

## Designation of neotypes for *Cyrtophium orientale* Dana, 1853, *Podocerus brasiliensis* (Dana, 1853) and *P. cristatus* (Thomson, 1879) and the description of a new species *Podocerus cyrenensis* (Crustacea: Amphipoda: Podoceridae)

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**Abstract.** Neotypes are established for three species of podocerid, *Cyrtophium orientale* Dana, 1853 from Singapore; *Podocerus brasiliensis* (Dana, 1853) from Rio de Janeiro, Brazil and *P. cristatus* (Thomson, 1879) from Lyttleton, New Zealand. Specimens of *C. orientale* from the Singapore Biodiversity Workshop 2013 are the first collection of the species since its original record in the mid-1800s, and the new species *Podocerus cyrenensis* is also described from Singapore waters. In redescribing these species to stabilise their identification, *Podocerus brasiliensis* is recognised as an invasive species in Australian waters. This is the first report of *P. brasiliensis* as an invasive species in the region and distribution details are provided from recent and historic museum collections.

**Key words.** *Cyrtophium*, *Podocerus*, amphipod, taxonomy, invasive

### INTRODUCTION

Podocerid amphipods are filter-feeding detritivores with recurved pereopods adapted for clinging to the substrate. The antennae 1 and 2 are elongate and held above the head during feeding, with particulate matter collected in the long ventral setae (J.L. Barnard et al., 1988). In both natural and artificial habitats podocerids are well-documented as fouling organisms where hundreds of individuals can be collected in a sample.

Until present, only one species of Podoceridae, *C. orientale* Dana, 1853, was previously known from Singapore. Recent sampling during the Singapore Biodiversity Workshop 2013 recollected a single male specimen of *C. orientale*. This is the first record of the species since the original description. Additionally, the new species *Podocerus cyrenensis* was also collected and sampled in abundance from intertidal algal habitats and is described here.

Of the fifty known species of *Podocerus*, only three species have particularly broad distributions: *P. brasiliensis* (Dana, 1853), is a highly cited invasive species originally described from Rio de Janeiro, Brazil; *P. chelonophilus* (Chevreux & de Guere, 1888) (jn. syn *P. umigame* Yamato, 1992), is recorded from turtle carapaces around the Pacific, Atlantic and Mediterranean (Baldinger, 2001); and *P. cristatus* Thomson

(1879), originally described from New Zealand, is cited as an invasive on the California coast (J.L. Barnard, 1962). Both *P. brasiliensis* and *P. cristatus* are recently and more frequently becoming cited in reports and policies for invasive species (Boyd et al., 2002; Llanos & Sillett, 2008; Ashton et al., 2012). Despite being widely cited, *P. brasiliensis* and *P. cristatus* have limited original descriptions and are without extant type material. The original taxonomic descriptions of these species are no longer sufficient to delineate these species from their congeners.

This paper describes four species including designation of neotypes for three known species. The neotype material is established for *Cyrtophium orientale*, *Podocerus brasiliensis* and *P. cristatus* to stabilise their identity and to allow more accurate assessment of the species distribution, as a complex and/or invasive species.

### MATERIAL AND METHODS

The material examined for this study was an assessment of podocerid amphipods collected during fieldwork as part of the Singapore Biodiversity Workshop May 2013. Distribution records of material from Australia waters were an assessment of collections from the Australian Museum (AM), South Australian Museum (SAMA), Western Australian Museum (WAM) and Museum and Art Gallery of the Northern Territory (NTM). Loan material from Hawaii through the Bernice P. Bishop Museum (BPBM) was also examined. Neotype material for *E. brasiliensis* and *P. brasiliensis* are lodged with the Universidade Federal do Rio de Janeiro, Museu Nacional, Departamento de Invertebrados, Setor de Carcinologia, Rio de Janeiro, Brasil (MNRJ). Neotype material for *P. cristatus* is lodged with the Marine Invasives

Australian Museum, 6 College Street, Sydney, New South Wales, 2010, Australia;  
Email: [lauren.hughes@austmus.gov.au](mailto:lauren.hughes@austmus.gov.au)

Taxonomic Service, based at the New Zealand Institute for Water and Atmospheric Research (NIWA). Material from Singapore is deposited in the Lee Kong Chian Natural History Museum, National University of Singapore (ZRC). Material was dissected in 80% ethanol. Permanent slides were made using Aquatex™ mounting agent. Illustrations were made using a Leitz Laborlux K and Wilde Heerbrugg stereomicroscopes fitted with camera lucida. Specimens were prepared for electron microscopy as follows: preserving solution was sequentially advanced in 5% increments from 80% to 100% ethanol; critical point dried; mounted individually on pins and gold sputter coated. Images were captured using on a Zeiss EVO LS15 Scanning Electron Microscope with Robinson Backscatter Detector (SEM). Terminology of structures includes: setae, articulating extrusions of the cuticle, and tooth or spine, non-articulating extrusions of the cuticle. In particular reference to head, pereonite and pleonite non-articulating extrusions of the cuticle: carina(e), extrusions along the dorsal margin; lateral projections, extrusions between the dorsal and ventral margins; and ventral projections, extrusions near the ventral margin. Abbreviations for parts are as follows: A – antenna; F – accessory flagellum; G – gnathopod; LL – lower lip; Md – mandible; Mx1 – maxilla 1; P – pereopod; p – palp; T – telson; and U – uropod. Descriptions were generated from an Open DELTA database of the Podoceridae containing all Indo-Pacific and Atlantic species. Synonymy citations are from published peer-reviewed work and do not include thesis compilations, identification manuals or ecological studies.

## SYSTEMATICS

### Podoceridae Leach, 1814

#### *Cyrtophium* Dana, 1852

#### *Cyrtophium orientale* Dana, 1853 (Figs. 1–3)

*Cyrtophium orientale* Dana, 1853: 840.—Dana, 1855: pl. 56, fig. 1.—Stebbing, 1906: 698.

*Platophium orientale*.—Della Valle, 1893: 332–334 (in part).

**Type material.** Neotype. male specimen, 3.3 mm, ZRC 2014.1080, southwest Tekukor, Singapore (1°13.8'N 103°50.25'E), 8 m, hand collection (scuba diving), coll. Tan Heok Hui et al., May 2013 (IT 84).

**Type locality.** Southwest Tekukor, Singapore (1°13.8'N 103°50.25'E).

**Diagnosis.** *Body* cuticle dorsally smooth to rugose, without posterior dorsal carinae, laterally smooth.

*Head* with weak hump; eyes greatly bulging. *Gnathopod 1* propodus subrectangular, palm margin smooth, without robust setae near corner of palm; dactylus posterior margin with a few serrate teeth. *Gnathopod 2* basis twice as long as broad, anterodistal corner produced, lobe apically rounded,

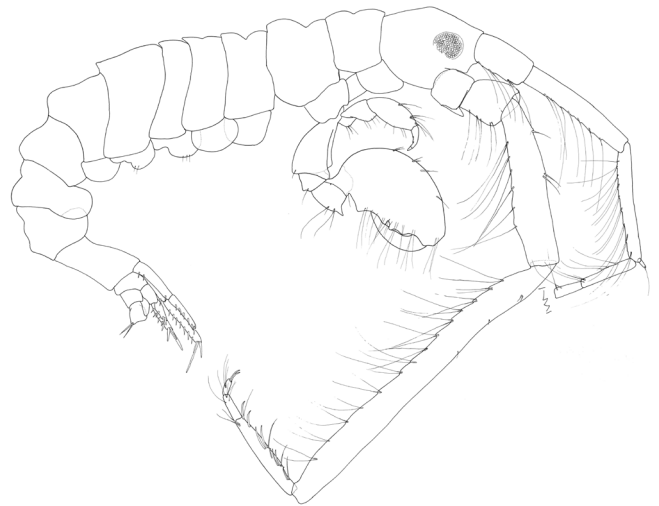


Fig. 1. *Cyrtophium orientale* Dana, 1853, neotype male, 3.3 mm, habitus, ZRC 2014.1080, Tekukor, Singapore.

reaching beyond ischium; merus posterior margin with narrow produced lobe, lobe as long as broad, apically acute; propodus palm with long distal shelf, margin with 2 sinuses, defined by corner with tooth; dactylus closing short of palm.

**Description.** Based on neotype male, 3.3 mm, ZRC 2014.1080. *Body* cuticle dorsally smooth to rugose, without posterior dorsal carinae, laterally smooth. *Head* with weak hump; rostrum short, one tenth of head length; eyes greatly bulging; lateral cephalic lobe subquadrate; anteroventral corner subquadrate. *Antenna 1* at least 0.5 body length (broken); peduncle article 2 length subequal to article 3; primary flagellum broken; accessory flagellum 1-articulate, twice as long as broad. *Antenna 2* distinctly longer than antenna 1, with dense concentration of long slender setae along posterior margin; article 4 shorter than article 5, 0.5 times article 5 length; flagellum 0.25 times peduncular length, posterior margin with line of short robust setae. *Mandible* accessory setal row with 2 setae. *Maxilla 1* palp article 2, distal margin with 7 robust setae.

*Coxae 3–7* contiguous. *Gnathopod 1* coxa smaller than coxa 2, broader than long, anteroventral corner produced anteroventrally, apically subacute; basis 2.1 times as long as broad, without anterodistal setae; carpus subrectangular, twice as long as broad; propodus subrectangular, anterior margin with clusters of long slender setae, palm margin smooth, without robust setae near corner of palm; dactylus posterior margin with a few serrate teeth, cuticle surface smooth. *Gnathopod 2* basis twice as long as broad, anterodistal corner produced, lobe apically rounded, reaching beyond ischium, with a few robust setae; merus posterior margin with a few rows of slender setae, posterior margin with narrow produced lobe, lobe as long as broad, apically acute; carpus compressed, cup-shaped; propodus elongate subovoid, length 1.8 times width, anterior margin with clusters of long robust setae, palm acute, straight, with long distal shelf, margin with 2 sinuses, defined by corner with tooth, palm length 0.8 times propodus posterior margin; dactylus closing short of palm. *Pereonite 7* without dorsal carina.

