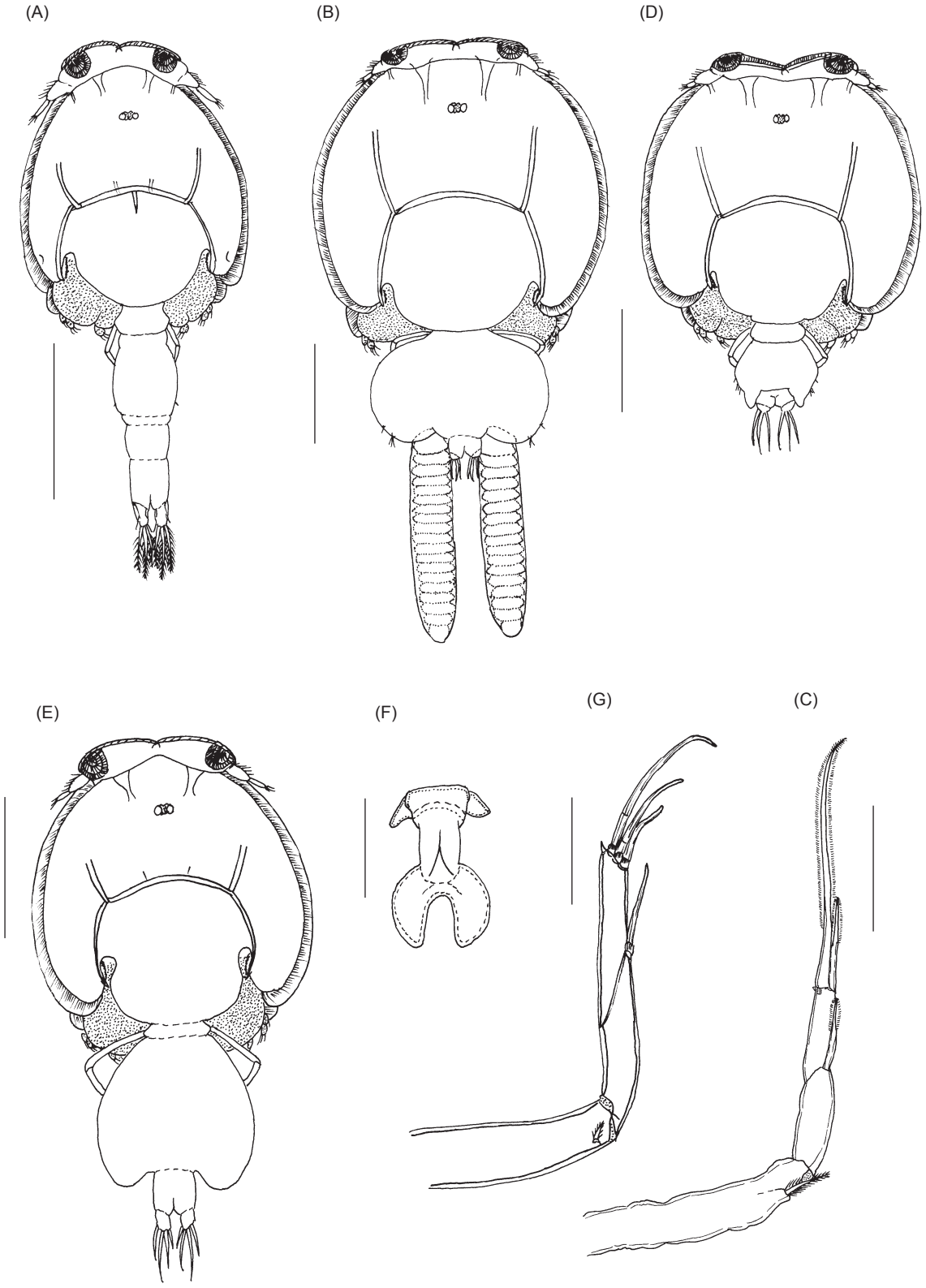

Fig. 2. *Caligus chiastos* Lin and Ho, 2003 male (A). (A) Habitus. *Caligus epidemicus* Hewitt, 1971 female (B, C). (B) Habitus; (C) leg 4. *Caligus epidemicus* Hewitt, 1971 male (D). (D) Habitus. *Caligus longipedis* Bassett-Smith, 1898 female (E-G). (E) Habitus; (F) sternal furca; (G) leg 4. Scale: A, E = 1 mm; B, D = 0.5 mm; C, F, G = 0.1 mm.

