

A new stygobitic prawn of the genus *Macrobrachium* Spence Bate, 1864, from anchialine caves in Christmas Island, Indian Ocean; with a rediagnosis of *M. miyakoense* Komai & Fujita, 2005 (Crustacea: Decapoda: Caridea: Palaemonidae)

Yoshihisa Fujita^{1*}, Peter J. F. Davie² and Peter K. L. Ng³

Abstract. A new species of stygobitic palaemonid prawn of the genus *Macrobrachium* Spence Bate, 1864, is described from Christmas Island, Indian Ocean Territory, Australia. The new anchialine species resembles *M. miyakoense* Komai & Fujita, 2005, from Japan, but can be distinguished by its relatively longer and more slender rostrum, the proportionately smaller eye cornea with a more swollen eye stalk, and more teeth on the post-rostral margin of the carapace. The taxonomy of *M. miyakoense* is also discussed based on additional material recently obtained from Japan, and the species rediagnosed. *Macrobrachium miyakoense* was originally described from two young males collected from Miyako Island, Ryukyu Islands, Japan.

Key words. Palaemonidae, *Macrobrachium*, new species, anchialine cave, Christmas Island, Indian Ocean, taxonomy

INTRODUCTION

Macrobrachium Spence Bate, 1864, is the most diverse genus in the family Palaemonidae with around 245 species (De Grave & Fransen, 2011). Its species have adapted well to many freshwater and estuarine habitats (e.g., Holthuis, 1986; Chace & Bruce, 1993), but relatively few have made the move into subterranean environments. Currently, there are 12 stygobitic species of *Macrobrachium* described: *M. acherontium* Holthuis, 1977 [Mexico], *M. cationium* Hobbs & Hobbs, 1995 [Belize], *M. cavernicola* (Kemp, 1924) [Assam, India], *M. elegantum* Pan, Hou & Li, 2010 [Guangxi, China], *M. gua* Chong 1989 [Sabah, Borneo], *M. linyunense* Li, Cai & Clarke, 2006 [Guangxi, China], *M. lucifugum* Holthuis, 1974 [Cuba and nearby islands], *M. microps* Holthuis, 1978 [New Ireland, Papua New Guinea; New Caledonia and Samoa], *M. miyakoense* Komai & Fujita, 2005 [Ryukyus, Japan], *M. sbordonii* Mejía-Ortiz, Baldari & López-Mejía, 2008 [Chiapas, Mexico], *M. poeti* Holthuis, 1984 [Java, Indonesia], and *M. villalobosi* Hobbs, 1973 [Oaxaca, Mexico] (see Holthuis, 1986; Li et al., 2006; Mejía-Ortiz et al., 2008; Pan et al., 2010).

In Christmas Island, Indian Ocean Territory, Australia, there are extensive subterranean habitats with a significant subterranean fauna (Humphreys & Eberhard, 2001), including endemic decapods such as the shrimp *Procaris noelensis* Bruce & Davie, 2006, and two species of varunid crab, *Orcovita orchardorum* Davie & Ng, 2012, and *O. hicksi* Davie & Ng, 2012. As for freshwater palaemonids, *Macrobrachium lar* (Fabricius, 1798) has been reported from surface waters on the island, where it is relatively common (De Man, 1906; Short & Meek, 2000; Ng & Davie, 2012). Gordon (1935: 629) also listed *M. rosenbergii* (De Man, 1879) (as *Palaemon carcinus*) from the island but there have been no records since (e.g., Short & Meek, 2000). We have not obtained this species in our surveys and it is unlikely such a large and distinctive species would have been missed. This record is almost certainly a mistake as there are no suitable habitats on Christmas Island for this species (e.g., large freshwater rivers) (see Wowor & Ng, 2007). A third species, *M. microps*, was recorded by Short & Meek (2000) on the basis of one adult female (pocl 23.8 mm) specimen from Daniel Roux Cave, and an undeveloped male (pocl 11.9 mm) from Freshwater Cave. This species was originally described from the Danmin Cave in New Ireland, Papua New Guinea, and thereafter recorded from Samoa and New Caledonia (Lifou Island) (Holthuis, 1978; Bruce & Iliffe, 1993; Short & Marquet, 1998).

One of the objectives of the Christmas Island Expeditions conducted in January–February 2010, March 2011 and February 2012 (see Tan et al., 2014a, b), was to collect more adult specimens of the stygobiotic *Macrobrachium*, including adult males and females, to verify the identification of Short & Meek (2000). After detailed examination of the new specimens collected, we are now confident that

¹Okinawa Prefectural University of Arts, 1-4 Shuri-tounokura, Naha, Okinawa 903-8602, Japan; Email: fujitayo@okigei.ac.jp (*corresponding author)

²Queensland Museum, PO Box 3300, South Brisbane, Queensland, Australia; Email: Peter.Davie@qm.qld.gov.au

³Lee Kong Chian Natural History Museum, Faculty of Science, National University of Singapore, 2 Conservatory Drive, Singapore 117377, Republic of Singapore; Email: dbsngkl@nus.edu.sg

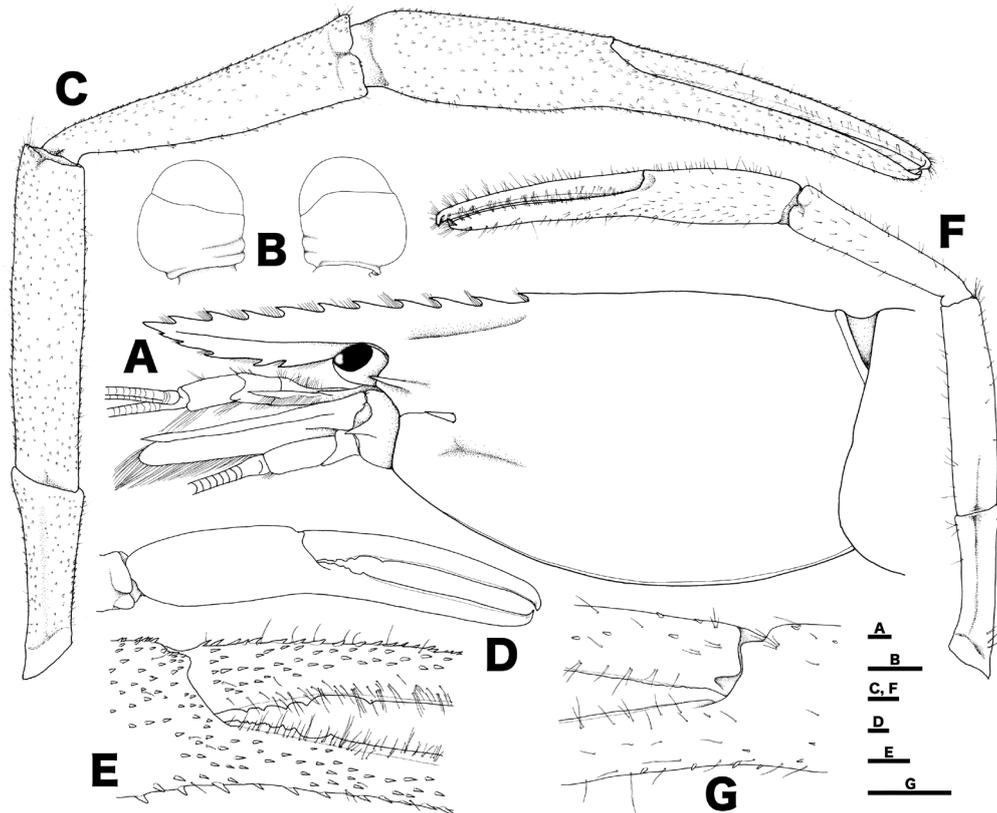


Fig. 1. *Macrobrachium miyakoense* Komai & Fujita, 2005, adult male (pocl 18.9 mm) from Miyako Island, Ryukyu Islands, Japan (RUMF-ZC-2665). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view (left), dorsal view (right); C, left second pereiopod, lateral view; D, same, chela (setae and spinules omitted); E, same, basal part of fingers, dorsal view; F, right second pereiopod, lateral view; G, same, basal part of fingers, dorsal view. Scale bars = 1.0 mm.

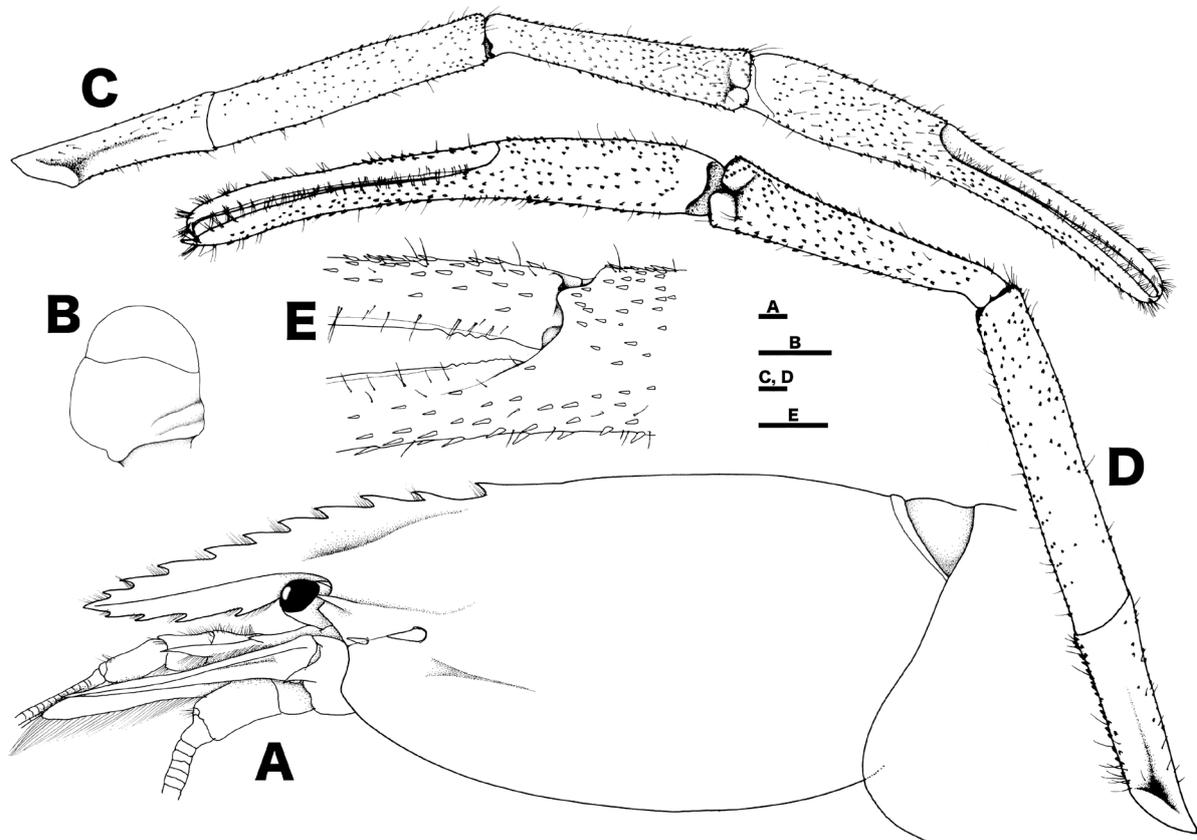


Fig. 2. *Macrobrachium miyakoense* Komai & Fujita, 2005, adult female (pocl 21.8 mm) from Miyako Island, Ryukyu Islands, Japan (RUMF-ZC-2664). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view; C, left second pereiopod; D, right second pereiopod; E, same, basal part of fingers, dorsal view. Scale bars = 1.0 mm.

our specimens have sufficient differences from known species to recognise them as belonging to a new species, *Macrobrachium xmas* n. sp.; and specimens which have been reported as "*M. microps*" by Short & Meek (2000) are probably also conspecific with the new species. This new species most closely resembles *M. miyakoense* from Japan, a species described on the basis of two small specimens. Fortunately, the first author (YF) has since collected two more adult specimens of *M. miyakoense* from an anchialine cave near the type locality in Japan. This additional material has allowed us to make more detailed comparisons with *M. xmas* n. sp. The opportunity is thus also taken to redescribe *M. miyakoense* on the basis of the new adult material.

