

Redescription of *Luetkenia elongata* (Copepoda: Siphonostomatoida: Pandaridae), an Ectoparasite of *Luvarus imperialis* (Actinopterygii: Perciformes: Luvaridae), with a New Record from Japanese Waters

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A rare copepod parasitic on marine fish, *Luetkenia elongata* Shiino, 1963 (Siphonostomatoida: Pandaridae), is re-described based on type specimens and additional specimens obtained from *Luvarus imperialis* Rafinesque, 1810 caught in the eastern and western North Pacific Ocean off California and Japan, respectively. This represents the first record of this parasite from Japanese waters. The copepod differs from its sole congener, *L. asterodermi* Claus, 1864, by following features of the female: fourth pedigerous somite with one pair of elongate posterolateral lobes; genital complex bearing a pair of well-developed posterolateral lobes with one conical protuberance on lateral corner; abdomen clearly longer than wide; and caudal rami more than 2.0 times longer than wide.

Key Words: Luvar, parasitic copepod, redescription, North Pacific Ocean, Japanese waters.

Introduction

Pandaridae (Siphonostomatoida) is a copepod family associated with marine fishes. Most species of the family are found on the body surface and fins, around gills, and in the mouth and nasal passages of elasmobranchs (Boxshall and Halsey 2004). The pandarid genus *Luetkenia* Claus, 1864 is unusual because the two known species attach to an actinopterygian fish, *Luvarus imperialis* Rafinesque, 1810 (Perciformes: Luvaridae) (Kabata 1979). Since capture of the host fish, luvar, are uncommon, opportunities to collect copepods from them are rare (see Kabata 1979). Claus (1864) described the type species, *Luetkenia asterodermi* based on specimens collected from the Mediterranean. Although this genus was originally attributed to another siphonostomatoid family, Cecropidae Dana, 1852, that family is currently regarded as a junior synonym of Pandaridae (Tang *et al.* 2012). The other congener, *L. elongata* Shiino, 1963, was described based on specimens of both sexes from *L. imperialis* caught in the eastern North Pacific Ocean off California (Shiino 1963). Since then, there have been no further records of it.

In this paper, *L. elongata* is re-described based on types and newly collected material from a specimen of *L. imperialis* stranded in the surf zone at Enoshima island, Sagami Bay, Japan in the western North Pacific Ocean.

Materials and Methods

Copepods taken from a luvar stranded in the surf zone were fixed in 70% ethanol, subsequently soaked in lactophenol for 24 hrs, dissected using sharpened tungsten needles, and examined under a compound microscope using a modified version of the wooden slide method of Humes and Gooding (1964). Drawings were made with the aid of a drawing tube. Copepod body parts were measured using a calibrated ocular micrometer, and measurements are given in millimeters (mm) shown as ranges, followed by the mean and standard deviation in parentheses. Body length was measured from the frontal plates to the tips of the caudal rami without setae. Specimens are deposited in the crustacean collection of the Kanagawa Prefectural Museum of Natural History, Odawara (KPM) and the National Museum of Nature and Science, Tsukuba (NSMT), Japan. Type specimens examined were loaned from NSMT. The photographs in Fig. 1 are taken from the database of digital images of KPM (KPM-NR 108977 O and KPM-NR 108977 P).

Genus *Luetkenia* Claus, 1864
Luetkenia elongata Shiino, 1963
(Figs 1–5)

Lütkenia elongata Shiino, 1963: 349–356, figs 1, 2.