(2.78-2.86) × 2.76 (2.73-2.79) mm. Genital complex 0.70 (0.66-0.72) × 0.44 (0.40-0.47) mm, longer than wide. Abdomen (Fig. 3B) small, 0.36 (0.35-0.37) × 0.38 (0.37-0.39) mm, 2 segmented. Caudal ramus 0.21 × 0.15 mm, longer than wide with 3 long and 3 short setae.

Antenna (Fig. 3C) 3 segmented; proximal segment slender, with corrugated patches laterally; middle segment largest, armed with corrugated adhesion pads at distal and lateral regions; terminal segment smallest with 2 medial setae in basal region, with 3 overlapping pointed cuticular flaps at tip. Post-antennal process (Fig. 3C) moderately long carrying 2 basal papillae with 2 setules each; another similar papilla located near sternum. Maxillule (Fig. 3C) moderately sized having basal papilla with 3 setae, including long middle seta. Maxilliped (Fig. 3D) indistinctly 3 segmented; proximal segment robust with 2 projecting small and larger tooth-like processes in myxal area; middle and distal segments fused to form subchela, claw with barbel at base. Sternal furca (Fig. 3E) as in female. Leg 1 (Fig. 3F) with small, plumose outer seta; vestigial endopod unarmed; 1st segment of exopod with a row of setules on posterior edge and small spiniform seta at outer distal corner; middle two of 4 terminal elements on last segment of exopod with an accessory process, element 4 spiniform longer than element 1 (Fig. 3G). Endopod of leg 2 (Fig. 3H) 3 segmented, all segments possessing marginal patches of spinules on anterior surface. Posterolateral margin of leg 5 (Fig. 3I) with 2 papillae, 1 tipped with a small, pinnate seta and other with 2 long setae. Leg 6 (Fig. 3I) located on posterior region of genital complex having 2 papillae, tipped with 1 small seta and 2 long pinnate setae.

Remarks: The unique characteristic features of this species are the long and slender in structure of leg 4, exopod with the armature of I, III spines with pecten at base, and the possession of marginal patches of spinules on the anterior surface of the terminal endopodal segment of leg 2.

The present specimens show an unusual phenomenon in the size and sternal furca. From a total of 13 females and 5 males found in Malaysia, all males (with a mean body length of 4.38 mm) are larger than females (with a mean of 3.78 mm), in contrast to Taiwanese specimens (based on descriptions) where males (with a mean of 2.82 mm) are comparatively smaller than females (with a mean of 5.86 mm) (Ho and Lin 2004). In addition, the antennae, abdomen, sternal furca, maxilliped, and legs 5 and 6 totally differed from those of Taiwanese specimens (see Ho and Lin 2004). On the other hand, they are similar to the Japanese ones (based on descriptions) (Ogawa 1992). Ho and Lin's male specimen descriptions are not conspecific to the female (see Ho and Lin 2004). Specimens show a prominent sexual dimorphism in size as males are larger than females (♂ 4.38 mm; ♀ 3.78 mm), which is known for *C. acanthopagri* Lin, Ho and Chen, 1994 (♂ 5.35 mm; ♀ 3.79 mm); *C. latigenitalis* Shiino, 1954 (♂ 6.90 mm; ♀ 4.33 mm) (see Ho and Lin 2004); *C. oviceps* Shiino, 1952 (♂ 3.08 mm; ♀ 2.62 mm) (Lin et al. 1996), and *C. orientalis* Gussev, 1951 (♂ 5.76 mm; ♀ 3.85 mm) (Ho and Lin 2004).

