Crustacean Research 2021 Vol.50: 75–86

©*Carcinological Society of Japan.* doi: 10.18353/crustacea.50.0_75

Lamproglena chinensis Yü, 1937 (Copepoda: Cyclopoida: Lernaeidae), a gill parasite of the snakehead *Channa argus* (Cantor), from Kyushu, Japan, with an observation of the type specimens of *L. ophiocephali* Yamaguti, 1939

Daisuke Uyeno, Tadashi Tomizono, Yoshiyuki Osako & Kazuya Nagasawa

Abstract.— A lernaeid copepod, *Lamproglena chinensis* Yü, 1937, is redescribed based on the newly collected specimens from the snakehead *Channa argus* (Cantor) (Actinopterygii: Perciformes: Channidae) caught in Lake Imuta, Satsumasendai, Kagoshima Prefecture, Kyushu, southern Japan and the type specimens of *L. ophiocephali* Yamaguti, 1939, a junior synonym of *L. chinensis*, from the Kizu River, Kyoto Prefecture. The adult male was found from Japan for the first time. The collection of the species in this study represents the first record from Kyushu. The previous records of *L. chinensis* and its related species reported from Asian countries are also reviewed.
LSID urn:lsid:zoobank.org:pub:FA7725B4-5BBF-43E9-82C6-89A2665841BF

Key words: snakehead, invasive species, parasitic copepod, Lernaeidae, gill filaments

■ Introduction

The members of the cyclopoid family Lernaeidae are known to be parasites of freshwater fishes (Boxshall & Halsey 2004). In Japan, three species in two genera in the family have been reported (Nagasawa *et al.* 2007). *Lamproglena chinensis* Yü, 1937 is one of those lernaeids and has been recorded from the snakehead, *Channa argus* (Cantor) (Perciformes: Channidae), in Kyoto, Gifu, and Shiga prefectures (Nagasawa *et al.* 2007; Fig. 1). In Japan, the copepod was first reported as *Lamproglena ophiocephali* Yamaguti, 1939 from Kyoto (Yamaguti 1939). Sproston *et al.* (1950) mentioned that Yamaguti (1939) overlooked the original description of *L. chinensis* by Yü (1937) published two years ealier than his work. Therefore, *L. ophiocephali* is now regarded as a junior synonym of *L. chinensis*, since there is no major morphological difference shown (see Sproston *et al.* 1950; Nagasawa *et al.* 2007).

The snakehead was introduced in 1923–24 from the Korean Peninsula to Nara Prefecture, central Japan, and then established the populations on all four major islands of Japan (Honshu, Shikoku, and Kyushu by the 1950s–60s and Hokkaido by 1990s) (Maehata 2002). Based on these historical backgrounds, *L. chinensis* has been regarded as an invasive species (Grygier & Urabe 2003).

In this study, *L. chinensis* is redescribed using the specimens of both sexes collected from *C. argus* in Kagoshima Prefecture, Japan, and the type specimens of *L. ophiocephali* Yamaguti, 1939 from *C. argus* from the Kizu River, Kyoto Prefecture.

■ Materials and Methods

Fishes were collected from Lake Imuta,

Received: 08 Oct 2020. Accepted: 6 May 2021. Published online: 25 June 2021.

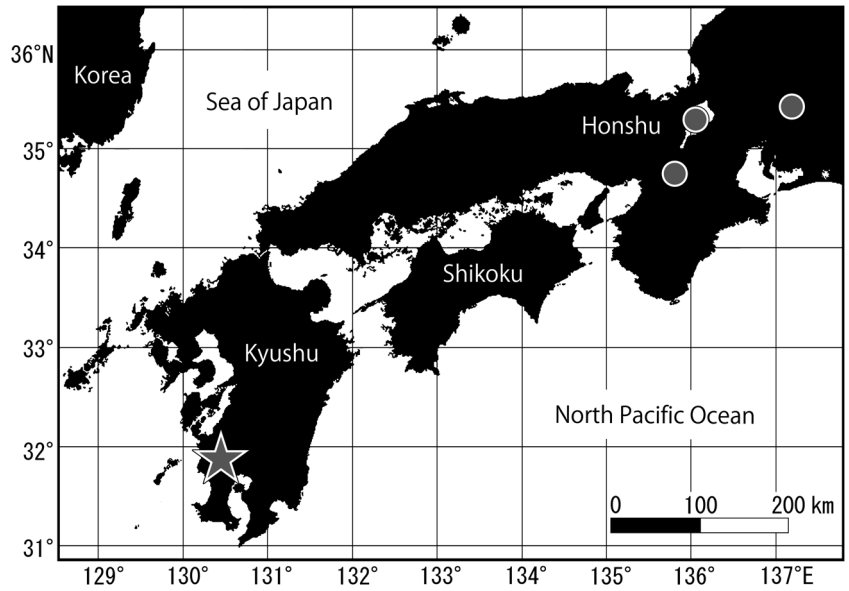

Fig. 1. Map showing the localities of *Lamproglena chinensis* Yü, 1937 in Japan. Star indicates the locality of the specimens in this study. Closed circles indicate the localities previously recorded: as *L. ophiocephali* from the Kizu River in Kyoto Prefecture (Yamaguti 1939); as *L. chinensis* from Lake Biwa in Shiga Prefecture (Grygier & Urabe 2003), a tributary of the Kiso River in Gifu Prefecture (Anonymous 2002).

Satsumasendai, Kagoshima Prefecture, Kyushu by hand nets. Copepods were removed from the hosts' gill filaments under a dissecting microscope (Leica M80) in the laboratory, fixed in 80% ethanol, and preserved in 99% ethanol. Subsequently, selected specimens were dissected with a sharpened tungsten needle under the dissecting microscope. Appendages and other small body parts were soaked in lactophenol for 24 hours, and observed based on a modified procedure of the wooden slide method by Humes & Gooding (1964). Illustrations were made with the aid of a drawing tube mounted on a compound microscope (Olympus BX53). Copepods' bodies were measured in mm or μm by an ocular micrometer as range followed by mean and standard deviation in parentheses. Voucher specimens are deposited in the crustacean collection of the National Museum of Nature and Science, Tsukuba, Japan (NSMT-Cr). The type specimens of *L. ophiocephali* were loaned from the Meguro Parasitological Museum (MPM), Tokyo and similarly examined. The scientific and common names of fishes used in this paper follow FishBase (Froese & Pauly, 2019).