MATERIAL AND METHODS

Specimens were collected by using collapsible bait traps and tubular plastic shrimp/crab traps (of a type commonly used in Taiwan). Size of specimens is indicated by postorbital carapace length (pocl) measured from the orbital margin to the posterodorsal margin of the carapace. The abbreviation cl is used for carapace length (including the rostrum). The types specimens of the present new species are deposited in the following collections: ZRC – the Zoological Reference Collection of the Lee Kong Chian Natural History Museum, National University of Singapore; QM – the Queensland Museum, Brisbane; WAM – the Western Australian Museum, Perth; OUMNH.ZC – Oxford University Museum of Natural History, Oxford, U.K.; RUMF – the Ryukyu University Museum, Fujikan, Okinawa, Japan. We follow the classification and citation of authorities outlined in De Grave & Fransen (2011).

TAXONOMY

Family Palaemonidae

Macrobrachium miyakoense Komai & Fujita, 2005 (Figs. 1–3)

Macrobrachium miyakoense – Komai & Fujita, 2005: 14; De Grave & Fransen, 2011: 327.

Material examined. 1 female (RUMF-ZC-2664), pocl 21.8 mm, Ueno Ana-ga Cave, Miyako Island, 24°43'13.9"N, 125°19'19.5"E, Ryukyu Islands, Japan, baited trap, coll. by Y. Fujita, 15 September 2009; 1 male (RUMF-ZC-2665), pocl 18.9 mm, Ueno Ana-ga Cave, Miyako Island, Ryukyu Islands, Japan, baited trap, coll. by Y. Fujita, 15 August 2010.

Supplementary description. Compared to types, rostrum (Figs. 1A, 2A) directed anteriorly, sharply pointed distally, reaching/over-reaching distal end of antennular peduncle, not reaching distal margin of antennal scale, 0.45–0.52 of carapace length; dorsal margin with 10 teeth, 4 on carapace posterior to orbital margin; ventral margin with 4 or 5 teeth. Eye (Figs. 1B, 2B) reduced; stalk short, oblique, weakly swollen anteriorly; cornea small, oblique, faceted with dark pigments, 1.91–1.97 times wider than deep, 0.82–0.83 stalk width; ocellus absent. Epistome weakly bilobed by shallow

depression. Male (RUMF-ZC-2665): second pereopods (Fig. 1C, D, E) moderately robust, similar in form, unequal in length; left 1.68 times longer than right; surface from dactylus to ischium covered with numerous minute spinules, sparsely setose. Left (major) cheliped robust; ischium 0.68 of merus length; merus 1.01 of carpus length; carpus 0.58 length of chela; palm subcylindrical, 0.43 of chela length, dactylus 1.38 of palm length, 0.59 of chela length; cutting edge of fingers not gaping, with low, blunt teeth on proximal margins. Right (minor) cheliped (Fig. 1F, G) slender; ischium 0.78 of merus length; merus 1.12 of carpus length; carpus 0.55 length of chela; palm 0.40 of chela length; dactylus, 1.46 of palm length, 0.59 of chela length; cutting edge of fingers almost smooth, not gaping. Female (RUMF-ZC-2664): second pereopods (Fig. 2C, D, E) moderately slender, similar in form, equal in length; surface of dactylus to ischium covered with sparsely minute spinules and setose; ischium 0.72–0.75 of merus length; merus 1.14–1.16 of carpus length; carpus 0.55–0.56 length of chela; palm 0.39 of chela length; dactylus 1.60–1.61 of palm length, 0.62 of chela length; cutting edge of fingers not gaping, with very low, blunt teeth on proximal margins.

Remarks. *Macrobrachium miyakoense* was originally described from two young males (pocl 14.70 mm and 12.60 mm). The present full-grown specimens are similar in morphology to the type specimens, but some adult characters differ markedly. We have therefore amended the original description of Komai & Fujita (2005) accordingly and provided new figures.

Macrobrachium xmas n. sp. (Figs. 4–14)

Macrobrachium microps – Short & Meek, 2000: 83–85, fig. 2 [not *Macrobrachium microps* Holthuis, 1978].

Material examined. Holotype: male (QM-W28315), pocl 18.74 mm, cl 28.30 mm, station CI-23-2011, Freshwater Cave, Christmas Island, coll. 25 March 2011. Paratypes: 1 ovigerous female (ZRC 2015.281), pocl 21.66 mm, station CI-21-2010, Whip Cave, coll. 30 January 2010; 1 male (ZRC 2015.282), pocl 16.26 mm, station CI-11-2011, Runaway Cave, coll. 22 March 2011; 1 male (RUMF-ZC-2802), pocl 13.22 mm, station CI-19-2011, Runaway Cave, coll. 24 March 2011; 1 ovigerous female (QM-W28316), pocl 20.20 mm, station CI-10-2011, Freshwater Cave, coll. 22 March 2011; 1 male (OUMNH.ZC.2015-02-048), pocl 21.75 mm, station CI-18-2011, Freshwater Cave, coll. 24 March 2011. Non-types: 1 male (WAM-C44840), pocl 12.10 mm, Whip Cave, Christmas Island, coll. by R.D. Brooks & R. Anderson, 30 April 2006; 1 male (ZRC 2015.283), pocl 8.71 mm, station CI-23-2011, Freshwater Cave, coll. 25 March 2011.

Diagnosis. Medium sized prawn, maximum total length (including rostrum) 67.2 mm in largest male (OUMNH.ZC.2015-02-048). Rostrum slender, over-reaching distal end of antennular peduncle, sometimes reaching or over-reaching distal margin of antennal scale, 0.41–0.70 of carapace length; dorsal margin with 12–15 teeth, including

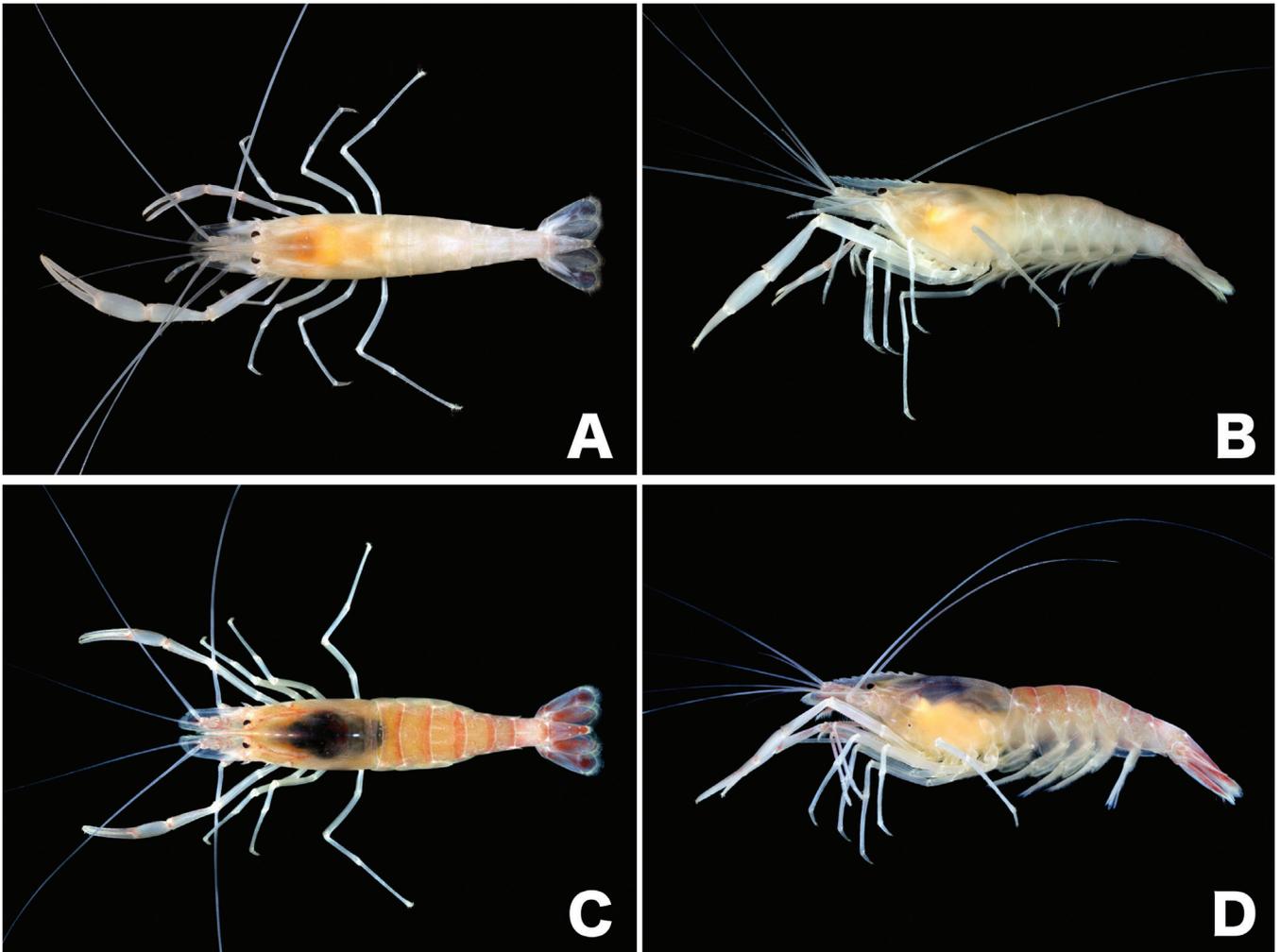


Fig. 3. *Macrobrachium miyakoense* Komai & Fujita, 2005, coloration of live specimens. A, adult male (RUMF-ZC-2665), dorsal view; B, same, lateral view; C, adult female (RUMF-ZC-2664), dorsal view; D, same, lateral view.