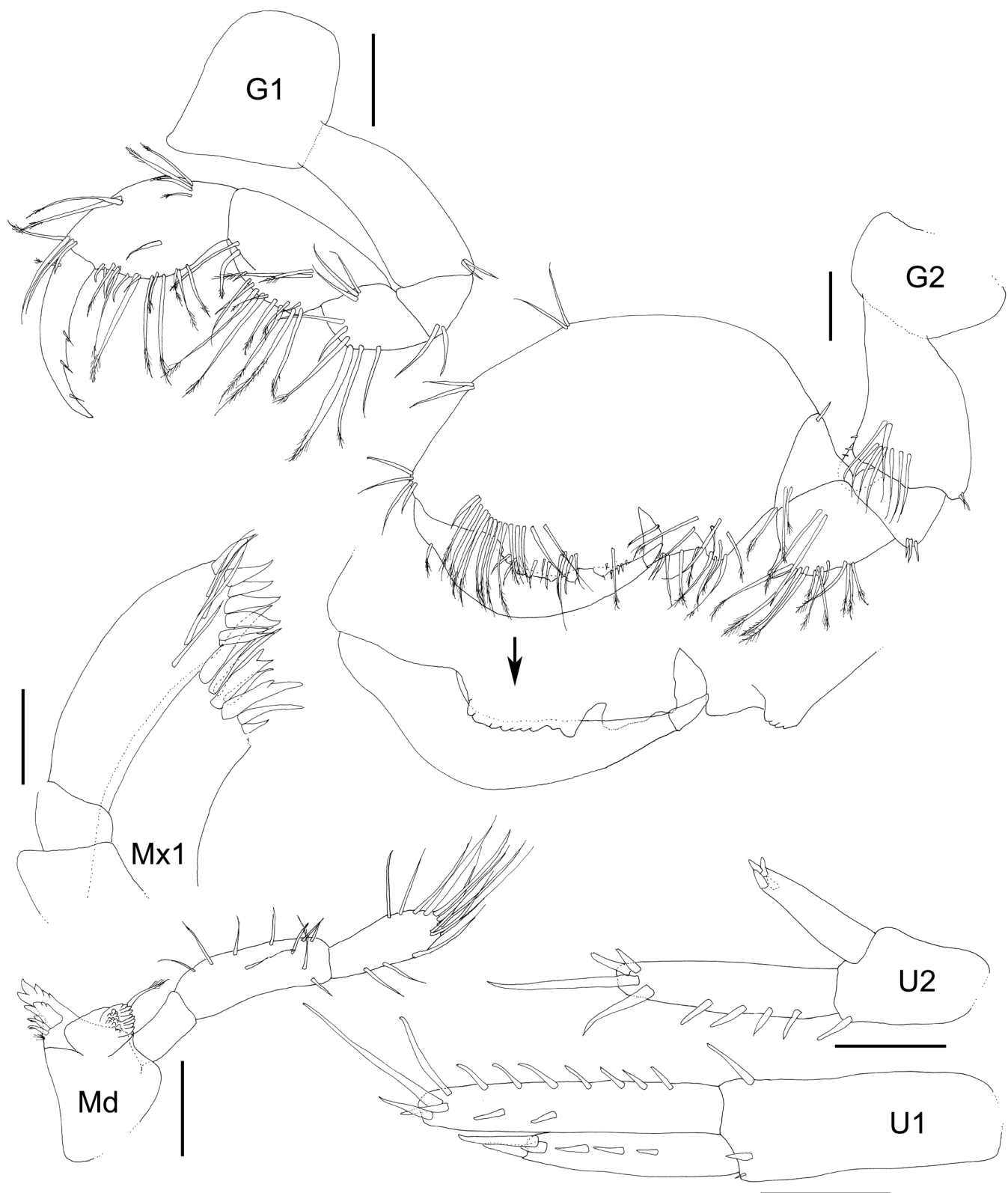


Fig. 2. *Cyrtophium orientale* Dana, 1853, neotype male, 3.3 mm, ZRC 2014.1080, Tekukor, Singapore. Scale bars = 100 µm.

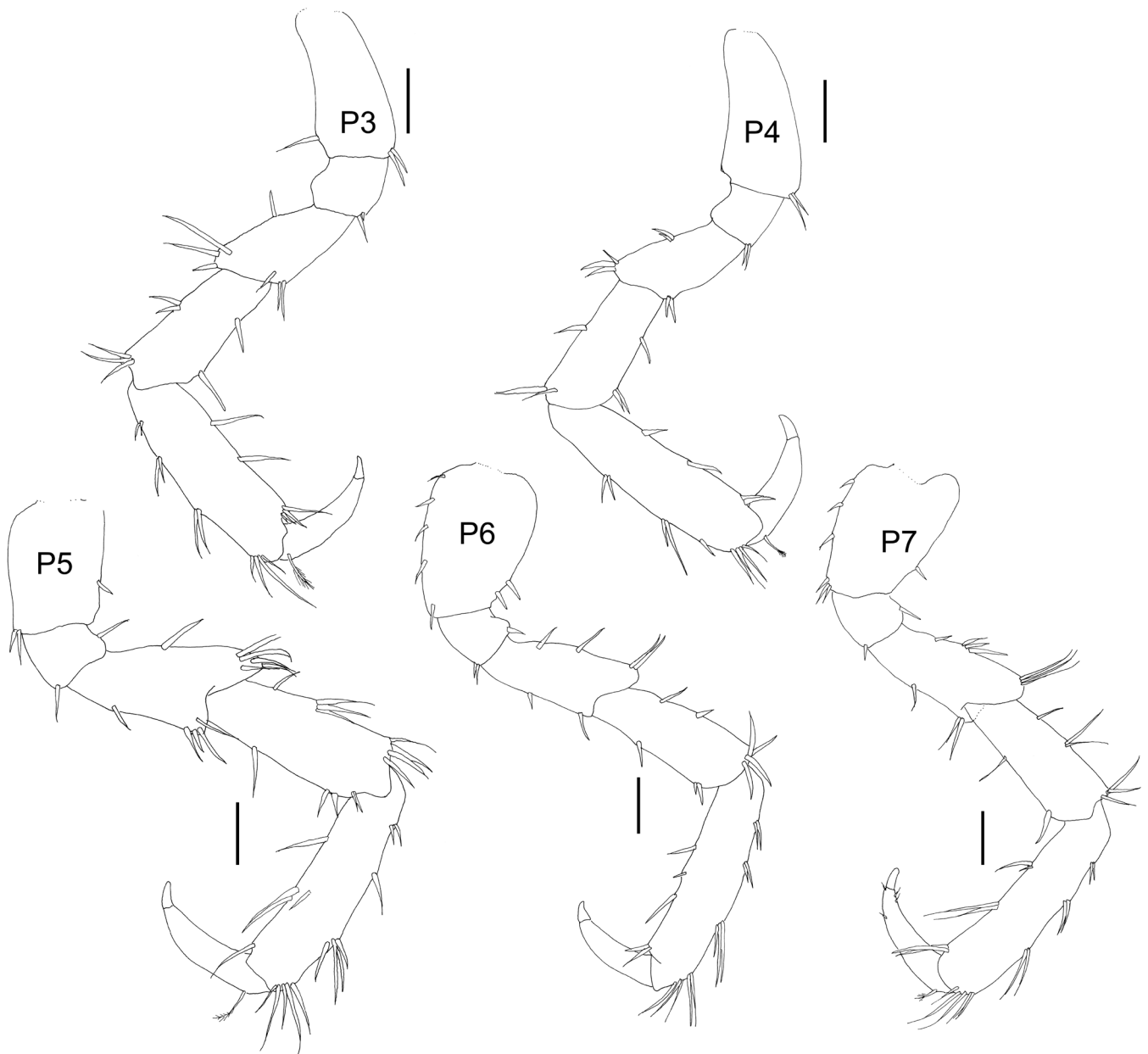


Fig. 3. *Cyrtophium orientale* Dana, 1853, neotype male, 3.3 mm, ZRC 2014.1080, Tekukor, Singapore. Scale bars = 100  $\mu$ m.

*Pleonites 1–2* without dorsal carinae. *Epimeron 1* posteroventral corner subquadrate. *Epimera 2–3* posterior margin rounded. *Urosomite 1* short, 1.5 times as long as broad. *Uropod 1* biramous; peduncle 3 times as long as broad, without well-developed ventromedial spine; inner ramus 1.1 times peduncle length; outer ramus  $\frac{3}{4}$  length of inner ramus. *Uropod 2* biramous, well developed; peduncle ventromedial spine absent; outer ramus 0.5 times length of inner ramus. *Uropod 3* uniramous; rami without apical setae. *Telson* dorsal lobe present, with 2 apical setae, lower margin without lateral or apical setae.

**Female.** Unknown.

**Remarks.** A neotype is established for *C. orientale* to stabilise the identity of the species, as it is the type and only species for the genus *Cyrtophium*. The type material designated by Dana is considered lost along with other amphipod material from the United States Exploring Expedition, through either

Shipwreck of the Peacock in 1841 during the expedition, a mishandling where curators reorganised material without preserving original numbering on bottles and tickets, additionally dry pin mounted specimen some ethanol during unpacking (Dana, unpublished handwritten notebook dated 1857, Smithsonian Library), lastly many specimens on loan to colleagues perished in the Chicago fire of 1871.

The genus *Cyrtophium* was established by Dana in 1852 without included species. Later in 1853 Dana nominated *C. orientale* as the type species for the genus by monotypy.

Despite only three illustrations forming the original description of *C. orientale*, the figures clearly indicate a set of characters which define the species, these include the presence of a dorsal head hump, weakly developed dorsal carinae along the body, the presence of long slender setae on gnathopod 2 propodus and the setation of both uropods 2 and 3.



The only other species attributed to the genus, *C. minutum* Haswell, 1879, was recently re-described by Hughes (2012). Both Hughes (2012) and Lowry & Stoddart (2003) indicate *Cyrtophium* has a 'dubious' generic status and could possibly be better placed as a junior synonym of *Podocerus* Leach, 1814. However without additional information on the type species of *Cyrtophium*, this relationship is difficult to assess. The new recent collection provides significant information for assessing the relationship between *Cyrtophium* and *Podocerus*, again however with just a single specimen, only a redescription is provided here in hope of more material becoming available to allow further morphological and genetic assessment.

**Distribution.** Singapore. Singapore Strait (Dana, 1853), Pulau Tekukor (current study).

***Podocerus* Leach, 1814**

***Podocerus brasiliensis* (Dana, 1853)**

(Figs. 4–8)

*Platophium brasiliense* Dana, 1853: 838.—Dana, 1855: pl. 55, fig. 9. *Platophium synptochair* Walker, 1904: 296, pl. 8, fig. 52.—Walker, 1909: 243.

*Podocerus brasiliensis*.—Stebbing, 1906: 704.—Stebbing 1914: 373.—K.H. Barnard, 1916, 279 —Shoemaker, 1921: 102.—K.H. Barnard, 1925: 366.—Gravelly, 1927: 123.—Schellenberg, 1928: 674.—Shoemaker, 1935: 250–251.—K.H. Barnard, 1935: 305–306.—Schellenberg, 1938: 94.—J.L. Barnard, 1953: 87.—J.L. Barnard, 1955: 39.—J.L. Barnard, 1959: 39, pl. 13.—Nayar, 1959: 45, pl.15 figs. 21–26.—J.L. Barnard, 1962: 66, fig. 30.—Nayar, 1967: 164, figs. 17d, e.—J.L. Barnard, 1970: 237, figs. 156, 157.—J.L. Barnard, 1971: 117, figs. 58B–60B.—Rabindranath, 1972: 302, fig. 2.—Griffiths, 1974: 322.—Ortiz, 1978: 9.—Wakabara & Tararam, 1983: 605.—Barnard & Karaman, 1991: 664–665.—Wakabara & Tararam, 1991, 73.—Valério-Berardo, 1992: 21.—Serejo, 1996: 55.—Ren & Huang, 1996: 66, fig. 7.—Wakabara & Serejo, 1998: 580.—Escobar-Briones & Winfield, 2003.—Winfield & Escobar-Briones, 2006.—Ortiz et al., 2007: 512–513.—Ren, 2012: 395, fig. 170.

Not *P. brasiliensis*.—Kilgallen, 2009: 842–844, figs. 1–2. (accepted as *P. lobatus* (Haswell, 1885), see Hughes, 2013).

Not *P. brasiliense*.—Della Valle, 1893: 329–332, Tav. 2, fig. 7; Tav. 7, figs. 39–58. (accepted as *P. variegatus* Leach, 1814, see Bellan-Santini et al., 1993).

