



***Caligus lini* n.sp., a new caligid (Copepoda, Siphonostomatoida) parasitic on the brilliant pomfret *Eumegistus illustris* Jordan & Jordan (Perciformes, Bramidae) of Taiwan**

JU-SHEY HO¹ & YU-RONG CHENG^{2,3}

¹Department of Biological Sciences, California State University, Long Beach, California, 90840-3702, U.S.A.

²Institute of Oceanography, National Taiwan University, Taipei, 106, Taiwan

³Corresponding author: E-mail: d94241001@ntu.edu.tw

Abstract

Caligus lini n.sp., a new species of caligid copepod parasitic on the gill rakers and caudal fin of the brilliant pomfret, *Eumegistus illustris* Jordan & Jordan (Perciformes, Bramidae), is described from fish caught off Tai-Dong, Taiwan. The new species differs from its congeners by its possession of the following, unique combination of features: (1) middle two elements at the tip of leg 1 simple (without accessory process), (2) innermost element shortest and smallest of the four terminal elements on leg 1, (3) leg 4 exopod with an armature formula of I,III, and (4) complex leg 5 represented by 2 seta-bearing processes, a simple anterior process tipped with 1 plumose seta and quadripartite posterior process carrying 3 setae (1 simple and 2 plumose). The new species differs from its closest congener, *Caligus tylosuri* (Rangnekar, 1956), in the structure of the middle two elements (simple without carrying accessory process) at the tip of leg 1 and a quadripartite (instead of tripartite) posterior process on leg 5.

Key words: Parasite, new species, caligid copepod, marine fishes

Introduction

Among the members of the parasitic copepod family Caligidae, *Caligus* Müller, 1785 is the largest genus; it comprises more than 250 species and is also the most widely represented genus in Taiwanese waters (Ho & Lin 2004; Ho *et al.* in press). Although 53 species of sea lice belonging to *Caligus* have been reported from Taiwan (Ho *et al.* in press), continuous examination of marine fishes landed at Cheng-Gong Fishing Port on the east coast of Taiwan has yielded several more species of unrecorded congeners; some of them turned out to be new to science. The teleost genus *Eumegistus* is known to contain two species, *E. illustris* Jordan & Jordan, 1922, mainly distributed around the Pacific, and *E. brevoorti* (Poey, 1860) in the Atlantic (Carvalho-Filho *et al.* 2009). Although they are distributed widely in the world's oceans, a limited amount of information is available on their biology and ecology as well as parasitism leads to the poor knowledge of their parasitic copepods. According to Shao (2015), the brilliant pomfret *E. illustris* distributes in a depth range of 0–200 m off the east coast of Taiwan. In this contribution we report on female specimens of *Caligus* obtained from the parasitological examination of 42 individuals of *E. illustris* collected from off Tai-Dong County, east Taiwan. These specimens represent a new species which is here described in full and compared with its closest congeners.

Methods

Fish caught and landed by fishermen at Cheng-Gong Fishing Port in Tai-Dong were purchased from September 2014 to June 2015 (Table. 1). The fishes were transported in an icebox to the laboratory for examination. The copepod ectoparasites were removed from the fish hosts and then preserved in 70% ethanol. They were later on cleared in 85% lactic acid for 1–2 hours before dissection in a drop of lactic acid on a wooden slide (Humes &

Gooding, 1964). The removed parts and appendages were examined under the compound microscope with a series of magnifications up to 1500 X. All drawings were made with a drawing tube attached to a compound microscope and measurements, in millimeters unless mentioned otherwise, were taken. Morphologic terminology used in the descriptive section follows Huys & Boxshall (1991).

TABLE 1. Summary of parasite statistics including numbers of collected and infected brilliant pomfret *Eumegistus illustris* Jordan & Jordan, infection sites, parasite abundance (total number of copepod individuals), numbers of ovigerous females, prevalence (%), and mean intensity (parasite individuals per infected fishes). From September 2014 to June 2015, a total of 42 fishes were collected and examined.

