

- time-lapse photography. Deep Sea Research. Part I: Oceanographic Research Papers 52(7):1228–1240.
- Spengel, J. W. 1893. Fauna und Flora des Golfes von Neapel und der angrenzenden Meeres-Ab-schnitte. Herausgegeben von der Zoologi-schen Station zu Neapel. 18. Monographie: Enteropneusten. R. Friedländer & Sohn, Berlin, 756 pp. + 37 pl.
- Spengel, J. W. 1901 [1902]. Die Benennung der Enteropneusten-Gattungen. Zoologische Jahrbücher Abtheilung für Systematik, Geo-graphie und Biologie der Thiere 15:209–218.
- Urata, M., S. Iwasaki, & S. Ohtsuka. 2012. Biology of the swimming acorn worm *Glandiceps hacksi* from the Seto Inland Sea of Japan. Zoological Science 29(5):305–310.
- Woodwick, K. H., & T. Sensenbaugh. 1985. *Saxipendium coronatum*, new genus, new species (Hemichordata: Enteropneusta): the unusual spaghetti worms of the Galápagos Rift hydrothermal vents. Proceedings of the Bio-logical Society of Washington 98:351–365.

Associate Editor: Rick Hochberg.

### *Microtripus tinggiensis*, new genus and species (Amphipoda: Caprellidea: Phtisicidae) from Pulau Tinggi, East Johor Islands Archipelago, Malaysia

Jacqueline Hui Chern Lim, Azman B. Abdul Rahim, and Ichiro Takeuchi\*

(JHCL) Marine Science Programme, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia;

(ABAR) Marine Ecosystem Research Centre (EKOMAR), Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia;

(IT) Department of Life Environment Conservation, Faculty of Agriculture, Ehime University, 3-5-7 Tarumi, Matsuyama, Ehime 790-8566, Japan, e-mail: takeuchi@agr.ehime-u.ac.jp

*Abstract.*—*Microtripus tinggiensis*, a new genus and species (Amphipoda: Caprellidea: Phtisicidae), was discovered in the interstitial benthos from Pulau Tinggi, an island in the East Johor Islands Archipelago (EJIA). *Microtripus tinggiensis* is distinct in its reduced pereopods 3–5 (1-articulate pereopods 3, 4 and 3-articulate pereopod 5). The new genus *Microtripus* most closely resembles *Perotripus* Dougherty & Steinberg, 1953 in its elongated body segments, shorter antennae 1 and 2 and gills on pereonites 2–4 but differs from the latter by its 3-articulate flagellum of antenna 1 and 1-articulate, vestigial pereopod 3.

**Keywords:** Amphipoda, East Johor Islands Archipelago, Malaysia, *Microtripus tinggiensis*, Phtisicidae

This paper is part of a series based on accumulation of material from various sites around the East Johor Islands Archipelago (EJIA), situated off the east coast of Johor State, Malaysia in the South China Sea. These materials have been collected mainly from shallow waters along the coasts of Pulau Tinggi, Pulau Ibol, Pulau Sibul, Pulau Tengah, and Pulau Besar, EJIA. While several new species of gammaridean amphipods from this region are already described (see Lim et al. 2010, Azman & Melvin 2011), studies on the caprellidean amphipods have just begun. Here, we describe for the first time a new genus and new species (Caprellidea: Phtisicidae), discovered in benthic samples from seagrass habitats of Pulau Tinggi. The new genus differs from *Perotripus* Dougherty & Steinberg, 1953 in its 3-

articulate flagellum of antenna 1 and 1-articulate pereopod 3.

#### Materials and Methods

Materials were collected from the sediment using a two-tiered epibenthic sledge with an opening of 60 × 20 cm (width × height) in each tier and mesh size of 140 μm, pulled along a 10 m transect. Appendages were dissected from the right side of the specimens. The following abbreviations are used on the figures: A, antenna; ABD (L), abdomen lateral view; ABD (V), abdomen ventral view; G, gnathopod; LL, lower lip; MD, mandible; MX, maxilla; MXP, maxilliped; P, pereopod; UL, upper lip; R, right; L, left. All materials are deposited at the Universiti Kebangsaan Malaysia Muzium Zoologi (UKMMZ), Malaysia.

\* Corresponding author.

## Systematics

Family Phtisicidae Vassilenko, 1968

*Microtripus*, new genus

**Diagnosis.**—Body elongated. Head completely fused with pereonite 1. Antenna 1 well developed; flagellum with 3 articles. Antenna 2 well developed; flagellum with 2 articles. Mandible well developed; molar absent; palp 3-articulate, setal formula 1-0-0. Maxilliped well developed; inner plate (basal endite) equal to outer plate (ischial endite); outer plate (ischial endite) well developed; palp article 3 without distal projection; palp article 4 well developed. Pereonite 4 clavate appendage absent. Pereonites 6 and 7 not fused. Pereopod 3 vestigial, with 1 article. Pereopod 4 vestigial, with 1 article. Pereopod 5 with 3 articles, dactylus well developed. Pereopods 6 and 7 well developed, with 6 articles. Gills on pereonites 2–4. Pleopods absent. Uropods 2 pairs; uniramous and vestigial. Telson (dorsal lobe) present.

**Type species.**—*Microtripus tinggiensis*, new species.

**Etymology.**—The generic name *Microtripus* is derived from the reduced three pairs of pereopods, i.e., pereopods 3–5.

**Gender.**—Masculine.

**Remarks.**—Genera of the Phtisicidae Vassilenko, 1968 are characterized by a combination of several diagnostic characters, including absence of a mandibular molar, palp of mandible 3-articulate, head and pereonite 1 completely fused, three pairs of gills, pereonites 5 and 6 separated and urosomites 1 and 2 coalesced (see Takeuchi 1993).