**Type material.** Neotype male, 4.3 mm, dissected, 3 slides, carcass wet specimen, MNRJ 25511, Lagoa de Itaipu, Niteroi, Rio de Janeiro, Brazil (22°57'S 43°2'W), coll. A. Magesiey and C.S. Serejo, 8 June 2005.

**Additional material examined.** Brazil. Male, 5.0 mm, undissected, carcass SEM pin mount whole, MNRJ 20779; D female, 3 mm, dissected, 1 slide, carcass wet specimen, MNRJ 20779; C juvenile male, 4.5 mm, dissected, 4 slides, carcass wet specimen, MNRJ 20779; 6 specimens (2 males and 4 females), MNRJ 20779, same details as neotype.

Hawai'i. A male, dissected, 5 mm, 3 slides, BPBM S12647; C male, dissected, 4 mm, 1 slide, BPBM S12647; D male, dissected, 4.2 mm, 1 slide, BPBM S12647; E male, dissected,

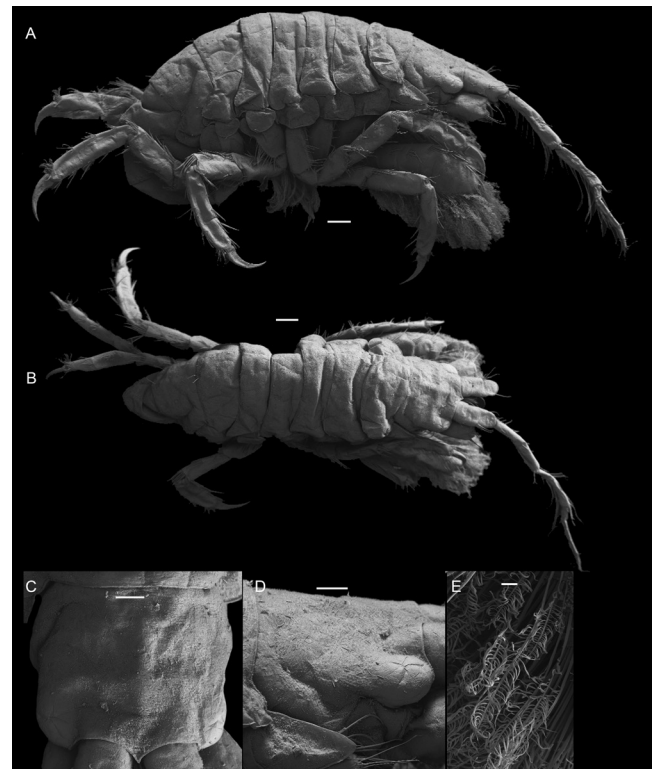


Fig. 4. *Podocerus brasiliensis* (Dana, 1853), male, 5.0 mm, MNRJ 20779, Lagoa de Itaipu, Niteroi, Rio de Janeiro, Brazil. SEM photographs: A, whole animal lateral view; B, whole animal dorsal view; C, head frontal view; D, head lateral view; E, gnathopod 2 propodus palm plumose setae. Scale bars = 200  $\mu$ m [A, B], 100  $\mu$ m [C, D], 20  $\mu$ m [E]

5 mm, 1 slide, BPBM S12647; F male, dissected, 5.8 mm, 1 slide, BPBM S12647; G male, 4.5 mm, dissected, 1 slide, carcass SEM pin mount, BPBM S12647; H male, dissected, 5.4 mm, 1 slide, BPBM S12647; I male, dissected, 6.2 mm, 1 slide, BPBM S12647, Honolulu Harbor, Oahu (HH station 23). A male, dissected, 5.5 mm, 3 slides, BPBM S12663; B female, dissected, 5.6 mm, 1 slide, BPBM S12663, McWaynes marine supply, Kewalo basin, Honolulu Harbor, Oahu (HH station 24).

Australia. Northern Territory. Male specimen, 5 mm, dissected, 4 slides, NTM Cr18344, Perkins Wharf, Gove Harbour, Gulf of Carpentaria, Northern Territory (12.1938°S 136.72°E), 7 June 2001; male specimen, 6.8 mm, SEM pin mount, AM P.85672, Perkins Wharf, Gove Harbour, Gulf of Carpentaria (12.1938°S 136.72°E), 7 June 2001; 5 specimens, NTM Cr015836, Perkins Wharf, Gove Harbour, Gulf of Carpentaria (12.1938°S 136.72°E), 7 June 2001; 5 specimens, NTM Cr015739, Site 2, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 7 June 2001; 4 specimens, NTM Cr015741, Site 2, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 7 June 2001; 1 specimen, NTM Cr015749, Site 2, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 7 June 2001; 12 specimens, NTM Cr015769, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 1 June 2001; 5 specimens, NTM Cr015770, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 1 June 2001; 12 specimens,

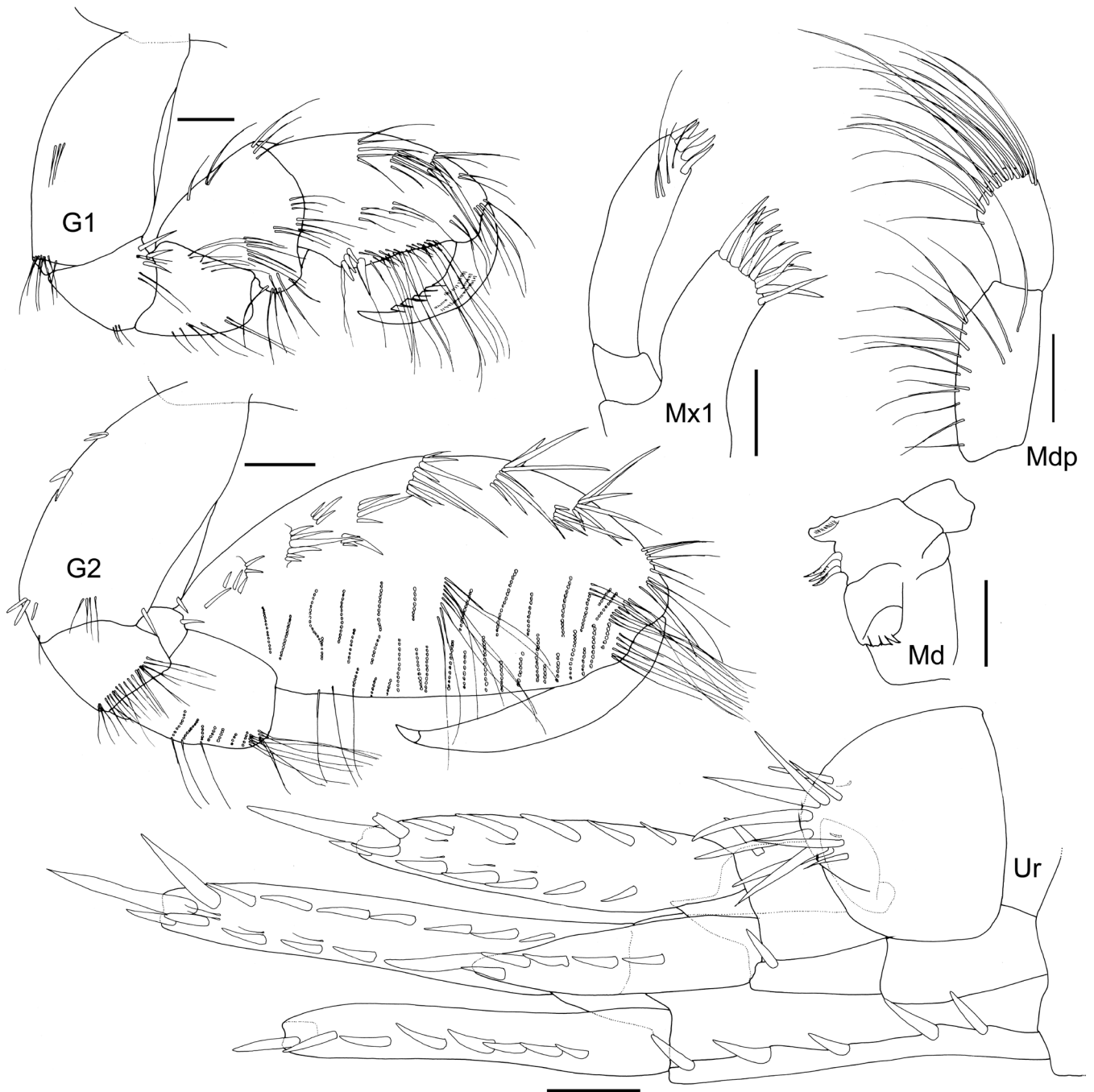


Fig. 5. *Podocerus brasiliensis* (Dana, 1853), neotype male, 4.3 mm, MNRJ 25511, Lagoa de Itaipu, Niteroi, Rio de Janeiro, Brazil. Scale bars = 100  $\mu$ m.

NTM Cr015773, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 1 June 2001; 8 specimens, NTM Cr015775, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 7 June 2001; 5 specimens, NTM Cr015776, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 1 June 2001; 5 specimens, NTM Cr015783, Site 1, Export Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.67°E), 1 June 2001; 4 specimens, NTM Cr015796, Yacht Club, Inverell Bay, Gove Harbour, Gulf of Carpentaria (12.2°S 136.7167°E), 1 June 2001; 3 specimens, NTM Cr015809, Cargo Wharf, Gove Harbour, Gulf of Carpentaria (12.2042°S 136.6808°E), 1 June 2001; 1 specimen, NTM Cr015823, Cargo Wharf, Gove Harbour, Gulf of Carpentaria (12.2042°S

136.6808°E), 8 June 2001; 1 specimen, NTM Cr015824, Cargo Wharf, Gove Harbour, Gulf of Carpentaria (12.2042°S 136.6808°E), 8 June 2001; 1 specimen, NTM Cr015827, Cargo Wharf, Gove Harbour, Gulf of Carpentaria (12.2042°S 136.6808°E), 8 June 2001; 16 specimens, NTM Cr015828, Cargo Wharf, Gove Harbour, Gulf of Carpentaria (12.2042°S 136.6808°E); female specimen, 4.7 mm, dissected, 1 slide, NTM Cr018343, Quarantine Anchorage, Darwin Harbour, (12.4724°S 130.8569°E), 18 August 1998; many specimens, NTM Cr015574, Quarantine Anchorage, Darwin Harbour, (12.4724°S 130.8569°E), 18 August 1998; 6 specimens, NTM Cr015424, Raffles Bay, Cobourgh Peninsula (11.2667°S 132.4°E), 6 April 2006; many specimens, NTM Cr015431, Raffles Bay, Cobourgh Peninsula (11.2667°S 132.4°E), 27