	2014					2015
	24 September	28 September	29 September	1 October	6 October	13 June
No. of collected fishes	6	4	4	11	11	6
No. of infected fishes	0	0	0	0	2	1
Infection sites	uninfected	uninfected	uninfected	uninfected	gill rakers / caudal fin	caudal fin
parasite abundance	0	0	0	0	3	1
No. of ovigerous females	0	0	0	0	1	0
Prevalence (%)	0	0	0	0	18.2	16.7
Mean intensity	0	0	0	0	1.5	1.0

Taxonomy

Order Siphonostomatoida Thorell, 1859

Family Caligidae Burmeister, 1835

Genus *Caligus* O.F. Müller, 1785

Caligus lini n. sp.

(Figs 1–3)

Type material. Four adult ♀♀ obtained from gill rakers (1 individual) and caudal fin (3 individuals) of 42 brilliant pomfret, *Eumegistus illustris* Jordan & Jordan 1922, landed at Cheng-Gong Fishing Port in Tai-Dong County between September 2014 and August 2015. Holotype ♀ (ASIZCR000329) deposited in the Biodiversity Research Museum, Academia Sinica, Taipei, Taiwan, and 3 ♀♀ paratypes (NTUIO-COPEPOD s002) deposited in the Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

Description. Body (Fig. 1A) 4.78 (4.70–4.82) mm long, excluding setae on caudal ramus. Cephalothoracic shield subcircular, 3.67 mm long and 2.28 mm wide, excluding lateral, hyaline membrane. Fourth pediger distinctly wider than long, 0.79 (0.77–0.81) × 0.38 (0.37–0.40) mm. Genital complex (Fig. 1B) subquadrate, 1.50 (1.46–1.52) × 1.67 (1.65–1.69) mm, with posterolateral protrusions. Abdomen (Fig. 1B) 1-segmented and longer than wide, 0.59 (0.58–0.60) × 0.40 (0.39–0.41) mm. Caudal ramus (Fig. 1C) slightly longer than wide, 110 (108–111) × 99 (97–100) µm, armed with usual 3 short and 3 long plumose setae, dorsal surface bearing 3 sensilla and posteromedial margin ornamented with a row of setules. Egg sac 7.62 (7.40–7.84) mm long.

Antennule (Fig. 1D) 2-segmented. Proximal segment strong, carrying 25 setose and 2 naked (on dorsal side) setae on anterodistal surface; distal segment short, cylindrical, about 2.25 times as long as wide, with 1 subterminal seta on posterior margin and 11 setae plus 2 aesthetascs on distal margin.

Antenna (Fig. 2A) 3-segmented; proximal segment with blunt process on posteromedial corner, second segment squarely and unarmed, distal segment represented by long, curved claw bearing 2 setae, one proximal and other one close to medial region. Postantennal process (Fig. 2A) represented by bluntly tipped spine with two papillae on basal region bearing 3 setules, another similar setule-bearing papilla close to cephalon.

