



REDESCRIPTION OF *BOMOLOCHUS BELLONES* BURMEISTER, 1835
(COPEPODA, CYCLOPOIDA, BOMOLOCHIDAE) RECOVERED FROM
COLOLABIS SAIRA (BREVOORT, 1856) (ACTINOPTERYGII) IN JAPAN,
WITH DESCRIPTIONS OF THE MALE AND COPEPODIDS V-III OF THE
SPECIES

BY

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ABSTRACT

Bomolochus bellones Burmeister, 1835 is redescribed based on specimens recovered from the bucco-branchial cavity of the Pacific saury, *Cololabis saira* (Actinopterygii, Beloniformes, Scomberesocidae), in Japan. The male, copepodid V female, copepodid IV female, and copepodid III male of the species are described. The postantennal processes and lateral processes have appeared in the female at copepodid V.

Key words. — Parasitic copepods, Cyclopoida, Bomolochidae, copepodids V-III, sexually dimorphic features, Beloniformes, post antennal process, lateral process

RÉSUMÉ

Bomolochus bellones Burmeister, 1835 est redécrit à partir de spécimens collectés dans la cavité bucco-branchiale du balaou du Pacifique, *Cololabis saira* (Actinopterygii, Beloniformes, Scomberesocidae), du Japon. Le mâle, le copépodite V femelle, le copépodite IV femelle, et le copépodite III mâle de l'espèce sont décrits. Les processus post-antennaires et les processus latéraux sont apparus chez la femelle au stade copépodite V.

Mots clés. — Copépodes parasites, Cyclopoida, Bomolochidae, copépodites V-III, caractères sexuellement dimorphiques, Beloniformes, processus post-antennaire, processus latéral

INTRODUCTION

Bomolochus bellones Burmeister, 1835 is redescribed based on specimens recovered from the bucco-branchial cavity of the Pacific saury, *Cololabis saira*

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(Actinopterygii, Beloniformes, Scomberesocidae), in Japan. The male, copepodid V female, copepodid IV female, and copepodid III male of the species are described. The possession of lateral processes was verified in the adult female of the species, in addition to that same presence in *B. decapteri* Yamaguti, 1936, as earlier described (Izawa, 2022e). The postantennal processes and lateral processes appear in the female at copepodid V.

MATERIAL AND METHODS

Specimens recovered from hosts were fixed in formalin and preserved in 70% alcohol. The specimens were stained with chlorazol black E in lactic acid and examined with a differential interference contrast microscope using the “wooden slide method” of Humes & Gooding (1964). Drawings were made with the aid of a drawing tube. The terminology for copepod morphology is based on Huys & Boxshall (1991). Common and scientific names of the hosts follow Froese & Pauly (2022). The specimens were deposited in the National Museum of Nature and Science, Tsukuba (NSMT).

TAXONOMIC DESCRIPTIONS

Bomolochus bellones Burmeister, 1835 (figs. 1-9)

Bomolochus bellones Burmeister, 1835: 298-305, pl. 24 figs. 2-6; Kabata, 1979: 64-65, figs. 25-37;

Ho et al., 1983: 2-5, figs. 1-21; Pillai, 1985: 34-36, fig. 1; Izawa, 2020: 892-896, figs. 1-3.

Parabomolochus bellones — Vervoort, 1962: 34-41, figs. 1-4; Cressey & Collette, 1970: 365-367, figs. 71-72.

Bomolochus tumidus Shiino, 1957: 417-422, figs. 3-4; 1959: 370-371, fig. 17.

Parabomolochus tumidus — Vervoort, 1962: 47.

Artacolax tumidus — Yamaguti, 1963: 16, pl. 2 fig. 1.

Bomolochus hyporhamphi Yamaguti & Yamasu, 1959: 92-94, pl. 1 figs. 12-21.

Parabomolochus hyporhamphi — Vervoort, 1962: 48.

Material examined.— Two females, recovered from the bucco-branchial cavity of the Pacific saury *Cololabis saira* (Brevoort, 1856), at Kuki, Mie prefecture, on 16 November 1969 (NSMT Cr-24802); 5 females, from same site on same host, off Owase, Mie Prefecture, on 9 December 2013 (NSMT Cr-25418); 1 female, 1 copepodid V female, 1 copepodid IV female, and 1 copepodid III male, from same site on same host, landed in Hokkaido, on 20 and 30 September 2022 (NSMT K-898); 1 male, from same site on same host, landed in Miyagi Prefecture, on 15 October 2022 (NSMT K-905).

Female (figs. 1-2).— Habitus (fig. 1A), body length excluding caudal rami 1.98-2.48 mm (2.17 ± 0.16) ($n = 8$), cephalothorax 0.75-0.83 (0.78 ± 0.03) \times 1.13-1.45 mm (1.33 ± 0.09). Width ratios of pedigers 2 and 3 to cephalothorax