In Asia, *C. longipedis* was so far reported only from India (Gnanamuthu 1950), Japan (Ogawa 1992), and Taiwan (Ho and Lin 2001). This species was identified from cultured fishes such as the striped jack *Pseudocaranx dentex* (Bloch and Schneider, 1801) in Japan (Ogawa 1992) and from the wild torpedo scad *Megalaspis cordyla* (Linnaeus, 1758) in Taiwan (Ho and Lin 2001). It was found on 16 fish hosts of 5 families. It should be noted that the Carangidae is a preferable host family for this parasite (see Ho and Lin 2004).

***Caligus punctatus* Shiino, 1955**
(Figs. 4A-C)

Material examined: 1 ♀ (NSMT-Cr 20400) with an egg sac from the body surface and gill cavities of *L. calcarifer* at Penang, Malaysia in Apr. 2006.

Description: *Female* (*n* = 1). Body (Fig. 3A) 3.25 mm long (excluding setae on caudal rami). Cephalothorax suborbicular 1.92 × 1.87 mm (excluding hyaline membranes). Fourth pediger wider and not covered by cephalothorax. Genital complex 0.51 × 0.66 mm; slightly rectangular in shape, but rounded at corner. Abdomen, small, 0.28 × 0.26 mm. Caudal ramus small with 3 long and 3 short setae. Egg sac with 16 eggs.

Exopod of leg 4 (Fig. 3B) armed with I, III serrated spines, terminal spine longer than other spines. Leg 5 (Fig. 3C) possessing 2 small papillae on posterior part of genital complex, one tipped with 2 pinnate setae and another with plumose seta.

Remarks: This is a common parasite collected from both cultured and wild fish in Japan such as *Acanthopagrus* spp., *Chanos chanos* (Forsskål, 1775), *Epinephelus* spp., *L. calcarifer*, *Mugil cephalus* (Linnaeus, 1758), *Oreochromis* spp., and