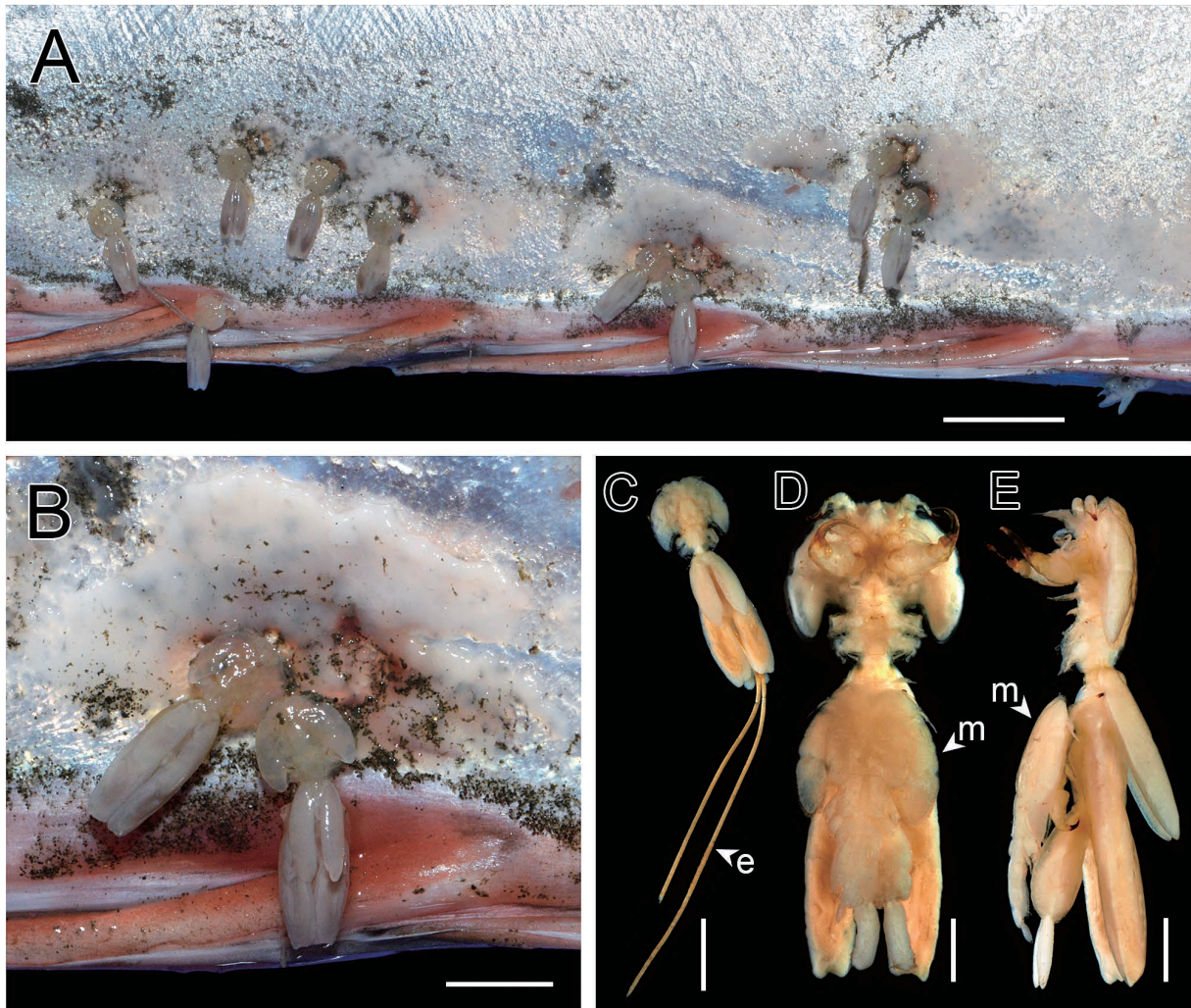


Fig. 1. Specimens of *Luetkenia elongata* Shiino, 1963 (KPM-NH 1772) and their host, *Luvarus imperialis* Rafinesque (KPM-NI 39783; 1520 mm FL). A, fresh copepod specimens attached to the body surface near the anal fin base; B, enlarged image of copepods and the infection site; C, a fixed adult female carrying egg sacs; D, a fixed adult male attached to the urosome of an adult female, ventral; E, same, lateral. Abbreviations: e, egg sac; m, adult male. Scale bars: A, 20 mm; B, 7 mm; C, 5 mm; D, E, 2 mm.

Type material. Lectotype: adult female (NSMT-Cr 20757), *ex Luvarus imperialis* Rafinesque (Perciformes: Luvaridae), 98.156 km (as 35 miles) from the coast of California (32°38'N, 117°57'E), eastern North Pacific Ocean, 21 October 1962. Paralectotype: adult male (NSMT-Cr 24638), collection data same as for lectotype.

Other material examined. 1 adult female and 1 adult male (NSMT-Cr 24637), *ex L. imperialis* [KPM-NI 39783; 1520 mm fork length (FL)] stranded in the surf zone of Enoshima island (35°18'9.858"N, 139°28'56.094"E), Sagami Bay, western North Pacific Ocean, Kanagawa prefecture, Japan, 8 October 2015, leg. T. Sakiyama; 9 adult females and 8 adult males (KPM-NH 1772), collection data same for NSMT-Cr 24637.

Adult female. Body (Fig. 2A) 14.19–20.97 (16.45±1.78) long ($n=10$). Prosome comprising cephalothorax and free thoracic somite. Cephalothorax (Fig. 2A) round, flattened dorsoventrally, with indented mid-lateral margin, wider than long, 4.56–5.48 (4.87±0.31)×5.22–5.94 (5.61±0.24), with pair of adhesion pads on each anterolateral corner