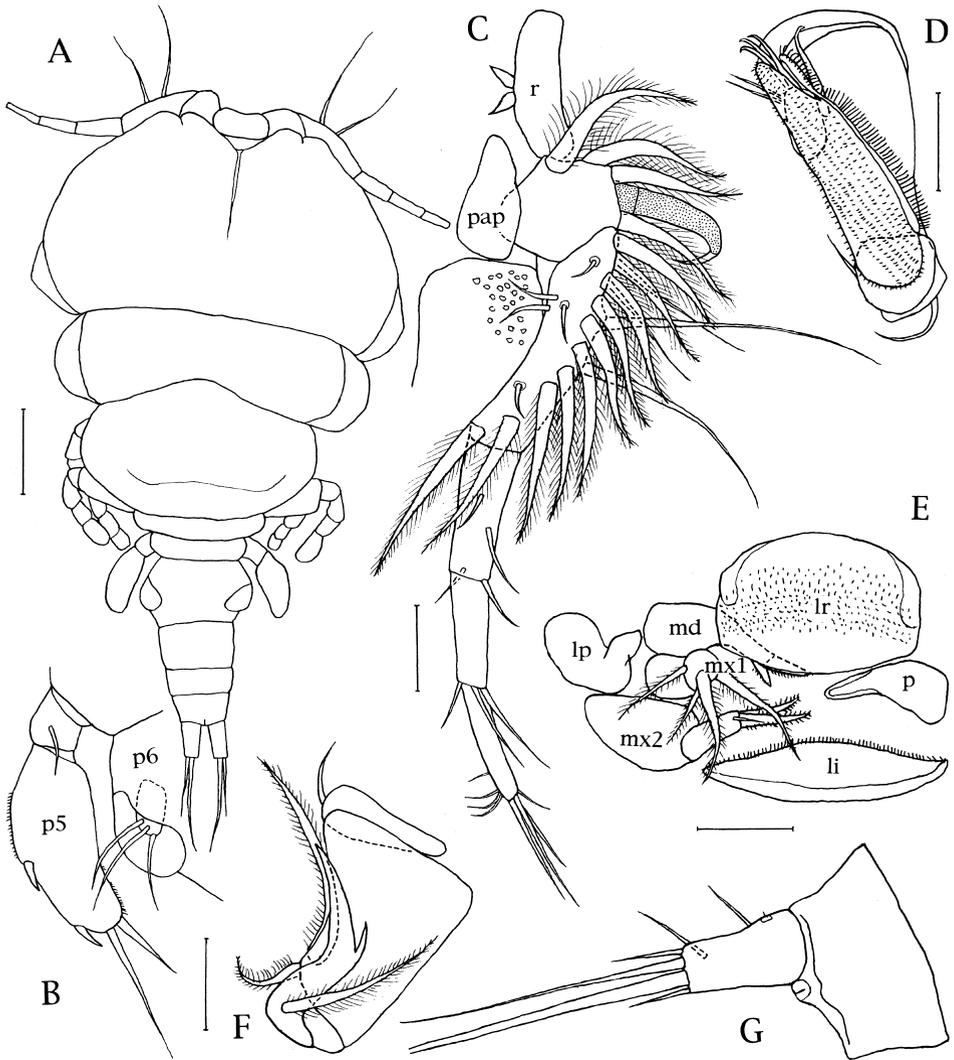


Fig. 1. *Bomolochus bellones* Burmeister, 1835, female. A, Habitus, dorsal; B, legs 5 and 6 dorsal; C, antennule and adjacent structure, ventral; D, antenna, ventral; E, mouthparts and lateral process, ventral; F, maxilliped, ventral; G, anal somite and caudal ramus, ventral. Abbreviations: li, labium; lp, lateral process; lr, labrum; md, mandible; mx1, maxillule; mx2, maxilla; p, paragnath; pap, postantennal process; p5, leg 5; p6, leg 6; r, rostral plate. Scale bars: 0.3 mm for A; 0.1 mm for B-G.

0.84 and 0.62, respectively. Genital somite about 1.6 times as wide as long, with leg 6 in dorsolateral gonopore of each side (fig. 1B, p6), represented by small lobe tipped by 3 setae. Abdomen 3-segmented, anal somite 1.6 times as wide as long (fig. 1G). Caudal ramus (fig. 1G) 1.7 times as long as wide, with 6 setae including 2 major setae (fig. 1G). Egg sac $1.60\text{--}1.85 \times 0.63\text{--}0.67$ mm ($n = 3$).

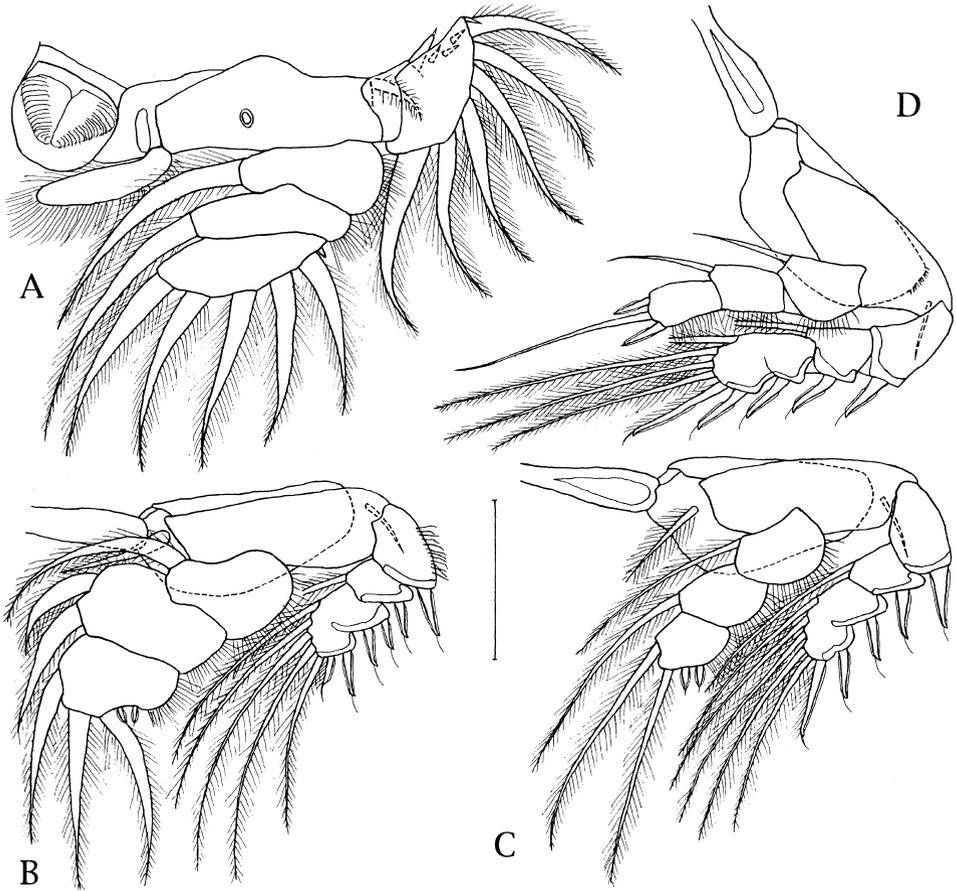


Fig. 2. *Bomolochus bellones* Burmeister, 1835, female. A, Leg 1, ventral; B, leg 2, ventral; C, leg 3, ventral; D, leg 4, ventral. Scale bar: 0.2 mm for A-D.