Among the genera in the Phtisicidae, *Microtripus* is most closely related to *Perotripus* Dougherty & Steinberg, 1953. Dougherty & Steinberg (1953) established this genus based on *Paedaridium breve* La Follette, 1915 collected from the coast of California. *Perotripus* is one of the most apomorphic genera in this family (see Takeuchi 1993) in terms of its 2-articulate flagellum of antennae 1 and 2, 3-articulate

pereopod 3, 1-articulate pereopod 4, 3-articulate pereopod 5, 6-articulate pereopods 6 and 7, mandibular palp 3-articulate, molar process absent and male abdomen with vestigial uropods. The present description clearly indicates that *Microtripus* differs from *Perotripus* in its 3-articulate flagellum of antenna 1 and 1-articulate pereopod 3.

In addition to *Perotripus*, *Microtripus* also shares several diagnostic characters with *Caprellaporema* Guerra-García, 2003, such as mandibular palp with 3 articles, absence of a mandibular molar, 2-articulate flagellum of antenna 2, 6-articulate pereopods 6 and 7, and male abdomen with vestigial uropods (Guerra-García 2003). However, *Caprellaporema* is placed in the family Caprellidae Leach, 1814 by Guerra-García (2003) and not in Phtisicidae. *Caprellaporema* appears similar to *Perotripus* in its flagellum of antenna 1 and 2 with two articles each, mandibular palp 3-articulate, absence of a molar process, outer lobe of maxilliped larger than inner lobe, pereopod 5, 3-articulate and abdomen of male with vestigial uropods. Thus, these close similarities of *Caprellaporema* to *Perotripus* and to *Microtripus* indicate that *Caprellaporema* should be placed in the family Phtisicidae. *Microtripus* differs from *Caprellaporema* in general morphological structure, setal formula of the mandibular palp, gills present on pereonites 2, 3 and 4 (gills only present on pereonites 3 and 4 in *Caprellaporema*), presence of pereopods 3 and 4 (both absent in *Caprellaporema*) and 3-articulate pereopod 5 (only 2 articles in *Caprellaporema*).

*Microtripus tinggiensis*, new species

Figs. 1–6

**Type material.**—Holotype, male, 8.25 mm, UKMMZ-1439 (Fig. 1A), Kampung Pasir Panjang, Pulau Tinggi, EJIA, Johor, 02°17.528'N, 104°06.048'E, epibenthic sledge, 7 Jan 2010, depth 5 m, coll. B. A.



Fig 1. *Microtripus tinggiensis*. A, male holotype, 8.25 mm, UKMMZ-1439; B, female paratype, 3.45 mm, UKMMZ-1440, Pulau Tinggi, EJIA. Photographs based on fixed specimens. Scale = 0.5 mm.

R. Azman, S. Y. Gan, J. H. C. Lim, B. Shamsul, & T. Yoshida.

**Paratypes.**—1 female, UKMMZ-1440 (Fig. 1B); 2 males, 15 females, 4 premature males, 1 premature female, 73 juveniles, UKMMZ-1441; 3 males, 15 females, 4 premature males, 2 premature females, 72 juveniles, UKMMZ-1442; 2 males, 15 females, 5 premature males, 1 premature female, 72 juveniles, UKMMZ-1443, same station data. Dissected appendages were

stored in 9 semi-permanent slides mounted on glycerol.