■ Taxonomic Account

Family Lernaeidae Cobbold, 1879
[Japanese name: Ikari-mushi-ka]
Lamproglena von Nordmann, 1832
[Japanese name: Hime-ikari-mushi-zoku]
***Lamproglena chinensis* Yü, 1937**
[Japanese name: Hime-ikari-mushi]
(Figs. 2–4)

Lamproglena chinensis Yü, 1937: 132, 133–139, figs. 1–8. — Markewitsch, 1946: 234, 235. — Sproston *et al.*, 1950: 62, 70–75, 77, 79, figs. 22–28. — Dogel & Akhmerov, 1952: 285. — Markewitsch, 1956: 275. — Wang, 1958: 163–164, 168, pl. 2, fig. 11. — Yin, 1962: 41. — Yamaguti, 1963: 165 (list). — Wang, 1964: 469, 473 (key, list). — Smirnova, 1971: 190. — Chen, 1973: 238,

239, 269, pl. CXLIII, figs. 154–163. — Song & Kuang, 1980: 31, 84, 87. — Gusev, 1987: 435, 436. fig. 513. — Kuang & Qian, 1985: 367 (key). — Kuang & Qian, 1991: 44. 115, 119, 120. fig. 76. — Kim, 1998: 820–823, figs. 405–406. — Anonymous, 2002: 210. — Grygier & Urabe, 2003: 6. — Kim & Choi, 2003: 89–92, figs. 21–22. — Nagasawa *et al.*, 2007: 27–28.

Lamproglena ophiocephali Yamaguti, 1939: 473–474, 486, 487, pl. XXVIII, figs. 139–149. — Yamaguti, 1963: 166 (list).

? *Lamproglena chinensis*: — Mendis & Fernando, 1962: 66. — Jafri & Mahar, 2009: 38, fig. 1. — Batool *et al.*, 2018: 106–108, fig. 1. — Dev Roy & Venkataraman, 2018: 125. — Vankara, 2018: 1750–1752.

? *Lamproglena ophiocephali*: — Kumari *et al.*, 1989: 16, 17, 21, figs. 28–37. — Dev Roy & Venkataraman, 2018: 126.

Type material

Syntype (not examined): multiple number of females, ex *Channa argus* (Cantor) (reported as *Ophiocephalus argus*) (Perciformes: Channidae), the fish markets in Beijing (= Peiping, Hopei Province), China, date uncertain in 1936, leg. H.-J. Na, registered to the Zoological Museum of Fan Institute of Biology, the predecessor of Institute of Zoology, Chinese Academy of Sciences.

Material examined

1 adult female (NSMT-Cr 29035), ex *Channa argus* (50.7 cm standard length), Lake Imuta (31°48′N, 130°28′E), Satsumasendai City, Kagoshima Prefecture, Japan, 3 July 2019, leg. T. Tomizono, Y. Osako, H. Uyeno, and D. Uyeno; 1 adult male (NSMT-Cr 29036), collection data same as NSMT-Cr 29035; 3 adult females and 2 adult males (NSMT-Cr 29037), collection data same as NSMT-Cr 29035; "Syntype" of *Lamproglena ophiocephali* Yamaguti, 1939: 17 adult females (including 1 premetamorphic adult female) (MPM SY103), ex *Channa argus*, Kizu River, Kyoto Prefecture, Japan, 5 June 1935.

Description

Newly collected adult female. Body (Fig. 2A, B) slender, 4.23–4.40 (4.32 ± 0.07) mm long (n = 4). Cephalon (Fig. 2C, D) wider than long, 266–343 (293 ± 35) × 403–418 (414 ± 7) μm, separated by constriction from first thoracic somite. Neck region comprising premaxillipedal process, maxilliped, and leg 1, with laterally expanded anterior portion. Second to fifth pedigerous somites fused and forming trunk (Fig. 2A, B). Trunk longer than wide, 711–883 (802 ± 72) × 443–533 (487 ± 37) μm. Fifth pedigerous somite incompletely separated by constrictions from both trunk and following genital double somite (Fig. 2A, E). Genital double somite (Fig. 2A, E) almost same as long as wide, 271–342 (308 ± 34) × 283–340 (324 ± 27) μm, with genital openings on lateral sides (Fig. 2F). Abdomen (Fig. 2A, B) 3-segmented; terminal segment elongate, longer than first two; 360–483 (432 ± 52) × 260–290 (263 ± 26) μm, 505–572 (533 ± 28) × 232–272 (254 ± 20) μm, and 1238–1337 (1291 ± 45) × 198–220 (212 ± 10) μm, respectively. Caudal ramus (Fig. 2G) longer than wide, 87–101 (95 ± 6) × 37–41 (39 ± 2) μm, bearing five small setae and single stout distal seta. Egg sac (Fig. 2A) uniseriate.

Antennule (Fig. 2H) un-segmented, bearing 16 setae on anterior margin, three setae on posterior margin, and five normal and single bifurcated distal setae; all setae naked. Antenna (Fig. 2I) unsegmented, bearing four small setae on anterior margin and six distal setae. Mandible and maxillule not found. Maxilla (Fig. 2J) robust, 2-segmented with terminal claw. Premaxillipedal process (Fig. 2K) knob-like. Maxilliped (Fig. 2K) 2-segmented; proximal segment with conical basal process and subterminal process tipped with seta; distal segment tipped with four subequal claws and single minute element.