Rostral plate (fig. 1C, r) concave anteriorly, with pair of ventral processes. Antennule (fig. 1C) accompanied by vesicular postantennal process (pap) posterior to base, 6-segmented, first segment forming pedestal, number of setal elements per segment (base to apex) as follows: 0, 5, 10 + 9, 4, 3, 8, fourth seta on first free segment modified. Antenna (fig. 1D) 5-segmented, first segment unarmed, second with distal seta, third with medial seta, fourth tapered distally, spinulose ventrally, with comb-plate and hook-like seta anteriorly, fifth with 3 hook-like setae and 2 simple setae distally.

Mouthparts (fig. 1E), labrum (lr) spinulose ventrally; mandible (md) with 2 blades; paragnath (p) thumb-shaped, pectinate on distal lobe; maxillule (mx1) with 4 setae; maxilla (mx2) 2-segmented, second segment with setula distally and tipped by 2 pectinate processes; labium (li) spinulose on distal margin. Lateral

process (fig. 1E, lp) present lateral to mandible (md) and maxillule (mx1), arising from lateral wall of oral depression of each side, represented by vesicular lobe. Maxilliped (fig. 1F) 3-segmented, syncoxa with seta medially, basis broadened proximally, with 2 setae mediolaterally, endopod forming recurved claw, claw with seta proximally and accessory process.

Legs 1-4 (fig. 2A-D) each with intercoxal plate, biramous, rami 3-segmented except 2-segmented exopod of leg 1. Formulae for spines (Roman numerals) and setae (Arabic numerals) of these legs as follows:

- Leg 1 coxa 0-1 basis 1-1 exopod I-0; IV, 6 endopod 0-1; 0-1; I, 5
- Leg 2 coxa 0-1 basis 1-0 exopod I-0; I-1; III, I, 5 endopod 0-1; 0-2; II, 3
- Leg 3 coxa 0-1 basis 1-0 exopod I-0; I-1; II, I, 5 endopod 0-1; 0-1; II, 2
- Leg 4 coxa 0-0 basis 1-0 exopod I-0; I-1; II, I, 4 endopod 0-1; 0-1; I, 1, I

Medial seta of leg 1 basis atrophied, lateral spines of exopods of legs 2-4 pectinate on both sides, tipped with flagella, distal spines of exopodal segments 3 of legs 2-4 pectinate laterally and pinnate medially, tipped with flagella, distal spines of endopodal segments 3 of legs 2-4 pectinate on both sides, tipped with flagella. Leg 5 (fig. 1B, p5) 2-segmented, first segment with dorsal seta, second segment 2.5 times as long as wide, with 4 setal elements.

Male (figs. 3-4).— Habitus (fig. 3A), body length excluding caudal rami 1.01 mm ($n = 1$), cephalothorax, 0.39×0.45 mm, pedigers 2-4 successively decreasing in width, genital somite 1.06 times as long as wide, with genital slits ventrally, abdomen 2-segmented. Anal somite (fig. 3F) 1.3 times as wide as long, spinulose ventrally. Caudal ramus (fig. 3F) 1.9 times as long as wide, with 6 setae including 2 major setae, longest seta about 54% of body length.

Rostral plate (fig. 3B) gently rounded anteriorly, with pair of sensilla on anterior margin, without ventral processes. Antennule (fig. 3C) sexually dimorphic, 7-segmented, first segment forming pedestal, number of setal elements per segment (base to apex) as follows: 0, 5, 5 + 8, 5 + 1, 1 + 3, 3, 8. Antenna and mouthparts (not illustrated) almost as in female. Lateral process absent. Maxilliped (fig. 3D) sexually dimorphic, subchelate, 3-segmented, syncoxa with medial seta, basis tuberculose along inner margin, with 2 inner setae, endopod forming claw, claw notched on inner margin, with 2 setae proximally.

Legs 1-4 (fig. 4) each with intercoxal plate, biramous, rami 3-segmented except 2-segmented endopod of leg 4. Formulae for spines (Roman numerals) and setae (Arabic numerals) of these legs as follows:

- Leg 1 coxa 0-1 basis 1-1 exopod I-0; I-1; II, I, 4 endopod 0-1; 0-1; I, 5
- Leg 2 coxa 0-1 basis 1-0 exopod I-0; I-1; II, I, 5 endopod 0-1; 0-1; II, 3
- Leg 3 coxa 0-1 basis 1-0 exopod I-0; 0-1; II, I, 5 endopod 0-1; 0-1; II, 2
- Leg 4 coxa 0-0 basis 1-0 exopod I-0; 0-1; II, I, 4 endopod 0-1; I, 1, I

Lateral spines of exopods of leg 2-4 pectinate on both sides, tipped with flagella, distal spines of exopodal segments 3 of legs 2-4 pectinate laterally and pinnate