**Type locality.**—Kampung Pasir Panjang, Pulau Tinggi, Johor, Malaysia, South China Sea.

**Etymology.**—Named after the type locality, Pulau Tinggi in the EJIA. “Pulau” means Island, and “Tinggi” means high.

**Description of male.**—Holotype, 8.25 mm (Fig. 2). UKMMZ-1439. Head and pereonite 1, 0.41 mm, completely fused,

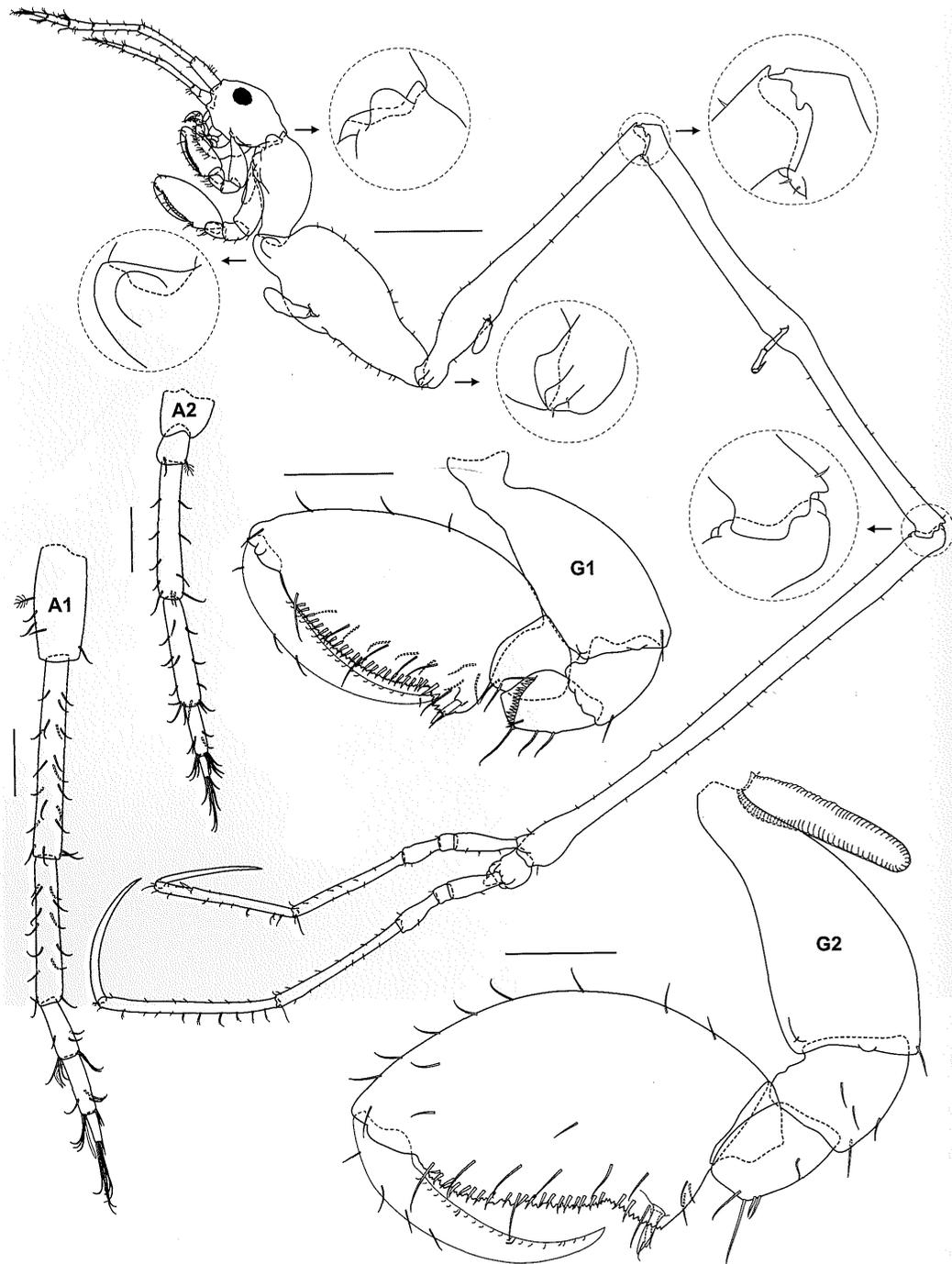


Fig. 2. *Microtripus tinggiensis*. Male holotype, 8.25 mm, UKMMZ-1439, Pulau Tinggi, EJIA. Scales for A1, A2, G1, G2 = 0.1 mm; whole body = 0.5 mm.

