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by

Lauren Elizabeth Hughes

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Review of *Xenocheira* Haswell, 1879 (Crustacea: Amphipoda: Aoridae)

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ABSTRACT. *Xenocheira fasciata* Haswell, 1879 is redescribed from the female type material collected from Port Jackson, New South Wales, Australia. An additional male and female specimen from recent collections made in New South Wales are also illustrated. New records of *Xenocheira pirloti* Moore, 1988 from tropical northern Australia are provided which include a growth series of male and female specimens. This development range indicates that the type specimens from Aru Islands in east Indonesia are immature individuals. The new species *X. xandrothrix* is described from a single male specimen collected in the Beagle Gulf, Northern Territory, Australia. An updated generic diagnosis for *Xenocheira* Haswell, 1879 is provided, along with a key to the five known species.

KEYWORDS. Crustacea; Amphipoda; Aoridae; *Xenocheira*; taxonomy; new species

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Introduction

Xenocheira Haswell, 1879 are filter-feeding aorids recorded in shallow-water benthic samples from tropical to temperate waters (Moore, 1988). *Xenocheira* have a basket of long setae on gnathopod 2 in male and females, which is similar in appearance, although analogous, to other filter-feeding groups including *Autonoe* Bruzelius, 1859; *Grandidierella* Coutiere, 1904; *Haplocheira* Haswell, 1879; *Lemboides* Stebbing, 1895; *Microdeutopus* Costa, 1853 and *Leptocheirus* Zaddach, 1844 (see Moore, 1988; Myers, 2009). The diagnosis of *Xenocheira* has lagged behind other well defined aorid genera due to the limited knowledge of the type species *X. fasciata* Haswell, 1879 (Moore, 1988; Lyons & Myers, 1990).

Currently three species are placed in *Xenocheira*: *X. fasciata* Haswell, 1879 from southern Australia, *X. longisetosa* Ren, 2006 from the South China Sea and *X. pirloti* Moore, 1988 from the Aru Islands in east Indonesia.

This study recognizes the new species *X. xandrothrix* collected from the Beagle Gulf in Northern Territory, Australia and expands the known distribution of *X. fasciata* and *X. pirloti* in Australian waters. The numerous specimens of *X. pirloti* from a single sample has allowed a detailed analysis of the growth stage variation and development of the male gnathopod 2 is documented with increasing body size. An updated diagnosis of the genus *Xenocheira* is provided to stabilize the generic name and more clearly define the genus from other closely related groups. A key to males of *Xenocheira* species is provided.

Material and methods

Specimens examined for this study are lodged with the Australian Museum (AM), Museums Victoria (NMV), South Australian Museum (SAMA), the Museum and Art Gallery of the Northern Territory (NTM) and the Western Australian Museum (WAM). Slides were made using Aquatex™ mounting agent. Illustrations were made using a Leitz Laborlux K fitted with Nomarski lens and camera lucida. Plates were assembled using Photoshop CS6. Underlined text indicates diagnostic characters. Abbreviations for parts are as follows: *G,* gnathopod; *LL,* lower lip; *Md,* mandible; *Mx,* maxilla; *Mxp,* maxilliped; *P,* pereopod; *p,* palp; *T,* telson; *U,* uropod; *UL,* upper lip. Comparative material: *Autonoe seurati* (Chevreux, 1907), AM P.75672–P.75676, Torres Strait, Queensland.

Systematics

Aoridae Stebbing, 1899

Xenocheira Haswell, 1879

Xenocheira Haswell, 1879: 272. —Haswell, 1885: 105. —Stebbing, 1906: 624. —Moore, 1988: 706. —Myers, 1988: 191. —Barnard & Karaman, 1991: 240–241, figs 45E, 46E. —Lowry & Stoddart, 2003: 73 (catalogue).