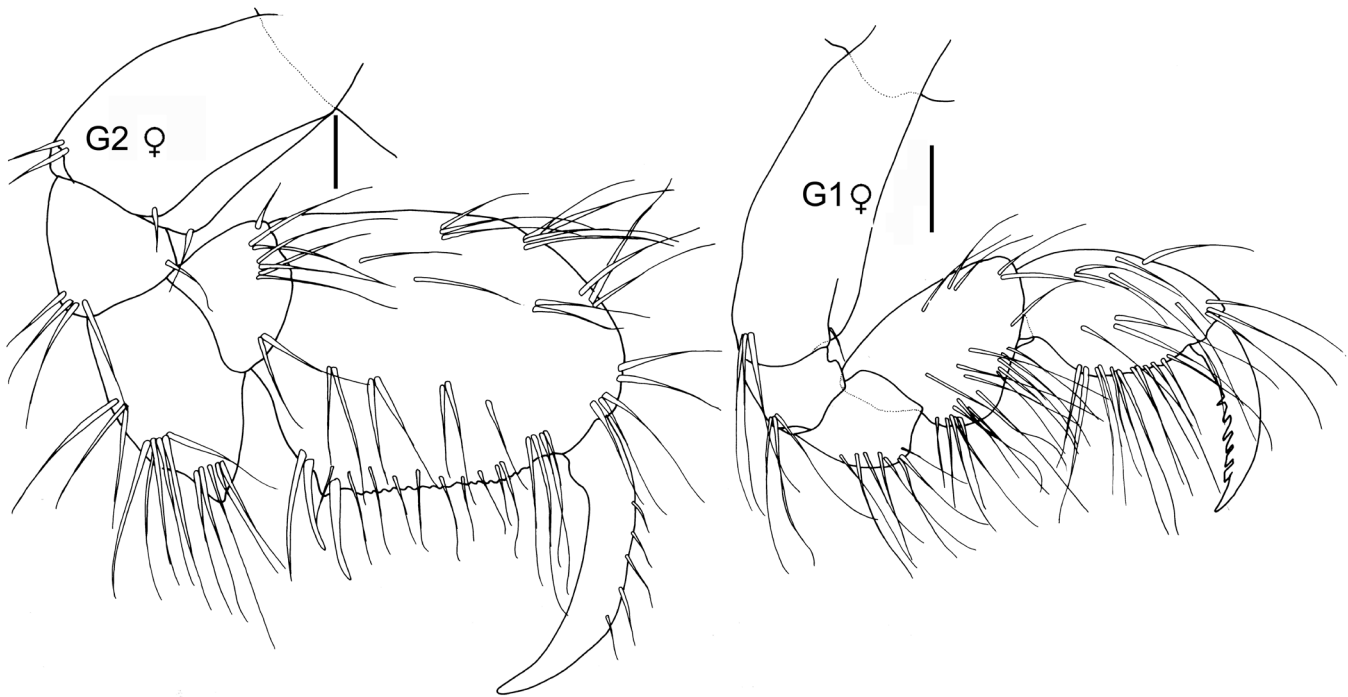


Fig. 6. *Podocerus brasiliensis* (Dana, 1853), female, 3 mm, MNRJ20779, Lagoa de Itaipu, Niteroi, Rio de Janeiro, Brazil. Scale bars = 100  $\mu$ m.

July 2006; 9 specimens, NTM Cr015453, Raffles Bay, Cobourg Peninsula (11.2667°S 132.4°E), 8 April 2007; many specimens, NTM Cr015459, Milner Bay, Groote Eylandt, Gulf of Carpentaria (13.8612°S 136.417°E), 22 July 2004; many specimens, NTM Cr015467, Groote Eylandt, Gulf of Carpentaria (13.8612°S 136.417°E), 14 March 2006; many specimens, NTM Cr015471, Groote Eylandt, Gulf of Carpentaria (13.8612°S 136.417°E), 24 October 2006; many specimens, NTM Cr015485, Alcan Wharf, Gove Harbour, Gulf of Carpentaria (12.205°S 136.675°E), 14 March 2006; 15 specimens, NTM Cr015599, Iron Ore Wharf, Darwin Harbour (12.4725°S 130.8428°E), 27 March 1999.

Western Australia: 1 male specimen, dissected, 5 mm, 4 slides, AM P.83915, Cygnet Bay Pearl Farm outside lines, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28.831'S 123°2.264'E), 2 m, coll. J.K. Lowry and K.B. Attwood, 23 May 2010 (MIWA 1094); 1 female specimen, dissected, 1 slide, 4 mm, AM P.92216, Cygnet Bay Pearl Farm outside lines, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28.831'S 123°2.264'E), 2 m, coll. J.K. Lowry and K.B. Attwood, 23 May 2010 (MIWA 1094); 2 male specimens, AM P.83915, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28.831'S 123°2.264'E), 2 m, coll. J.K. Lowry and K.B. Attwood, 23 May 2010 (MIWA 1094); 1 male specimen, 4 mm, SEM pin mount, AM P. 85664, Cygnet Bay Pearl Farm inside lines, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°29.728'S 123°1.768'E), 2 m, 26 May 2010, coll. L.E. Hughes (MI WA1139); 1 male specimen, AM P.83809, Cygnet Bay Pearl Farm inside lines, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°29.728'S 123°1.768'E), 2 m, coll. L.E. Hughes, 26 May 2010 (MI WA1139); 2 male specimens, AM P.80988, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28'40"S 123°02'06"E), 2 m, off floating rope line, 10 April 2008;

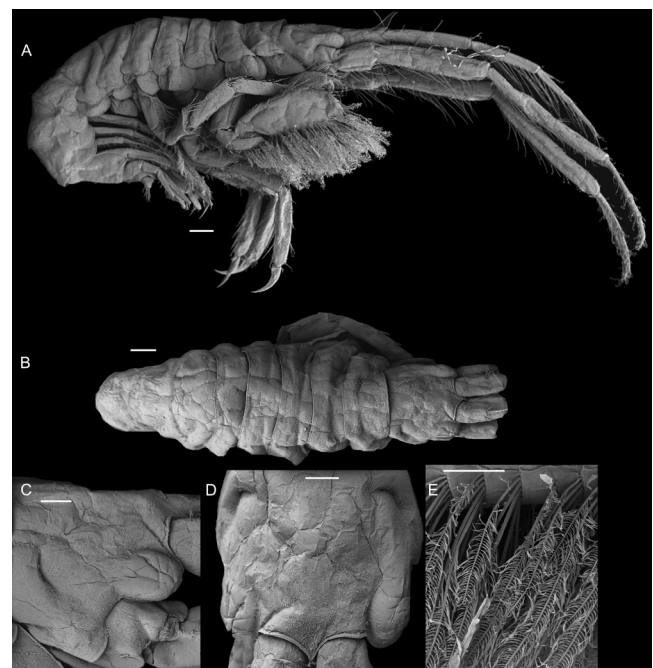


Fig. 7. *Podocerus brasiliensis* (Dana, 1853), male, 4 mm, AM P. 85664, Cape Leveque, Buccaneer Archipelago, Western Australia. SEM photographs: A, whole animal lateral view; B, whole animal dorsal view; C, head lateral view; D, head frontal view; E, gnathopod 2 propodus palm plumose setae. Scale bars = 200  $\mu$ m [A, B], 100  $\mu$ m [C, D], 20  $\mu$ m [E].

6 specimens, AM P.80987, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28'40"S 123°02'06"E), 2 m, off floating rope line (2 m depth), 10 April 2008; 2 specimens (1 male and 1 female), AM P.80993, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28'26"S 123°01'42"E), 3 m, off pearl shell in panel, 11 April 2008; many specimens, AM P.80991, Cygnet Bay, Cape Leveque, Buccaneer Archipelago



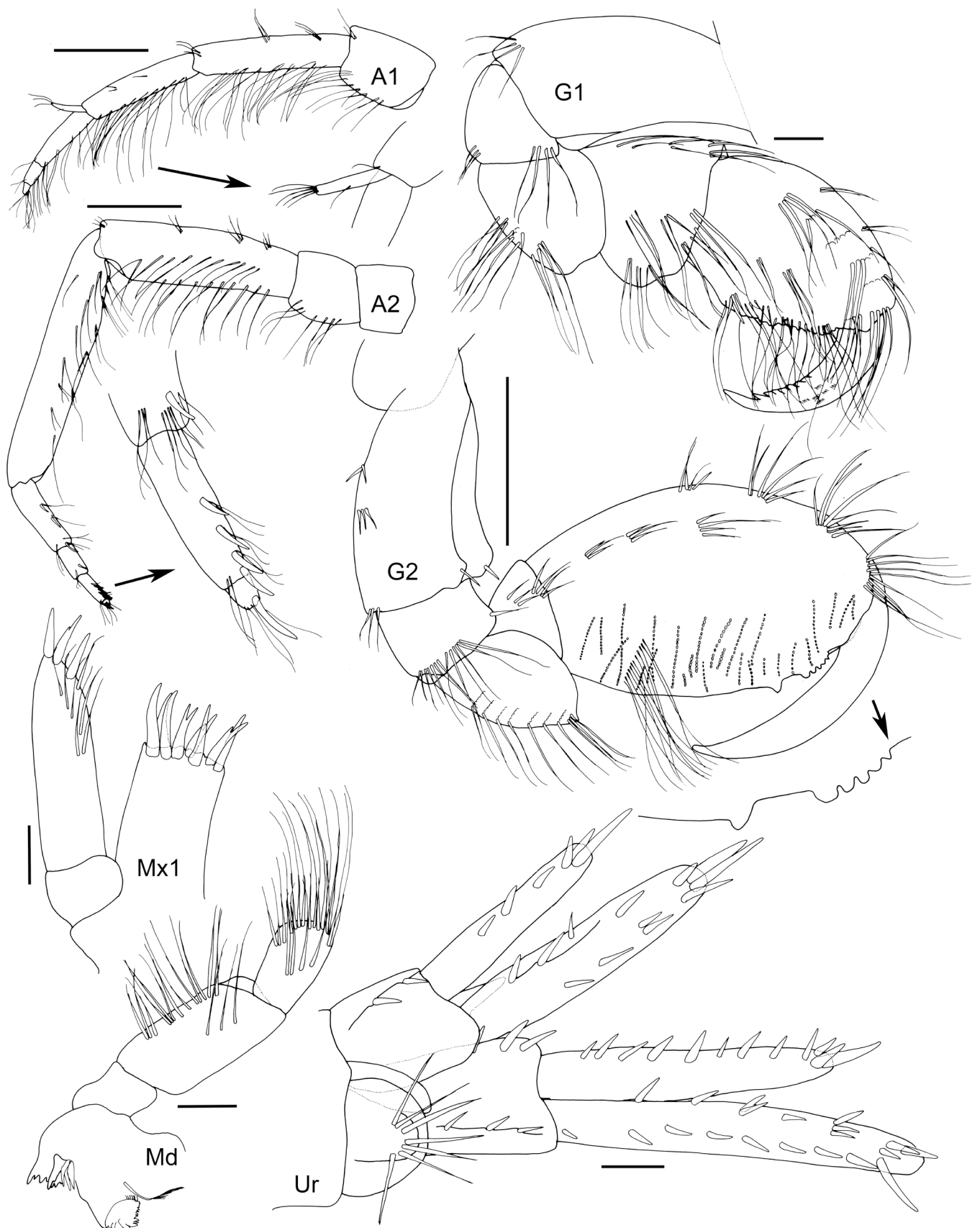


Fig. 8. *Podocerus brasiliensis* (Dana, 1853), female, 4.0 mm, AM P.92216, Cape Leveque, Buccaneer Archipelago, Western Australia. Scale bars = 100  $\mu$ m.



(16°28'39"S 123°02'46"E), 3 m, off pearl shell in panel, 10 April 2008; many specimens, AM P.80989, Cygnet Bay, Cape Leveque, Buccaneer Archipelago (16°28'40"S 123°02'06"E), 2 m, off floating rope line, 10 April 2008; 3 specimens (2 male and 1 female), AM P.80984, Vansittart Bay, Cape Bougainville (14°04'00"S 126°12'18"E), 3 m, off pearl shell in panel, 17 April 2008; many specimens, AM P.80985, Port George IV, Bonaparte Archipelago (15°23'30"S 124°40'54"E), 3 m, off pearl shell in panel, 15 April 2008; many specimens (inc. 1 A male diss., 1 slide), WAM C49251, Exmouth Navy Pier, Pier Head Pylon 03 (21°49'S 114°11'E), coll. C. Astbury, 26 June 2011.