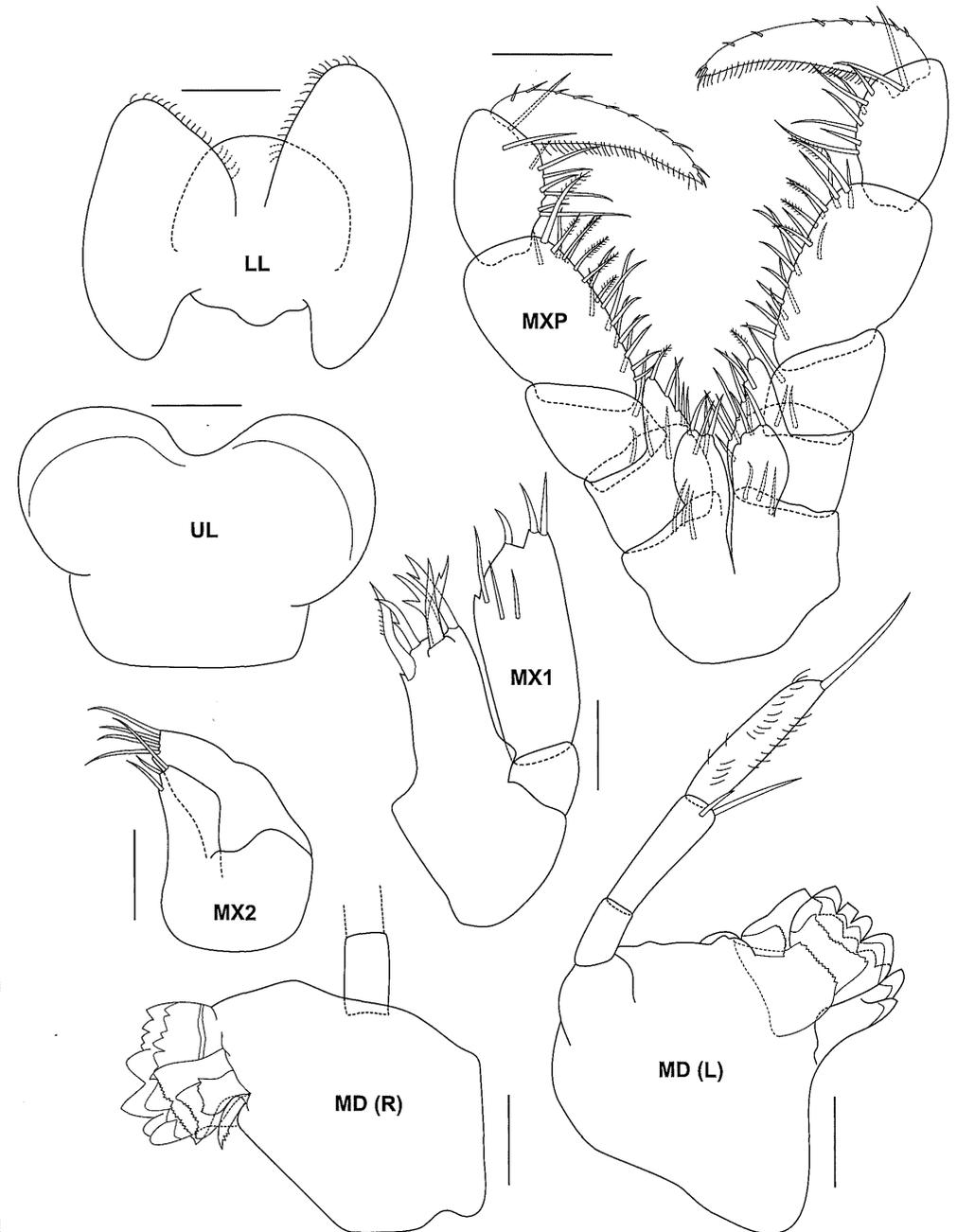


Fig. 3. *Microtripus tinggiensis*. MD (L), MD (R), MX1, MX2, MXP, UL, male holotype, 8.25 mm, UKMMZ-1439, Pulau Tinggi, EJIA. Scales: MD (L), MD (R), MX1, MX2, UL = 0.025 mm; MXP = 0.05 mm. LL, female paratype, 3.45 mm, UKMMZ-1440, Pulau Tinggi, EJIA. Scale: 0.025 mm.

suture absent. Pereonite 2, 0.49 mm, with anterolateral projection. Pereonite 3, 0.93 mm, with anterolateral rounded projection. Pereonite 4, 1.56 mm, slender and

long with anterolateral rounded projection and distolateral sculpturing. Pereonite 5, 2.22 mm with distolateral sculpturing. Pereonite 6 longest, 2.47 mm, slender and

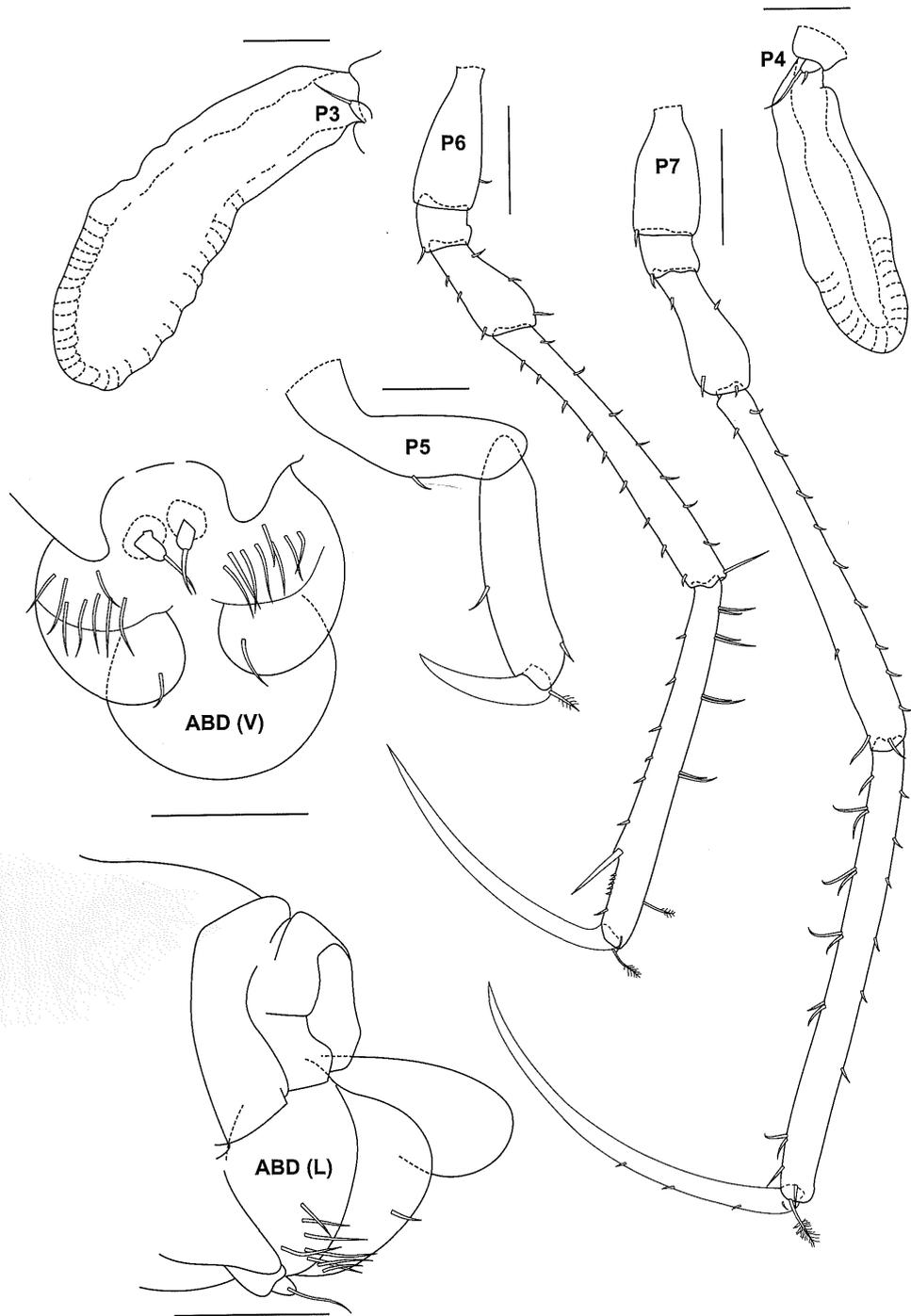


Fig. 4. *Microtripus tinggiensis*. Male holotype, 8.25 mm, UKMMZ-1439, Pulau Tinggi, EJIA. Scales: ABD (L), ABD (V), P3, P4, P5 = 0.05 mm; P6, P7 = 0.2 mm.