Generic diagnosis. Sternal processes absent. Mandibular molar triturative, palp article 3 longer than 2, posterodistal margin straight, with setae of several lengths. Maxilliped basal endite anterior margin without wing-like flanges. Gnathopod 1 merus short; carpus shorter than propodus. Male gnathopod 1 propodus enlarged. Female gnathopod 1 simple to weakly subchelate. Male and female gnathopod 2 carpus anterior margin with flange, with line of long slender setae. Pereopods 3–4 merus and carpus distal margins without long slender setae. Pereopods 5–7 basis posterior margin lined with dense plumose setae. Uropods

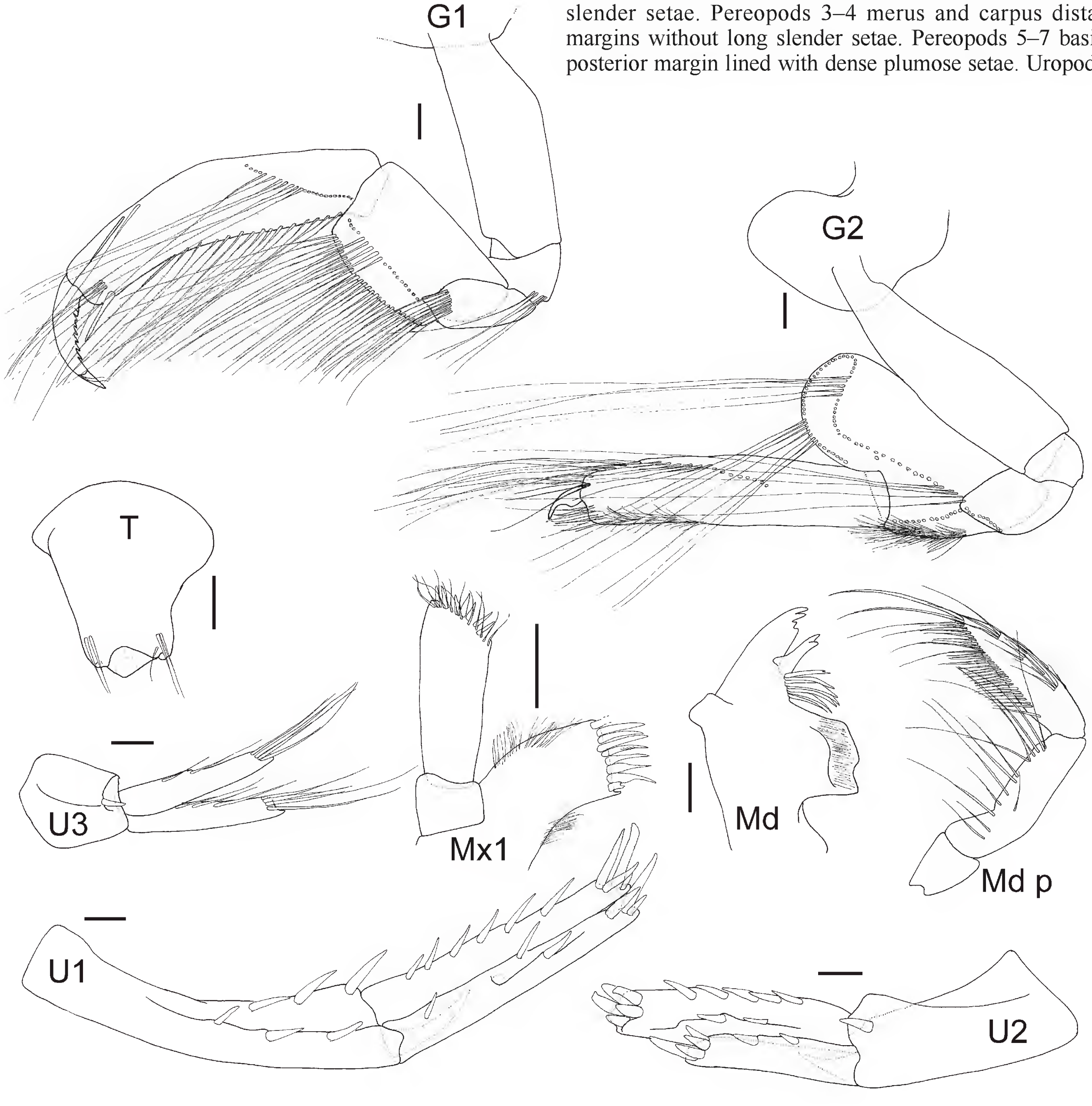

Figure 1. *Xenocheira fasciata* Haswell, 1879, female lectotype, AM P.25466, Port Jackson, New South Wales (scale 0.1 mm).