South Australia: 8 specimens, SAMA 6569, Angas Islet, Garden Island, Gulf St Vincent (34.810°S 138.523°E), from boat fouling, wooden boat, coll. B.J. Brock, 29 August 1975.

**Diagnosis.** *Head* dorsally smooth; eyes weakly bulging; lateral cephalic lobe rounded. *Gnathopod 1* propodus subtriangular, palm margin minutely crenulate, with 1 robust seta near corner of palm. *Gnathopod 2* anterodistal corner with produced rounded lobes, with short robust setae; merus posterior margin lined with dense brush of setae, with broad produced lobe, lobe twice as broad as long, apically subacute, without short robust setae; propodus subovate, length 1.8 times width, palm acute, weakly convex, lined with dense bunch of plumose setae, with broad, well developed distal shelf, shelf margin strongly crenulate, palm with one proximal subtriangular tooth, without palm defining corner or tooth; dactylus closing along palm. *Uropod 1* peduncle ventromedial spine absent. *Uropod 2* peduncle ventromedial spine 1.5 times as long as broad. *Uropod 3* rami without setae. *Telson* dorsal lobe present, with 7 robust setae.

**Description.** Based on neotype male, 4.3 mm. MNRJ 25511.

*Body* cuticle dorsally smooth, laterally smooth.

*Head* dorsally smooth; rostrum short, about one tenth of head length; eyes weakly bulging; lateral cephalic lobe rounded; anteroventral corner subquadrate. *Antenna 1* length 0.8 times body; peduncle article 2 shorter than article 3; primary flagellum 0.7 times peduncle length, with 3 articles; accessory flagellum minute, scale-like, 1-articulate, 5 times as long as broad. *Antenna 2* distinctly longer than antenna 1, with dense concentration of long slender setae along posterior margin; article 4 shorter than article 5; flagellum about 0.25 times peduncle length, posterior margin with line of short robust setae, with 3 articles. *Mandible* accessory setal row with 3 setae. *Maxilla 1* palp article 2 distal margin with 3 robust setae.

*Coxae 1–7* contiguous. *Gnathopod 1* coxa subequal to coxa 2, as broad as long, anteroventral corner not produced, apically subacute; basis twice as long as broad, without anterodistal setae; carpus subtriangular, 1.1 times as long as broad; propodus subtriangular, anterior margin with clusters of long slender setae, palm margin minutely crenulate, with 1 robust seta near corner of palm; dactylus posterior margin with serrate teeth, cuticle surface with raised serrations.

*Gnathopod 2* basis 2.3 times as long as broad, anterodistal corner with produced rounded lobes, with short robust setae; merus posterior margin lined with dense brush of setae, with broad produced lobe, lobe twice as broad as long, apically subacute, without short robust setae; carpus free, distinct from propodus; propodus subovate, length 1.8 times width, anterior margin with clusters of long slender setae, palm acute, weakly convex, lined with dense bunch of plumose setae, with broad, well developed distal shelf, shelf margin strongly crenulate, palm with one proximal subtriangular tooth, without palm defining corner or tooth; dactylus closing along palm.

*Epimeron 1* posteroventral corner rounded. *Epimera 2–3* posteroventral corner subquadrate. *Urosomite 1* short, twice as long as broad. *Uropod 1* biramous; peduncle 4 times as long as broad, ventromedial spine absent; inner ramus subequal to peduncle length; outer ramus about 3/4 the length of the inner ramus. *Uropod 2* biramous; peduncle ventromedial spine 1.5 times as long as broad; outer ramus 3/4 length of inner ramus. *Uropod 3* uniramous; rami without setae. *Telson* dorsal lobe present, with 7 robust setae, lower margin without lateral or apical setae.

**Female** (sexually dimorphic characters). *Gnathopod 1* basis 3 times as long as broad. *Gnathopod 2* basis 1.6 times as long as broad, anterior margin with robust setae, anterodistal corner without lobe; propodus subovate, length 1.2 times width, palm define by 2 long robust setae.

**Remarks.** Following its description in 1853, *P. brasiliensis* was recorded several times in the early literature. Walker (1904) is the first reviewer with material collected in Galle Bay, Sri Lanka from naturally occurring pearl shell banks (as the jr. synonym *Platophium synaptochair* Walker, 1904 following J.L. Barnard, 1959). The first reference identifying *P. brasiliensis* as potentially translocating as a hull fouling organism was by Stebbing (1914) from the Falkland Islands. These collections were made in Stanley Harbour from mud on the bottom of a sunken ship hull.

Schellenberg (1938) was the first to place *P. brasiliensis* in Hawaii, citing several males (4–5.5 mm) and several females (3.5 mm) from Kaneohe Bay collected in 1927. In contemporary literature, *P. brasiliensis* became more frequently cited after J.L. Barnard, 1953, 1958 and 1969 recorded material from a survey of fouling organisms in Los Angeles, California. Later J.L. Barnard identified additional collections and supported Schellenberg's records citing *P. brasiliensis* in Hawaii (J.L. Barnard, 1970, 1971). A more recent port and marina survey again recognised *P. brasiliensis* at multiple Hawaii island sites (Eldridge & Carlton, 2002).

Within the taxonomic literature, *P. brasiliensis* is now known from at least 16 geographically separated locations (see distribution section). Three distinct morphological forms of *P. brasiliensis* have been figured. Dana's original illustrations of an adult male specimen show a strong head hump, the gnathopod 2 propodus without teeth and uropods 1 and 2 without a ventromedial spine. A second morphological form

figured by J.L. Barnard 1958 from Los Angeles has the head without a hump, a well-developed distal shelf and one tooth. J.L. Barnard's (1970, 1971) material drawn from Hawaii has no head hump, no shelf or tooth on gnathopod 2 and both ventromedial spines present. Other minor morphological differences which are attributable to intraspecific variation include the more pronounced dorsal carination and increased number of uropod robust setae with size. In discussing the *Podocerus* group J.L. Barnard (1970: 237) commented that the California open-sea material was most likely a closely related congener and not *P. brasiliensis*, but considered estuarine material an invasive introduction of *P. brasiliensis*.

Within the genus, *P. brasiliensis* is readily recognised by the extremely setose gnathopod 2 propodus where the setae charismatically project forward from the dactylus and also secondarily by the telson apical margin with many long robust setae. The closest species morphologically is *P. varigatus* Leach 1814, described from Devon, England, both species with a densely plumose male gnathopod 2 propodus and the telson with numerous short robust setae. Many subsequent workers conclude these could be the same species (K.H. Barnard, 1916; J.L. Barnard, 1965; Rabindranath, 1972). Establishing a neotype for *P. brasiliensis* with material from Rio de Janeiro is the first step to resolving this hypothesis. Stabilising the identity of this species allow further hypotheses testing about the invasive distribution of the species.

Based on first hand identification of specimens here, *P. brasiliensis* is reported from numerous commercial port locations in northern and western Australia. The abundance of this species within artificial habitats is particularly high with several hundred individuals scraped from artificial rope habitats.

**Distribution.** ATLANTIC OCEAN: Rio de Janeiro (Dana, 1853; Wakabara & Tararam, 1991; Valério-Berardo, 1992; Serejo, 1996; Wakabara & Serejo, 1998); Antigua (Dana, 1853; Shoemaker, 1921; Ortiz, 1978); Mexico; Puerto Rico; Cuba; Venezuela (Escobar-Briones & Winfield, 2003; Winfield & Escobar-Briones, 2006; Miloslavich et al., 2010). MEDITERRANEAN. (Della Valle, 1893). INDIAN OCEAN: South Africa (K.H. Barnard, 1916, 1925; Griffiths, 1974); Zanzibar (Walker, 1909); Red Sea (Walker, 1909; Schellenberg, 1928); India, Gulf of Mannar, Neendakara (Gravely, 1927; K.H. Barnard, 1935; Rabindranath, 1972; Nayar, 1959, 1967); Sri Lanka (Walker, 1904). PACIFIC OCEAN: Los Angeles (J.L. Barnard, 1953, 1958); Hawaii (Schellenberg, 1938; J.L. Barnard, 1970, 1971). Australia. Northern Territory: Darwin Harbour, Gove Harbour, Groote Eylandt. Western Australia: Cape Leveque, Port George IV, Cape Bougainville, Exmouth. South Australia: Garden Island (current study).

***Podocerus chelonophilus*  
(Chevreux & de Guerne, 1888)**

*Cyrtophium chelonophilum* Chevreux & de Guerne, 1888: 625.  
*Platophium cheloniae* Stebbing, 1888: 1190, pl. 30.  
*Platophium chelonophilum* Chevreux & de Guerne, 1893: 445.—  
Chevreux, 1900: 115, pl. 13, fig. 2; pl. 14, fig. 7.

*Podocerus cheloniae* Stebbing, 1906: 701.

*Podocerus chelonophilus* Stebbing, 1906: 703.—Chevreux, 1911: 272.—Chevreux & Fage, 1925: 375, fig. 383.—Chevreux, 1935: 130.—Mateus & Alfonso, 1974: 36, figs. 27, 28.—Thomas & Barnard, 1992: 110, figs. 1, 2.—Ruffo, 1993: 675, fig. 462.—Moore, 1995: 253.—Baldinger, 2001: 441, figs. 1–6.—Kilgallen, 2009: 848–850.—Sezgin et al., 2009: 435–436.—Zakhama-Sraieb et al., 2010: 2.—Lazo-Wazem, et al., 2011: 230–232, fig. 6c.

? *Podocerus umigame* Yamato, 1992: 281, figs. 1–3.—Ren, 1994: 265, fig. 13.—Ren, 2012: 404, fig. 175.

**Material examined.** 20+ specimens, AM P.88624, reef off Kirra, Gold Coast, Queensland, Australia (28°8'30"S 153°31'55"E), coll. Ian Banks & D. Potter, 26 June 2012.

**Ecology.** *Podocerus chelonophilus* is recorded from both sides of the Atlantic and the Mediterranean, while its junior synonym *P. umigame* accounts for records of the species from Japan and the South China Sea. Material studied here from Kirra on the Gold Coast, Australia, is the most southerly distribution record for the species. This part of the Australian coast is subject to the Eastern Australian Current which carries warm water south from the Great Barrier Reef. Associated with this collection is video footage of rapid recruitment behaviour, where more than 1,000 individuals can be observed crawling on a scuba diver in 3–5 m of water. Individuals recruited to the floating scuba diver in under five minutes, reaching the observed high densities. This phenomenon of recruiting *P. chelonophilus* is a regular occurrence at the dive site (Ian Banks, pers. com.) (Media file one).

*Podocerus chelonophilus* is most frequently collected as an epibiont on the loggerhead turtle (*Caretta caretta*), the Green turtle (*Chelonia mydas*), the Olive Ridley sea turtle (*Lepidochelys olivacea*) and the hawksbill turtle (*Eretmochelys imbricata*) (Lazo-Wasem et al., 2011; Baldinger, 2001).