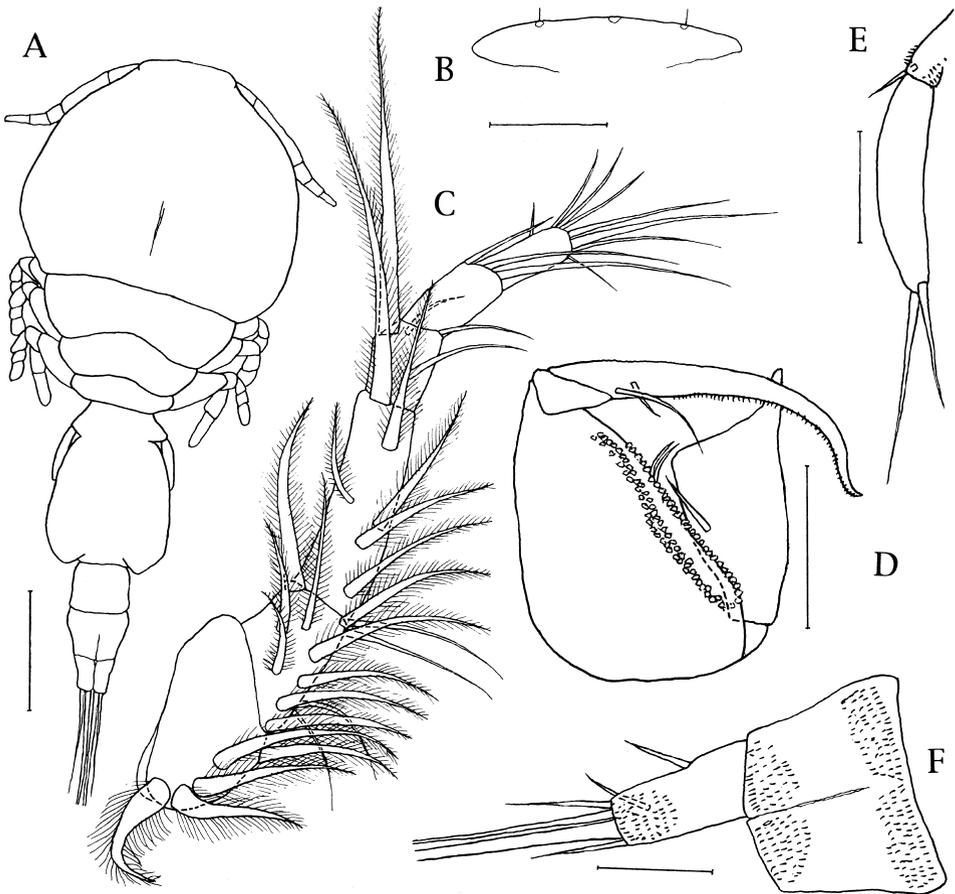


Fig. 3. *Bomolochus bellones* Burmeister, 1835, male. A, Habitus, dorsal; B, rostral plate, ventral; C, antennule, ventral; D, maxilliped, ventral; E, leg 5, ventral; F, anal somite and caudal ramus, ventral. Scale bars: 0.2 mm for A; 0.1 mm for D; 0.05 mm for B, C, E, F.

medially, tipped with flagella, distal spines of distal endopodal segments of legs 2-4 pectinate on both sides, tipped with flagella. Leg 5 (fig. 3E) 2-segmented, first segment with dorsodistal seta, second segment 4.7 times as long as wide, with 2 distal setae.

Copepodid V female (figs. 5-6).— Body (fig. 5A) 1.57 mm long excluding caudal rami ($n = 1$), cephalothorax wider than long, 0.52×0.74 mm, pedigers 2-4 successively diminishing in width, genital somite almost as long as wide, without gonopores and legs 6, abdomen 3-segmented. Anal somite (fig. 5E) about 1.8 times as wide as long, caudal ramus about 1.8 times as long as wide, with 6 setae including 2 major ones.

Rostral plate (fig. 5B, r) rounded anteriorly, with pair of ventral processes. Antennule (fig. 5B) accompanied by vesicular postantennal process (pap) posteri-