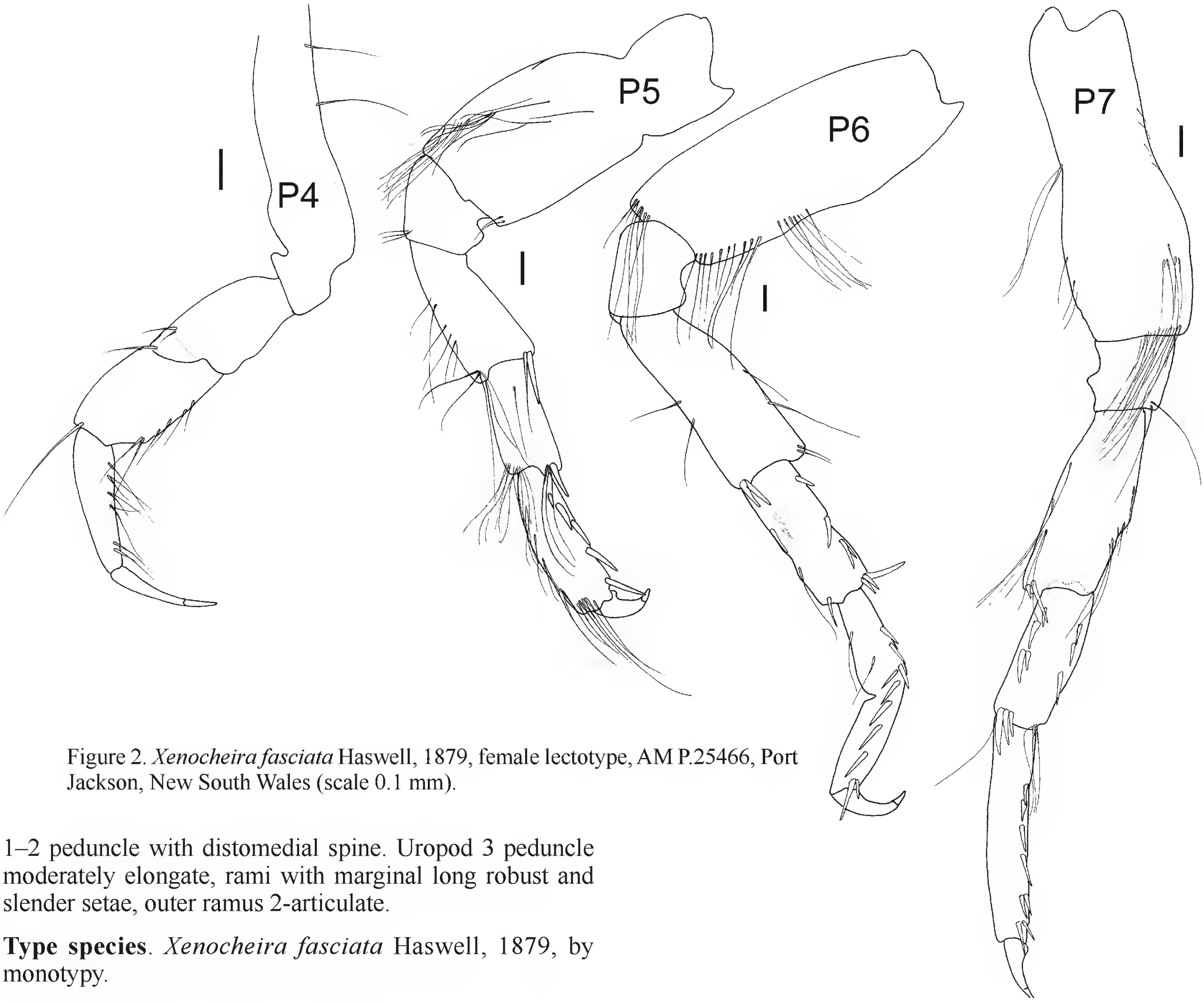

Figure 2. *Xenocheira fasciata* Haswell, 1879, female lectotype, AM P.25466, Port Jackson, New South Wales (scale 0.1 mm).