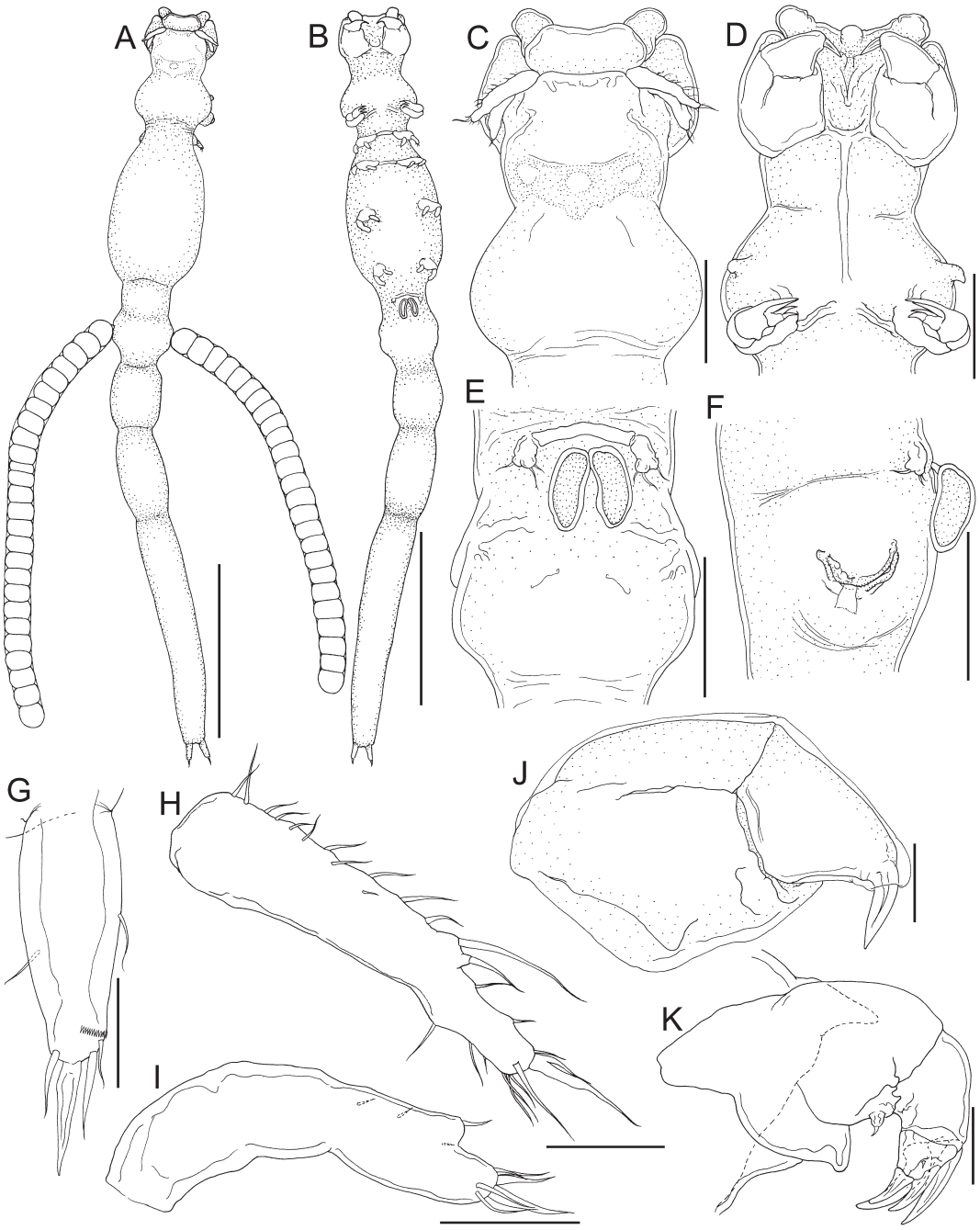

Fig. 2. *Lamproglena chinensis* Yü, 1937, adult female, NSMT-Cr 29035. A, habitus, dorsal; B, same, ventral; C, anterior portion of body, dorsal; D, same, ventral; E, fifth pedigerous somite and genital double somite, ventral; F, same, right lateral; G, left caudal ramus, ventral; H, right antennule, anterior; I, right antenna, anterior; J, right maxilla, posterior; K, right maxilliped, posterior. Scale bars: A, B, 1 mm; C–F, 200 μm; G–I, 40 μm; J, K, 50 μm.

Legs 1–4 (Fig. 3A–D) biramous; both rami 2-segmented; armature formula shown in Table 1. Intercoxal sclerites present on legs 1 and 2 (Fig. 3A, B). Basis of legs 1 to 4 with marginal spinulated flanges. Distal exopodal segments of legs 1 to 4 with sclerotised, squamate, dorsal denticles. Endopods of legs 1 to 4 with pectinated outer margins. Leg 5 (Fig. 3E) represented by unsegmented, quadrangular lobe bearing three setae, with intercoxal sclerite-like frame. All setae on legs 1 to 5 naked.

Table 1. Armature formula of legs 1 to 4 of *Lamproglena chinensis* Yü, 1937, adult female. Arabic numbers = number of setae, Roman numbers = number of spines.

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-1; II, 5	0-1; I, 5
Leg 2	0-1	1-0	I-1; II, 5	0-1; I, 5
Leg 3	0-1	1-0	I-1; II, 5	0-1; I, 5
Leg 4	0-1	1-0	I-1; II, 5	0-1; 5

Adult female among the syntype specimens of *Lamproglena ophiocephali* from the Kizu River. Morphology as in the newly collected specimens. The measurements of the body parts (n = 5) are as follows: body length, 3.15–3.30 (3.22 ± 0.07) mm; cephalon wider than long, 231–302 (267 ± 28) × 302–334 (317 ± 14) μm; trunk longer than wide, 723–777