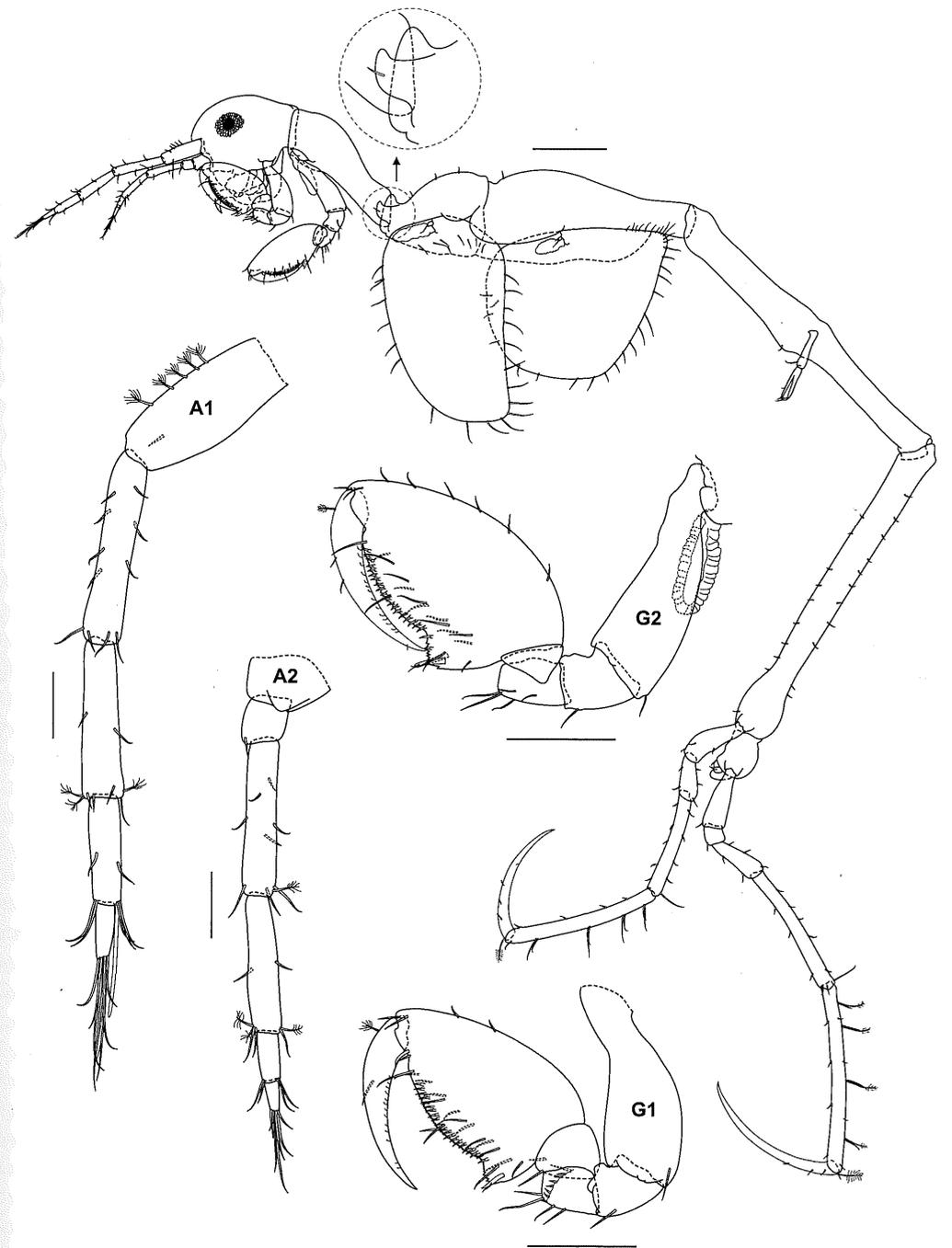


Fig. 5. *Microtripus tinggiensis*. Female paratype, 3.45 mm, UKMMZ-1440, Pulau Tinggi, EJIA. Scales: A1, A2 = 0.05 mm; G1, G2 = 0.1 mm; whole body = 0.2 mm.