(Fig. 2F), pair of longitudinal suture lines, and paired posterolateral lobes; frontal plates (Fig. 2A, F) without lunules. Free thoracic somite (Fig. 2A) wider than long, 1.40–1.72 (1.55±0.10)×2.98–3.38 (3.15±0.11), composed of fused second and third pedigerous somites, bearing pair of well-developed lateral plates with adhesion pad on anterolateral corner; sternite 1 (Fig. 4A) with posterior margin indented at middle. Urosome comprising fourth pedigerous somite, genital complex, and abdominal somite. Fourth pedigerous somite longer than wide, 5.38–6.42 (6.05±0.39)×3.16–3.80 (3.52±0.20), with pair of elongate posterolateral lobes. Genital complex longer than wide, 8.27–10.32 (9.43±0.71)×4.09–4.44 (4.26±0.13), bearing elongate posterolateral lobes each with conical protuberance (Fig. 2A, B); genital apertures (Fig. 2B, C) situated adjacent surface of abdomen. Abdomen (Fig. 2B) teardrop-shaped, longer than wide, 3.30–3.99 (3.70±0.18)×2.44–2.97 (2.74±0.21), with indented lateral margin at posterior 3/4. Caudal ramus (Fig. 2B, D, E) longer than wide, 2.15–2.74 (2.49±0.20)×0.82–1.22 (0.95±0.12), with six simple setae on distal tip. Egg

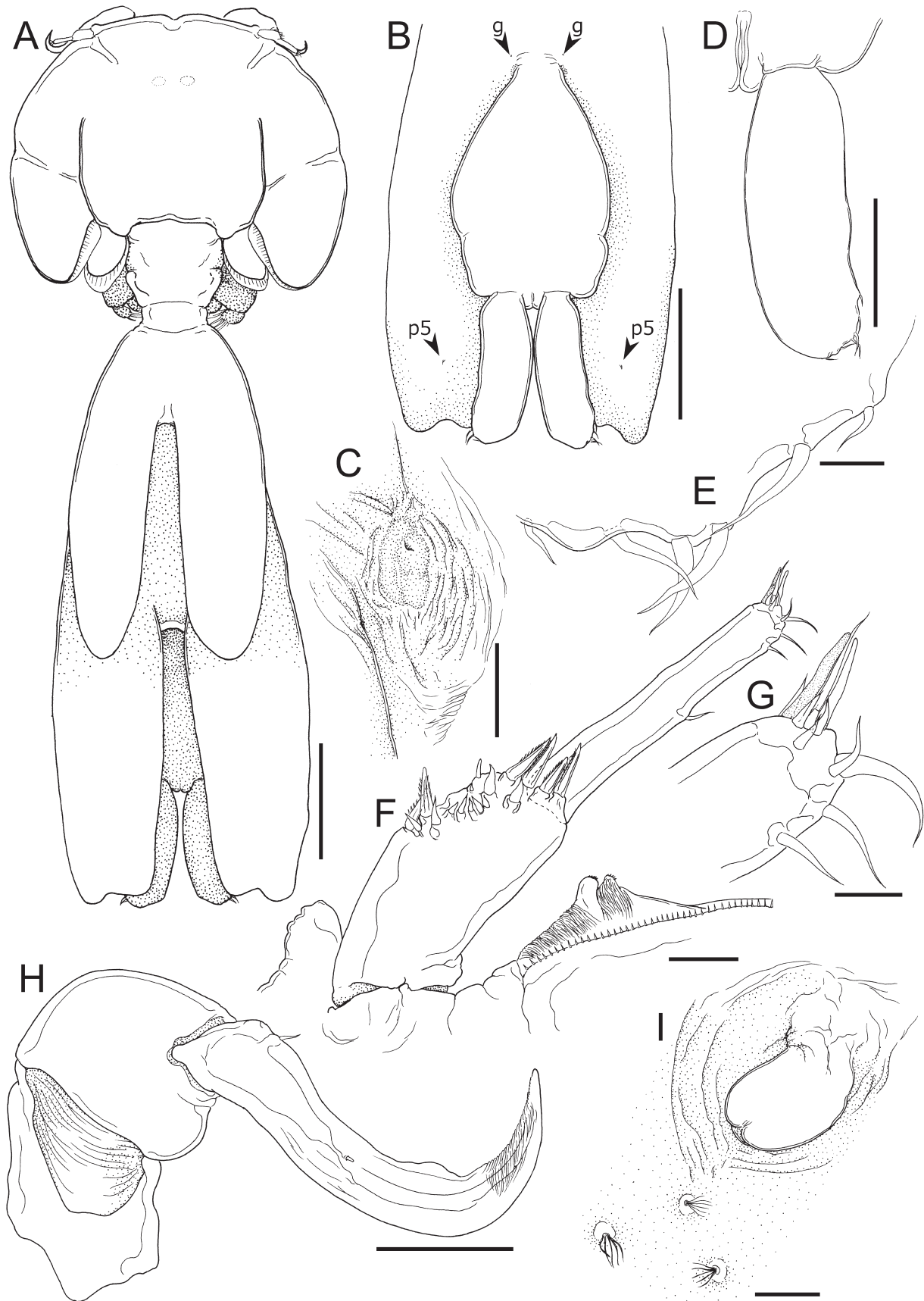


Fig. 2. *Luetkenia elongata* Shiino, 1963, adult female, KPM-NH 1772. A, habitus, dorsal; B, posterior part of urosome, ventral; C, left genital aperture; D, left caudal ramus, ventral; E, distal tip of left caudal ramus, ventral; F, left antennule and adhesion pad on anterolateral corner of cephalothorax, posterior; G, distal tip of left antennule, posterior; H, right antenna, anterior; I, right postantennal process and setulate papillae. Abbreviations: g, genital aperture; p5, leg 5. Scale bars: A, B, 2 mm; C, 0.2 mm; D, 1 mm; E, F, 0.1 mm; G, 0.03 mm; H, 0.4 mm; I, 0.05 mm.