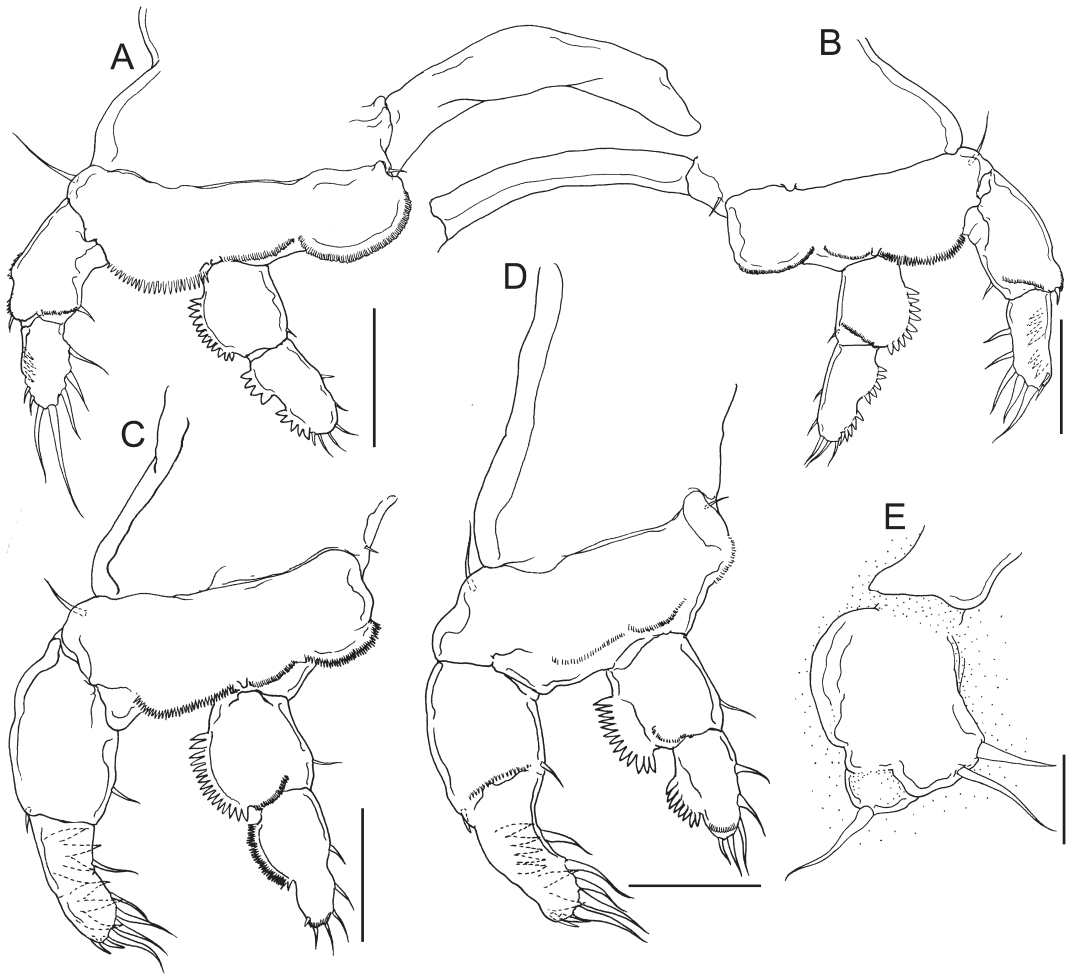

Fig. 3. *Lamproglena chinensis* Yü, 1937, adult female, NSMT-Cr 29035. A, right leg 1, anterior; B, left leg 2, anterior; C, right leg 3, anterior; D, right leg 4, anterior; E, right leg 5, anterior. Scale bars: A–D, 50 μm; E, 20 μm.