**Remarks.** This is the most southerly distribution record for the species.

**Distribution.** ATLANTIC OCEAN. Azores (Chevreux, 1900); Madeira (Moore, 1995); Florida and South Carolina, North America (Thomas & Barnard, 1992); Mexico (Lazo-Wazem et al., 2011), Ecuador (Baldinger, 2001). MEDITERRANEAN SEA. Algeria (Chevreux & de Guerne, 1888), Turkey (Sezgin et al., 2009). PACIFIC OCEAN. Heron Island, Mon Repos Beach, Kirra, Queensland, Australia (Kilgallen, 2009; current study); ?Wakayama, Japan (Yamato, 1992). ?South China Sea: Hong Kong (Ren, 1994).

***Podocerus cristatus* (Thomson, 1879)  
(Figs. 9–11)**

*Cyrtophium cristatum* Thomson, 1879: 331–332, pl. 16, figs. 9–15.—Thomson, 1881: 219–20, pl. 8, fig. 8.—Thomson & Chilton, 1886: 143.

*Podocerus cristatus*.—Stebbing, 1906: 706.—Thomson, 1913: 245.—Chilton, 1926: 513–515, fig. 2.—Hurley, 1957: 7.—J.L. Barnard, 1972: 146.—Barnard & Karaman, 1991: 665.  
not *P. cristatus* K.H. Barnard, 1916: 277.

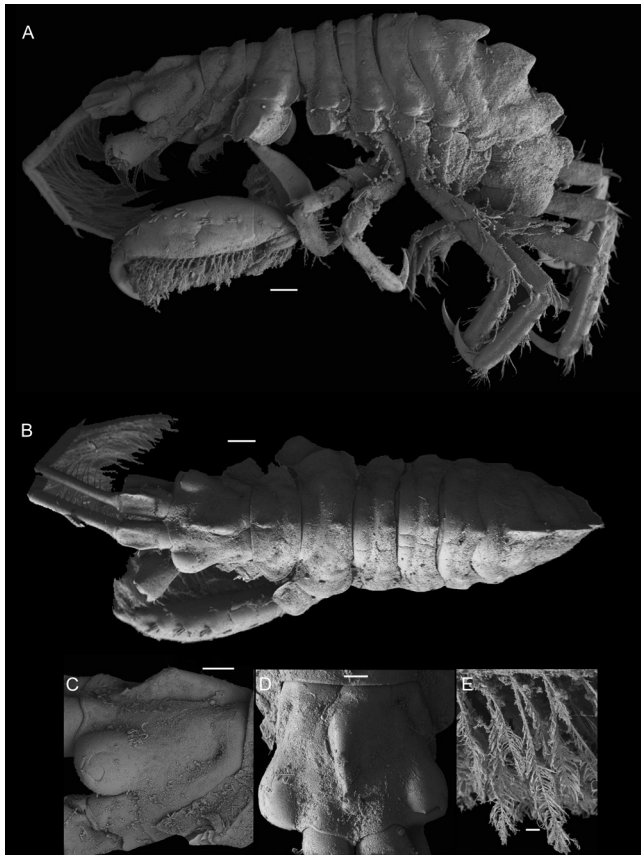


Fig. 9. *Podocerus cristatus* (Thomson, 1879), male, 5.1 mm, NIWA 103437 Lyttelton, New Zealand. SEM photographs: A, whole animal lateral view; B, whole animal dorsal view; C, head lateral view; D, head frontal view; E, gnathopod 2 propodus palm plumose setae. Scale bars = 200  $\mu$ m [A, B], 100  $\mu$ m [C, D], 20  $\mu$ m [E].

**Type material.** Neotype A male, 5.0 mm, dissected, 4 slides, MITS 57193, Lyttelton, New Zealand (LY039, AM 2487947, 5733090 PSC, AM-7).

**Type locality.** Lyttelton, New Zealand.

**Additional material examined.** New Zealand. B male, 5.1 mm, carcass SEM pin mount whole, NIWA 103437, MITS 57193, Lyttelton, 19 March 2002 (LY039, AM 2487947, 5733090 PSC, AM-7); 1 b female, 3.85 mm, dissected, 1 slides, carcass wet specimen, Lyttelton, 19 March 2002 (LY039, AM 2487947, 5733090 PSC, AM-5); 1 male, Lyttelton, 19 March 2002 (LY039, AM 2487947, 5733090 PSC, AM-7); 2 male, Lyttelton, 19 March 2002 (LY039, AM 2487947, 5733090 PSC, AM-5); 2 females, MITS 57326, Lyttelton (LY045, AM 2487947, 5733090 PSC); 4 males, MITS 64908, Timaru, 12 February 2002 (TM027, AM2371040, 5644806 PSC, AM-02); 1 female, MITS 64939, Timaru, 12 February 2002 (TM029, AM2371040, 5644806 PSC, AM-02); 1 male, MITS 65597, Timaru, 14 February 2002 (TM077, AM 2371110, 5645100 PSC); 1 male, MITS 65616, Timaru, 14 February 2002 (TM079, AM 2371110, 5645100 PSC).

**Diagnosis.** *Body* cuticle dorsally smooth to rugose, with posterior dorsal carinae, laterally smooth. *Head* with well-developed hump; rostrum short; eyes greatly bulging.

*Gnathopod 1* propodus palm with 9 robust setae near corner of palm. *Gnathopod 2* basis with dense brush of plumose setae; merus posterior margin with narrow produced lobe, lobe as long as broad, apically subacute; propodus elongate, subovoid, length 2.9 times width, palm acute, with well developed distal shelf, shelf margin smooth, palm with 2 proximal rounded teeth. *Pereonite 6* dorsal carina broad, produced posteriorly, subtriangular, apically subacute. *Pereonite 7* dorsal carina broad, produced evenly and posteriorly, subtriangular, apically subacute. *Pleonites 1–2* dorsal carinae broad, produced evenly, subrectangular. *Urosomite 1* short, twice as long as broad. *Uropods 1–2* peduncle with well-developed ventromedial spine.

**Description.** Based on neotype male, 5.0 mm, NIWA 103437.

*Body* cuticle dorsally smooth to rugose, with posterior dorsal carinae, laterally smooth.

*Head* with well-developed hump; rostrum short, one tenth of head length; eyes greatly bulging; lateral cephalic lobe rounded; anteroventral corner subquadrate. *Antenna 1* 0.3–0.5 times body length; peduncle article 2 subequal to article 3; primary flagellum 0.3–0.5 times peduncle length, with 7 articles; accessory flagellum 1-articulate, three times as long as broad. *Antenna 2* distinctly longer than antenna 1, with dense concentration of long slender setae along posterior margin; article 4 shorter than article 5; flagellum 0.25 times peduncular length, posterior margin with line of short robust setae. *Mandible* accessory setal row with 2 setae. *Maxilla 1* palp article 2 distal margin with 5 robust setae.

*Coxae 3–7* contiguous. *Gnathopod 1* coxa smaller than coxa 2, broader than long, anteroventral corner greatly produced ventrally, apically subacute; basis 2.1 times as long as broad, without anterodistal setae; carpus subtriangular, 1.5 times as long as broad; propodus subtriangular, anterior margin with clusters of long slender setae, palm margin smooth, with 9 robust setae near corner of palm; dactylus posterior margin with serrate teeth, cuticle surface with raised serrations. *Gnathopod 2* basis 3 times as long as broad, anterodistal corner rounded, with dense brush of plumose setae; merus posterior margin with a few rows of slender setae, posterior margin with narrow produced lobe, lobe as long as broad, apically subacute; carpus free, distinct from propodus; propodus elongate, subovoid, length 2.9 times width, anterior margin with clusters of long robust setae, palm acute, straight, not defined, with narrow, well developed distal shelf, shelf margin smooth, palm with two proximal rounded teeth, without sinus, without palm defining corner or tooth; dactylus closing along palm. *Pereonite 6* dorsal carina broad, produced posteriorly, subtriangular, apically subacute. *Pereonite 7* dorsal carina broad, produced evenly and posteriorly, subtriangular, apically subacute.

*Pleonites 1–2* dorsal carina broad, produced evenly, subrectangular. *Urosomite 1* short, twice as long as broad. *Uropod 1* biramous; peduncle 3 times as long as broad, with well-developed ventromedial spine; inner ramus 1.2 times peduncle length; outer ramus 3/4 the length of the



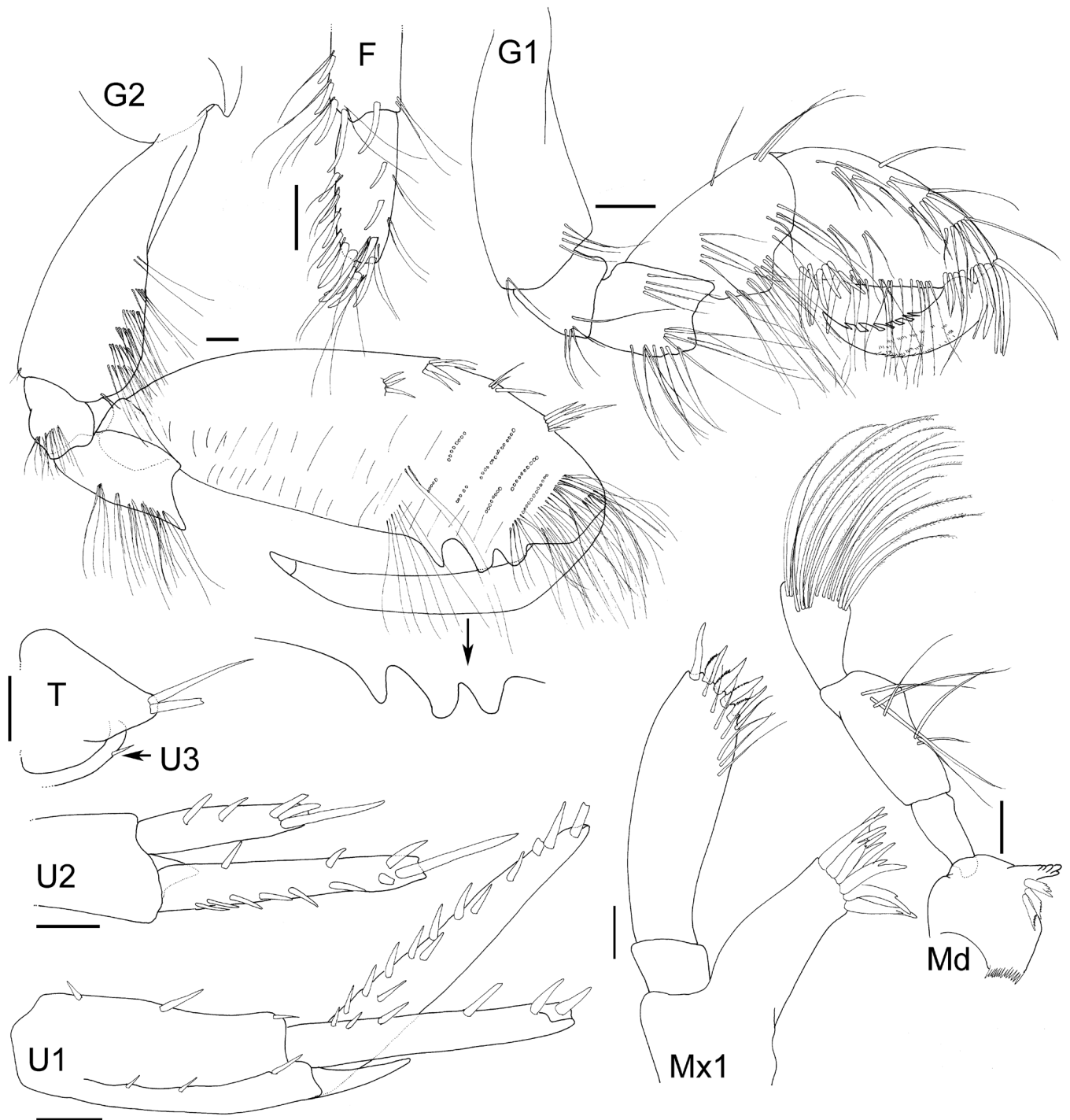


Fig. 10. *Podocerus cristatus* (Thomson, 1879), neotype male, 5.0 mm, MITS 57193, Lyttelton, New Zealand. Scale bars = 100  $\mu$ m.

inner ramus. *Uropod* 2 biramous, well developed; peduncle ventromedial spine present; outer ramus 0.4 times length of inner ramus. *Uropod* 3 uniramous; rami with 1 apical seta. *Telson* dorsal lobe present, with 2 apical setae, lower margin without lateral or apical setae.