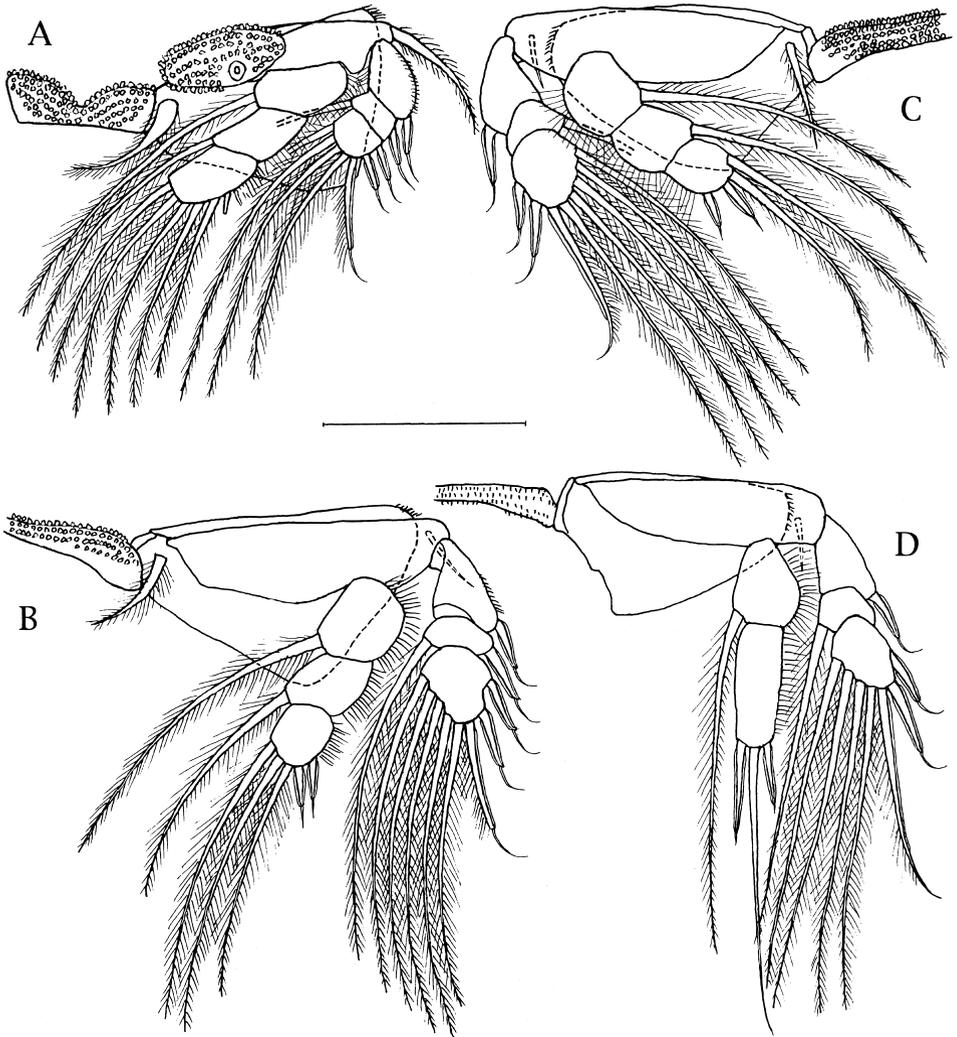


Fig. 4. *Bomolochus bellones* Burmeister, 1835, male. A, Leg 1, ventral; B, leg 2, ventral; C, leg 3, ventral; D, leg 4, ventral. Scale bar: 0.1 mm for A-D.

only to base, 6-segmented, first segment forming pedestal, number of setal elements per segment (base to apex) as follows: 0, 5, 10 + 8, 4, 3, 8, fourth seta on first free segment unsclerotized.

Mouthparts (fig. 5C) almost as in adult, lateral processes present. Maxilliped (not illustrated) almost as in adult female.

Legs 1-4 (fig. 6A-D), structure and setal formulae of these legs as in adult female, ornament of setal elements of legs 2-4 almost as in adult. Leg 5 (fig. 5D)

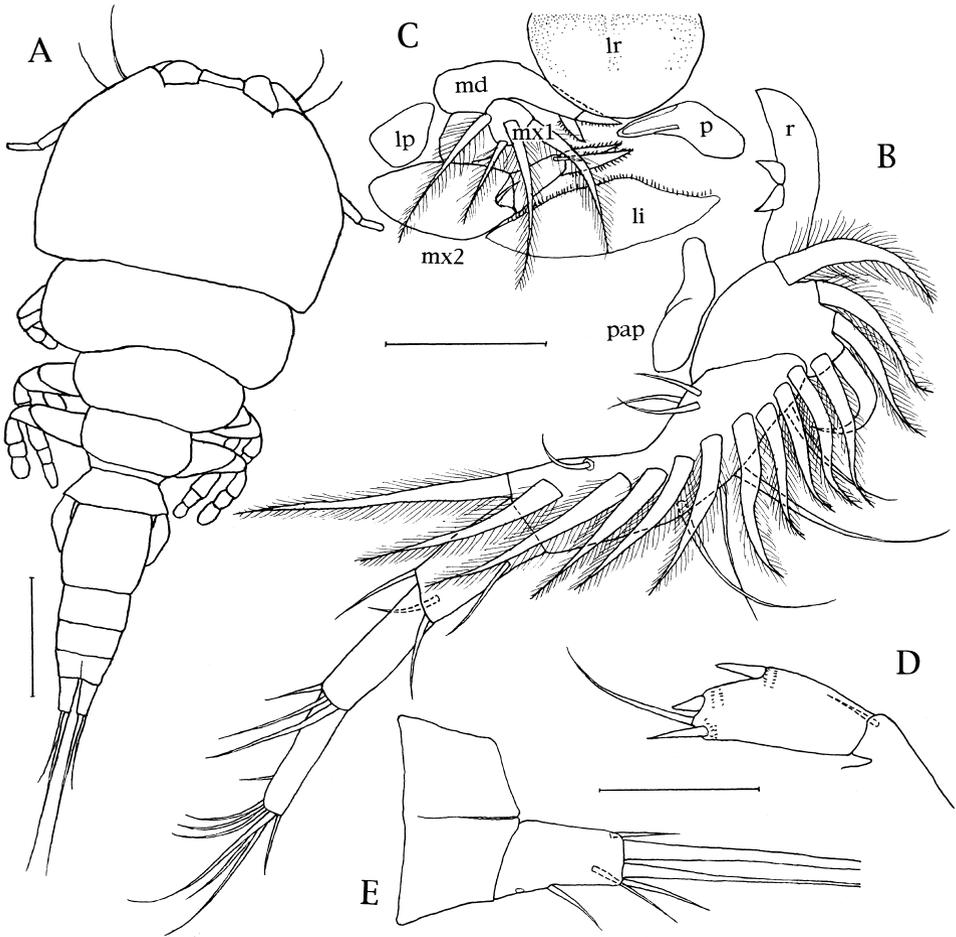


Fig. 5. *Bomolochus bellones* Burmeister, 1835, copepodid V female. A, Body, dorsal; B, antennule and adjacent structure, ventral; C, mouthparts and lateral process, ventral; D, leg 5, ventral; E, anal somite and caudal ramus, ventral. Scale bar: 0.3 mm for A; 0.1 mm for B-E.

2-segmented, first segment with dorsodistal seta, second segment about 2.3 times as long as wide, with 4 setal elements.

Copepodid IV female (figs. 7-8).— Body (fig. 7A) 0.79 mm long excluding caudal rami ($n = 1$), cephalothorax wider than long, 0.34×0.40 mm, pedigers 2-4 successively diminishing in width, genital somite slightly wider than long, 1.1 times as wide as long, abdomen 2-segmented. Anal somite slightly wider than long, 1.2 times as wide as long, caudal ramus 2.2 times as long as wide, with 6 setae including 2 major ones.