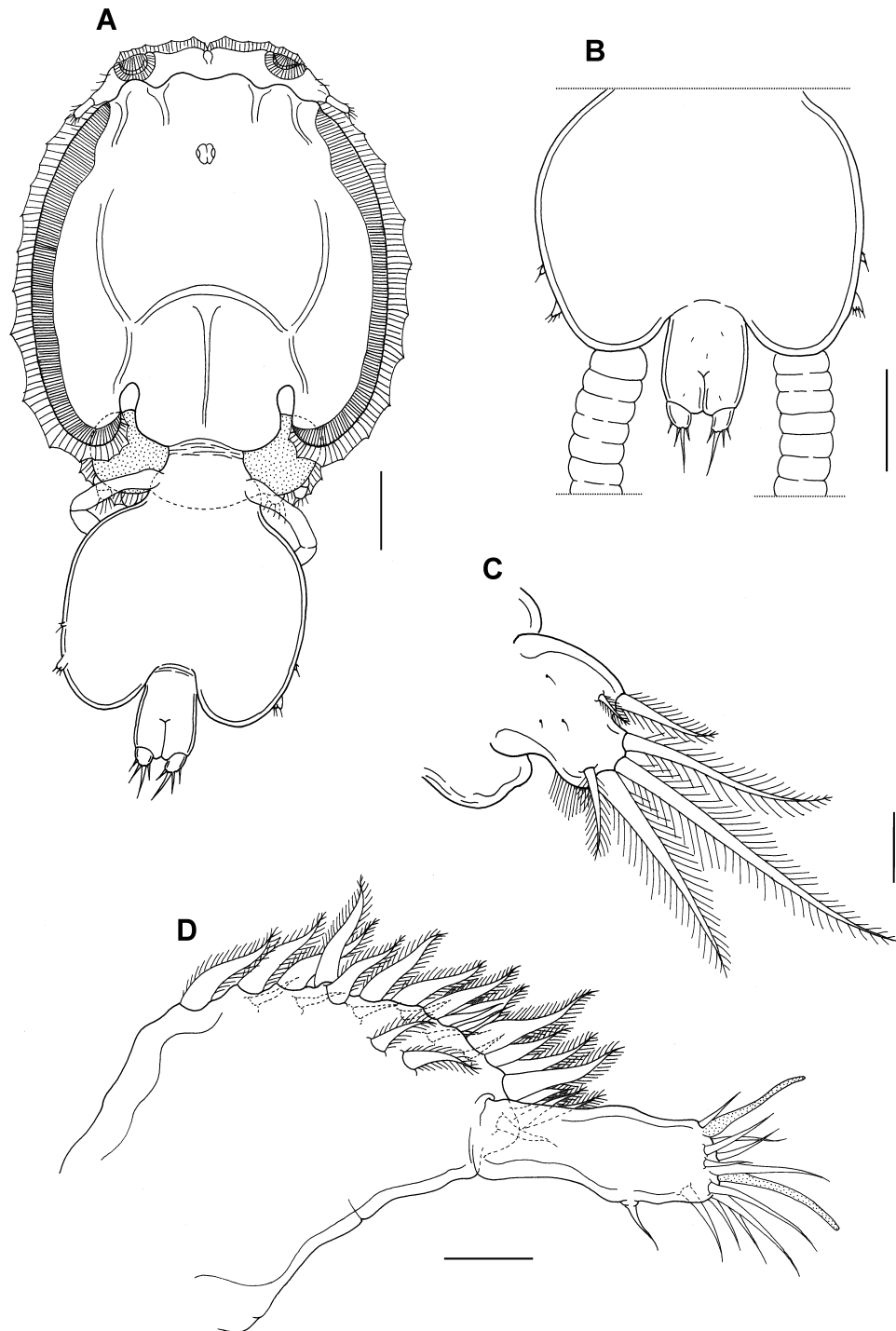


FIGURE 1. *Caligus lini* n. sp., female. A, habitus, dorsal; B, genital complex and abdomen, ventral; C, caudal ramus, dorsal; D, antennule. Scale bars: 0.5 mm in A and B; 0.05 mm in C and D.

Mandible (Fig. 2F) with 4 sections; proximal 3 sections unarmed, distal section forming slender blade bearing 12 teeth along medial margin (arrowed in Fig. 2F). Maxillule (Fig. 2B) comprising large stout dentiform process and proximal basal papilla armed with 3 unequal setae; another small process situated by basal papilla. Maxilla (Fig. 2C) 2-segmented; proximal segment (lacertus) unarmed; slender distal segment (brachium) with subterminal outer short spiniform element ornamented only on outer edge; terminal calamus longer than subterminal canna, both elements pinnate along medial and outer margins. Maxilliped (Fig. 2D) 3-segmented, with distal 2 segments almost completely fused to form subchela; proximal segment (corpus) unarmed; middle (shaft) and distal (claw) segments each carrying minute seta; claw strongly bent at tip. Box of sternal furca (Fig. 2E) indistinct; tines blunt, widely divergent.