5 or 6 on carapace posterior to orbital margin; ventral margin with 3–8 teeth. Carapace with inferior orbital angle roundly produced; antennal spine large, acute, situated at lower orbital angle, over-reaching inferior orbital angle; hepatic spine sharp, articulated basally, smaller than antennal spine; branchiostegal groove delineated, not extending posteriorly beyond hepatic spine; pterygostomial angle broadly rounded. Fourth and fifth abdominal pleura each acutely produced posteroventrally; inter-uropodal sclerite with median triangular tooth. Eye reduced; stalk swollen anteriorly; cornea faceted with dark pigments, width about 0.71–0.78 of stalk width. First pereopods very slender, subequal in length, similar in form, over-reaching antennal scale by entire chela and about half of carpus length; chela about half of carpus length. Second pereopods similar in form, subequal in length, but size and form noticeably different with male larger than female, in large individuals relatively more robust than small ones. Second pereopods of full-grown male moderately robust, surface of segments profusely spinose, densely setose; palms subcylindrical, about 0.4 of chela length; fingers with cutting edge weakly dentate in proximal half, not noticeably gaping; dactylus 1.2–1.3 times longer than palm; carpus about 0.5 length of chela, 1.0–1.2 length of merus. Ambulatory legs (third to

fifth pereopods) slender, carpi and propodi profusely but minutely spinose, spines minute; fifth pereopod longer than third or fourth pereopods, over-reaching antennal scale by length of dactylus and about half of propodus.

Description of holotype. Medium sized prawn, total length (including rostrum) to 63.9 mm. Rostrum (Fig. 4A–C) directed forward, sharply pointed distally, over-reaching distal end of antennular peduncle, but not reaching distal margin of antennal scale, 0.51 of carapace length; dorsal margin slightly rugged, with 15 teeth and rows of plumose setae; 6 teeth extend onto carapace posterior to orbital margin, sixth distal-most tooth bifid; anterior 9 teeth unequally spaced, posterior 6 teeth subequally spaced; ventral margin with 8 unequal teeth with rows of plumose setae, anterior 7 teeth on anterior half and posteriormost tooth on distal half of margin; lateral surface with sharp carina from orbital margin to distalmost. Carapace (Fig. 4A, C) smooth; inferior orbital angle slightly produced; antennal spine large, acute, situated at lower orbital angle, over-reaching inferior orbital angle; hepatic spine sharp, articulated basally, smaller than antennal spine; branchiostegal groove delineated, not extending posteriorly beyond hepatic spine; pterygostomial angle broadly rounded.

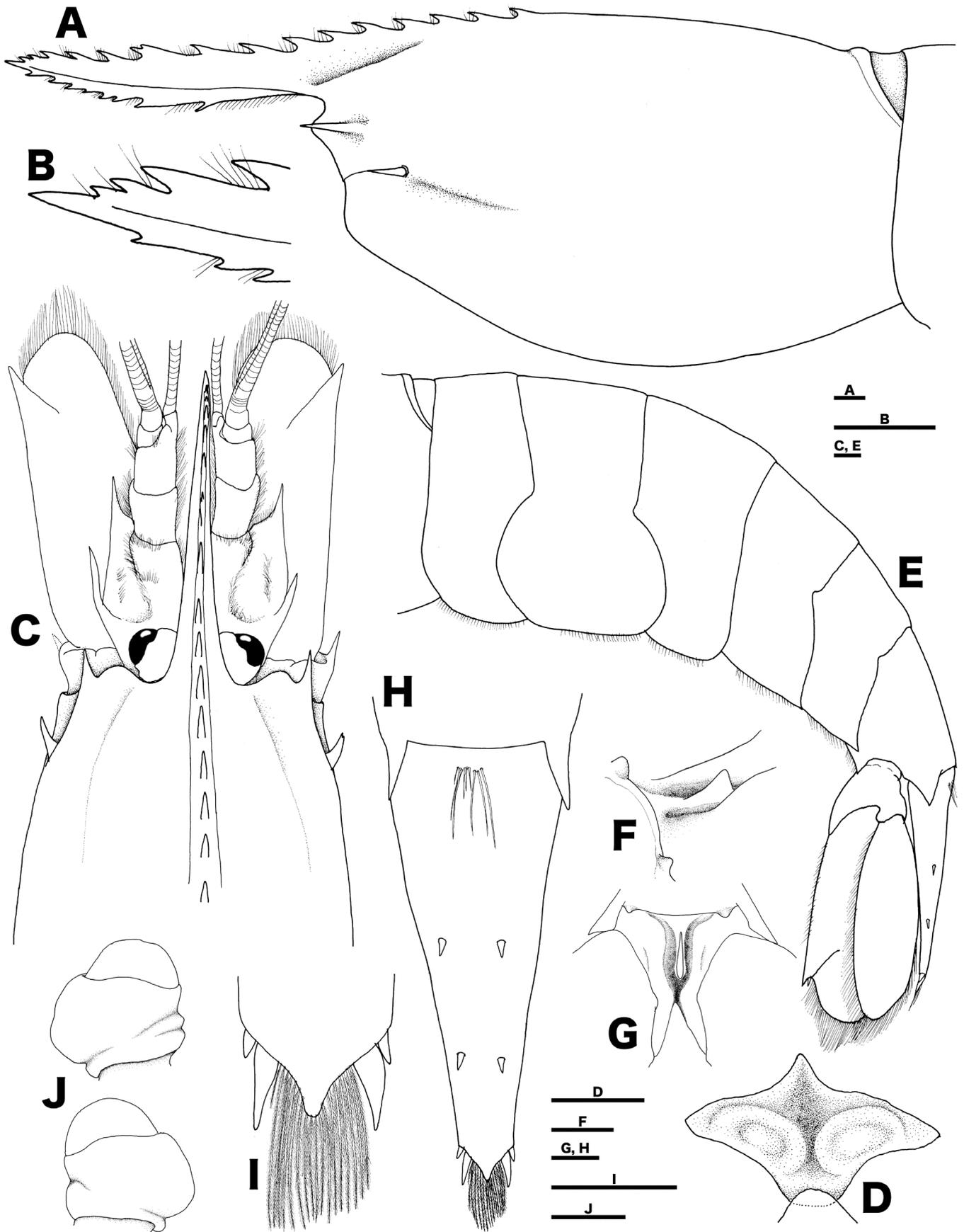


Fig. 4. *Macrobrachium xmas* n. sp., holotype male (pocl 18.74 mm) (QM-W28315). A, rostrum and carapace, lateral view; B, tip of rostrum, lateral view; C, rostrum, anterior part of carapace and cephalic appendages, dorsal view; D, epistome, ventral view; E, abdomen and telson, and left uropod, lateral view; F, posterior margin of sixth abdominal sternite and interuropodal sclerite, ventrolateral view; G, same, ventral view; H, telson, dorsal view; I, posterior margin of telson, dorsal view; J, eye (left side), ventral view (above), dorsal view (below). Scale bars = 1.0 mm.

Thoracic sternum narrow; fourth sternite with low transverse ridge along posterior border; fifth sternite with prominent paired plates posterior to coxae of second pereopods; sixth and seventh sternites each with pair of rounded protuberances concealed by coxae of third and fourth pereopods; eighth sternite with pair of obliquely transverse ridges along posterior border of coxae of fifth pereopods.

Abdomen (Fig. 4E) with 6 somites, smooth, rounded dorsally; pleura of first 3 somites broadly rounded, fourth and fifth somites each acutely produced posteroventrally; sixth somite 1.41 of fifth somite length, 1.39 times longer than deep, with sharp posterolateral process, posteroventral angle subacute. First 3 abdominal sternites each with transverse ridge and low triangular median tooth, second abdominal sternite more developed than other abdominal sternites; fourth sternite with very small median tubercle; fifth sternite with low median carina; sixth sternite with pair of blunt teeth on posterior margin. Inter-uropodal sclerite (Fig. 4F, G) with conspicuous triangular tooth medially.

Telson (Fig. 4H, I) long, slender, 2.43 times as long as wide, 1.53 times as long as sixth abdominal somite, tapering posteriorly, terminating in blunt tooth: dorsal surface with tuft of plumose setae and 2 pairs of spines, anterior pair of spines arising about midlength of telson; posterior margin with 2 pairs of spines on either side of posteromedian tooth, mesial pair of spines well developed, 3.0 times as long as lateral pair, posteromedian margin with long setae.

Eye (Fig. 4C, J) strongly reduced; stalk short, oblique, swollen anteriorly; cornea small, oblique, faceted with dark pigments, 2.01–2.16 times wider than deep, 0.71–0.73 of stalk width; ocellus not visible.

Antennular peduncle (Fig. 5A) 0.76 times as long as antennal scale. Proximal segment moderately broad, longer than 2 distal segments combined; inner margin sublinear, with numerous plumose setae marginally, 1 short tooth present on ventral side; outer margin somewhat swollen laterally, with marginal plumose setae; distal angle strongly produced, terminating in sharp spine over-reaching proximal margin of third segment of antennular peduncle; stylocerite long, acute, over-reaching midlength of proximal segment; dorsal surface concave, with short or long setae. Middle segment subcylindrical, about 0.45 of proximal segment length, about 1.86 times as long as wide; lateral margins with numerous plumose setae; distal margin with oblique articulation with distal segment. Distal segment subcylindrical, 0.81 of middle segment length, 1.68 times longer than width, anterior and anterolateral margins with some plumose setae. Inner flagellum 0.61 of longer ramus of outer flagellum; outer flagellum biramous, 6 proximal segments fused, shorter ramus about 0.27 length of longer ramus.

Antenna (Fig. 5B, C) with stout basicerite, with 1 strong distoventral tooth (absent on left antenna); ischiocerite and merocerite short; carpocerite cylindrical, reaching 0.34 of antennal scale; flagellum well developed, longer than body. Antennal scale (scaphocerite) with lamella, 2.76 times longer

than broad; inner margin somewhat swollen, with numerous marginal setae; outer margin nearly straight, with strong acute tooth on distolateral margin; distal margin broadly rounded, with numerous marginal setae.

Epistome (Fig. 4D) weakly bilobed by shallow depression.