Rostral plate (fig. 7B, r) concave anteriorly, with poorly developed ventral processes. Antennule (fig. 7B) 6-segmented, first segment forming pedestal, number

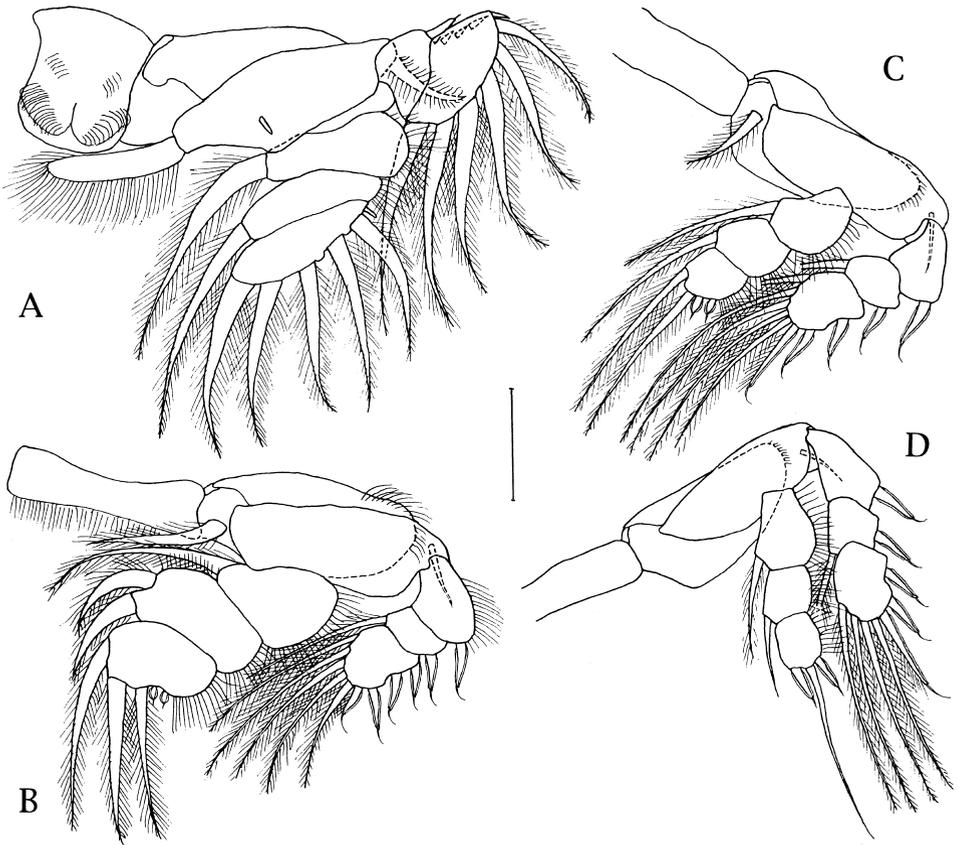


Fig. 6. *Bomolochus bellones* Burmeister, 1835, copepodid V, female. A, Leg 1, ventral; B, leg 2, ventral; C, leg 3, ventral; D, leg 4, ventral. Scale bar: 0.1 mm for A-D.

of setal elements per segment (base to apex) as follows: 0, 4, 8 + 4, 4, 3, 7. Postantennal process absent.

Mouthparts (not illustrated) almost as in adult, lateral process absent. Maxilliped (fig. 7C) female type.

Legs 1-4 (fig. 8A-D) each with intercoxal plate, biramous, rami 2-segmented, formulae for spines (Roman numerals) and setae (Arabic numerals) of these legs as follows:

- Leg 1 coxa 0-1 basis 1-1 exopod I-0; III, 5 endopod 0-1; I, 6
- Leg 2 coxa 0-1 basis 1-0 exopod I-0; III, I, 5 endopod 0-1; II, 5
- Leg 3 coxa 0-1 basis 1-0 exopod I-0; III, I, 5 endopod 0-1; II, 3
- Leg 4 coxa 0-0 basis 1-0 exopod I-0; III, I, 5 endopod 0-1; I, I, I, 1

Ornament of spines of legs 2-4 almost as in adult. Leg 5 (fig. 7D) 2-segmented, first segment with dorsal seta, second segment about 2.9 times as long as wide, with 4 setal elements.

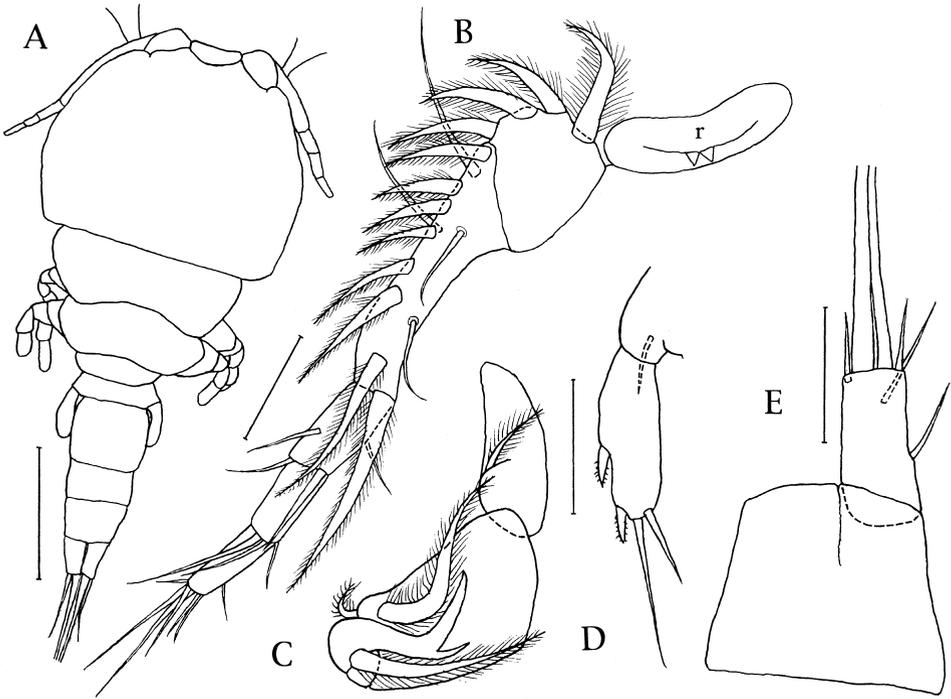


Fig. 7. *Bomolochus bellones* Burmeister, 1835, copepodid IV female. A, Body, dorsal; B, rostral plate and antennule, ventral; C, maxilliped, ventral; D, leg 5, ventral; E, anal somite and caudal ramus, ventral. Scale bars: 0.2 mm for A; 0.05 mm for B-E.