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

	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,III	(absent)

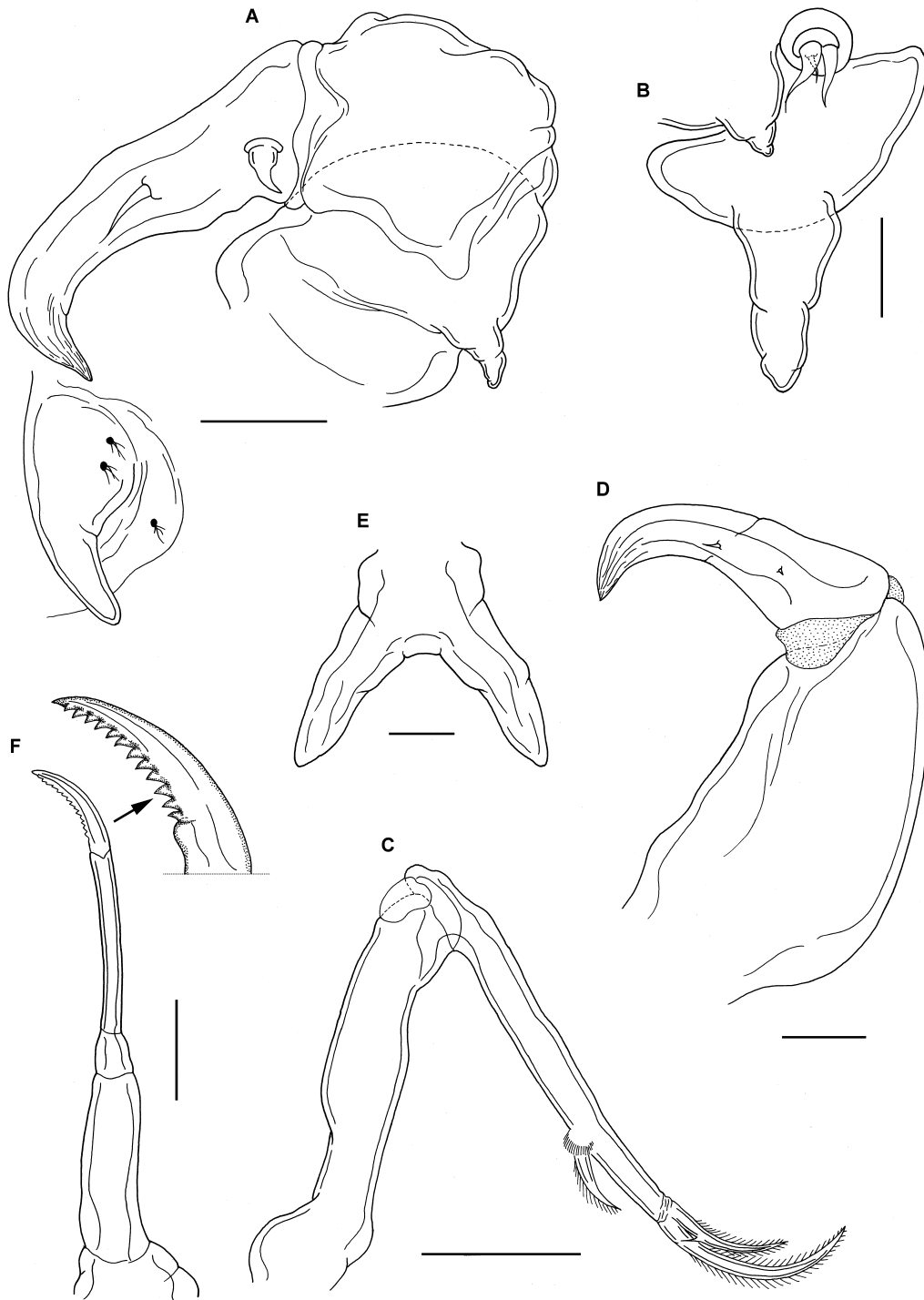


FIGURE 2. *Caligus lini* n. sp., female. A, antenna and post-antennal process; B, maxillule; C, maxilla; D, maxilliped; E, sternal furca; F, mandible. Scale bars: 0.1 mm in A, C, and D; 0.05 mm in B, E, and F.