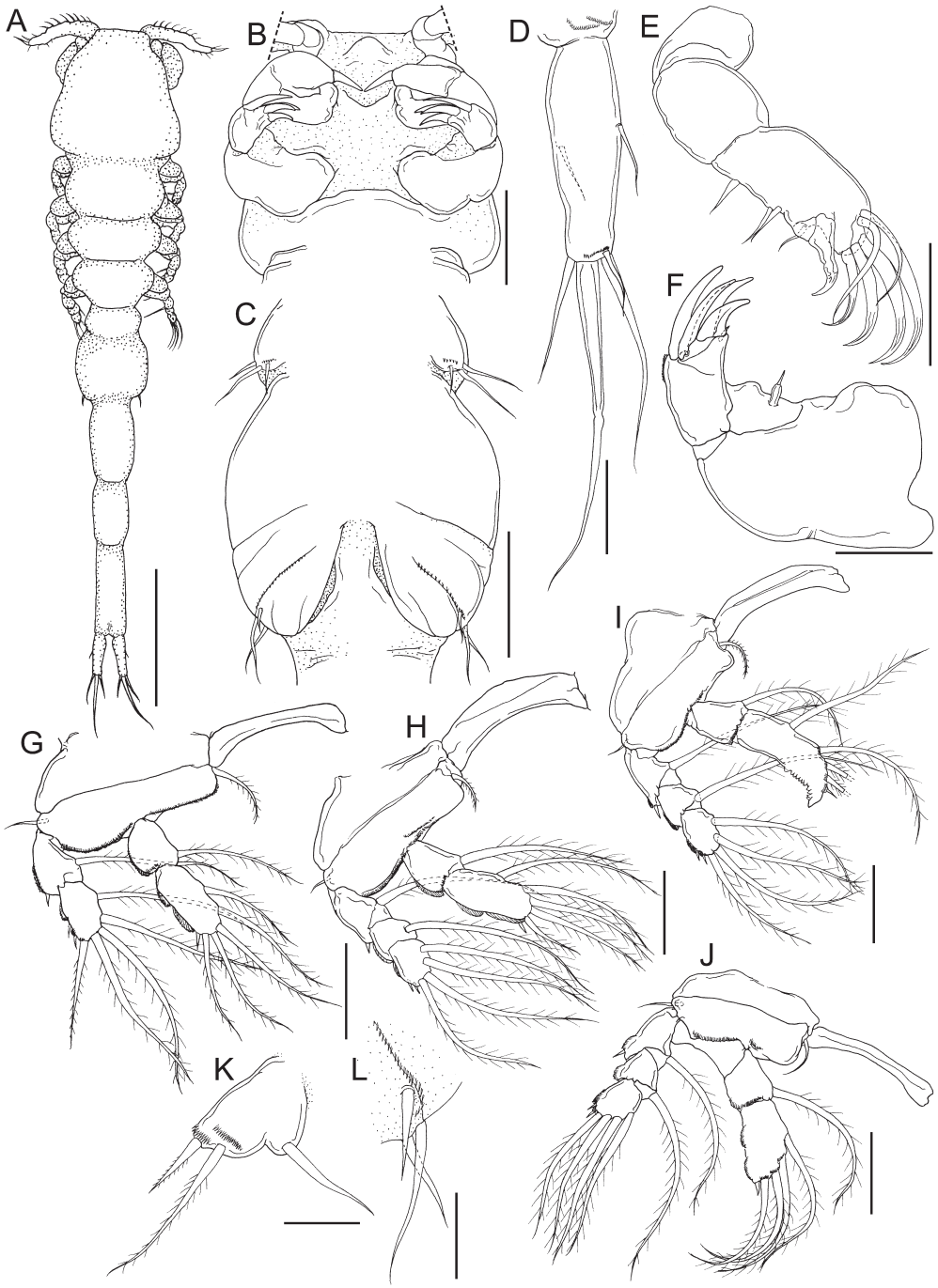

Fig. 4. *Lamproglena chinensis* Yü, 1937, adult male, NSMT-Cr 29036. A, habitus, dorsal; B, anterior portion of body, ventral; C, fifth pedigerous somite and genital somite, ventral; D, left caudal ramus, ventral; E, left antenna, anterior; F, right maxilla, posterior; G, right leg 1, anterior; H, right leg 2, anterior; I, right leg 3, anterior; J, right leg 4, anterior; K, left leg 5, anterior; L, left leg 6. Scale bars: A, 300 μm; B, 100 μm; C, 30 μm; D, E, 40 μm; F–J, 50 μm; K, L, 20 μm.

(746 ± 22) × 403–580 (505 ± 80) μm; genital double somite wider than long, 226–242 (233 ± 6) × 268–303 (282 ± 14) μm; first and second urosomites and anal somite length and width as follows, 309–377 (342 ± 28) × 211–232 (222 ± 9) μm, 332–398 (377 ± 26) × 191–211 (200 ± 8) μm, and 778–865 (826 ± 39) × 158–182 (165 ± 11) μm; caudal ramus 2.13–2.34 (2.20 ± 0.08) times longer than wide, 66–75 (69 ± 3) × 30–32 (31 ± 1) μm.

Newly collected adult male. Body (Fig. 4A) cyclopiform, 1.42–1.54 (1.49 ± 0.07) mm long (n = 3). Prosome (Fig. 4A), 612–661 (641 ± 25) μm long, consisting of cephalosome (Fig. 4B), first to fourth pedigerous somites. Cephalosome almost same as long as wide or slightly wider, 274–291 (281 ± 9) × 287–311 (301 ± 13) μm. Fifth pedigerous somite small (Fig. 4A), incompletely fused to genital somite. Genital somite (Fig. 4C) almost same as long as wide, 158–187 (168 ± 16) × 158–164 (162 ± 3) μm. Urosome (Fig. 4A) 3-segmented, 168–191 (180 ± 11) × 92–100 (96 ± 4) μm, 138–157 (147 ± 9) × 78–89 (83 ± 6) μm, and 202–224 (214 ± 12) × 67–77 (74 ± 6) μm, respectively. Caudal ramus (Fig. 4A, D) longer than wide, 89–96 (92 ± 4) × 30–33 (31 ± 2) μm, with six setae.

Antennule and maxilla as in female. Sexual dimorphisms presented on antenna and maxilliped. Antenna (Fig. 4E) 3-segmented: proximal segment (coxa) and middle segment (basis) unarmed; distal segment (endopod) bearing three setae on inner margin, single claw and single seta on subterminal inner margin, and four claws and two setae on distal tip. Mandible and maxillule not found. Maxilliped (Fig. 4F) 2-segmented; proximal segment with small round basal projection and subterminal process tipped with seta and small round projection; distal segment tipped with four claws and two tiny elements and bearing row of spinules on outer margin.

Legs 1–4 (Fig. 4G–J) biramous; both rami 2 to 3-segmented; armature formula shown in Table 2. Intercoxal sclerites present on legs 1 to 4 (Fig. 4G–J). Basis of legs 1 to 4 with spinulated flanges on posterior margins. Distal endopodal segment of leg 3 bearing serrated outer margin and pointed apex (Fig. 4I). Both rami of legs 1 to 4 with spinulated flanges on outer margins. Setae on coxae and both rami plumosed, excluding distal tiny seta on distal endopodal segments of legs 3 and 4. Leg 5 (Fig. 4C, K) represented by unsegmented, quadrangular lobe bearing three setae and spinulated flanges. Leg 6 (Fig. 4C, L) represented by three setae on genital opercula.

Table 2. Armature formula of legs 1 to 4 of *Lamproglena chinensis* Yü, 1937, adult male. Arabic numbers = number of setae, Roman numbers = number of spines.

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-1; II, 5	0-1; I, 5
Leg 2	0-1	1-0	I-1; 0-1; II, 4	0-1; I, 5
Leg 3	0-1	1-0	I-1; 0-1; II, 4	0-1; I, 4
Leg 4	0-1	1-0	I-1; 0-1; II, 4	0-1; I, 4

Site of infection

Gill filaments.

Remarks

Lamproglena chinensis was originally described based on female specimens from the gills of *Channa argus* (reported as *Ophiocephalus argus*) collected at fish markets in Beijing (= Peiping) and Hebei (= Hopei Province), China (Yü 1937). In Japan, Yamaguti (1939) described *L. ophiocephali* based on numerous females from the same fish host species, *C. argus* (reported as *O. argus*) collected in the Kizu River, Kyoto Prefecture. While *L. ophiocephali* was listed to be a valid species by Yamaguti (1963), it has been regarded as a junior synonym of *L. chinensis* (see Sproston *et al.* 1950; Nagasawa *et al.* 2007). In this study, some differences are found in body size of the syntype specimens of *L. ophiocephali* and the newly collected females (*e.g.*, body length 3.15–3.30 mm *vs.* 4.23–4.40 mm, respectively).