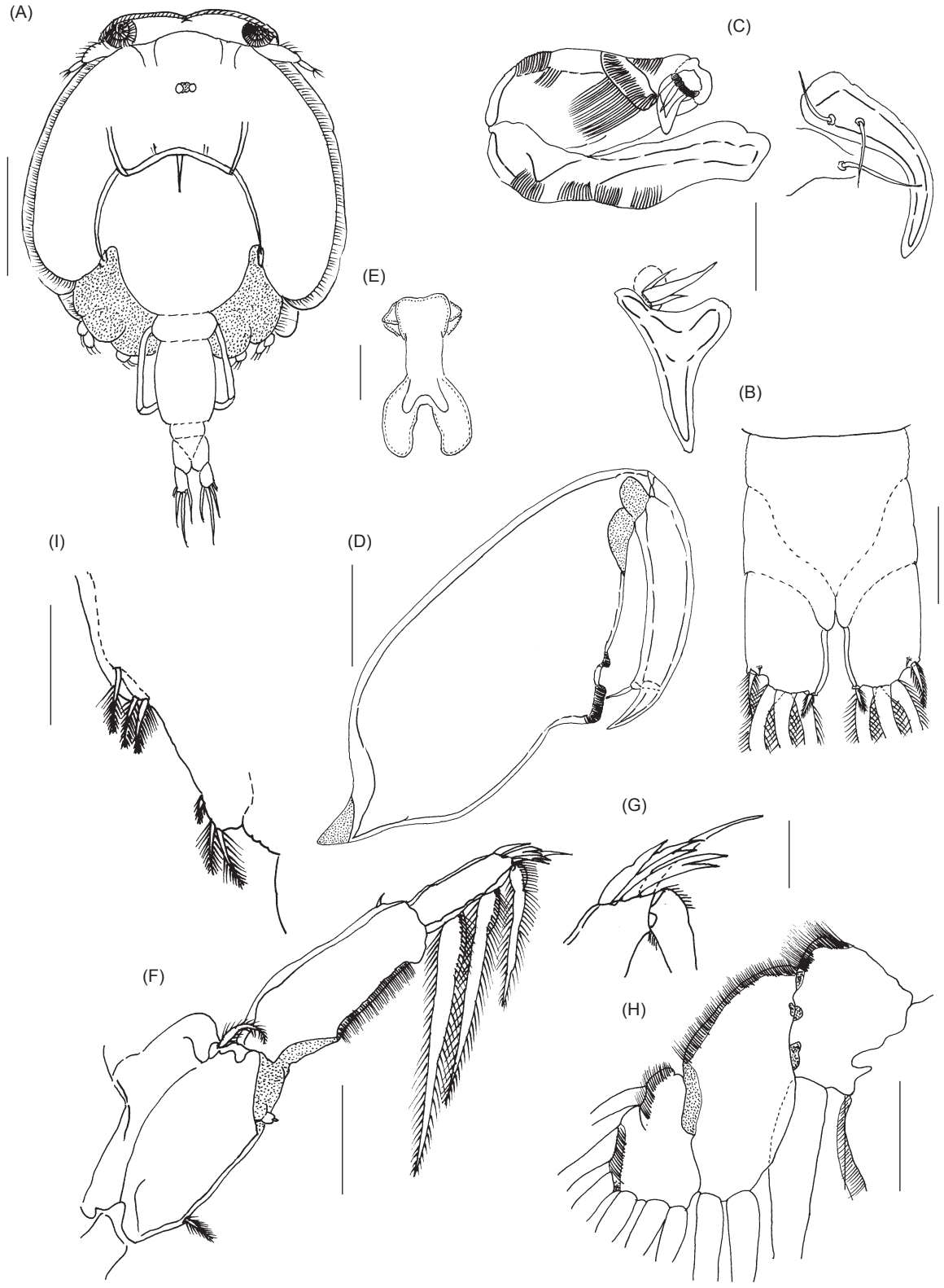

Fig. 3. *Caligus longipedis* Bassett-Smith, 1898 male (A-I). (A) Habitus; (B) abdomen; (C) antenna, post antennal process, and maxillule; (D) maxilliped; (E) sternal furca; (F. leg 1; (G) tip of exopod of leg 1; (H) leg 2; (I) legs 5 and 6. Scale: A = 1 mm; B = 0.2 mm; C-F, H, I = 0.1 mm; G = 0.05 mm.