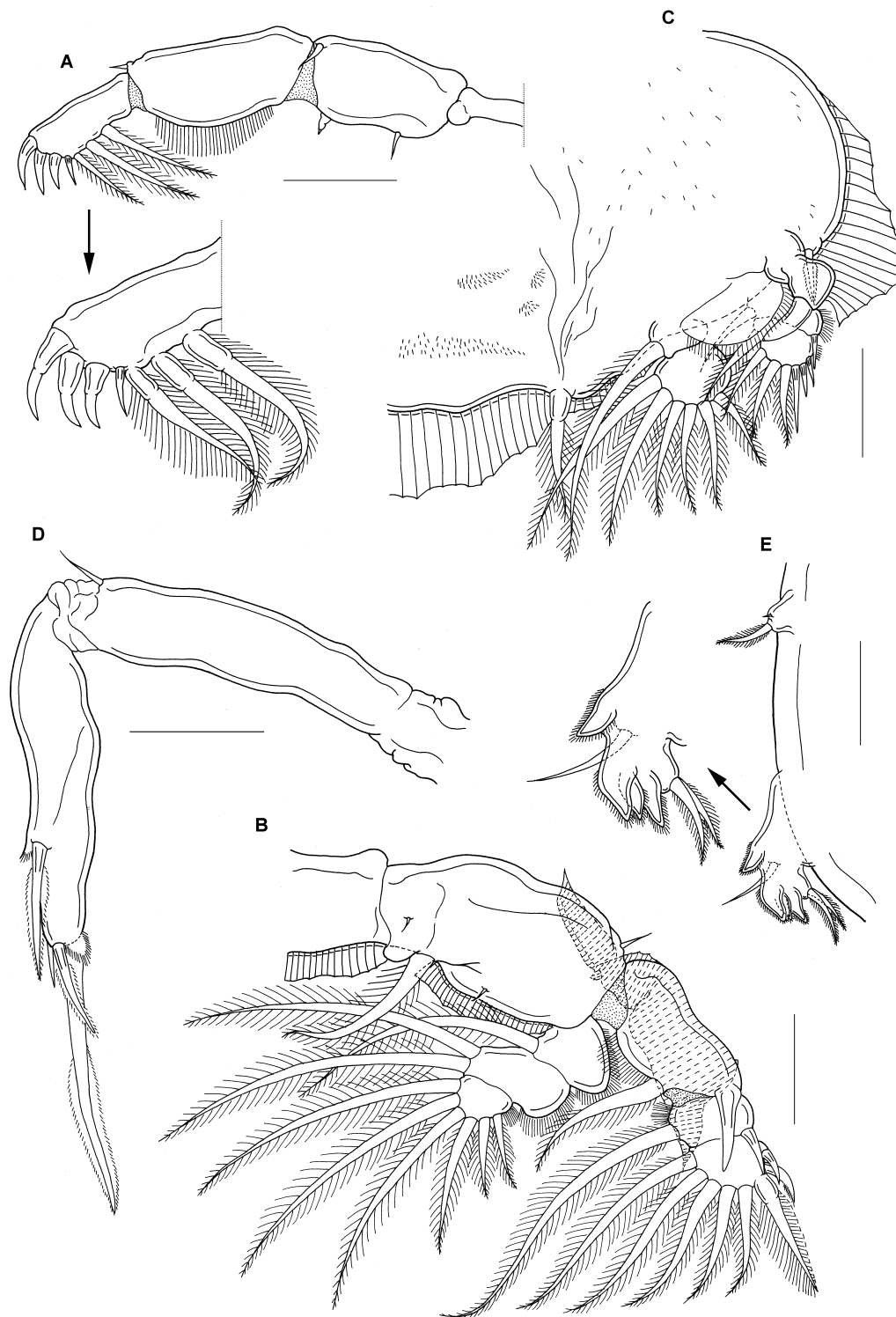


FIGURE 3. *Caligus lini* n. sp., female. A, leg 1; B, leg 2; C, leg 3; D, leg 4; E, leg 5. Scale bars: 0.2 mm in A–D; 0.1 mm in E.