However, there is no significant morphological difference in females from China (Yü 1937; Sproston *et al.* 1950; Chen 1973; Song & Kuang 1980; Kuang & Qian 1991), Japan (Yamaguti 1939; this paper), Korea (Kim 1998; Kim & Choi 2003), and Far Eastern Russia (Markewitsch 1946, 1956; Gusev 1987). Therefore, based on these facts, both *L. chinensis* and *L. ophiocephali* are considered conspecific as suggested in previous studies. All records are based on the specimens collected from the snakehead *Channa argus*, except for a single record from the small snakehead *Channa asiatica* (Linnaeus) (Channidae) in China (Kuang & Qian 1991).

The adult males collected in this study differ from those described by Sproston *et al.* (1950) in having both rami of leg 1 and the endopods of legs 2 to 4 being all 2-segmented (*vs*. all rami 3-segmented). Moreover, despite the fact the total elemental number on each ramus of legs 1 to 4 is identical in the present and Sproston *et al.*'s male specimens, one spine is present on the endopod of leg 3 in the former specimens, while no spine is found in the latter specimens. Sproston *et al.* (1950) might have miscounted the number of the segments.

■ Discussion

While *L. chinensis* has been reported only from channids (*Channa argus* and *C. asiatica*) in Far East Asia (see above), there are records of *L. chinensis* from a fish of different family, the climbing perch *Anabas testudineus* (Bloch) (Anabantidae), from Thailand (Capart 1943; Ho & Kim 1997). Yamaguti (1963) also listed the Burmese trout *Raiamas guttatus* (Day) (= *Barillus* [sic] *harmandi*) (Cyprinidae) as an additional host of *L. chinensis*, but the fish species was, most probably, erroneously listed because it is the host of *Lamproglena inermis* Capart, 1943 from Thailand (see Capart 1943). According to Ho & Kim (1997), there was a difference in body length of female *L. chinensis* from Thailand and China: 2.67–2.80 mm (Capart 1943; Ho & Kim 1997) and 3.1–3.95 mm (Kuang & Qian 1991), respectively. However, Yü (1937) reported the type specimens from China as being 2.89 mm long, and Sproston *et al.* (1950) collected a specimen of 2.40 mm long from China. Therefore, the body length of females cannot be used to distinguish them from both countries. The Japanese female specimens also show variations in body length (see the above Remarks).

Kim & Choi (2003) reported on morphological differences in females from Thailand (Capart 1943; Ho & Kim 1997) and Korea and stated the copepods from both countries are not conspecific. We also noticed the following morphological differences of females from Thailand (Ho & Kim 1997) and Japan: fifth pedigerous somite distinctly separated from both the trunk and the following genital double somite (*vs*. indistinctly segmented); the maxilliped without armature on the proximal segment (*vs*. bearing one subterminal process tipped with seta); one of distal claws of the maxilliped remarkably recurved (*vs*. slightly curved); bases of legs 1 to 4 with blunt, inner protrusions with spinules (*vs*. inner margins not greatly protruded with spinules); and the second endopodal segment of the leg 4 with smooth outer margin (*vs*. with pectinated margin). Kim & Choi (2003) stated that there were no detailed illustrations in the original description of *L. chinensis*, in which, however, the pectinated outer margin of the second endopodal segment of leg 4 was clearly illustrated (Yü 1937, fig. 7), and this character is shared with specimens from China, Japan, Korea, and Far East Russia but not shared with specimens from Thailand (Yamaguti 1939, fig. 148; Chen 1973, fig. 161; Gusev 1987, fig. 513IV; Kuang & Qian 1991, fig. 76I; Kim 1998, fig. 406D; Kim & Choi 2003, fig. 22C; this paper, Fig. 3D). Therefore, the copepods reported from Thailand are considered a different species from *L. chinensis*.

There are some records of "*L. chinensis*" and "*L. ophiocephali*" from the striped sneakhead *Channa striata* (Bloch), the spotted snakehead *C. punctata* (Bloch) (both Channidae), and the Philippine catfish *Clarias batrachus* (Linnaeus) (Clariidae) from other tropical Asian countries, including Sri Lanka, India, and Pakistan (Mendis & Fernando 1962; Kumari *et al.* 1989; Jafri & Mahar 2009; Dev Roy & Venkataraman 2018; Vankara 2018). There is also a record of "*L. chinensis*" from the silver pomfret *Pampus argenteus* (Euphrasen) (Stromateidae) in coastal marine waters of Pakistan (Batool *et al.* 2018). However, all these copepods cannot be readily identified as *L. chinensis* because their morphology has been insufficiently reported (Kumari *et al.* 1989; Jafri & Mahar 2009; Batool *et al.* 2018) or has not been described (Mendis & Fernando 1962; Dev Roy & Venkataraman 2018; Vankara 2018). As suggested below, it is most likely that the copepods reported by Kumari *et al.* (1989) and Jafri & Mahar (2009) are different from *L. chinensis*.