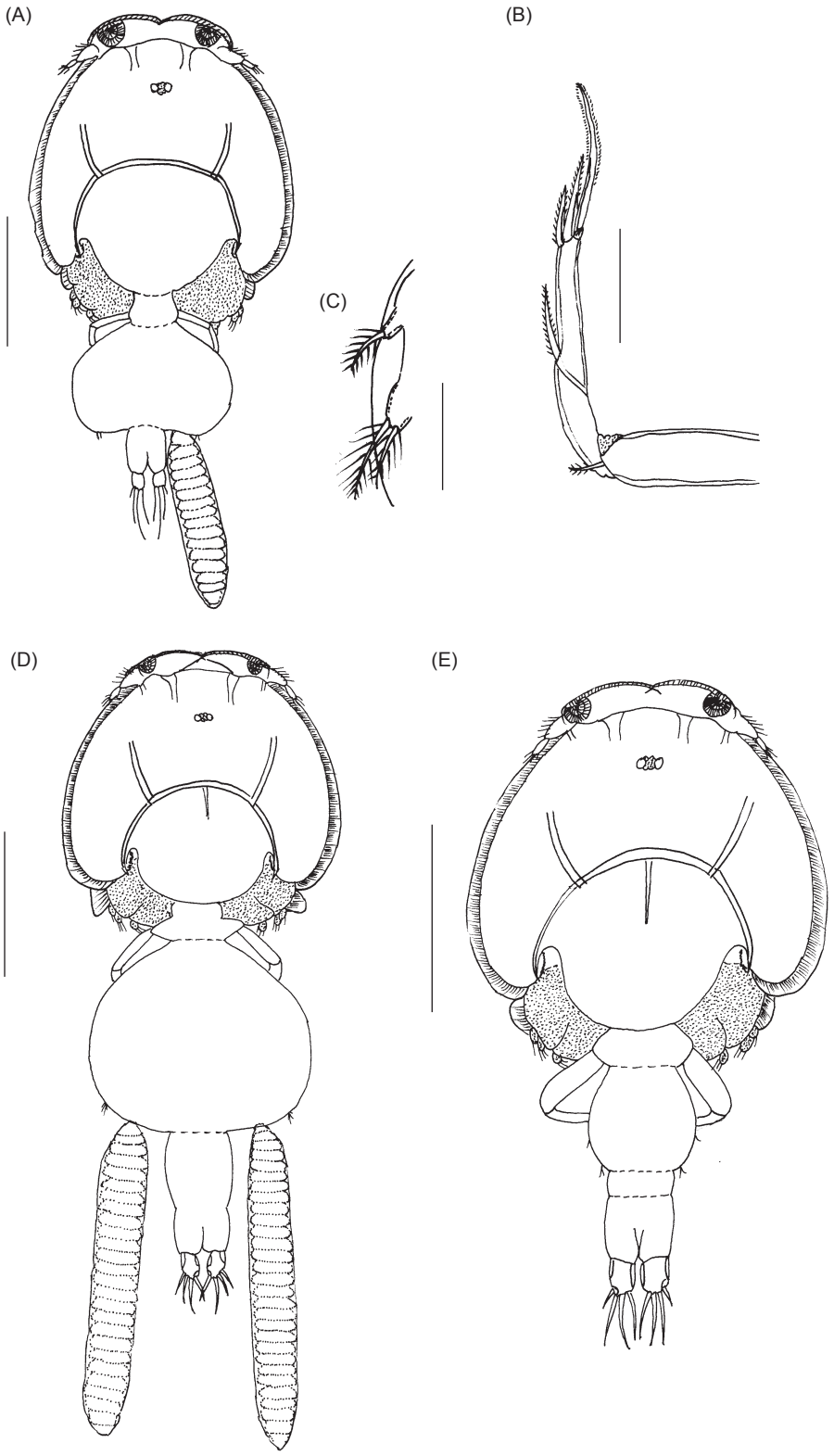

Fig. 4. *Caligus punctatus* Shiino, 1955 female (A-C). (A) Habitus; (B) leg 4; (C) leg 5. *Caligus rotundigenitalis* Yü, 1933 female (D). (D) Habitus. *Caligus rotundigenitalis* Yü, 1933 male (E). (E) Habitus. Scale: A = 1 mm; B, C = 0.1 mm; D = 0.8 mm; E = 0.5 mm.

Takifugu vermicularis (Temminck and Schlegel, 1850) (Shiino 1955). Records from these hosts indicate its low host specificity (Ho and Lin 2004). It was also collected in plankton samples off Taiwan (Lin 1996).

In Taiwan, it was found on 18 fish species and was frequently encountered on cultured fish (Ho and Lin 2004). Hundreds of juveniles and adults of *C. punctatus* were removed from a single gobiid, *Chaenogobius castaneus* (O'Shaughnessy, 1875) caught in a brackish lagoon on the eastern coast of Korea (Kim 1993). It parasitizes various phylogenetically remote fish and can complete its life cycle in a brackish lagoon where the environmental conditions vary in the extreme (Kim 1993). It is also regarded as a pest with potential threats to aquaculture similar to those posed by *C. epidemicus* (Kim 1993, Ho and Lin 2004).