Leg 1 (Fig. 3A) protopod carrying simple outer seta and another similar inner seta in addition to a vestigial endopod; first segment of exopod with row of setules along posterior margin plus small, spiniform outer seta; middle 2 of 4 terminal spines on last exopodal segment simple (without accessory process) (arrow in Fig. 3A); fourth terminal element smallest and shortest.

Leg 2 (Fig. 3B) protopod carrying large plumose inner seta on posteromedial edge, setule-bearing papillae on ventral surface, and small, simple, outer seta; posterior edge of protopod fringed with marginal membrane and outer edge of endopodal segments together with medial edge of proximal two exopodal segments fringed with row of setules.

Leg 3 (Fig. 3C) protopod (apron) with short outer and long inner setae; wide marginal membrane on outer edge and another marginal membrane on posterior edge of basis inner to velum; ventral surface of protopod with patches of spinules as shown in Fig. 3C.

Leg 4 (Fig. 3D) protopod with small, simple outer seta; exopod 2-segmented; proximal segment of exopod with single, moderately long spine; tip of exopod with 2 short outer and 1 long, inner elements (outermost element a simple seta; inner 2 elements spiniform); pecten on exopodal segments at insertion of proximal outer and distal innermost spines.

Leg 5 (Fig. 3E) comprising 2 processes with simple anterior process tipped with 1 plumose seta and quadripartite posterior process carrying 3 (1 simple and 2 plumose) setae. Leg 6 absent.

Male. Unknown.

Etymology. The new species is named after the late Professor Ching-Long Lin (Department of Aquatic Biosciences, National Chiayi University) who made great contributions to our knowledge on the parasitic copepod fauna of Taiwan.

Type locality. Off Tai-Dong County, Taiwan.

Type host. *Eumegistus illustris* Jordan & Jordan 1922

Infection site and intensity. One individual and three individuals of copepods appear on the gill rakers and caudal fin, respectively. Prevalence: 0–18.2%; mean intensity: 1.0–1.5 parasites per fish specimen (Table. 1).

Discussion

The new species, *Caligus lini* sp. nov. can be easily differentiated from its congeners by the combination of the following four features: (1) simple elements (without accessory process) at the tip of leg 1 exopod; (2) innermost terminal element at the tip of leg 1 exopod being the shortest (oppose to longest in many congeners); (3) an armature formula of I,III on leg 4 exopod; and (4) a quadripartite posterior process of leg 5 carrying 3 (1 simple and 2 plumose) setae. Many species of *Caligus* have 2-segmented exopod on leg 4 carrying an armature of I,III as in *Caligus lini*; however, there is only one species, *Caligus rogercresseyi* Boxshall & Bravo, 2000, bearing the same armature on leg 1 like the above described new species.

The most outstanding characteristic of *C. lini* is the structure of its leg 5. Currently, there are 255 nominal species of *Caligus* known (Ho *et al.* in press); however, not one of them is armed with a setae-bearing quadripartite process on its leg 5 like *C. lini*. Although many species of *Caligus* have 2 seta-bearing processes on their leg 5, all of them are represented by simple process or papillae and not a compound structure with 4 digital lobes as seen in *C. lini*. So far as we are aware, there is only one species, *C. tylosuri* (Rangnekar, 1956), with a special seta-bearing posterior process on leg 5. According to Lin & Ho's (2007) redescription, the posterior process of leg 5 in *C. tylosuri* is different from that of *C. lini* in being tripartite (instead of quadripartite). The new species also differs from *C. tylosuri* in bearing no accessory process on the middle two of the four terminal elements on leg 1 exopod.