Mouthparts typical of genus. Mandible (left) (Fig. 5D) stout; molar process robust, truncate distally, with 4 blunt peripheral teeth; incisor process large, armed with 3 subequal teeth distally; palp slender, 3-segmented, with marginal setae. Maxillule (Fig. 5E) with tapering coxal endite, with numerous setae distally; basal endite truncate distally, with rows of spines and stiff setae on distal margin; palp (endopod) deeply bilobed, outer lobe somewhat elongate, slender, with some setae on distal margin, inner lobe broad, short, rounded, somewhat curved inwards, with setae distally. Maxilla (Fig. 5F) with coxal endite obsolete; basal endite deeply bilobed, both lobes subequal, with numerous setae marginally; palp (endopod) moderately broad, curved mesially, tapering distally; scaphognathite moderately broad, anterior lobe narrow distally, medial margin deeply emarginate, posterior lobe moderately rounded. First maxilliped (Fig. 5G) with relatively thickened coxal endite, separated from basal endite by narrow notch, bearing numerous setae on distal margin; basal endite suboval, numerous marginal setae; palp (endopod) slender, not reaching distal margin of basal endite; exopod well developed, flagellum long, slender, with long plumose setae distally, caridean lobe moderately broad, with numerous plumose setae marginally; epipod bilobed, anterior lobe larger than posterior. Second maxilliped (Fig. 5H) with coxa rounded mesially, with numerous setae on mesial margin; endopod 5-segmented, basis and ischium fused; carpus with blunt projections at ventrodial angle; propodus large, oblique articulation with dactylus, with numerous spiniform bristles and setae on mesial margin; dactylus broadly rounded, with numerous spiniform bristles and setae on mesial margin; exopod long, slender, with long plumose setae distally; epipod moderately large, rounded, with well-developed podobranch. Third maxilliped (Fig. 5I) slender, over-reaching distal end of antennular peduncle by tip of distal segment of endopod; coxa feebly produced medially, sparsely setose, with small lateral plate; endopod 3-segmented, long, slender; proximal segment (ischiomeral or antepenultimate segment) incompletely segmented, slightly bowed, swollen and flattened distally, with numerous tufts of setae on medial/lateral margins, 4.23 times longer than greatest width; middle segment (carpus or penultimate segment) with tufts of setae marginally, 0.76 length of proximal segment, 5.07 times longer than greatest width; distal (ultimate) segment tapering to acute claw distally, with numerous setae, 0.72 length of middle segment, 5.10 times longer than proximal width; exopod slender, with plumose setae distally, 0.75 as long as ischiomeral segment.

First pereopod (Fig. 6A, B) very slender, subequal in length, similar in form, over-reaching antennal scale by entire chela and 0.53 of carpus length; basis short, with numerous setae on ventral margin; ischium broad, with numerous setae on ventral margin, 4.31 times longer than greatest width,

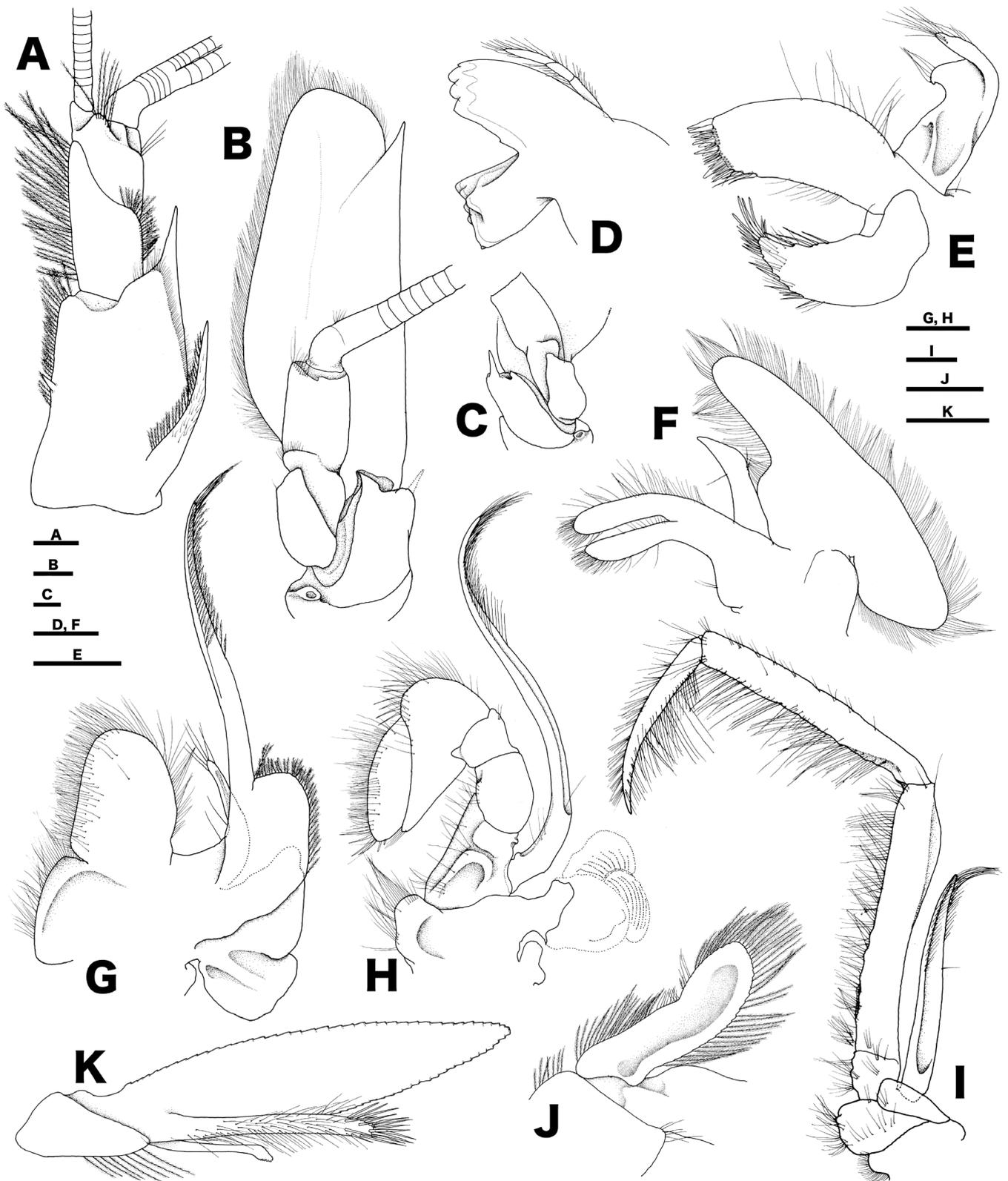


Fig. 5. *Macrobrachium xmas* n. sp., holotype male (pocl 18.74 mm) (QM-W28315). Left appendages. A, antennule, ventral view; B, antenna, ventral view; C, basal part of right antenna, ventral view; D, mandible, ventral view; E, maxillule, ventral view; F, maxilla, ventral view; G, first maxilliped, ventral view; H, second maxilliped, ventral view; I, third maxilliped, lateral view; J, endopod of first pleopod, ventral view; K, appendix interna and appendix masculine of second pleopod, mesial view. Scale bars = 1.0 mm.

0.70 of merus length; merus long, slender, sparsely setose marginally, 7.76 times longer than greatest width, 0.84 of carpus length; carpus very long, 10.26 times longer than distal width, 1.81 length of chela; chela slender, 4.91 times longer than greatest width; palm subcylindrical, 0.46 of chela length, fixed finger terminating in small, curved claw which crosses claw of dactylus, cutting edge entire, with tufts of short setae mesially; dactylus 1.12 of palm length, terminating in small, curved claw, with cutting edge entire, tufts of short setae mesially.

Second pereopod (Fig. 6C–I) moderately robust, similar in form, subequal in length but right 1.06 times longer than left; surface of dactylus to ischium covered with numerous minute spinules, sparsely setose. Right cheliped (Fig. 6C–E) over-reaching antennal scale by length of entire chela and about 0.5 of carpus length; basis short, with a few minute spinules and some setae on ventral margin; ischium swollen distally, 2.98 times longer than greatest width, 0.77 of merus length; merus 3.92 times longer than greatest width, equal in length to carpus; carpus 3.62 times longer than distal width, 0.51 length of chela; chela 4.89 times longer than greatest width, cutting edge of fingers not gaping; palm subcylindrical, 0.44 of chela length, fixed finger slender, slightly deflexed, terminating in curved, cutting edge thin, proximal margin of cutting edge uneven, with very low, blunt tooth on proximal 0.26; dactylus, 1.21 of palm length, 0.54 of chela length, terminating in curved, acute claw, cutting edge thin, with 5 blunt teeth on 0.36 of entire length, distalmost tooth largest, remaining edge smooth. Left cheliped (Fig. 6F–I) over-reaching antennal scale by length of entire chela and about 0.5 of carpus length; basis short, with a few small spinules and some setae on ventral margin; ischium somewhat swollen distally, 3.19 times longer than greatest width, 0.83 of merus length; merus 3.86 times longer than greatest width, 1.01 times carpus length; carpus 3.81 times longer than distal width, 0.52 length of chela; chela 5.34 times longer than greatest width, cutting edge of fingers not gaping; palm subcylindrical, 0.43 of chela length, fixed finger slender, slightly deflexed, terminating in curved, acute claw crossing claw of dactylus, cutting edge thin, with 1 very low, small tooth on proximal 0.22; dactylus slender, 1.30 times palm length, 0.56 of chela length, terminating in curved, acute claw, cutting edge thin, with 1 low, blunt tooth on 0.32 of entire length.

Ambulatory legs (third to fifth pereopods) slender. Third pereopod (Fig. 7A, B) over-reaching antennal scale by length of dactylus and 0.36 of propodus; ischium 3.63 times longer than greatest width, 0.51 of merus length, with some minute spinules on ventral margin; merus 7.35 times longer than greatest width, 1.66 of carpus length, with some minute spinules on dorsal and ventral margins; carpus 5.1 times longer than distal width, 0.65 of propodus length, with minute spinules dorsally; propodus 10.53 times longer than greatest width, with 2 rows of widely spaced spinules on ventral margin and numerous minute spinules on surface; dactylus compressed laterally, feebly curved, terminating in acute tip, unguis not clearly demarcated, 4.08 times longer than proximal depth, 0.31 of propodus length, lateral surface

with 5 tufts of short setae along dorsal margin and 4 tufts of setae along ventral margin. Fourth pereopod (Fig. 7C, D) slightly longer than third pereopod, over-reaching antennal scale by length of dactylus and 0.55 of propodus; ischium 3.86 times longer than greatest width, 0.52 of merus length; merus 8.68 times longer than greatest width, 1.6 times carpus length; carpus 6.06 times longer than distal width, 0.66 of propodus length, with numerous minute spinules on dorsal surface; propodus 11.07 times longer than depth, with 2 rows of widely spaced spinules on ventral margin and numerous minute spinules on surface; dactylus 4.36 times longer than proximal width, 0.31 of propodus length, lateral surface with 6 tufts of short setae along dorsal margin and 4 tufts of setae along ventral margin. Fifth pereopod (Fig. 7E, F) longer than third or fourth pereopods, over-reaching antennal scale by length of dactylus and 0.54 of propodus; coxa with gonopore; ischium 4.67 times longer than greatest width, 0.48 of merus length; merus 9.8 times longer than greatest width, 1.32 of carpus length; carpus 7.93 times longer than distal width, 0.72 of propodus length, with numerous minute spinules on dorsal surface; propodus 14.09 times longer than greatest width, with 2 rows of widely spaced spinules on ventral margin and numerous minute spinules on surface, with subdistal tufts of grooming setae; dactylus 4.44 times longer than proximal width, 0.26 of propodus length, lateral surface with 6 tufts of short setae along dorsal margin and 2 tufts of setae along ventral margin.

First pleopod with moderately stout protopod; endopod (Fig. 5J) about 0.49 of exopod length, weakly curved mesially, rounded distally, ventral surface concave, fringed with plumose setae marginally. Second pleopod with appendix masculina (Fig. 5K) elongate, slender, 0.6 of endopod length, with numerous setae; appendix interna slender, 0.56 of appendix masculina.