1–2 peduncle with distomedial spine. Uropod 3 peduncle moderately elongate, rami with marginal long robust and slender setae, outer ramus 2-articulate.

Type species. *Xenocheira fasciata* Haswell, 1879, by monotypy.

Included species. *Xenocheira fasciata* Haswell, 1879; *X. longisetosa* Ren, 2006; *X. pirloti* Moore, 1988 and *X. xandrothrix* sp. nov.

Remarks. Haswell's original description of *Xenocheira* was of a female specimen only, collected in Port Jackson, New South Wales. Moore (1988) was the first to describe a male specimen of *Xenocheira* using material collected from Tasmania. This important contribution established that *Xenocheira* males are sexually dimorphic.

Xenocheira is close to *Bemlos* Shoemaker, 1925 and *Autonoe,* which are all sexually dimorphic genera where the propodus of gnathopod 1 is larger in males. *Xenocheira* and *Bemlos* can be separated from *Autonoe* by the carpus of gnathopod 1 being shorter than the propodus in males. *Xenocheira* differs from *Bemlos* in the presence of an anterior carpal flange lined with setae on gnathopod 2 in both males and females.

Xenocheira spp. are similar to *Autonoe seurati* Chevreux, 1907 which also has a flange and setae, with *A. seurati* being the only *Autonoe* species with this character state. *Xenocheira* can be separated from all *Autonoe* species by the mandibular palp article 3 straight posterodistal margin (versus concave); the gnathopod 1 carpus which is shorter than the propodus (versus subequal) and the uropod 3 rami with long robust and slender setae (versus robust setae only).

Key to males of *Xenocheira* Haswell, 1879 species

1 Gnathopod 1 propodus palm weakly obtuse 2
—— Gnathopod 1 propodus palm transverse to subacute 3

2 Gnathopod 1 dactylus posterior margin smooth .... *X. fasciata* Haswell, 1879
—— Gnathopod 1 dactylus posterior margin with proximal hump .... *X. xandrothrix* sp. nov.

3 Gnathopods 1 and 2 basis anterior margin without rows of slender setae .... *X. pirloti* Moore, 1988.
—— Gnathopods 1 and 2 basis anterior margin with rows of slender setae .... *X. longisetosa* Ren, 2006