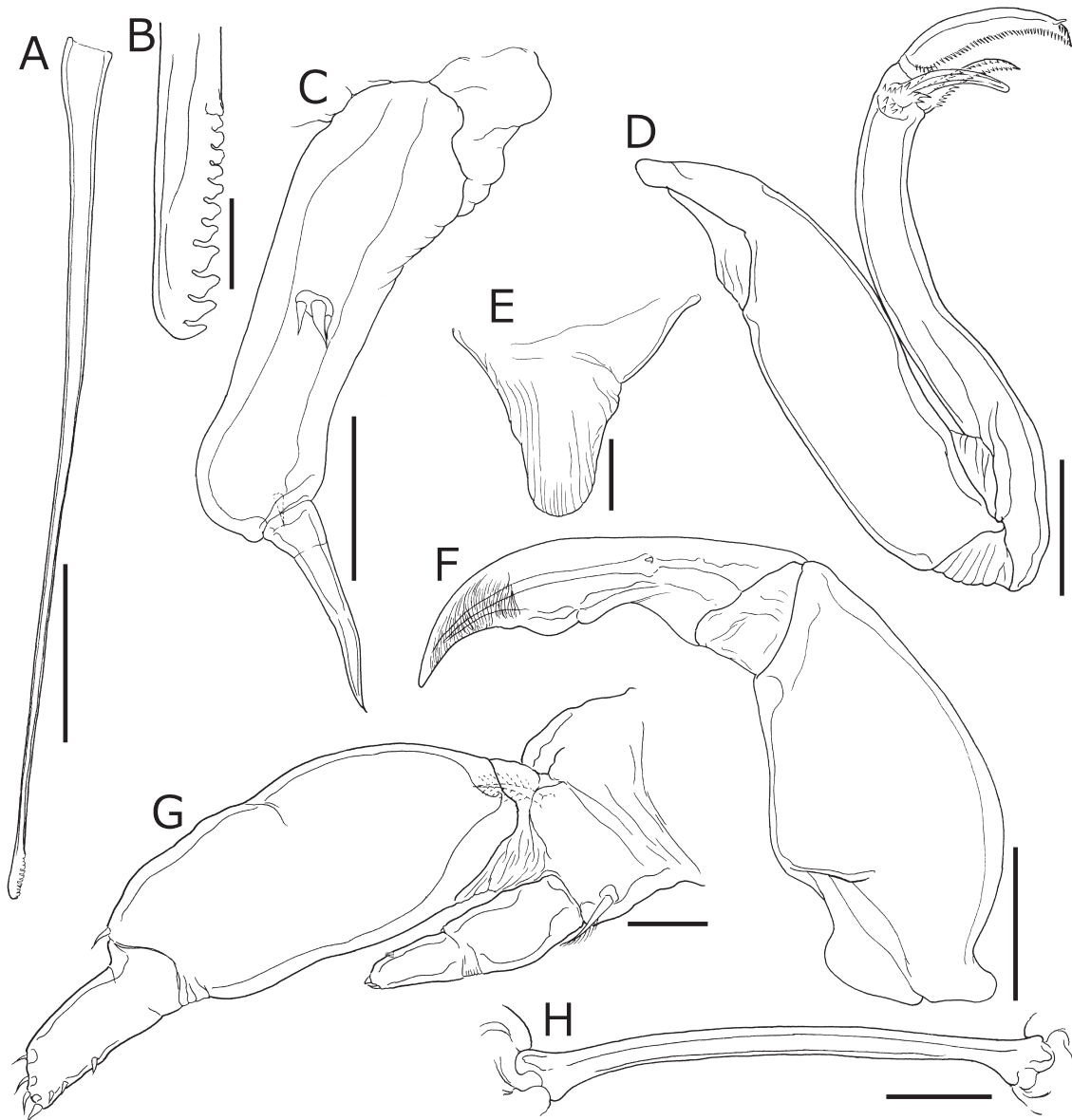


Fig. 3. *Luetkenia elongata* Shiino, 1963, adult female, KPM-NH 1772. A, left mandible, posterior; B, same, distal tip; C, left maxillule, anterior; D, left maxilla, posterior; E, right sclerotized process, anterior; F, left maxilliped, posterior; G, left leg 1 without intercoxal sclerite, posterior; H, intercoxal sclerite of leg 1. Scale bars: A, 0.2 mm; B, 0.02 mm; C, E, G, H, 0.1 mm; D, 0.3 mm.

sacs (Fig. 1C) uniseriate, straight.