Uropod (Fig. 4E) with protopod bearing strong acute posterolateral tooth; endopod 0.96 of exopod length; exopod over-reaching tip of telson, lateral margin straight, terminating in small acute tooth at about 0.86 of length, with small movable spine just mesial to posterolateral tooth.

Notes on paratypes. All paratype specimens examined, including full-grown male/female (pocl 13.22–21.75 mm), are basically similar to the holotype, but some variation occurs: rostrum can be relatively more slender, varying in shape and length, 0.48–0.70 of carapace length, over-reaching distal end of antennular peduncle, reaching or over-reaching distal margin of antennal scale to different degrees; dorsal margin of the rostrum armed with 12 or 13 teeth, with 5 or 6 on carapace posterior orbital margin; ventral margin with 3–8 teeth; cornea of eye 1.89–2.15 times wider than deep, 0.75–0.78 of stalk width. The rostrum of the largest male (pocl 21.75 mm) appears atypical (Fig. 8A), with unusual anterior margins, suggesting that it had probably been damaged and regrown; it is relatively shorter, being only 0.41 of carapace length, and does not over-reach the distal end of the antennular peduncle. Second pereopods similar in form, subequal in length, but varied in size and shape due to growth and sexual features; male larger than female, and

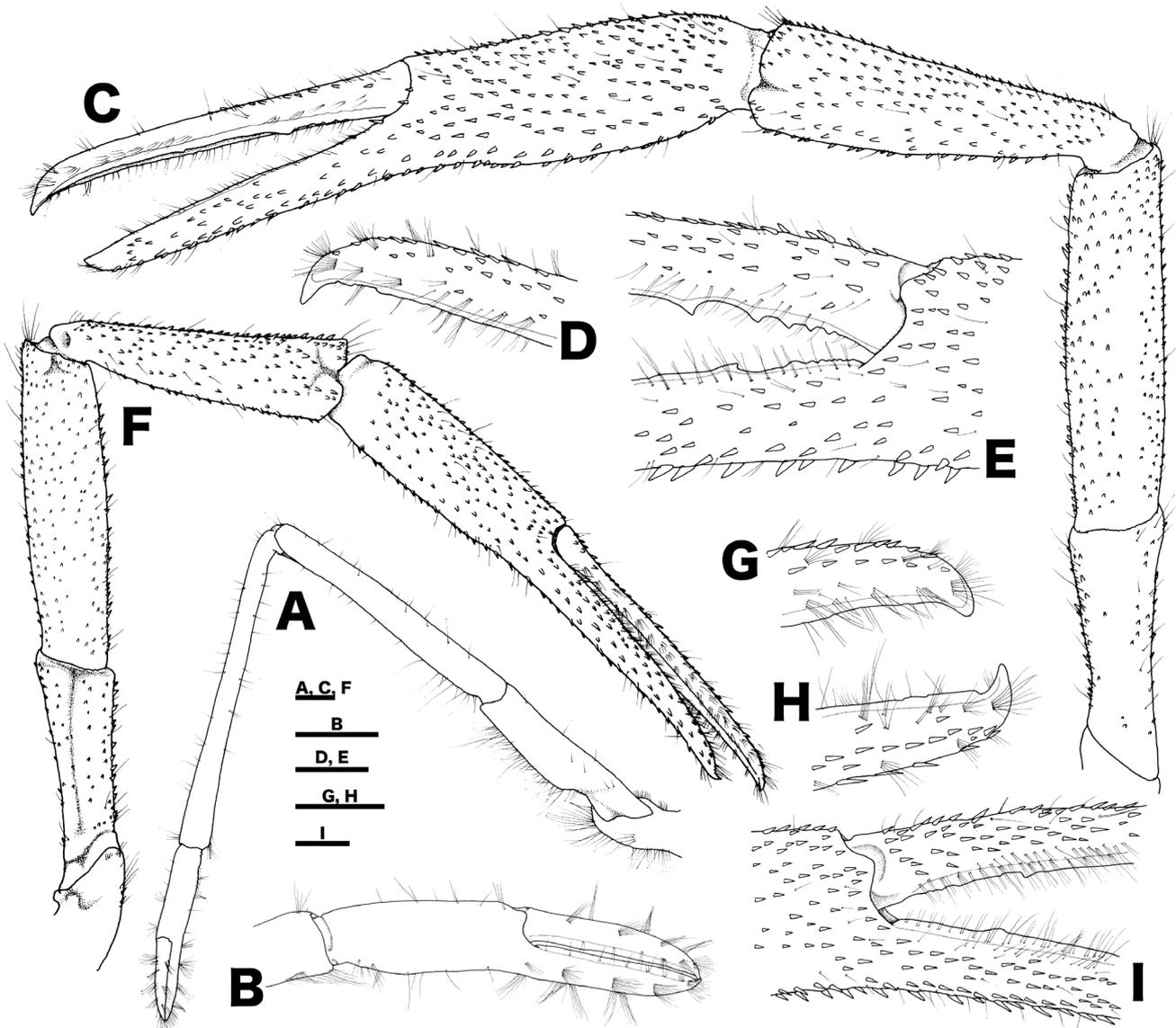


Fig. 6. *Macrobrachium xmas* n. sp., holotype male (pocl 18.74 mm) (QM-W28315). Chelipeds. A, first pereiopod, lateral view; B, chela of first pereiopod, ventral view; C, right second pereiopod, lateral view; D, same, tip of dactylus, dorsal view; E, same, basal part of fingers, dorsal view; F, left second pereiopod, lateral view; G, same, tip of dactylus, dorsal view; H, same, tip of fixed finger, dorsal view; I, same, basal part of fingers, dorsal view. Scale bars = 1.0 mm.

large individuals relatively more robust than smaller ones (Figs. 8–12); the carpi of ovigerous females (pocl 20.20 mm, QM-W28316; pocl 21.66 mm, ZRC 2015.281) slightly longer than that in males (carpi 0.61–0.66 of chela length in females vs. 0.48–0.53 in males); the length of dactylus to palm in smaller males (pocl 16.26 mm, ZRC 2015.282; pocl 13.22 mm, RUMF-ZC-2802) is distinctly shorter than that in large males (ratio of 1.56–1.75 in smaller males versus 1.21–1.35 in large males) (Figs. 8–12).

Color in life. Whole body (carapace, abdomens, and appendages) generally whitish to pale yellow (Figs. 13, 14).

Habitat and biology. *Macrobrachium xmas* n. sp. was collected from three anchialine caves (Freshwater Cave, Runaway Cave and Whip Cave). Specific habitat information for these localities has been given by Humphreys & Eberhard (2001). Co-inhabiting decapod crustaceans reported from Christmas Island caves include: a procaridid *Procaris*

noelensis Bruce & Davie, 2006, an alpheid *Metabetaeus minutus* (Whitelegge, 1897), a barbouriid *Parhippolyte* cf. *uveae* Borradaile, 1899, an atyid *Antecaridina lauensis* (Edmondson, 1935), and three crabs, *Karstarma jacksoni* (Balss, 1934) [Sesarmidae], *Orcovita hicksi* Davie & Ng, 2012, and *Orcovita orchardorum* Davie & Ng, 2012 [both Varunidae] (Anker, 2010; Bruce & Davie, 2006; Davie & Ng, 2012). In this study, two ovigerous females of *M. xmas* were collected, and the pre-eyed eggs are small, 0.56–0.70 mm (on female pocl 21.66 mm, ZRC 2015.281, average 0.64 mm, n = 10) in size, suggesting an amphidromous life cycle.

Distribution. Only known from Christmas Island thus far.

Etymology. The new species name is a common arbitrary abbreviation of “Christmas” and is derived from the type locality, Christmas Island. The name is used as a noun in apposition.

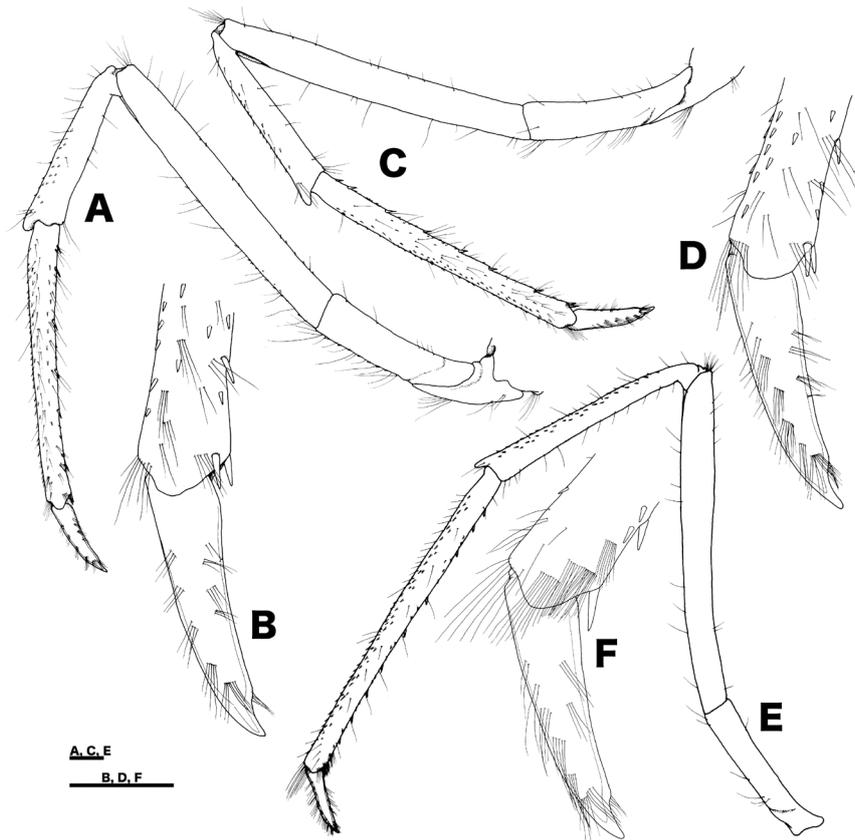


Fig. 7. *Macrobrachium xmas* n. sp., holotype male (pocl 18.74 mm) (QM-W28315). Third to fifth pereiopods, lateral view. A, third pereiopod, lateral view; B, same, posterior part of propodus, lateral view; C, fourth pereiopod, lateral view; D, same, posterior part of propodus, lateral view; E, fifth pereiopod, lateral view; F, same, posterior part of propodus, lateral view. Scale bars = 1.0 mm.