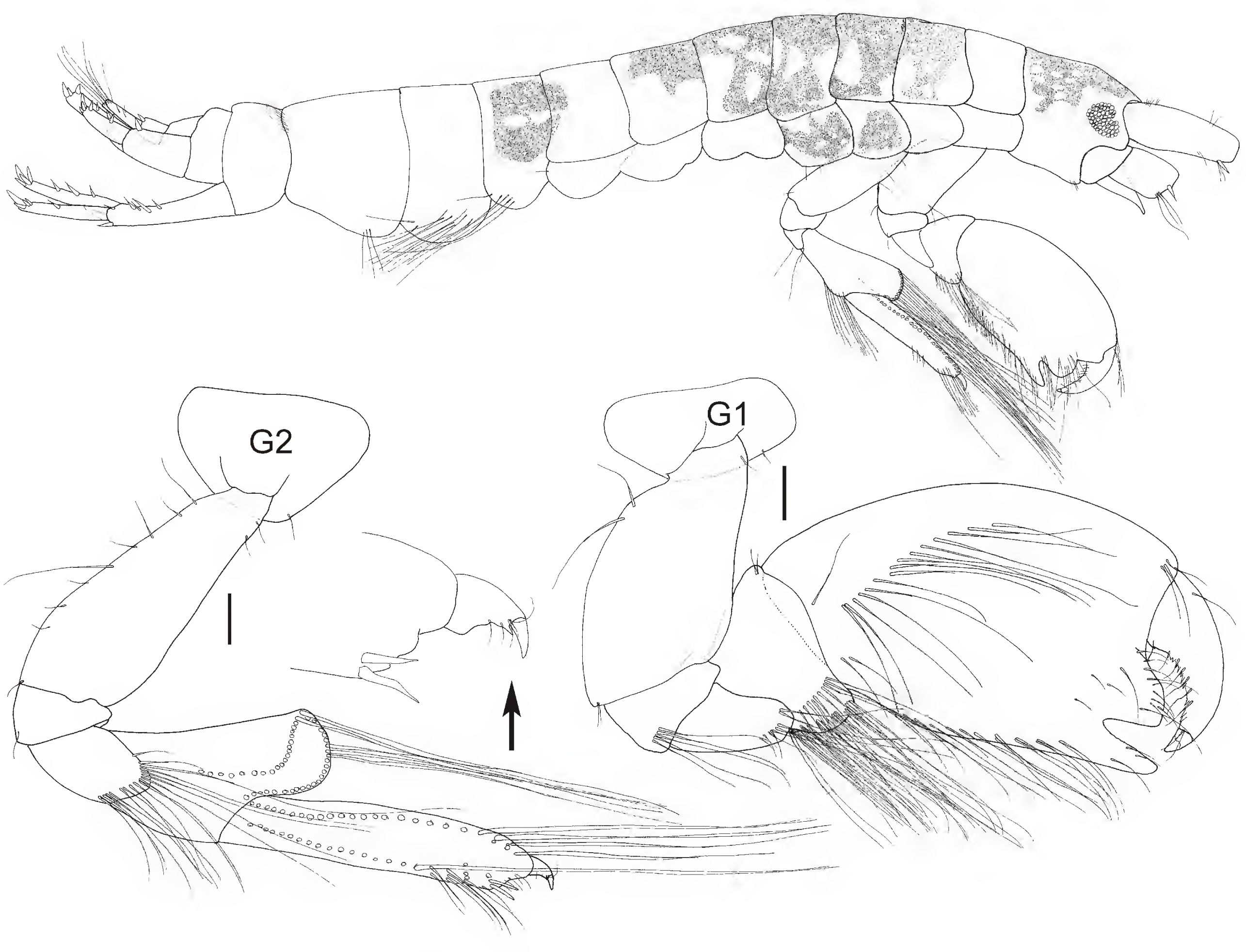

Figure 3. *Xenocheira fasciata* Haswell, 1879, male, 4.9 mm, AM P.99086, east of Red Head, New South Wales (scale 0.1 mm).

Xenocheira fasciata Haswell, 1879

Figs 1–6

Xenocheira fasciata Haswell, 1879: 272, pl. XI, fig. 6a–c. —Haswell, 1885: 105, pl. XVI, figs 1–3. —Stebbing, 1906: 624. —Moore, 1988: 706, figs 1–3 (invalid designation of holotype status). —Barnard & Karaman, 1991: 240–241, figs 45E, 46E. —Springthorpe & Lowry, 1994: 16 (catalogue). —Lowry & Stoddart, 2003: 73 (catalogue).

not *Xenocheira fasciata*. —K. H. Barnard, 1931: 125, fig. 4a, b. (accepted as *Grandidierella gilesi* Chilton, 1921 see Moore, 1988). —Pirlot, 1938: 335, fig. 150 (accepted as *X. pirloti* Moore, 1988).

Type locality. Port Jackson, New South Wales, Australia, 33°51'S 151°16'E.

Material examined. **Lectotype**, female, AM P.25466, 4 slides, carcass in parts on slides, length unknown, Port Jackson, New South Wales, Australia, 33°51'S 151°16'E, Australian Museum old collection (pre-1905), no further details. **Possible syntype**, female (poor condition, some parts of gnathopods and uropods missing), AM P.99078, Port Jackson, New South Wales, Australia, 33°51'S 151°16'E, Keith Sheard Collection (label Cotype. One Co-type mounted. KS).