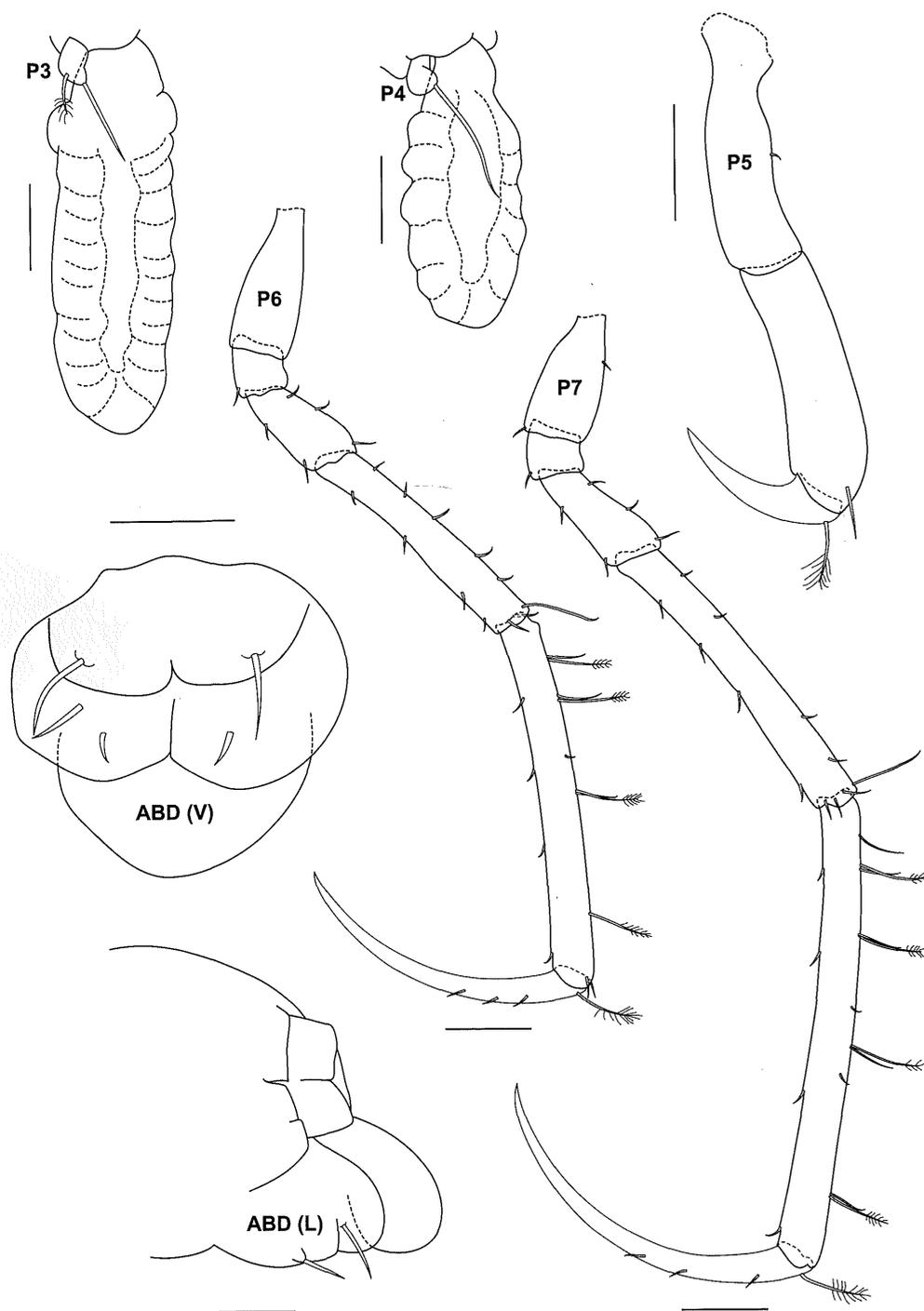


Fig. 6. *Microtripus tinggiensis*. Female paratype, 3.45 mm, UKMMZ-1440, Pulau Tinggi, EJIA. Scales: ABD (L), ABD (V), P3, P4 = 0.025 mm; P5 = 0.05 mm; P6, P7 = 0.1 mm.

elongated. Pereonite 7, 0.17 mm. Antenna 1,  $0.1 \times$  body length, peduncular article 2 longest,  $1.8 \times$  article 1; article 3,  $0.9 \times$  article 2; flagellum 3-articulate (Fig. 2, A1). Antenna 2,  $0.7 \times$  length of antenna 1; flagellum  $0.2 \times$  peduncular length with 2 articles (Fig. 2, A2).

Mouthparts (Fig. 3, all based on male, except lower lip): upper lip wider than deep; bilobed; smooth on each lobe (Fig. 3, UL). Mandibular palp both left and right similar, 3-articulate, article 2 longer than article 1 with 1 long and 1 short distal setae, article 3 longest, pubescent, with 1 slender terminal seta; left incisor with 6 teeth; lacinia mobilis with 4 teeth followed by 3 plates, one in front of the other; molar absent [Fig. 3, MD (L)]; right incisor with 8 teeth; lacinia mobilis plate-like, serrated, followed by 2 plates one in front of the other, decreasing in size, and accessory bundled seta; molar absent [Fig. 3, MD (R)]. Maxilla 1 outer plate with 6 stout apical setal-teeth (4 bifid and 2 normal); palp 2-articulate; article 2 subequal in length with outer plate,  $3 \times$  longer than article 1 with 3 triangular projections distally, armed with 3 apical setae and 3 facial setae (Fig. 3, MX1). Maxilla 2 inner plate with 4 setae; outer plate with 4 apical setae (Fig. 3, MX2). Lower lip (based on female, 3.45 mm, UKMMZ-1440), right and left inner lobes fused; distal margin finely setose (Fig. 3, LL). Maxilliped basal endite (inner plate) apically provided with 2 setae; ischial endite (outer plate)  $1.7 \times$  length of inner plate with 1 plumose seta apically and row of setae on inner margin; palp 4-articulate, article 2 longest, setose along entire inner margin with several plumose setae at distal margin, article 3 subequal in length with article 1, setose along entire inner margin and provided with 1 facial seta, no triangular distal projection; dactylus falcate, with row of setules on inner margin and row of fine setae on outer margin (Fig. 3, MXP).