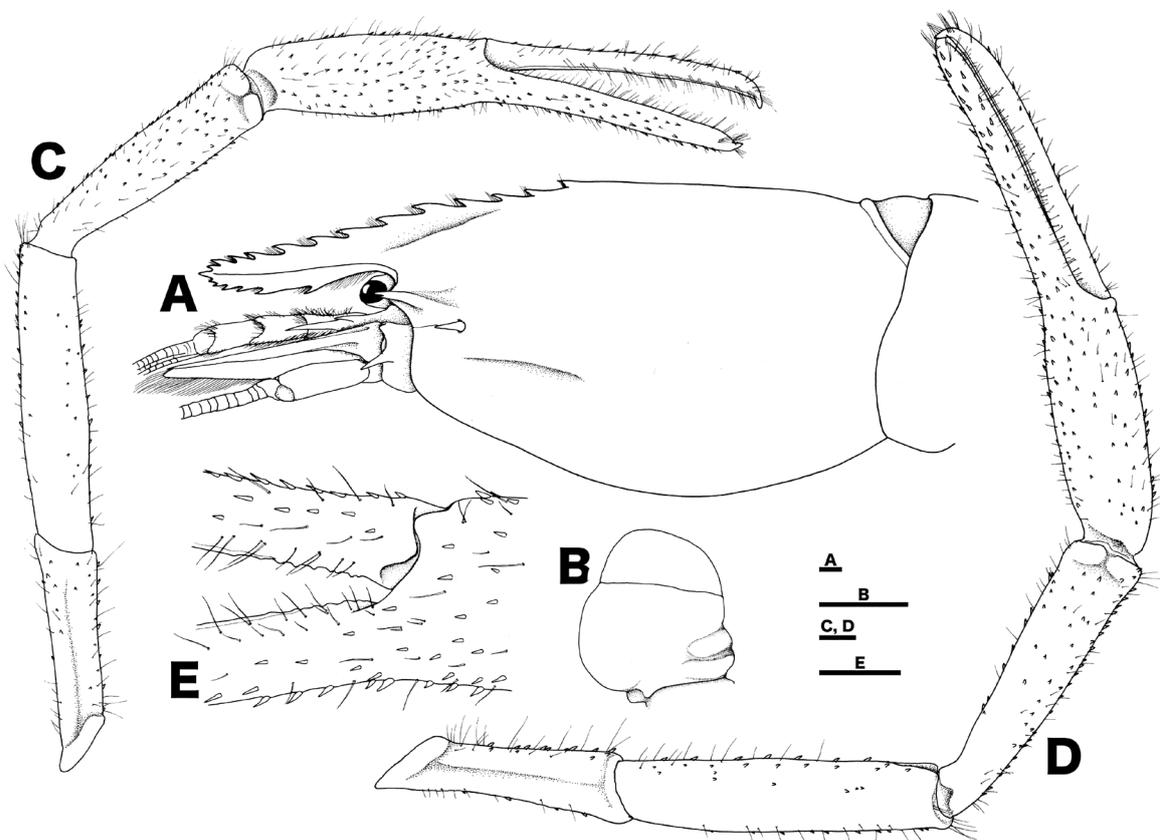


Fig. 8. *Macrobrachium xmas* n. sp., paratype male (pocl 21.75 mm) (OUMNH.ZC.2015-02-048). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view; C, left second pereiopod, lateral view; D, right second pereiopod, lateral view; E, same, basal part of fingers, dorsal view. Scale bars = 1.0 mm.

Remarks. Among the 12 stygobitic *Macrobrachium* species, it is known that *M. gua*, and *M. lucifugum*, have well developed eyes like their epigeal congeners (see Chong, 1989; Holthuis, 1974) and therefore can easily be distinguished from the present new species. On the other hand, *M. elegantum*, *M. villalobosi* and *M. linyunense* are also readily separated from the present new species by lacking faceted corneas (*M. villalobosi* and *M. linyunense*) or lacking pigmented corneas (*M. elegantum*) (see Hobbs, 1973; Li et al., 2006; Pan et al., 2010). *Macrobrachium acherontium*, *M. cavernicola* and *M. sbordonii* can be easily distinguished from *M. xmas* by having even more reduced corneas and having fewer dorsal rostral teeth (7–11 teeth in *M. acherontium*, 5–9 in *M. cavernicola*, 7 in *M. sbordonii*, versus 12–15 teeth in *M. xmas*) (cf. Figs. 4, 8–12; Kemp, 1924; Holthuis, 1977; Mejía-Ortíz et al., 2008). In addition to these differences, *M. cavernicola* can be separated from *M. xmas* by having the following characters: (1) mandibular palp is 2-segmented (Kemp, 1924: pl. 3, fig. 4) (3-segmented in *M. xmas*, Fig. 5D), (2) the dactyli of the second pereopods are thinly coated by “dark brown fur” (Kemp, 1924: pl. 3, fig. 1) (absent in *M. xmas*, Fig. 6C–H), and the carpi of the second pereopods are proportionally shorter (Kemp, 1924: pl. 3, fig. 1) than in *M. xmas* (Fig. 6C, F) (0.27–0.34 of the chela length versus about 0.5). In the morphology of the second pereopod, *M. acherontium* (Holthuis, 1977) and *M. sbordonii* (Mejía-Ortíz et al., 2008: figs. 2A, 3E) differ from *M. xmas* by having a proportionally longer carpus (0.8–0.9 of the chela length in *M. acherontium* versus about 0.5 in *M. xmas*; and twice the chela length in *M. sbordonii* versus 1.18–1.59 in *M. xmas*) (cf. Fig. 6C, F).

Macrobrachium poeti differs from *M. xmas* by the proportionally broader rostrum, having fewer ventral rostral teeth [1–2 versus 3–8 teeth in *M. xmas* (cf. Figs. 4, 8–12; Holthuis, 1984: fig. 1a), the smooth second pereopod (Holthuis, 1984: fig. 1e, f) (profusely spinose in *M. xmas*, Fig. 6C, F), and the proportionally shorter second pereopod carpus (Holthuis, 1984: fig. 1e) (about 0.3 of the chela length versus about 0.5 in *M. xmas*, Fig. 6C, F).

Macrobrachium cationium can be distinguished from *M. xmas* by the relatively broader rostrum with fewer dorsal rostral teeth (6–9 versus 12–15 in *M. xmas*), and the proportionally longer second pereopod carpus (1.2 times as long as propodus versus about 0.5 in *M. xmas*) (cf. Fig. 6C, F; Hobbs & Hobbs, 1995: fig. 1a).

Based on the present description of additional adult male and female specimens of *Macrobrachium miyakoense*, it is clear that this species is morphologically very similar to *M. xmas*. However, *M. xmas* can be distinguished by the relatively longer and more slender rostrum (cf. Figs. 1A, 2A, 4A, 9A, 10A, 11A; Fujita & Komai, 2005: figs. 2B, 6A), the slightly smaller eye cornea [0.71–0.78 of stalk width vs. about 0.8 (0.82–0.83) in *M. miyakoense*], the proportionally more swollen eye stalk (cf. Figs. 1B, 2B, 4J, 8B, 9B, 10B, 11B, 12B; Komai & Fujita, 2005: fig. 2C), and by having more teeth on the post-rostral margin of the carapace (5 or

6 versus 4 in *M. miyakoense*) (cf. Figs. 1A, 2A, 4A, 8A, 9A, 10A, 11A, 12A; Fujita & Komai, 2005: figs. 2A, 6A).

The taxonomy of *Macrobrachium microps* is, in our opinion, somewhat confused, and it may currently include several quite similar species. *Macrobrachium microps* was originally described from the Danmin Cave in New Ireland, Papua New Guinea, and later recorded from Samoa, New Caledonia (Lifou Island), and Christmas Island (Holthuis, 1978; Bruce & Iliffe, 1993; Short & Marquet, 1998; Short & Meek, 2000). The holotype of *M. microps* is not in Naturalis (Leiden), and may have been returned to the collector from Bulgaria (Sammy De Grave, personal communication). The holotype of *M. microps* (cl 22.0 mm) can be easily distinguished from *M. xmas* by the slightly shorter rostrum (cf. Fig. 4C, 8A, 9A, 10A, 11A, 12A; Holthuis, 1978: fig. 1a, b), the more reduced cornea (slightly more than half of the eyestalk width versus about 0.71–0.78 in *M. xmas*) (cf. Fig. 4C, J; Holthuis, 1978: fig. 1b), and the remarkably larger and stouter second pereopods (cf. Fig. 6C, F; Holthuis, 1978: fig. 1f–h). In addition to those differences, it is different from *M. xmas* in the shape and armature of the second pereopods: (1) the second pereopods are obviously unequal and dissimilar in *M. microps*, whereas they are similar and subequal in *M. xmas*; (2) the cutting edge of the major chela bears large teeth between which there is a distinct gap, whereas the cutting edges are armed with very low, blunt tooth on the proximal margin, and lack the gap between fingers, in *M. xmas*; (3) the dactylus of the major chela is distinctly shorter and slightly more than half as long as the palm in *M. microps*, whereas the dactyli of both chelae is 1.2–1.3 of the palm length in *M. xmas*; and (4) the minor chela bears numerous long stiff setae on the cutting edges of the fingers (such that they fill the gap between the fingers) in *M. microps*, whereas *M. xmas* lacks any such setae (cf. Fig. 6C–I; Holthuis, 1978: fig. 1).

Short & Meek (2000) reported *M. microps* from Christmas Island based on an adult female (pocl 23.8 mm) and young male (pocl 11.9 mm) from Daniel Roux Cave and Freshwater Cave, respectively. Although the diagnosis they gave was very brief, the female they described agrees well with our samples of *M. xmas*. The young male differs a little in having only 4 teeth on the carapace posterior to the dorsal margin (Short & Meek, 2000: Fig. 2A); and by the second pereopods lacking setal pubescence (Short & Meek, 2000: Fig. 2B). Although we borrowed the available specimens of *Macrobrachium* from Christmas Island from WAM, the two specimens studied by Short & Meek (2000) were not among the material and we are not sure where they are. The present WAM material from Whip and Freshwater Caves are small males (non-types: WAM-C44840, pocl 12.1 mm; ZRC 2015.283, pocl 8.71 mm), here referred to *M. xmas*. We did not manage to collect any specimens of *M. xmas* from Daniel Roux Cave but had several specimens (including the holotype) from Freshwater Cave.