Copepodid III male (fig. 9).— Body (fig. 8A) 0.52 mm long excluding caudal rami ($n = 1$), cephalothorax almost as long as wide, 0.23×0.22 mm, pedigers 2-5 successively diminishing in width, genital somite almost as long as wide. Abdomen (fig. 9C) 1-segmented, almost as long as wide, with 1 row of spinules each anterior and posterior on ventral side. Caudal ramus (fig. 9C) 1.5 times as long as wide, with 6 setae.

Rostral plate (fig. 9B, r) simple, rounded anteriorly, without ventral processes. Antennule (fig. 9B) 6-segmented, first segment forming pedestal, number of setal elements per segment (base to apex) as follows: 0, 3, 5 + 4, 1 + 3, 3, 7. Antenna and mouthparts (not illustrated) almost as in adult. Maxilliped (not illustrated) female type.

Legs 1-4 (fig. 9E-H) each with intercoxal plate, biramous, rami 2-segmented except 1-segmented rami of leg 4, formulae for spines (Roman numerals) and setae (Arabic numerals) of these leg as follows:

Leg 1 coxa 0-1 basis 1-1 exopod I-0; III, I, 4 endopod 0-1; I, 6

Leg 2 coxa 0-1 basis 1-0 exopod I-0; III, I, 5 endopod 0-1; II, 4

Leg 3 coxa 0-1 basis 1-0 exopod I-0; II, I, 4 endopod 0-1; II, 2

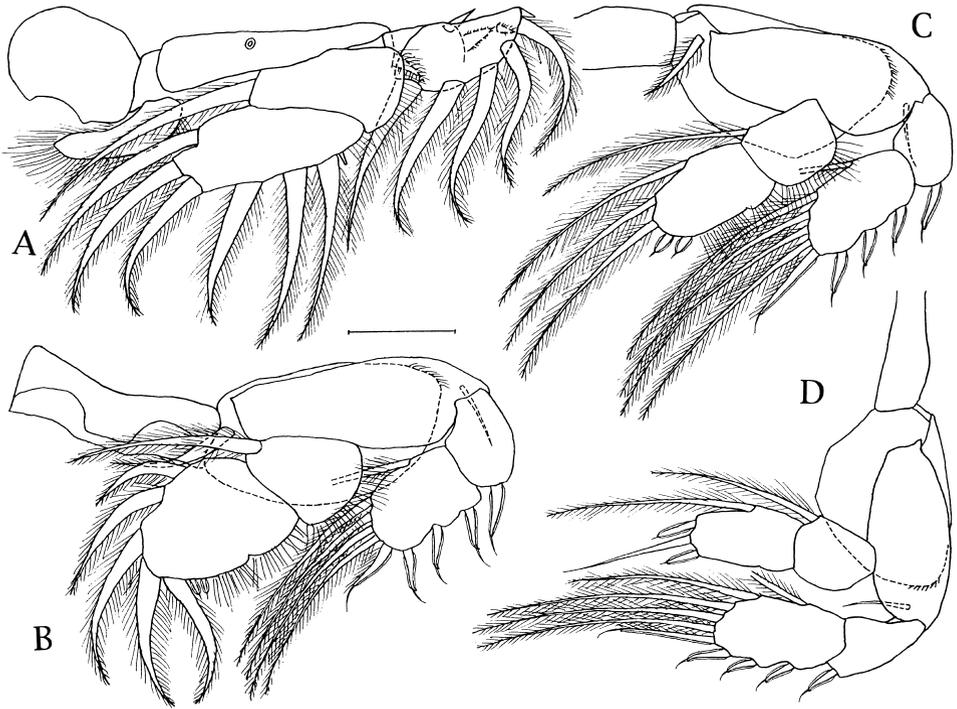


Fig. 8. *Bomolochus bellones* Burmeister, 1835, copepodid IV female. A, Leg 1, ventral; B, leg 2, ventral; C, leg 3, ventral; D, leg 4, ventral. Scale bar: 0.05 mm for A-D.

Leg 4 coxa 0-0 basis 1-0 exopod III, I, 3 endopod I, 1, I, 1

Ornament of setal elements almost as in adult. Leg 5 (fig. 9D) rudiment, represented as lateral lobe of pediger 5, bearing 2 setae on each side.

Remarks.— The possession of the postantennal processes and lateral processes was verified in the female of the adult (this paper, fig. 1C, pap; 1E, lp) and copepodid V (this paper, fig. 5B, pap; 5C, lp) of the species, next to those same structures reported earlier in *B. decapteri* Yamaguti, 1936 (cf. Izawa, 2022e, fig. 1C, pap; 1E, lp), though the lateral process was previously unperceived in *B. bellones* (cf. Izawa, 2020, fig. 1) and *B. decapteri* by Izawa (2020, fig. 5). The possession of lateral processes was observed for the first time in the female of *Nothobomolochus aigo* Izawa, 2022 (cf. Izawa, 2022a, fig. 1E, lp), *N. cypseluri* Yamaguti, 1953 (cf. Izawa, 2022b, fig. 1E, lp), and *N. oomenatsutobi* Izawa, 2022 (cf. Izawa, 2022d, fig. 1F, lp).