Pereon (Figs. 2, 4). Gnathopod 1 basis almost as long as ischium, merus and

carpus combined; basis and ischium each with 1 seta at posterodistal corner; merus subrectangular, with row of distolateral serrated teeth; carpus very short, subtriangular; propodus longer than wide (length  $1.9 \times$  width), palm serrated, begins one-sixth along posterior margin, with 1 row of short submarginal setae and several facial setae, proximal projection equipped with 1 robust seta and 1 normal seta; dactylus falcate, inner margin lined with very fine setae (Fig. 2, G1). Gill 2 elongated,  $0.35 \times$  pereonite 2, inserted anteroventrally on pereonite 2. Gnathopod 2 begins one-quarter along anterior margin of pereonite 2; basis,  $0.65 \times$  pereonite 2 length,  $1.4 \times$  longer than ischium, merus and carpus combined, basis with 1 seta at posterodistal corner; ischium sparsely setose; merus subrectangular with posterodistal setae; carpus compressed, subtriangular; propodus longer than wide (length  $2.0 \times$  width), palm serrated, begins one-fifth along posterior margin, proximal projection with 1 robust seta (grasping spine) and 1 normal seta; dactylus falcate, with several fine setae (Fig. 2, G2). Gill 3 length  $0.3 \times$  pereonite 3, oval. Pereopod 3 very small,  $0.01 \times$  pereonite 3, 1-articulate with 1 distal seta (Fig. 4, P3). Gill 4 length slightly shorter than gill 3,  $0.15 \times$  pereonite 4, oval. Pereopod 4 subequal with pereopod 3,  $0.01 \times$  pereonite 4, 1-articulate with 1 short and 1 long distal setae (Fig. 4, P4). Pereopod 5 reduced to 3 articles, article 1 subequal with article 2, article 2 propodus-like, with 2 setae, article 3 falcate, dactyl-like with 1 plumose seta (Fig. 4, P5). Pereopods 6 and 7 well developed, 6-articulate; carpus and propodus slender and elongated. Pereopod 6 length subequal with pereonite 6; merus, carpus, and propodus flanked by setae on inner and outer margins; propodus inner distal margin with 1 large spine followed by 5 small spines; dactylus falcate and slender (Fig. 4, P6). Pereopod 7 longer than pereopod 6 ( $1.1 \times$  longer); carpus with setae on outer margin; propodus with short setae along

inner and outer margin, outer margin with 1 plumose seta distally; dactylus slender and falcate, nearly as long as propodus ( $0.9 \times$  length of propodus) (Fig. 4, P7).

Pleon (Fig. 4). Penes small, positioned laterally. Uropod 1 base with tuft of 8 setae, uniramous, with 1 long seta apically. Uropod 2 ramus vestigial with 1 seta distally. Telson large and smooth, no setae present [Fig. 4, ABD (V)].

*Description of female.*—Body length, 3.45 mm (Fig. 5). UKMMZ-1440. Head, and pereonite 1, 0.35 mm. Pereonite 2, 0.36 mm. Pereonite 3, 0.30 mm with anterolateral rounded projection. Pereonite 4, 0.55 mm; slender and long. Pereonite 5, 0.90 mm. Pereonite 6 subequal with pereonite 5, 0.91 mm, slender and elongated. Pereonite 7, 0.13 mm. Antenna 1,  $0.15 \times$  body length, peduncular article 2 longest,  $1.1 \times$  longer than article 1; article 3 shortest,  $0.8 \times$  article 2; flagellum 2-articulate (Fig. 5, A1). Antenna 2,  $0.7 \times$  the length of antenna 1, peduncular article 3 and 4 subequal in length; flagellum  $0.2 \times$  peduncular length with 2 articles (Fig. 5, A2).

Pereon (Figs. 5, 6). Gnathopod 1 basis longer than ischium, merus and carpus combined; propodus subovate, slightly expanded proximally, longer than wide (length  $1.6 \times$  width), palm serrated, begins one-sixth along posterior margin, with row of short submarginal setae and several facial setae, proximal projection with 1 robust seta (grasping spine) and 1 normal seta; dactylus falcate with 1 plumose seta on outer margin (Fig. 5, G1). Gill 2 length  $0.28 \times$  pereonite 2, oval. Gnathopod 2 basis longer than ischium, merus and carpus combined ( $1.3 \times$  longer); propodus longer than wide ( $2.0 \times$  width), palm serrated, begins one-fifth along posterior margin, with 1 row of short submarginal setae and several facial setae, proximal projection with 1 robust seta (grasping spine) and 1 normal seta; dactylus falcate with several fine setae, 1 plumose seta on outer margin (Fig. 5, G2). Gill 3 length  $0.35 \times$  pereonite 3, oval. Pereopod 3 very small, 1-articulate

with 1 long seta and 1 plumose seta (Fig. 6, P3). Oostegite 3 longer than wide, length  $1.7 \times$  width with fine setae along entire outer margin. Gill 4 length  $0.15 \times$  width with fine marginal setae. Pereopod 5, 3-articulate, article 1 and article 2 almost of equal length, article 2 with 1 distal seta, article 3 with 1 plumose seta at proximal margin (Fig. 6, P5). Pereopod 6 carpus less setose on inner margin than outer margin; propodus lacking spines on inner distal margin, outer margin with several normal setae and plumose setae; dactylus falcate with 3 small setae on outer margin (Fig. 6, P6). Pereopod 7 basis  $0.8 \times$  shorter than basis of pereopod 6; propodus outer margin with several normal and plumose setae; dactylus slender and falcate,  $0.7 \times$  length of male dactylus (Fig. 6, P7).