The smallest male (pocl 8.71 mm, ZRC 2015.283) has no second pereopods, but the number of post-rostral teeth of the carapace is the same (only 4 teeth) as the “young male”

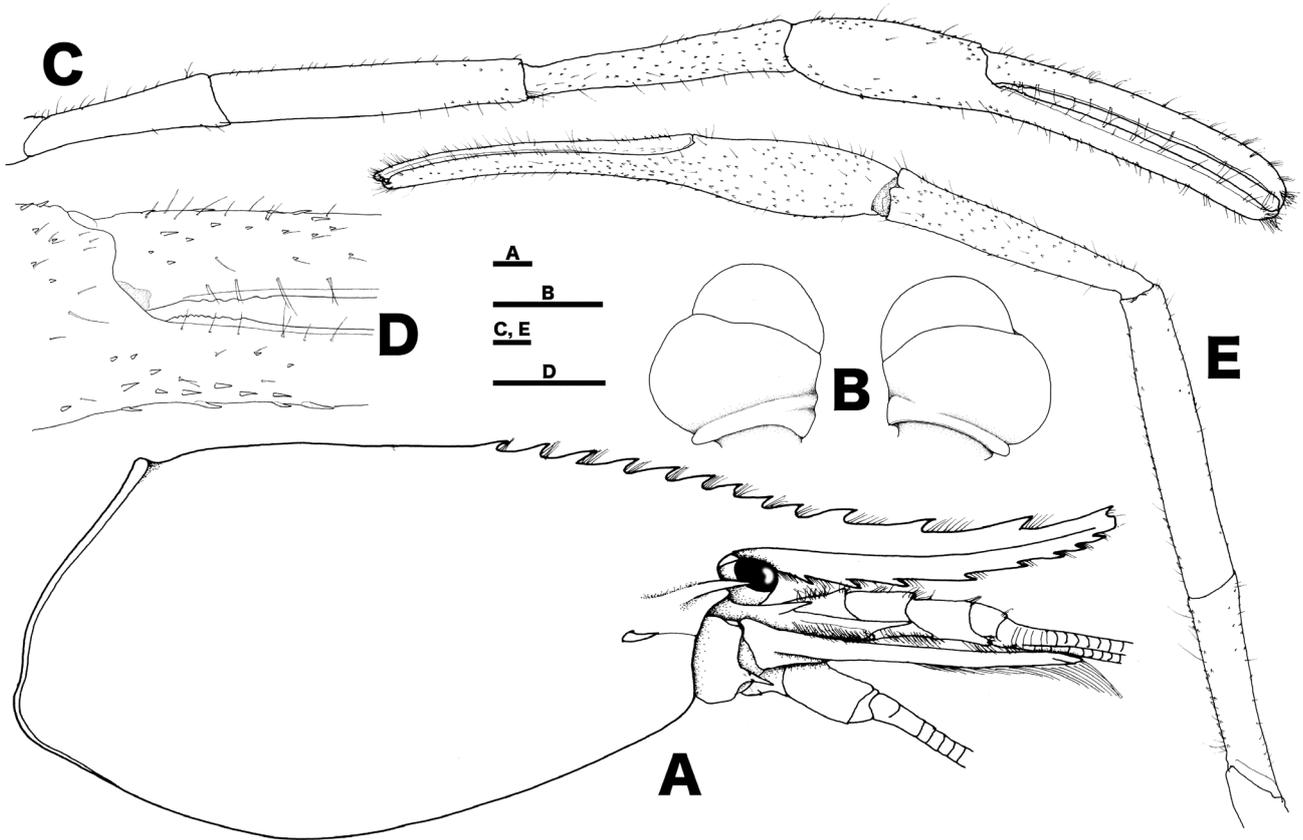


Fig. 9. *Macrobrachium xmas* n. sp., paratype male (pocl 16.26 mm) (ZRC 2015.282). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view (left), dorsal view (right); C, left second pereiopod, lateral view; D, same, basal part of fingers, dorsal view; E, right second pereiopod, lateral view. Scale bars = 1.0 mm.

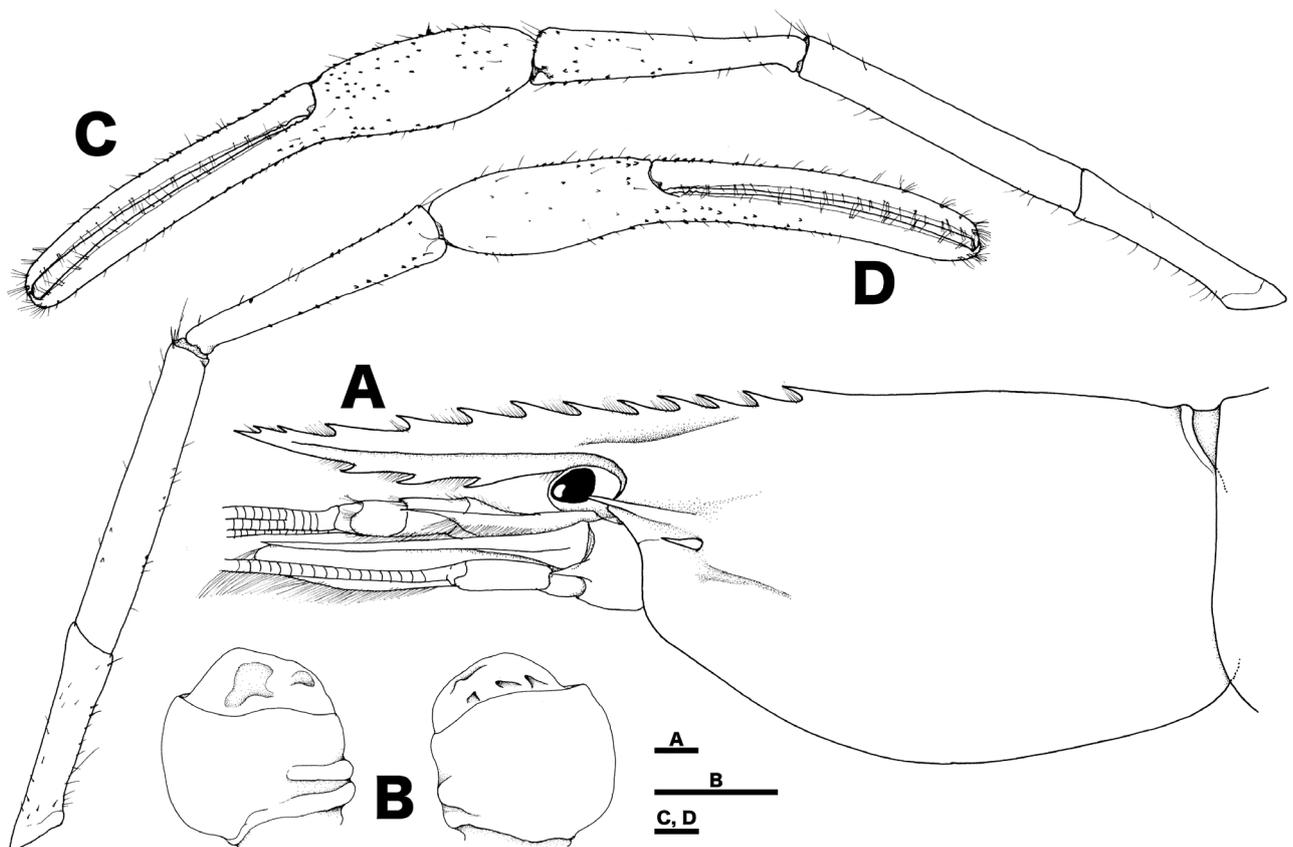


Fig. 10. *Macrobrachium xmas* n. sp., paratype male (pocl 13.22 mm) (RUMF-ZC-2802). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view (left), dorsal view (right); C, right second pereiopod, lateral view; D, left second pereiopod, lateral view. Scale bars = 1.0 mm.

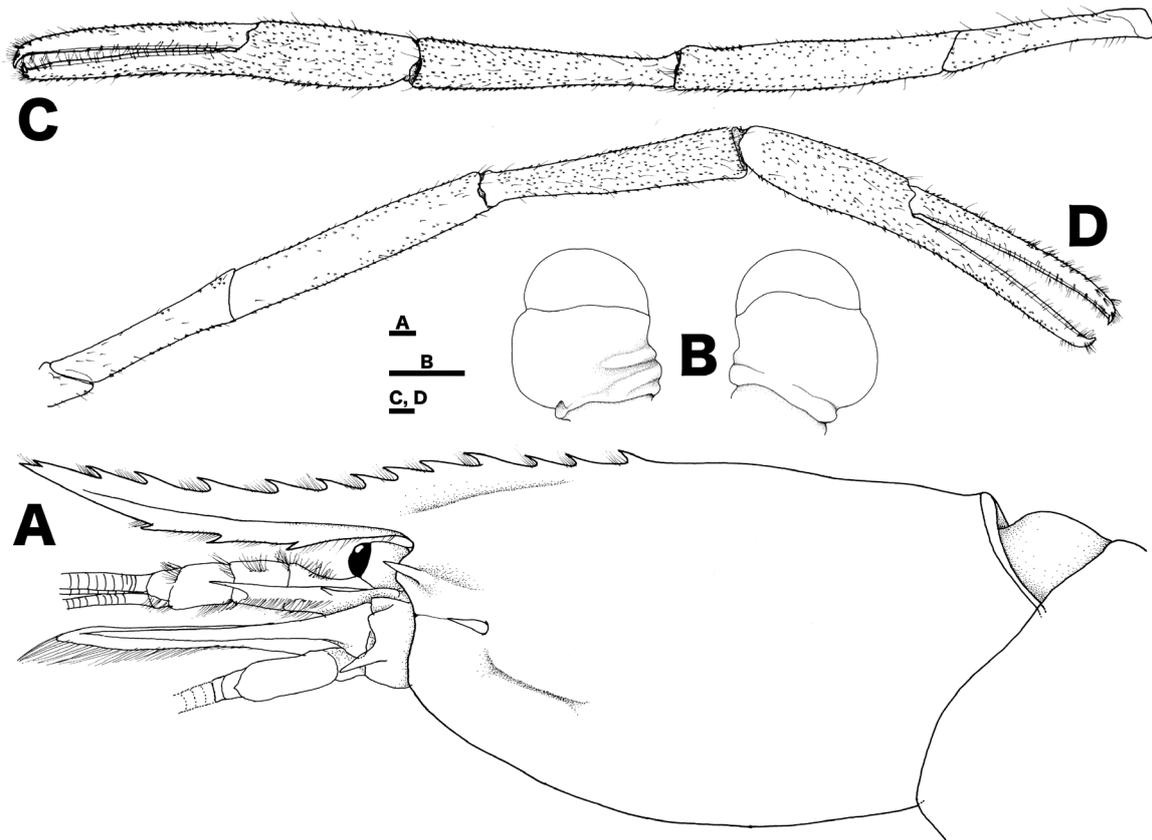


Fig. 11. *Macrobrachium xmas* n. sp., paratype ovigerous female (pocl 21.66 mm) (ZRC 2015.281). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view (left), dorsal view (right); C, right second pereiopod, lateral view; D, left second pereiopod, lateral view. Scale bars = 1.0 mm.