Antennule (Fig. 2F, G) 2-segmented; proximal segment slightly shorter than terminal segment, bearing 16 spinulate setae and small, sharp process; distal segment bearing median seta in addition to aesthetasc and 11 setae on distal tip. Antenna (Fig. 2H) 3-segmented; basal (coxa) and middle (basis) segment unarmed; terminal claw (endopod) bearing single basal and single median elements. Postantennal process (Fig. 2I) represented by round process with three setulate papillae located on adjacent surface. Oral cone elongate. Mandible (Fig. 3A, B) represented by elongate, sharp stylet bearing single distal and 11 inner teeth. Maxillule (Fig. 3C) represented by rod-shaped lobe bearing three median, single small subterminal, and single long distal elements. Maxilla (Fig. 3D) 2-segmented; syncoxa rod-shaped, unarmed; basis slender, curved, ornamented with spinules, bearing

blunt element, long calamus, and short canna; calamus and canna ornamented with serrate hyaline membranes. Sclerotized process (Fig. 3E) located on body surface adjacent to base of maxilla. Maxilliped (Fig. 3F) 2-segmented, subchelate; proximal segment (corpus) unarmed; terminal segment (shaft and claw) bearing tiny element.

Legs 1 to 4 biramous (Figs 3G, H, 4B–E); legs 1 to 3 bearing 2-segmented rami; leg 4 bearing unsegmented rami. Armature of legs 1 to 4 shown in Table 1. Leg 1 (Fig. 3G, H) bearing plumose setae on coxa and basis and simple setae on rami; intercoxal sclerite elongate, unarmed; endopod with row of spinules on terminal segment. Leg 2 (Fig. 4B) with intercoxal sclerite bearing row of hairs on posterior margin; protopod bearing five adhesion pads and two processes with conical tips on anterior surface and row of hairs on inner margin; basal segment of exopod bearing spinules