Pleon (Fig. 6). Uropod 1 ramus vestigial, 1 long seta apically. Uropod 2 ramus vestigial with 1 short seta and 1 long seta. Telson large and smooth, setae lacking [Fig. 6, ABD (V)].

*Ontogeny.*—Flagellum of antenna 1 in males develops from 2 articles to 3 articles as the individual matures ( $>5.9$  mm). Number of articles for female antenna 1 flagellum remains the same (2 articles) for mature individuals ( $>2.5$  mm).

*Remarks.*—Currently the genus *Perotripus* consists of three species, namely *P. brevis* (La Follette, 1915) from the west coast of North America, *P. keablei* Guerra-García, 2006 from Lizard Island in Queensland, Australia, and *P. koreanus* Lee & Hong, 2010 from Korea. In addition to these species, an undescribed species of *Perotripus* was recorded from the Pacific coasts of central Japan (see Takeuchi & Hirano 1995, Takeuchi 1999, Aoki & Takeda 2006).

Generally, the external morphological characters of *Microtripus tinggiensis* are most similar to *Perotripus keablei* in terms of the elongated body somites, low number of grasping spines on gnathopods 1 and 2, 1-articulate pereopods 3 and 4, 3-articulate pereopod 5 and presence of spines on palmar margin of pereopod 6. However, it

is easily distinguished from *P. keablei* by its longer and more sculptured body and anterolateral projections, 3-articulate flagellum of antenna 1, maxilla 1 palp article 2 broad and short (slender and long in *P. keablei*), gnathopod 1 merus with row of distolateral serrated teeth, laterally situated small penes and presence of a pair of appendages in the abdomen. The above differences in external morphology were confirmed by observations on type specimens of *P. keablei* deposited at the Australian Museum.

The recent discovery of *Microtripus* by the present study and *Caprellaporema* by Guerra-García (2003) indicates the potential that the Phtisicidae holds in hosting a wide variety of yet to be discovered genera and species.

#### Acknowledgments

We express our sincere thanks to Prof. Othman bin Haji Ross for his continuous support and encouragement throughout the present study. We would like to thank Dr. Teruaki Yoshida, Ms. Gan Sim Yee, and Mr. Shamsul Bahar for their kind assistance in the field sampling and Dr. Stephen Keable and Ms. Helen Stoddard for their kind arrangements for the study of type specimens of *Perotripus keablei* at the Australian Museum. This research was partially funded by the Ministry of Science, Technology and Innovation (UKM-ST-08-FRGS0020-2009) and Universiti Kebangsaan Malaysia (UKM) research grants UKM-GGPM-PLW-034-2010 and UKM-GUP-ASPL-08-04-231.

#### Literature Cited

Aoki, M., & M. Takeda. 2006. Caprellid amphipods from the coastal waters of Shimoda, Izu Peninsula, Central Japan. *Memoirs of the National Science Museum* 41:65–70 (in Japanese with English Abstract).

- Azman, B. A. R., & C. W. H. Melvin. 2011. Two new species of *Urothoe* (Crustacea, Amphipoda, Gammaridea) from the East Johor Islands Archipelago, Malaysia. *ZooKeys* 87:43–62.
- Dougherty, E. C., & J. E. Steinberg. 1953. Notes on the skeleton shrimps (Crustacea: Caprellidae) of California. *Proceedings of the Biological Society of Washington* 66:39–50.
- Guerra-García, J. M. 2003. The caprellidean Amphipoda from the subantarctic islands of New Zealand and Australia with the description of a new genus and two new species. *Scientia Marina* 67(2):177–194.
- Guerra-García, J. M. 2006. Caprellidae (Crustacea: Amphipoda) from the Great Barrier Reef and adjacent localities. *Records of the Australian Museum* 58:417–458.
- La Follette, R. 1915. Caprellidae from Laguna Beach, II. *Journal of Entomology and Zoology* 7:55–63.
- Leach, W. E. 1814. Crustaceology. *In* The Edinburgh Encyclopaedia; conducted by David Brewster, LL.D. 7:383–437.
- Lee, K.-S., & S.-S. Hong. 2010. A new species of the genus *Perotripus* (Crustacea: Amphipoda: Caprellidae) from Korea. *Animal Cells and Systems* 14:53–58.
- Lim, J. H. C., B. A. R. Azman, & B. H. R. Othman. 2010. Melitoid amphipods of the genera *Ceradocus* Costa, 1853 and *Victoriopisa* Karaman and Barnard, 1979 (Crustacea: Amphipoda: Maeridae) from the South China Sea, Malaysia. *Zootaxa* 2348:23–39.
- Takeuchi, I. 1993. Is the Caprellidea a monophyletic group? *Journal of Natural History* 27(4):947–964.
- Takeuchi, I. 1999. Checklist and bibliography of the Caprellidea (Crustacea: Amphipoda) from Japanese waters. *Otsuchi Marine Science* 24:5–17.
- Takeuchi, I., & R. Hirano. 1995. Clinging behavior of the epifaunal caprellids (Amphipoda) inhabiting the *Sargassum* zone on the Pacific coast of Japan, with its evolutionary implications. *Journal of Crustacean Biology* 15:481–492.
- Vassilenko, S. V. 1968. K voprosu o sistematike i osnovnykh linijakh razvitija sem. Caprellidae (Amphipoda, Caprellidea). [Contribution to the systematics and principal evolutionary lines of the family Caprellidae (Amphipoda, Caprellidea)]. *Doklady Akademii Nauk SSSR* 183(6):1461–1464 (in Russian).

Associate Editor: Christopher B. Boyko.