Although one copepodid specimen recovered together with the adult of *B. bellones* was wrongly described as copepodid IV female of the species (cf. Izawa, 2020, figs. 3, 4), in the sense that the maxilliped possesses no accessory process on

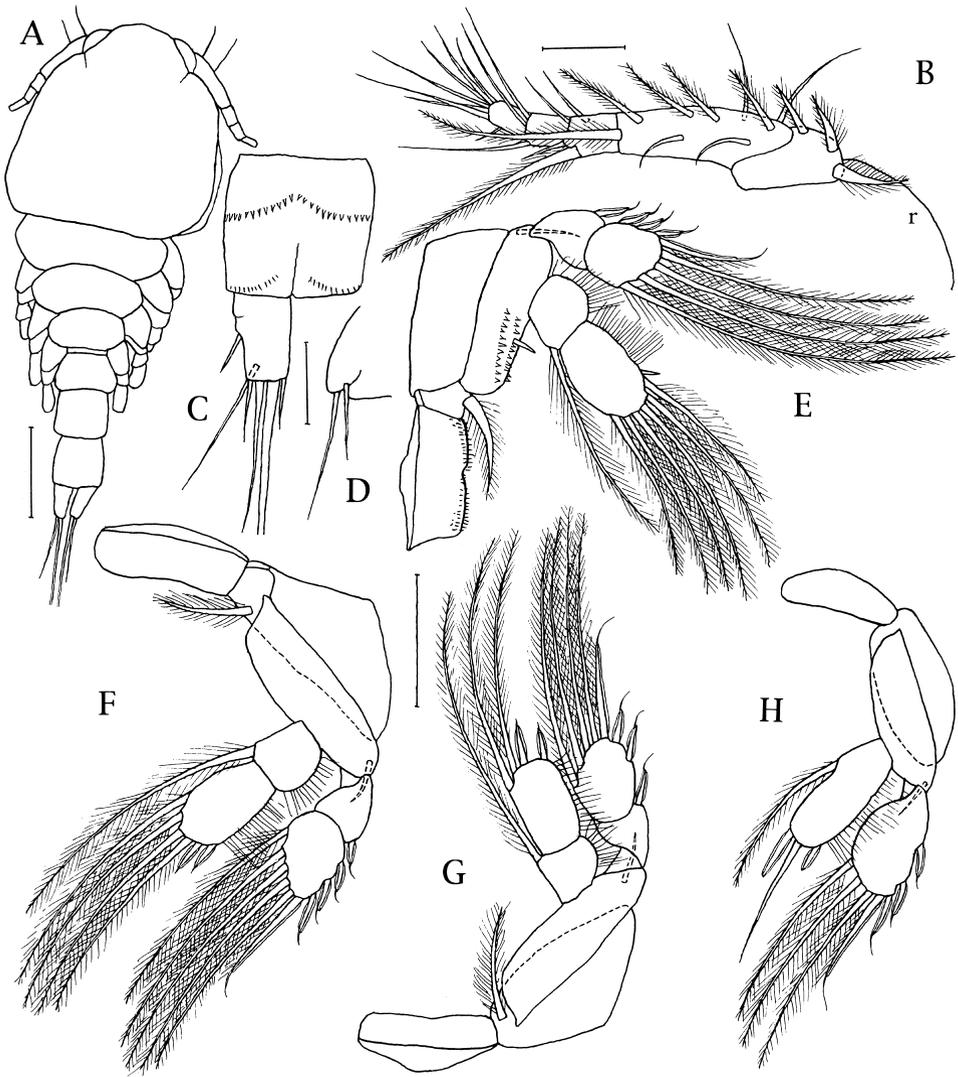


Fig. 9. *Bomolochus bellones* Burmeister, 1835, copepod III male. A, Body, dorsal; B, antennule, ventral; C, anal somite and caudal ramus, ventral; D, rudiment of leg 5, ventral; E, leg 1, ventral; F, leg 2, ventral; G, leg 3, ventral; H, leg 4, ventral. Scale bar: 0.1 mm for A; 0.05 mm for E-H; 0.03 mm for B-D.

the claw, it is now obvious that this copepod IV female is of an as yet unidentified species, obviously of a different genus of the family.

The antennule and leg 5 are sexually dimorphic in the adult and late copepodid stages in the Bomolochidae (cf. Izawa, 2021b). The leg 5 armature makes a convenient criterion to judge sex in the copepodid V and IV (cf. Izawa, 2021b), with the exception of *Boylea* (cf. Cressey, 1977), *Megacolax* (cf. Izawa, 2021a) and

Tegobomolochus (cf. Izawa, 1976), as representatives of these genera bear 4 setae on the distal segment in both sexes, however, as leg 5 is incomplete in copepodid III, it is useless in this stage as seen in this study (fig. 9D). The antennule possesses 4 simple setae on the third segment from distal in the female as seen in this study (figs. 1C, 5B, 7B), while in the male, one of these setae is replaced by a long, plumose seta as seen in this study (figs. 3C, 9B), with the exception of *Hamaticolax* (cf. Pérez-i-García et al., 2017, fig. 4A; Izawa, 2022a, fig. 3B) and *Orbitacolax* (cf. Izawa, 2022c, figs. 3B, 8D), in which such plumose seta is absent on that segment in both sexes. Although the copepodids III and II of *Nothobomolochus tricerus* (Bassett-Smith, 1898) were described as sex undetermined (cf. Izawa, 2021c, figs. 11B, 12B), these are judged to be both juvenile males, as the antennule possesses a long plumose seta on that segment. The copepodid III of *Holocolax nemipteri* (Pillai, 1973) described as sex undetermined (cf. Izawa, 2022e) is judged to be male since the antennule possesses one long, plumose seta on that segment (cf. Izawa, 2022e, fig. 3D). By the way, although copepodid IV of *Nothobomolochus cypseluri* (Yamaguti, 1953) was wrongly described as female (cf. Izawa, 2020, fig. 17), it is obviously male, because leg 5 bears 2 setae on the distal segment (male type), instead of 4 (female type), and the antennule possesses one long, plumose seta on that segment.

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