***Caligus rotundigenitalis* Yü, 1933**
(Figs. 4D, E)

Material examined: 4 ♀♀ (NSMT-Cr 20401) from the body surface and gill cavities of *L. erythropterus* cultured at Penang in May 2003; 1 ♀ (NSMT-Cr 20402) and 6 ♂♂ (NSMT-Cr 20403) from *E. bleekeri*, 10 ♀♀ (NSMT-Cr 20404) and 3 ♂♂ (NSMT-Cr 20405) from *E. fuscoguttatus* and 30 ♀♀ (NSMT-Cr 20406) and 12 ♂♂ (NSMT-Cr 20407) from *G. specious* cultured at Penang, Malaysia in May 2006.

Description: *Female* (*n* = 10). Body (Fig. 3D) 3.16 (3.11-3.21) mm long excluding setae on caudal rami. Cepahlothoracic shield suborbicular, 1.55 (1.48-1.58) × 1.29 (1.25-1.31) mm. Genital complex 0.85 (0.81-0.87) × 0.94 (0.91-0.98) mm, wider than long, slightly ovate and bulging. Abdomen 2 segmented, but not distinct, 0.67 (0.65-0.69) × 0.32 (0.31-35) mm. Caudal ramus longer than broad, armed with 3 long and 3 short setae. Egg sac with 22-30 eggs.

Male (*n* = 5). Body (Fig. 3E) 1.68 (1.65-1.71) mm long excluding setae on caudal rami. Cephalothoracic shield suborbicular, 1.01 (0.98-1.05) × 1.03 (1.00-1.06) mm. Genital complex subquadrate 0.45 (0.40-0.50) × 0.33 (0.31-35) mm. Abdomen 2 segmented, 0.79 (0.73-0.85) × 0.71 (0.68-0.74) mm with small proximal segment. Caudal ramus longer than broad armed as in female.

Remarks: In this study, 45 females and 21 males of *C. rotundigenitalis* were found on 3 different hosts of marine fish cultured in floating cages in Penang. Ho and Lin (2004) reported that in Taiwan, 32 fish species belonging to 19 families are known hosts for *C. rotundigenitalis*. This is one of the most common species in cultured and wild fish in East Asia. The species is distributed worldwide with a broad range of hosts and is considered a cosmopolitan species (Ho et al. 2000).

The taxa reported as "*C. rotundigenitalis*" from gills of the Chinese silver pomfret *Pampus chinensis* (Euphrasen, 1788) from Malaysia (Leong 1984) was a misidentification of "*C. multispinosus*" (see Ho et al. 2000). In contrast, "*C. multispinosus*" reported from the black sea bream *Acanthopagrus schlegeli* (Bleeker, 1854) in Taiwan was a misidentification of "*C. rotundigenitalis*" (Lin et al. 1994). Although the abdomens of both species morphologically differ, *C. multispinosus* and *C. rotundigenitalis* can be differentiated by their hosts, in that *C. multispinosus* is specific to *P. chinensis*, but the latter species has so far not been found on *P. chinensis* (see Ho et al. 2000). This species is also considered to be a common species with a low host specificity (Ho et al. 2000).

In Asia, 10 species of sea lice are considered killer species on fish farms, including *C. acanthopagri* Lin, Ho and Chen, 2000; *C. epidemicus*; *C. orientalis*; *C. patulus* Wilson, 1937; *C. punctatus*; *C. rotundigenitalis*; *C. spinosus* Yamaguti, 1939; *Lepeophtheirus longiventris* Yü and Wu, 1932; *L. paralichthydis* Yamaguti and Yamasu, 1955; and *L. salmonis* (Ho 2000). Among these, *C. epidemicus* is considered to cause the most harm to its fish hosts. In addition to its low host specificity, it is distributed from the southern to the northern hemisphere (Lin et al. 1996, Hutson et al. 2007). In the present study, of these 10 species, 3 species *C. epidemicus*, *C. punctatus*, and *C. rotundigenitalis* were found in Malaysia. Hence, aquaculturists in this country should pay serious attention to controlling these parasites.

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