It is interesting to point out that there are two types of leg 5 in the species of *Caligus*, with either one process (papilla) or two processes (papillae). Furthermore, each type can carry either 3 or 4 setae. Thus, we state that there are four known patterns of leg 5 in *Caligus*: 1) Pattern I—with 3 setae on one process, like in *C. cordyla* Pillai, 1963; 2) Pattern II—with 3 setae on two processes, like in *C. bonito* Wilson, 1905 (1 seta on anterior process and 2 setae on posterior process); 3) Pattern III—with 4 setae on one process, like in *C. bennetti* Causey, 1953; and 4) Pattern IV—with 4 setae on two processes, like in *C. epidemicus* Hewitt, 1971 or *C. lini* (1 seta on anterior process and 3 setae on posterior process). It would be much interested to find out which type of structure is the original form. In terms of Leg 6, the absence of leg 6 is common on the female sea lice, while it is represented by a papilla tipped with 1 to 3 pinnate setae in the male.

During our sampling period, we found that only 3 (7.1%) brilliant pomfret collected from Cheng-Gong Fishing Port in Tai-Dong County were infected by *C. lini*. It suggests that it may be a rare parasite among the brilliant pomfret population around the east costal of Taiwan. Our results also show that the highest infection (prevalence: 18.2%) and infestation (1.5) of *C. lini* occurred in October (Table. 1), but the data set on this species is still limited.

Acknowledgements

We would like to thank Jui-Lin Lee for his kindness and cooperation in making the necessary arrangements for us to purchase the fishes landed at Cheng-Gong Fishing Port in Tai-Dong. Our thanks are also due to Chi-Hsiang Chin of National Taiwan University for his assistance in the examination and collection of parasitic copepods from infected fishes.

References

- Boxshall, G.A. & Bravo, S. (2000) On the identity of the common *Caligus* (Copepoda: Siphonostomatoida: Caligidae) from salmonid netpen systems in southern Chile. In: Schram, F.R. (Ed.), *Contributions to Zoology. Proceedings of the Third International Workshop on Sea Lice*, 69 (1–2), 137–146.
- Carvalho-Filho, A., Marcovaldi, G., Sampaio, C.L.S., Paiva, M.I.G. & Duarte, L.A.G. (2009) First report of rare pomfrets (Teleostei: Bramidae) from Brazilian waters, with a key to Western Atlantic species. *Zootaxa*, 2290, 1–26.
- Causey, D. (1953) Parasitic Copepoda of Texas coastal fishes. *Publication of the Institute of Marine Sciences, University of Texas*, 3, 6–16.
- Hewitt, G.C. (1971) Two species of *Caligus* (Copepoda, Caligidae) from Australian waters, with a description of some developmental stages. *Pacific Science*, 25, 145–164.
- Ho, J.-S. & Lin, C.-L. (2004) *Sea Lice of Taiwan*. The Sueichan Press, Keelung, 388 pp.
- Ho, J.-S., Lin, C.-L. & Liu, W.-C. (2016) High diversity of *Caligus* species (Copepoda, Siphonostomatoida, Caligidae) in Taiwanese waters. *Zootaxa*. [in press]
- Humes, A.G. & Gooding, R.U. (1964) A method for studying the external anatomy of copepods. *Crustaceana*, 6, 238–240. <http://dx.doi.org/10.1163/156854064x00650>
- Huys, R. & Boxshall, G.A. (1991) *Copepod Evolution*. The Ray Society, London, 468 pp.
- Lin, C.-L. & Ho, J.-S. (2007) Six species of sea lice (Copepoda, Caligidae) new to Taiwan. *Journal of the Fisheries Society of Taiwan*, 34, 41–67.
- Pillai, N.K. (1963) Copepods parasitic on South Indian fishes: family Caligidae. *Journal of the Marine Biological Association of India*, 5, 68–96.
- Rangnekar, M.P. (1956) Parasitic copepods from the marine fishes of Bombay. *Journal of the University of Bombay*, (B), 24 (5), 42–65.
- Shao, K.T. (2015) The Fish Database of Taiwan, Available from: <http://fishdb.sinica.edu.tw> version (accessed 1 October 2015)
- Wilson, C.B. (1905) North American parasitic copepods belonging to the family Caligidae. Part 1. The Caliginae. *Proceedings of the United States National Museum*, 28 (1404), 479–672.