New South Wales: male, 4.9 mm, dissected, 2 slides, AM P.99086, east of Red Head, 32°03'17"S 152°33'14"E, 12.4 m, orange lacy bryozoan (*Triphyllozoon*? sp.) from low profile rocky reef with sand gutters, 22 March 2003, coll. AM party (NSW 2245); b female, 5.8 mm, 4 slides, AM P.99087, east of Red Head, 32°03'17"S 152°33'14"E, 12.4 m, orange lacy bryozoan (*Triphyllozoon*? sp.) from low profile rocky reef with sand gutters, 22 March 2003, coll. AM party (NSW 2245); 2 female specimens, AM P.73749, east of Red Head, 32°03'17"S 152°33'14"E), 22 March 2003, coll. AM party (NSW 2263); 2 specimens, AM P.77259, east of Red Head, 32°03'17"S 152°33'14"E, 12.4 m, orange lacy bryozoan (*Triphyllozoon*? sp.) from low profile rocky reef with sand gutters, 22 March 2003, coll. AM party (NSW 2245); 4 specimens, AM P.26103, Sow and Pigs Reef, Port Jackson, 33°50'18"S 151°16'12"E, 30 September 1976, Sample 2; 3 specimens, AM P.77135, Bottle and Glass Rocks, Port Jackson, 33°50'54"S 151°16'12"E, 4 m, soft sediment, 23 April 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 102); 1 specimen, AM P.77276, south west side of Cabbage Tree Island, north east of Port Stephens, 32°41'24"S 152°13'20"E, 13.9 m, rocks, 9 March 2006, coll. R. T. Springthorpe (NSW 2889); 1 specimen, AM P.77279, south west side of Cabbage Tree Island, north east of Port Stephens, 32°41'24"S 152°13'20"E, 10.5 m, dead coral rubble, 9 March 2006, coll. K. B. Attwood (NSW 2901); 1 specimen, AM P.80522, south-west side of Boondelbah Island, east of Port Stephens, 32°42'30"S 152°13'32"E, 10 March 2006, coll. A. Murray (NSW 2909);17 specimens, AM P.77282, south-west side of Boondelbah Island, east of Port Stephens, 32°42'30"S 152°13'32"E, 16 m, rock with coelenterate *Acabaria* sp., 10 March 2006, coll. A. Murray (NSW 2909); 9 specimens, AM P.77283, south-west side of Boondelbah Island, east of Port Stephens, 32°42'30"S 152°13'32"E, 20 m, under stones, 10 March 2006, coll. R. T. Springthorpe (NSW 2914); 4 specimens, AM P.77302, sewerage pipeline, Nelson Bay, Port Stephens, 32°43'11"S 152°08'28"E, 10 m, mass of intertwined dead algae, 15 March 2006, coll. C. Fraser (NSW 3042); 5 specimens, AM P.77303, sewerage pipeline, Nelson Bay, Port Stephens, 32°43'11"S 152°08'28"E, 8 m, sponges and rubble, 15 March 2006, coll. C. Arango (NSW 3053); many specimens, AM P.77301, sewerage pipeline, Nelson Bay Port Stephens, 32°43'11"S 152°08'28"E, 10.9 m, bottom growth, 15 March 2006, coll. K. B. Attwood (NSW 3038); 3 specimens, AM P.77295, sloping rock reef with ledges,