**Remarks.** A neotype is established to stabilise the name and define *P. cristatus* from closely related and invasive *Podocerus* species. Original type material of Thomson deposited in the Portobello Marine Laboratory, University of Otago is considered lost, following inquiry with the Otago Museum and the Canterbury Museum (Cody Fraser, pers. comm.).

*Podocerus cristatus* was described from Dunedin in New Zealand, independently in the same year as *P. dentatus* (Haswell, 1879), was described from Sydney, Australia. *Podocerus dentatus* was placed in synonymy with *P. cristatus* by Stebbing, 1906. In 1962, J.L. Barnard identified material as *P. cristatus* from Los Angeles Harbour where it is listed as a regional invasive.

Recent work by Lowry & Stoddart (2003) along with further examination by Hughes, 2012 has reinstated *P. dentatus* as a distinct taxon. Much of the difficulty in distinguish these species is because of the similar dorsal carination pattern, including both carinae size and shape. However the pattern





Fig. 11. *Podocerus cristatus* (Thomson, 1879), female, 3.85 mm, NIWA 103437, Lyttelton, New Zealand. Scale bars = 100  $\mu$ m.

shared between these species is now recognised as a character shared across several taxa: *P. cristatus*, *P. dentatus*, *P. oliphantus* Hughes, 2012 and *P. vulgaris* Hughes, 2012.

Removal of *P. dentatus* from the *P. cristatus* synonymy reduced the current known distribution of the species to New Zealand and Los Angeles. Unfortunately no material of *P. cristatus* is present in Los Angeles County Museum collections and repeated attempts to gain loan material from other Californian sources were unsuccessful, leaving both the species and natural history records unverified for this study.

With designation of neotype here, *P. cristatus* can be defined from *P. cristatus*, *P. dentatus*, *P. oliphantus* and *P. vulgaris* by the male gnathopod 2 propodus palm with well-developed distal shelf and two distal teeth.

**Distribution.** New Zealand: Dunedin Harbour (Thomson, 1879); Cooks Strait (Chilton, 1926); Lyttelton (J.L. Barnard, 1972; current study); Timaru (current study).

*Podocerus cyrenensis* sp. nov.  
(Figs. 12–16)

**Type material.** Holotype male 4.5 mm, dissected, 3 slides, ZRC 2014.1081, SS 1706 IT 86; paratype male, 4.8 mm, dissected 4 slides, ZRC 2014.1082; paratype female, 4.1 mm, dissected, 3 slides, ZRC 2014.1083; paratype SEM pin mount specimen, male 4.9 mm, ZRC 2014.1084; 1 SEM pin mount specimen, male 5.2 mm, AM P.97431; paratypes 100+ specimens, ZRC 2014.1085; 40 specimens (20 male, 20 female), AM P.97442, Cyrene Reef, Singapore (1°15.374'N 103°44.816'E), intertidal, 27 May 2013, coll. Lee Yen-Ling et al. (SS 1706/IT 86).

**Type locality.** Cyrene Reef, Singapore (1°15.374'N 103°44.816'E).

**Etymology.** Named from the type locality.

**Additional material examined.** Singapore. 50+ specimens, ZRC 2014.1086, Cyrene Reef (1°15.374'N 103°44.816'E), intertidal, hand collection, 28 May 2013, coll. Koh Kwan Siong et al. (SS 2969/IT 94); 1 female specimen, ZRC 2014.1087, Pulau [=Island] Jong, south (1°12.55'N 103°47.2'E), 17 m, hand collection on scuba, 24 May 2013, coll. Tan Heok Hui et al. (SS 1692/SD 56); 20+ specimens, ZRC 2014.1088, Pulau [=Island] Jong, south (1°12.55'N 103°47.2'E), 17 m, hand collection on scuba, 24 May 2013, coll. Tan Heok Hui et al. (SS 1696/SD 56); 1 female specimen, ZRC 2014.1089, Pulau [=Island] Semakau (1°12'17"E 103°46'17.9"E), intertidal, hand collection, 27 May 2013, coll. Dwi Listyo Rahayu et al. (SS 3461/IT 86); 12 specimens, ZRC 2014.1090, Big Sister's Island, southern side, intertidal rocky reef, hand collection, 26 May 2013, coll. Lee Yen-Ling et al. (SS 1711/IT 81).

**Diagnosis.** Head without hump, eyes greatly bulging. *Gnathopod 1* coxa larger than coxa 2, broader than long, carpus subrectangular, 1.2 times as long as broad; propodus



Fig. 12. *Podocerus cyrenensis* sp. nov. colour image, holotype male, 4.5 mm, ZRC 2014.1081, Cyrene Reef, Singapore.

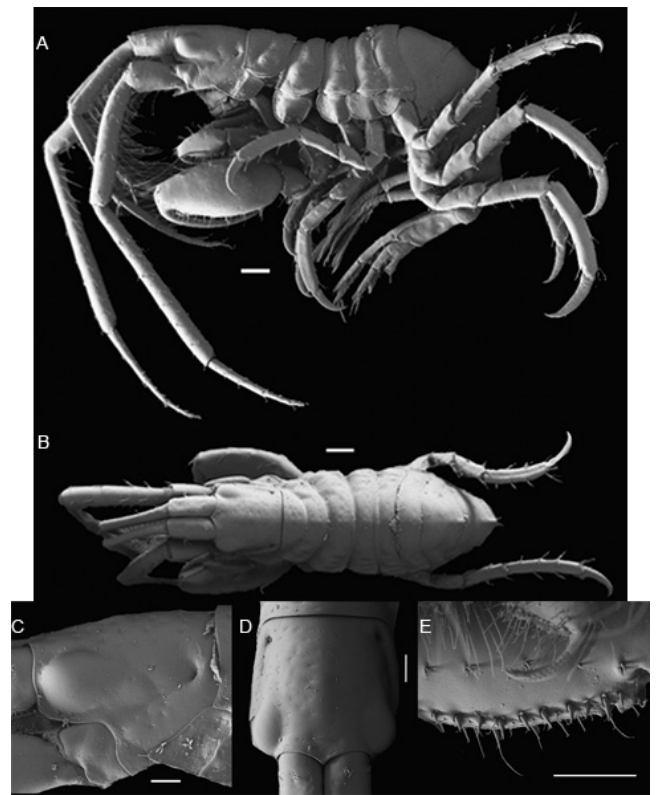


Fig. 13. *Podocerus cyrenensis* sp. nov. SEM image of paratype male, 4.9 mm, ZRC 2014.1084. A, lateral view; B, dorsal view; C, head lateral view; D, head dorsal view and paratype male, 5.2 mm, AM P.97431; E, gnathopod 2 propodus palm, scale 200  $\mu$ m Cyrene Reef, Singapore. Scale bars = 200  $\mu$ m [A, B, D, E] 100  $\mu$ m [C].

subtriangular, palm with 4 robust setae near corner of palm; *Gnathopod 2* basis anterodistal corner produced, lobe apically rounded, not reaching beyond ischium, with 2 short robust setae; carpus compressed, cup-shaped; propodus elongate, subovoid, length 1.7 times width, palm acute, straight, without distal shelf, lined with pairs of short robust setae, palm length 0.8 times propodus posterior margin. *Pereonite 7* dorsal carina broad, produced evenly, apically rounded. *Pleonites 1–2* dorsal carinae broad, produced evenly, apically rounded. *Uropod 1* without well-developed ventromedial spine. *Uropod 2* peduncle ventromedial spine absent.

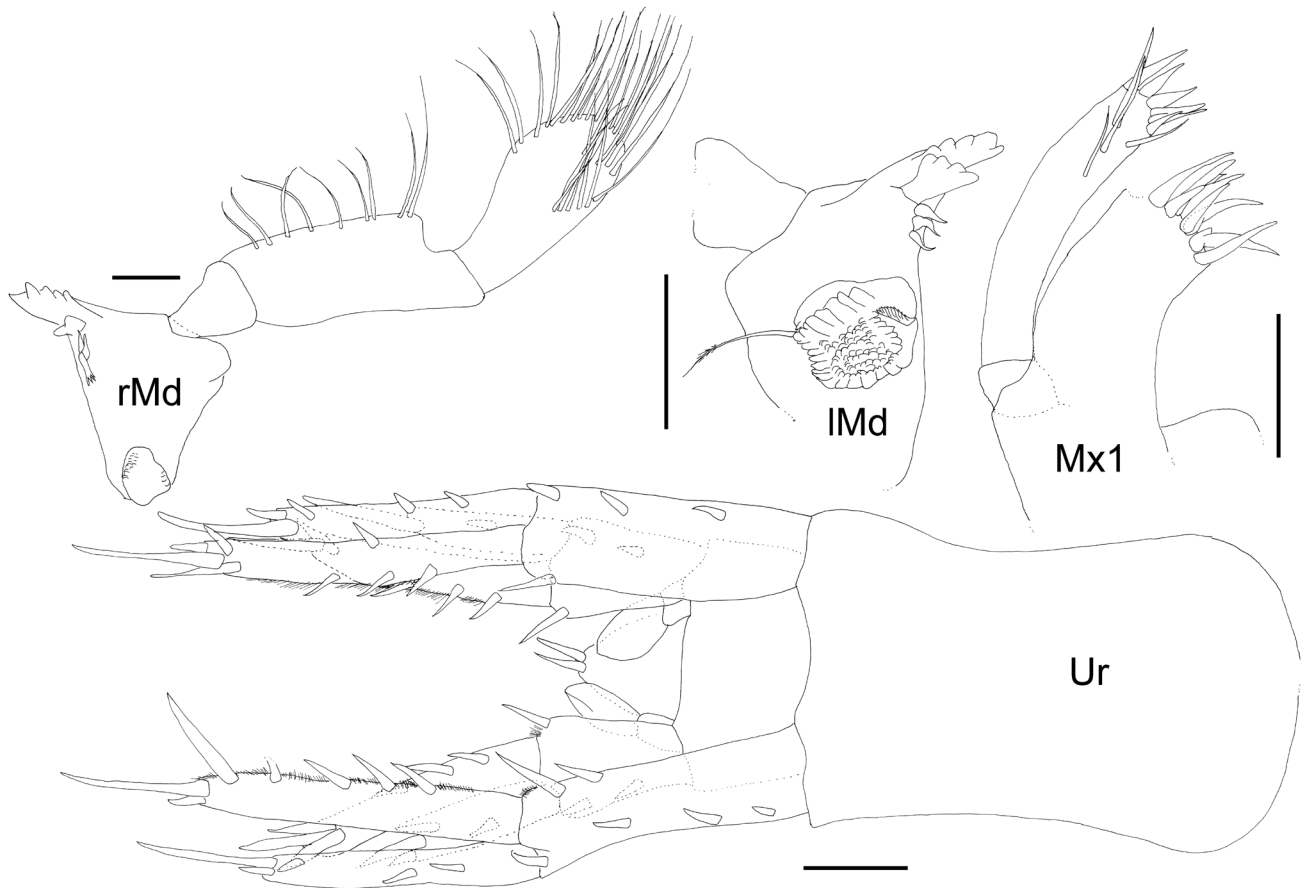


Fig. 14. *Podocerus cyrenensis* sp. nov. Holotype male, 4.5 mm, ZRC 2014.1081; Cyrene Reef, Singapore. Scale bars = 100  $\mu$ m.