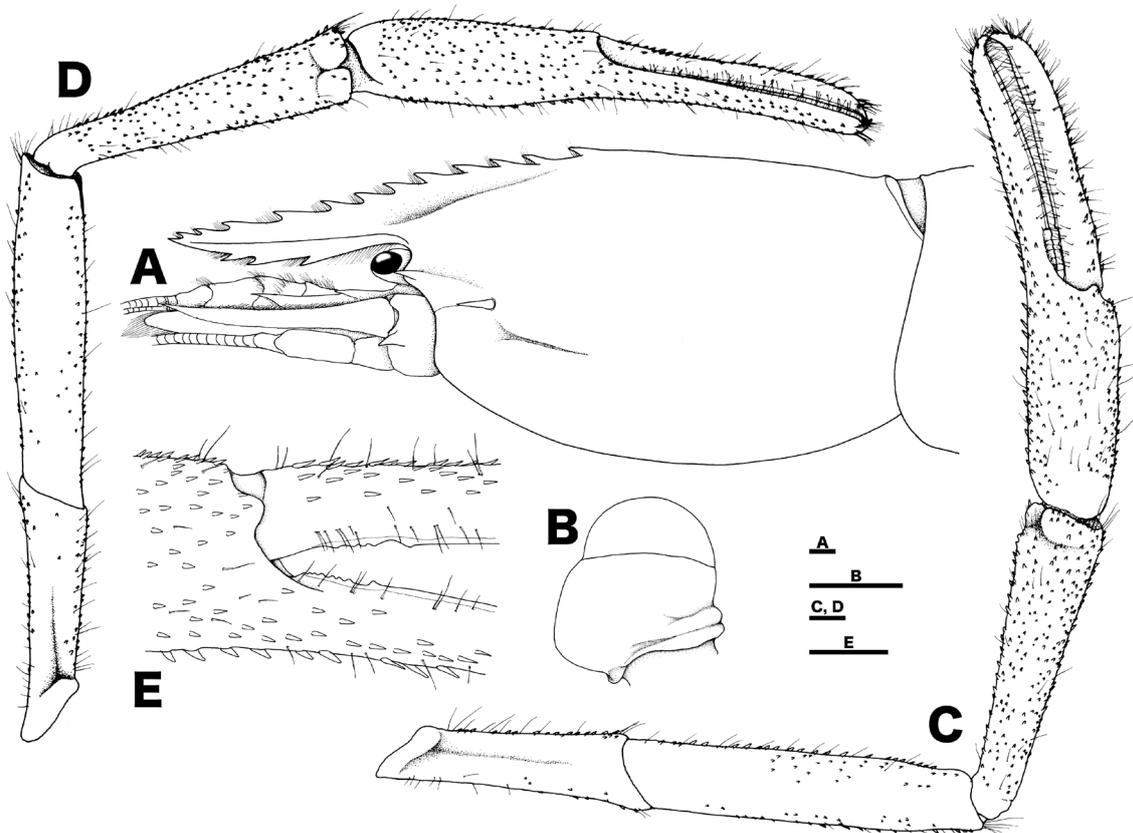


Fig. 12. *Macrobrachium xmas* n. sp., paratype ovigerous female (pocl 20.20 mm) (QM-W28316). A, rostrum, carapace, and cephalic appendages, lateral view; B, eye (left side), ventral view; C, right second pereiopod, lateral view; D, left second pereiopod, lateral view; E, same, basal part of fingers, dorsal view. Scale bars = 1.0 mm.

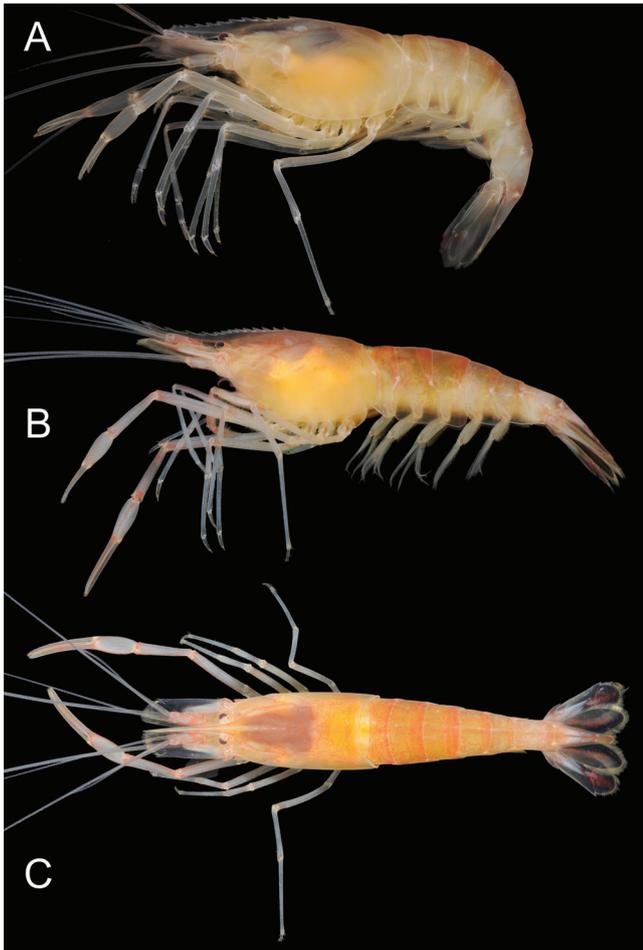


Fig. 13. *Macrobrachium xmas* n. sp., coloration of the live specimens. A, paratype male (pocl 21.75 mm) (OUMNH.ZC.2015-02-048), Freshwater Cave; B, C, paratype male (pocl 16.26 mm) (ZRC 2015.282), Runaway Cave (Photographs by: HH Tan).

reported by Short & Meek (2000: fig. 2A). The second pereiopods of WAM-C44840 (pocl 12.1 mm) also resemble those of Short & Meek (2000) in having only a few setal setae on the surface. We believe such differences are likely to be developmental in nature, and as such, we here refer their record of *M. microps* from Christmas Island to the present new species. We also examined 62 juveniles of “*Macrobrachium* sp.” from Christmas Island (pocl 2.5–12.1 mm: WAM-C44823, C44824, C44825, C44826, C44827, C44828, C44829, C44830, C44831, C44832, C44833, C44834, C44835, C44836, C44837, C44839, C44840) which were collected from cave systems but only 1 male (WAM-C44840, pocl 12.1 mm) could be identified as *M. xmas* and all of the rest are young of *M. lar* (Fabricius, 1798). The eyes of these specimens were not at all reduced, with the ocellus still clearly visible, and there was only one tooth on the post-rostral margin of the carapace (even in the largest pocl 6.1 mm specimen). Although we did not catch or observe adult *M. lar* inside the caves (they are otherwise common in epigeal waters in Christmas Island (Ng & Davie, 2012), they have been found in subterranean waters in the Ryukyus (Komai & Fujita, 2005; first author, unpublished data).

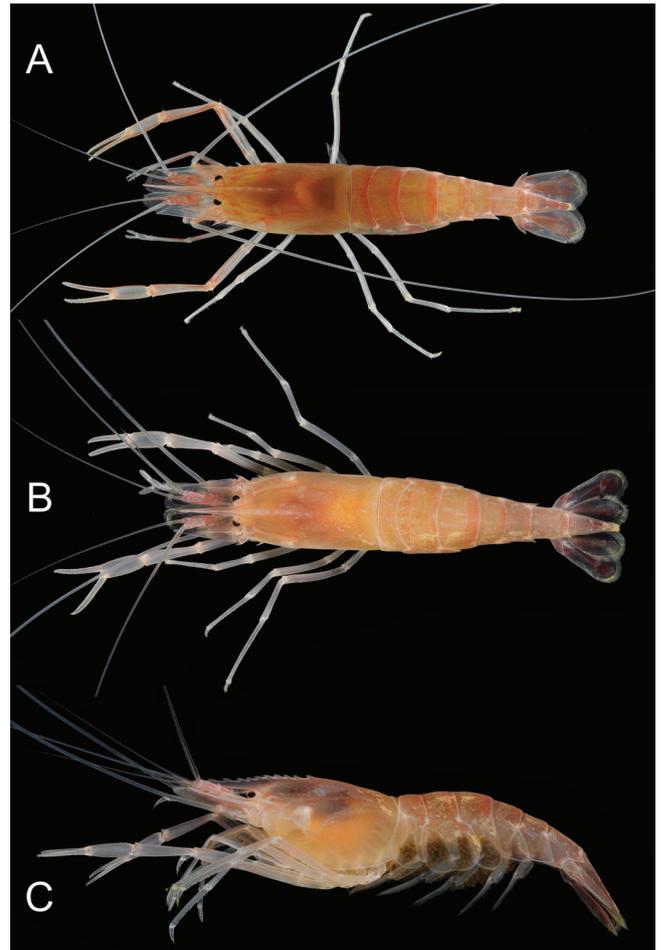


Fig. 14. *Macrobrachium xmas* n. sp., coloration of live specimens. A, paratype ovigerous female (pocl 21.66 mm) (ZRC 2015.281), Whip Cave; B, C, paratype ovigerous female (pocl 20.20 mm) (QM-W28316), Freshwater Cave (Photographs by: HH Tan).

Bruce & Iliffe (1993) reported one young male of *M. microps* (pocl 13.1 mm) from Upolu, Samoa. Their specimen is obviously different from the holotype of *M. microps* by characters of the rostrum, second pereiopods, and ambulatory pereiopods (see Holthuis, 1978; Bruce & Iliffe, 1993). Komai & Fujita (2005) had already pointed out that the Samoan specimen might represent an undescribed species. In any case, this Samoan specimen can be readily distinguished from *M. xmas* by the relatively shorter rostrum, that does not reach the distal end of the antennular peduncle (rostrum over-reaches the distal end of the antennular peduncle in *M. xmas*), and the more reduced eye cornea (0.5 of stalk width versus 0.71–0.78 in *M. xmas*) (cf. Figs. 4A, C, J, 8B, 9A–B, 10A, B, 11A, B, 12A, B; Bruce & Iliffe, 1993: figs. 1, 2A–D, H).

Short & Marquet (1998) reported two males (pocl 21.6 mm and 23.1 mm) of *M. microps* from Lifou Island, New Caledonia. The specimens illustrated (Short & Marquet, 1998: fig. 1A) are more similar to *M. xmas* than they are to the holotype of *M. microps*. In particular, they share with *M. xmas*: (1) the carapace posterior to the dorsal margin bears 5 teeth; and, (2) the rostrum is long and slender, over-reaching

the distal end of the antennular peduncle. The description by Short & Marquet (1998) is too brief, and it is difficult to compare with *M. xmas* in detail, however we believe that the material reported as *M. microps* from New Caledonia may represent another new species. The New Caledonian taxon differs mainly from *M. xmas* because the second pereopods lack setal pubescence, whereas the surface of the second pereopods is profusely spinose and setose even in similar size (pocl 21.66 mm and 20.20 mm) females of *M. xmas* (Figs. 11C, D, 12C, D).

ACKNOWLEDGEMENTS

We are indebted for the help and encouragement of Max Orchard, at that time, Senior Ranger of the Christmas Island Park Service. We thank the Australian National Parks Service for the various research and export permits to collect, as well as the substantial logistical support they provided us on the island. The authors are very grateful to our team members of Xmas Island Expeditions of 2010–2012 (Tan Heok Hui, Tan Swee Hee, Tohru Naruse, Joelle Lai, Tan Siong Kiat, Jose Mendoza and Tan Kai Xin) for their energy and enthusiasm during the fieldwork. Thanks are also due to Diana Jones and Andrew Hosie (WAM) for sending us specimens for study. We are also grateful to Sammy De Grave for some enthusiastic discussions on the identity of the present species, and for his help in searching for the types of *M. microps*. He and Charles Fransen provided many important suggestions to help improve the paper. This work has been supported by travel grants to the Raffles Museum from the Faculty of Science, National University of Singapore (to PNKL), and was further supported by Australian Biological Resources Study Grants no. 208-72, and 207-50 to PJFD.

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