The striped sneakhead *C. striata* (Bloch) is known to have infections by *Lamproglena chinensis sprostoni* Kirtisinghe, 1964, *Lamproglena krishnai* Thomas & Hameed, 1984, and *Lamproglena forficata* Kuang, 1977 in Sri Lanka, India, and southern China and Thailand, respectively (see Kirtisinghe 1950, 1964; Sproston *et al.* 1950; Kuang 1977; Thomas & Hameed 1984; Ho & Kim 1997). These *Lamproglena* species are indeed morphologically similar to *L. chinensis* but their females differ from those of *L. chinensis* in the following characters: 1) a conical caudal rami fused with the abdomen and; and 2) several rami of legs 1 to 4 being 3-segmented (see Sproston *et al.* 1950; Kim 1998; Kim & Choi 2003; this paper). Thus, *L. chinensis sprostoni*, *L. krishnai*, and *L. forficata* can be separated from *L. chinensis*. Moreover, the copepods reported as "*L. chinensis*" and "*L. ophiocephali*" from India and Pakistan (Kumari *et al.* 1989; Jafri & Mahar 2009) have the above first character, and those copepods have intercoxal screlites on legs 3 and 4 (Kumari *et al.* 1989, fig. 28; Jafri & Mahar 2009, fig. 1A; Batool *et al.* 2018, fig. 1C), which are not found in *L. chinensis.*

Based on the discussion in the above four paragraphs, the copepods of *Lamproglena* occur in tropical Asian countries (Thailand, Sri Lanka, India, and Pakistan), but there is no paper of the copepods whose characters clearly match those of *L. chinensis*. As pointed out by Dippenaar *et al.* (2001), the revision of the genus *Lamproglena* is required, because the species of the genus have been often inadequately described even in their original descriptions. In order to determine the taxonomic status of "*L. chinensis*" in tropical Asian countries, reexaminations of specimens from those countries are required.

In addition to the first record of *L. chinensis* as *L. ophiocephali* from Kyoto by Yamaguti (1939), the copepod has been reported from Gifu and Shiga prefectures, Honshu, central Japan. Therefore, the present collection of the species in this study represents the first record from Kyushu (Fig. 1). Two species of lernaeids, *L. chinensis* and *Lernaea cyprinacea* Linnaeus 1758 (Fukushima *et al.* 2020), are now known to occur in Kagoshima Prefecture.

■ Acknowledgements

We thank Kazuo Ogawa and Takashi Iwaki (Meguro Parasitological Museum) for their curatorial work to loan the type specimens of *L. ophiocephali*. We also acknowledge Hiroko Uyeno (Kagoshima Museum of Environment: Planet Earth and its Future) for her help in collecting specimens. Part of this work was supported by the Japan Society for Promotion of Science (JSPS) KAKENHI Grant Number JP15H06517 and JP17K15304; and "Establishment of Glocal Research and Education Network in the Amami Islands" project of Kagoshima University adopted by the Ministry

of Education, Culture, Sports, Science and Technology, Japan.

■ Literature cited

Anonymous, 2002. The parasite fauna of fishes in an experimental river and its characteristics. Annual Report of the Aqua Restoration Research Center 2001: 206–218. [In Japanese]

Batool, A., Farooq, S., Arshad, N., & Ara, M., 2018. New host record for parasitic copepod, *Lamproglena chinensis* Yü, 1937 from marine fish *Pampus argenteus*. Pakistan Journal of Marine Sciences, 27: 105–110.

Boxshall, G. A., & Halsey, S. H., 2004. An Introduction to Copepod Diversity. xv + 966 pp. Ray Society, London.

Capart, A., 1943. Notes sur les Copépodes parasites. I. Quelques Copépodes parasites des poissons d'eau douce de Thaïlande. Bulletin du Musée Royal d'Histoire Naturelle de la Belgique, 19: 1–12.

Chen, C. L., 1973. An Illustrated Guide to the Fish Disease and Causative Pathogenic Fauna and Flora in the Hupei Province. 456 pp. Science Press, Beijin. [In Chinese]

Cobbold, T. S., 1879. Parasites; a Treatise on the Entozoa of Man and Animals Including Some Account of the Ectozoan. 508 pp. J. & A. Churchill, London.

Dev Roy, M. K., & Venkataraman, K., 2018. Catalogue on copepod fauna of India. Part 2. Cyclopoida and Harpacticoida (Arthropoda: Crustacea). Journal of Environment and Sociobiology, 15: 109–194.

Dippenaar, S. M., Luus-Powell, W. J., & Roux, F., 2001. *Lamproglena hoi* n. sp. (Copepoda: Lernaeidae) from two yellowfish hosts, *Barbus marequensis* and *Barbus polylepis*, caught in a river in Mpumalanga, South Africa. Onderstepoort Journal of Veterinary Research, 68: 209–215.

Dogel, V. A., & Akhmerov, A. K., 1952. Parasitic Crustacea of Amur River fishes. Uchenie Zapiski Leningradskogo Ordena Gosudarstevennogo Univerrsiteta, Seria Biologiia Nauka, 141: 268–294. [In Russian]

Froese, R., & Pauly, D. (eds), 2019. FishBase. World Wide Web electronic publication, version (12/2019). Available at http://www.fishbase.org (3 October 2020).

Fukushima, K., Fukusima, S., Machigashira, Y., Oki, K., & Uyeno, D., 2020. New distributional records of the anchor worm *Lernaea cyprinacea* (Copepoda: Cyclopoida: Lernaeidae) from southern Kyushu and Amami Oshima Island, southern Japan. Fauna Ryukyuana, 55: 1–8. [In Japanese with English abstract]

Grygier, M. J., & Urabe, M., 2003. Fish parasites introduced into Lake Biwa from overseas. Umindo (Quarterly Newsletter of the Lake Biwa Museum), 8: 6. [In Japanese]

Gusev, A. V., 1987. Phylum Arthropoda. In: O. N. Bauer, (ed.), Key to the Parasites of Freshwater Fishes of the Fauna of the USSR. Part 3, Nauka, Leningrad, pp. 378–524. [In Russian]

Ho, J.-S., & Kim, I.-H., 1997. Lernaeid copepods (Cyclopoida) parasitic on freshwater fishes of Thailand. Journal of Natural History, London, 31: 69–84.

Humes, A. G., & Gooding, R. U., 1964. A method for studying the external anatomy of copepods. Crustaceana, 6: 238–240.

Jafri, S. I. H., & Mahar, M. A., 2009. New record of two copepod parasites from fresh water fishes of Sindh, Pakistan. Sindh University Research Journal (Science Serie), 41: 37–40.