**Description.** Based on holotype male, 4.5 mm, ZRC 2014.1081.

*Body* cuticle dorsally smooth to rugose, with posterior dorsal carinae, laterally smooth.

*Head* without hump; rostrum short, one tenth of head length; eyes greatly bulging; lateral cephalic lobe subquadrate; anteroventral corner subquadrate. *Antenna 1* 0.3–0.5 times body length; peduncle article 2 1.1 times article 3; primary flagellum 0.7 times peduncle length, with 7 articles; accessory flagellum 1-articulate, three times as long as broad. *Antenna 2* distinctly longer than antenna 1, with dense concentration of long slender setae along posterior margin; article 4 shorter than article 5; flagellum 0.25 times peduncular length, posterior margin with line of short robust setae. *Mandible* accessory setal row with 3 setae. *Maxilla 1* palp article 2 distal margin with 6 robust setae.

*Coxae 3–7* contiguous. *Gnathopod 1* coxa larger than coxa 2, broader than long, anteroventral corner produced anteroventrally, apically subacute; basis 1.8 times as long as broad, without anterodistal setae; carpus subrectangular, 1.2 times as long as broad; propodus subtriangular, anterior margin with clusters of long slender setae, palm margin smooth, with 4 robust setae near corner of palm; dactylus posterior margin with serrate teeth, cuticle surface with raised serrations. *Gnathopod 2* basis twice as long as broad, anterodistal corner produced, lobe apically rounded, not reaching beyond ischium, with 2 short robust setae; merus

posterior margin with a few rows of slender setae, posterior margin with narrow produced lobe, lobe broader than long, apically subacute; carpus compressed, cup-shaped; propodus elongate subovoid, length 1.7 times width, anterior margin with clusters of short robust setae, palm acute, straight, defined by corner with 3 long robust setae, without distal shelf, palm without sinus, lined with pairs of short robust setae, palm length 0.8 times propodus posterior margin; dactylus closing along palm. *Pereonite 7* dorsal carina broad, produced evenly, apically rounded.

*Pleonites 1–2* dorsal carinae broad, produced evenly, apically rounded. *Urosomite 1* short, 1.9 times as long as broad. *Uropod 1* biramous; peduncle 4 times as long as broad, without well-developed ventromedial spine; inner ramus 1.1 times peduncle length; outer ramus 3/4 the length of the inner ramus. *Uropod 2* biramous, well developed; peduncle ventromedial spine absent; outer ramus 0.5 times length of inner ramus. *Uropod 3* uniramous; rami without apical setae. *Telson* dorsal lobe present, with 2 apical setae, lower margin without lateral or apical setae.

**Female, sexually dimorphic characters.** Based on paratype 4.1 mm, ZRC 2014.1083. *Gnathopod 1* coxa much smaller than coxa 2, anterior margin produced, apically subacute, with robust seta; basis 2.6 times as long as broad. *Gnathopod 2* basis anterior margin with robust setae, anterodistal corner without lobe; propodus subovate, length 1.5 times width; dactylus overreaching palm.

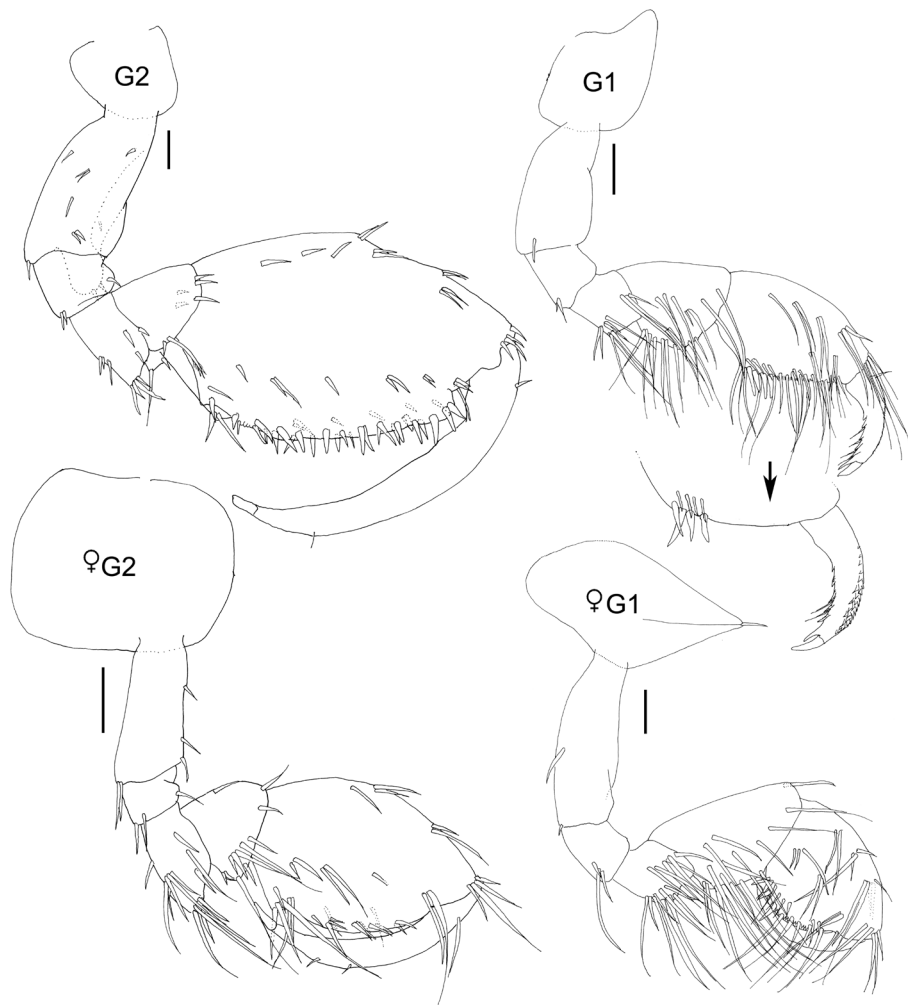


Fig. 15. *Podocerus cyrenensis* sp. nov. Holotype male, 4.5 mm, ZRC 2014.1081; paratype female, 4.1 mm, ZRC 2014.1083, Cyrene Reef, Singapore. Scale bars = 100  $\mu$ m.

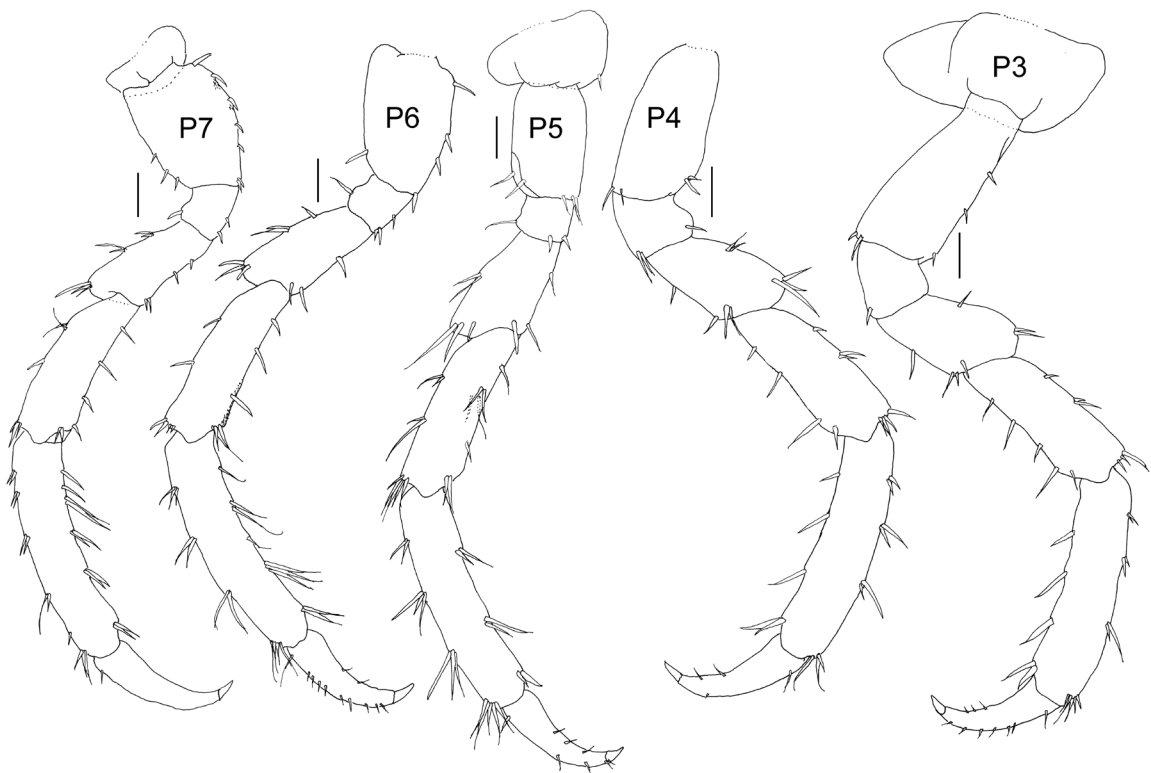


Fig. 16. *Podocerus cyrenensis* sp. nov. Holotype male, 4.5 mm, ZRC 2014.1081; Cyrene Reef, Singapore. Scale bars = 100  $\mu$ m.



**Remarks.** *Podocerus cyrenensis* sp. nov. is most similar to *P. walkeri* Rabindranath, 1972, from Gulf of Mannar, India and *P. walkeri pedunculata* Ledoyer, 1986, from Madagascar, based on the lack of plumose setae on the male gnathopod 2 propodus palm, which is only known from these three species.

*Podocerus cyrenensis* and *P. walkeri* can be separated from *P. walkeri pedunculata* by the uropods 1 and 2 peduncle without ventromedial spine, which is present in the latter two species. *Podocerus cyrenensis* can be separated from *P. walkeri* by the less prominent dorsal carinae in mature males while *P. walkeri* and *P. walkeri pedunculata* have more well-developed carinae. The shape of the gnathopod 1 propodus is subtriangular in *P. cyrenensis* and subovate in *P. walkeri* (see Hughes, 2013 and Ledoyer, 1986).

**Habitat.** Intertidal, occurring in high numbers on the green alga *Chlorodesmis* sp.

**Distribution.** Singapore. Cyrene Reef, Pulau [=Island] Jong, Pulau [=Island] Semakau and Big Sister's Island (current study).

## ACKNOWLEDGEMENTS

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