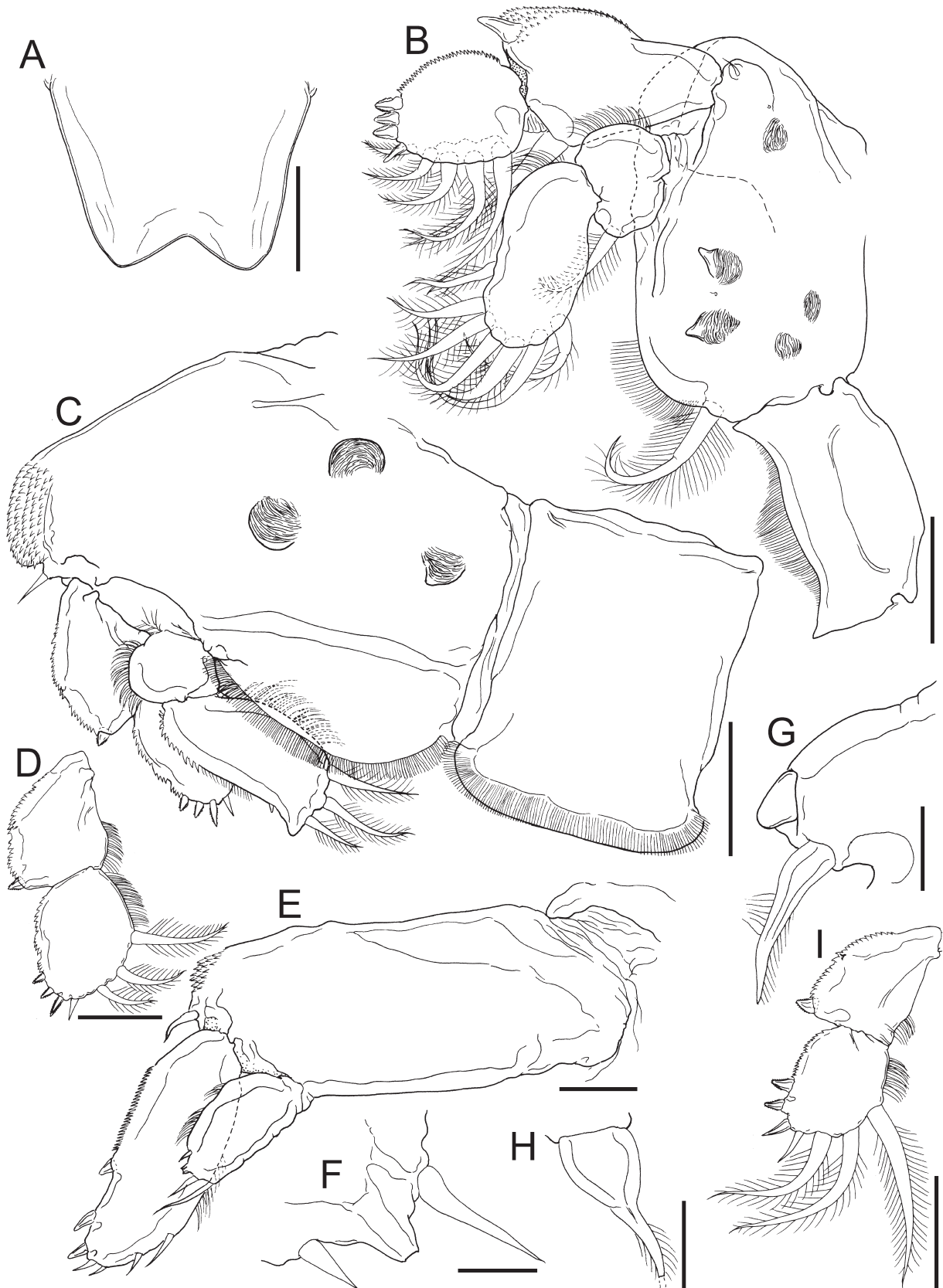


Fig. 4. *Luetkenia elongata* Shiino, 1963, adult female (A–H) and adult male (I), KPM-NH 1772. A, sternite 1, anterior; B, right leg 2, anterior; C, right leg 3, anterior; D, exopod of right leg 3, anterior; E, right leg 4, anterior; F, same, distal tip of endopod; G, right leg 5, ventral; H, seta of left leg 5; I, exopod of right leg 3, anterior. Scale bars: A, D, I, 0.2 mm; B, C, G, H, 0.03 mm; E, F, 0.02 mm.

Table 1. Armature formula of legs 1 to 4 of *Luetkenia elongata* Shiino, 1963, adult female, KPM-NH 1772. Arabic numbers=number of setae, Roman numbers=number of spines.

| | Protopod | Exopod | Endopod |
|-------|----------|----------------|-------------|
| Leg 1 | 1-1 | 1-0; 7 | 0-0; 2 or 3 |
| Leg 2 | 1-1 | I-1; III, I, 5 | 0-1; 7 |
| Leg 3 | 1-0 | I-0; III, I, 3 | 0-0; I, 3 |
| Leg 4 | 1-0 | II, I, 4 | 3 |

on outer margin; terminal segment of exopod with serrate outer margin; endopod bearing row of hairs on outer margin. Leg 3 (Fig. 4C, D) with intercoxal sclerite bearing row of hairs on posterior margin; protopod bearing three adhesion pads and process with conical tip on anterior surface and spinules on outer margin; exopod with serrate outer margin; basal segment of endopod bearing rows of hairs on outer and inner margins; terminal segment of endopod bearing row of serrate teeth on anterior half and row of hairs on posterior half of outer margin and row of hairs on inner margin. Leg 4 (Fig. 4E) lacking intercoxal sclerite; protopod bearing spinules on distal tip; exopod bearing row of serrate teeth on outer margin and row of hairs on inner margin; endopod with row of hairs on outer margin and distal process (Fig. 4F). Leg 5 (Fig. 4G, H) located on distal part of ventral surface of posterolateral lobes of genital complex (Fig. 2B), represented by small lobe with outer conical spine and seta; seta of left leg 5 (Fig. 4H) distinctly swollen proximally.

Adult male. Body (Fig. 5A) 7.87–8.29 (8.10 ± 0.15) long ($n=9$). Prosome comprising cephalothorax and free thoracic somite composed of fused second and third pedigerous somites as in female. Cephalothorax (Fig. 5A) round, flattened dorsoventrally, with indented mid-lateral margin, and longer than wide, 4.46–5.24 (4.83 ± 0.22) \times 4.11–4.77 (4.53 ± 0.24), with pair of longitudinal suture lines, and paired posterolateral lobes; pair of frontal plates (Fig. 5A) without lunules. Free thoracic somite (Fig. 5A) wider than long, 1.32–1.41 (1.35 ± 0.04) \times 2.29–2.51 (2.41 ± 0.08), with pair of well-developed lateral plates each with adhesion pad on anterolateral corner. Urosome comprising fourth pedigerous somite, genital complex, and abdominal somite. Fourth pedigerous somite wider than long, 0.91–1.05 (0.98 ± 0.05) \times 1.53–1.64 (1.59 ± 0.04), with pair of short, round posterolateral lobes. Genital complex, 1.50–2.53 (1.93 ± 0.28) \times 1.44–1.71 (1.54 ± 0.08), bearing round posterolateral lobes (Fig. 5A, B); genital apertures situated on ventral surface. Abdomen (Fig. 5A) pentagonal, 0.64–0.86 (0.72 ± 0.07) \times 0.66–0.89 (0.81 ± 0.07). Caudal ramus (Fig. 5A, C) longer than wide, 0.47–0.69 (0.62 ± 0.06) \times 0.32–0.40 (0.37 ± 0.04), with six simple setae on distal tip.

Antennule, antenna, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 5D) 2-segmented, subchelate; basal segment (corpus) bearing conical process and adhesion pad; terminal segment (shaft and claw) bearing element.