Kim, I.-H., 1998. Cirripedia, Symbiotic Copepoda, and Pycnogonida. Illustrated Encyclopedia of Fauna & Flora of Korea. Vol. 38. 1038 pp. Ministry of Education, Seoul. [In Korean]

Kim, I.-H., & Choi, S.-K., 2003. Copepod parasites (Crustacea) of freshwater fishes in Korea. Korean Journal of Systematic Zoology, 19: 57–93.

Kirtisinghe, P., 1950. Parasitic copepods of fish from Ceylon. III. Parasitology, 40: 77–86.

Kirtisinghe, P., 1964. A review of the parasitic

copepods of fish recorded from Ceylon, with descriptions of additional forms. Bulletin of the Fisheries Research Station, Sri Lanka (Ceylon), 17: 45–132.

Kuang, P. R., 1977. Parasitic copepods from freshwater fishes of China I. On the genus *Lamproglena* (Lernaeidae) with description of five new species. Acta Zoologica Sinica, 23: 290–302. [In Chinese with English summary]

Kuang, P. R., & Qian, J. H., 1985. Three new species of the genus *Lamproglena* from China (Copepoda: Cyclopoida, Lernaeidae). Acta Zootaxonomica Sinica, 10: 363–369. [In Chinese with English summary]

Kuang, P. R., & Qian, J. H., 1991. Parasitic Crustacea of Freshwater Fishes. Economic Fauna of China. 203 pp. Editorial Committee of Fauna Sinica, Academia Sinica, Science Press, Beijing. [In Chinese]

Kumari, P., Khera, S., & Gupta, N. K., 1989. On six new species of the genus *Lamproglena* Nordmann (Copepoda: Eudactylinidae), ectoparasitic on freshwater fishes of India. Research Bulletin of the Panjab University of Science, 40: 9–23.

Maehata, M., 2002. *Channa argus*. In: The Ecological Society of Japan, (ed.), Handbook of alien species in Japan, Chijinshokan, Tokyo, p. 120. [In Japanese]

Markewitsch, A. P., 1946. Parazitichni Copepoda ryb z basseinu r. Amura. Nauk. Zap. kyyiv. derzh. Univ, 5: 225–246. [In Russian with English summary]

Markewitsch, A. P., 1956. Parasitic Copepods on the Fishes of the USSR. 259 pp. Izdatelstvo Akademii Nauk Ukrainkoi SSR, Kief (Translated from Russian, Indian National Scientific Documentation Centre, Hillside Road, New Delhi, 445 p., 1976).

Mendis, A. S., & Fernando, C. H., 1962. A guide to the freshwater fauna of Ceylon. Bulletin of the Fisheries Research Station, Ceylon, 12: 1–160.

Nagasawa, K., Inoue, A., Myat, S., & Umino, T., 2007. New host records for *Lernaea cyprinacea* (Copepoda), a parasite of freshwater fishes, with a checklist of the Lernaeidae in Japan (1915–2007). Journal of the Graduate School of Biosphere Science, Hiroshima University, 46: 21–33.

Nordmann, A. von., 1832. Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere. Zweites Heft. Mit zehn Kupfertafeln, G. Reimer, Berlin, 18: 1–150, pls. I–X.

Smirnova, T. S., 1971. Parasitic Crustacea from the fishes of the river Amur's basin. Zoological Institute, Akademii Nauk USSR, Parasitological Papers, 25: 177–195. [In Russian]

Song, D. X., & Kuang P. R. (eds.), 1980. Zhongguo dongwu tupu. Jiaqiao dongw di 4-ce (Atlas of Chinese animals. Crustacea part 4). Science Press, Peking (Beijing): 1–90.

Sproston, N. G., Yin, W. Y., & Hu, Y. T., 1950. The genus *Lamproglena* (Copepoda Parasitica): the discovery of the life-histories and males of two Chinese species from food fishes, revealing their relationship with Lernaea, and of both to the Cyclopoidea. Sinensia, Shanghai. n. ser., 1: 60–84.

Thomas, S., & Hameed, M. S., 1984. Description of a new species of *Lamproglena* (Copepoda: Lernaeidae) from Kerala. Indian Journal of Fisheries, 31: 223–227.

Vankara, A., 2018. Community ecology of metazoan parasites of freshwater fishes of River Godavari, Rajahmundry, Andhra Pradesh, India. International Journal of Current Research in Life Sciences, 7: 1746–1761.

Wang, K.-N., 1958. Preliminary studies of *Lamproglena* parasitic on the gills of freshwater fishes taken from the area between Nanking and Shanghai. Acta Zoologica Sinica, 10: 163–172. [In Chinese with English summary]

Wang, K.-N., 1964. Parasitic crustaceans of freshwater fishes from Kiangsu and Shanghai. Acta Zoologica Sinica, 16: 465–473. [In Chinese with English abstract]

Yamaguti, S., 1939. Parasitic copepods from

fishes of Japan. Part 5. Caligoida, III. Volume Jubilare for Prof. Sadao Yoshida, 2: 443–487, pls. 14–33.

Yamaguti, S., 1963. Parasitic Copepoda and Branchiura of Fishes. 1104 pp. Wiley Interscience, New York.

Yin, W.-Y., 1962. Parasitic copepods and Branchiura of fresh-water fishes from Northeast China and Inner Mongolia. Acta Hydrobiologica Sinica, 1962(1): 31–46, pl. 1. [In Chinese with English abstract]

Yü, S. C., 1937. Synopsis of the genus *Lamproglena* Nordmann with description of a new species from North China. Bulletin of the Fan Memorial Institute of Biology, Zoology, 7: 131–139.

Addresses

(DU) Graduate School of Engineering and Science, Kagoshima University, 1–21–35 Korimoto, Kagoshima 890–0065, Japan

(TT, YO) Kedoin Ecosystem Preservation Archive Center Aquaim, 1999–2 Imuta, Kedoin, Satsumasendai, Kagoshima 895–1502, Japan

(KN) Aquaparasitology Laboratory, 365–61 Kusanagi, Shizuoka 424–0886, Japan

E-mail addresses

(DU)* duyeno@sci.kagoshima-u.ac.jp

*Corresponding author