Legs 1 and 4 as in female. Leg 2 (Fig. 5E) as in female except protopod without distinct processes, and exopod with basal segment bearing row of spinules on outer margin. Leg

3 (Figs 4I, 5F, G) as in female, except endopod incompletely 2-segmented and bearing hook-like spine and two thinner spines in depression (Fig. 5G). Leg 5 (Fig. 5H) represented by conical process with scale-like spine and seta, located on posterolateral corner of ventral surface of genital complex. Leg 6 (Fig. 5I) represented by small, conical element situated on genital operculum.

Lectotype female. All characters as in other specimens from Japanese waters, except fourth pedigerous somite with damaged right postolateral lobe. Measurements of body parts as follows: body length 18.53; cephalothorax length 5.34; cephalothorax width 6.04; free thoracic somite length 1.59; free thoracic somite width 3.16; fourth pedigerous somite length 6.48; free thoracic somite width 3.85; genital complex length 11.69; genital complex width 5.66; abdomen length 4.66; abdomen width 3.43; caudal ramus length 2.66; caudal ramus width 1.26.

Paralectotype male. All characters as in other specimens from Japanese waters. Measurements of body parts as follows: body length 7.98; cephalothorax length 4.80; cephalothorax width 5.00; free thoracic somite length 1.29; free thoracic somite width 2.47; fourth pedigerous somite length 1.11; free thoracic somite width 1.55; genital complex length 1.89; genital complex width 1.67; abdomen length 0.81; abdomen width 0.77; caudal ramus length 0.56; caudal ramus width 0.36.

Infection sites. Females attached to the host's body surface near the anal fin base (Fig. 1A, B). Males attached by antennae and maxillipeds to the urosome of females (Fig. 1D, E).

Infection number. Ten females and nine males from the single Japanese host specimen.

Remarks. *Luetkenia elongata* was originally described as the second member of the genus based on specimens of both sexes collected in the eastern North Pacific Ocean off California (Shiino 1963). It differs from its congener, *L. asterodermi*, by the following characters of the female: fourth pedigerous somite with a pair of elongate posterolateral lobes on the dorsal surface (*vs.* small lobes); genital complex about twice as long as the cephalothorax and bearing a pair of well-developed posterolateral lobes each with conical protuberance on lateral corner (*vs.* not markedly longer than cephalothorax and bearing posterolateral lobes without protuberance); abdomen clearly longer than wide, with indented lateral margins (*vs.* equally wide and long, without indented lateral margins); and caudal rami more than twice as long as wide (*vs.* round, equally long and wide) (see Claus 1864, figs 10, 12; Kabata 1979, figs 986, 987). Although Shiino (1963) described leg 4 of the female with a total of five distal setae on the endopod, our reexamination of the lectotype showed that it bears only three setae.

Newly established Japanese name. “Mayoi-same-jirami-zoku” for the genus and “Mayoi-same-jirami” for the species. “Same-jirami” is the Japanese name for pandarids, meaning “shark lice”. Since the host of *L. elongata* is not an elasmobranch, “mayoi”, meaning “strayed” in Japanese is added. “Zoku” means “genus”.

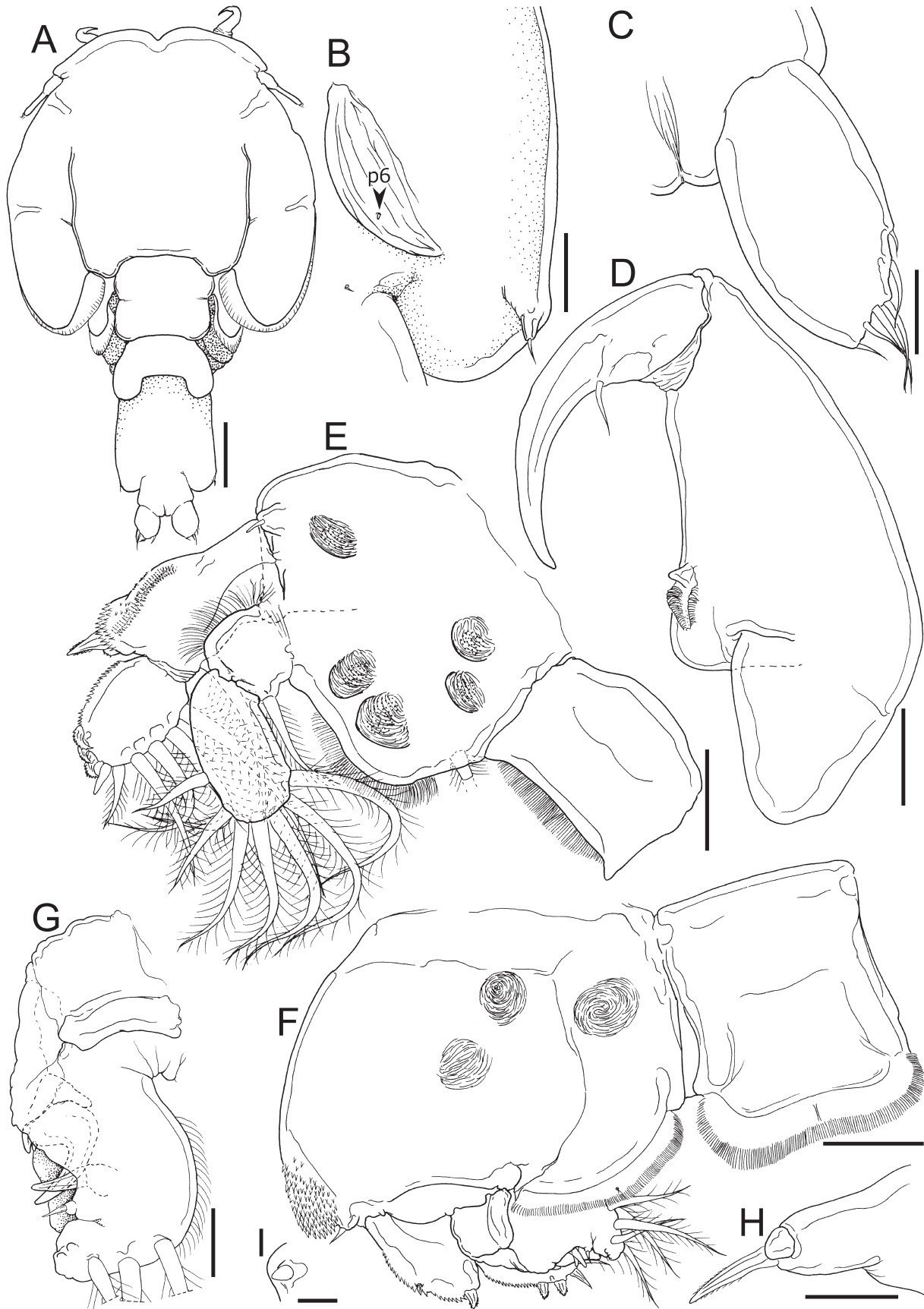


Fig. 5. *Luetkenia elongata* Shiino, 1963, adult male, KPM-NH 1772. A, habitus, dorsal; B, posterolateral corner of genital complex, ventral; C, left caudal ramus, ventral; D, left maxilliped, posterior; E, right leg 2, anterior; F, right leg 3, anterior; G, endopod of right leg 3, ventral; H, left leg 5; I, left leg 6. Abbreviation: p6, leg 6. Scale bars: A, 1 mm; B, C, E, 0.2 mm; D, F, 0.3 mm; G, 0.1 mm; H, 0.05 mm; I, 0.02 mm.

Discussion

Luetkenia elongata was originally described by Shiino (1963) based on single female and single male specimens collected from the eastern North Pacific Ocean off California. The new find reported in this study represents the second record of *L. elongata* and the first record from Japanese waters. *Luetkenia* consists of two species, *L. asterodermi* and *L. elongata*. Both infect the luvar, *Luvarus imperialis*, which is widely distributed from temperate to tropical waters in the Atlantic, Indian, and Pacific Oceans (Froese and Pauly 2016). Kabata (1979) remarked that the validity of *L. elongata* should be discussed because many morphological characters are shared between the two species. Additionally, some morphological variation in the shape and proportions of the fourth pedigerous somite and the genital complex are evident among previous descriptions of *L. asterodermi*. However, all reports agree on the following features of the female, which may thus be taken as diagnostic of the species: genital segment almost equally long and wide; caudal rami round, almost equally long and wide; posterolateral lobes of fourth pedigerous somite not well-developed; and posterolateral lobes of genital segment without protuberance (see Claus 1864; Heller 1865; Norman and Scott 1906; Scott and Scott 1913). Since these characteristic of *L. asterodermi* are not shared with the specimens of *L. elongata* examined in this study, the latter species is clearly distinct from the type species (see Shiino 1963; present study). Although both species of copepod have been recorded from the same host species, the infection sites were different (*i.e.*, *L. elongata* from the body surface especially near the anal fin base; *L. asterodermi* from the gills and branchial cavities) (*e.g.*, Claus 1864; Valle 1880; Brian 1906; Shiino 1963; Kabata 1979; present study). Furthermore, both species of copepod were collected from different seas (*i.e.*, *L. elongata* from the North Pacific Ocean but *L. asterodermi* from the North Atlantic Ocean and the Mediterranean) (Shiino 1963; Kabata 1979; present study). This might indicate that the Atlantic and Pacific populations of *L. imperialis* are infected by different but closely related copepod species, but it would be premature to conclude this because of the scarcity of records. Finally, there are still no records of *Luetkenia* from the Indian Ocean. Future research is required to reveal the true distributional ranges of both *L. asterodermi* and *L. elongata*.

Acknowledgments

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