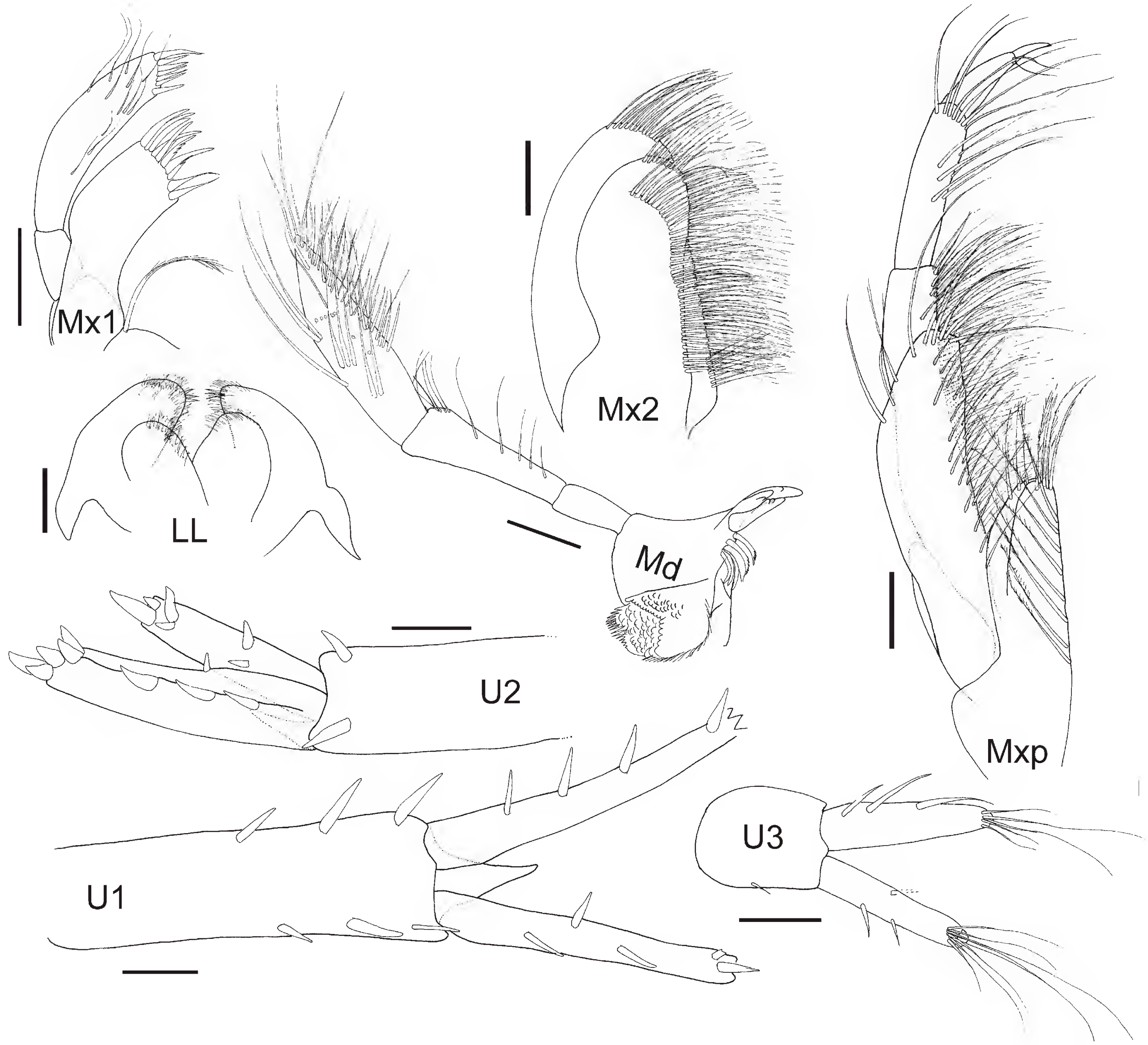

Figure 4. *Xenocheira fasciata* Haswell, 1879, male, 4.9 mm, AM P.99086, east of Red Head, New South Wales (scale 0.1 mm).

Esmerelda Cove, Broughton Island, north east of Port Stephens, 32°37'19"S 152°19'10"E, 18–19.2 m, bushy brown algae from under kelp, 11 March 2006, coll. K. B. Attwood and C. Fraser (NSW 2954); 1 specimen, AM P.77267, Park Beach Bommie, east of Coffs Harbour, 30°17'42"S 153°12'E, 14 m, ascidian, ?*Clavellina* sp., 3 May 2005, coll. K. B. Attwood (NSW 2833); 8 specimens, AM P.77261, Chopper Rock, north-west of North West Solitary Island, 30°00'30"S 153°15'22"E, 17 m, ascidian, *Herdmania momus*, low profile reef with plate corals, rocky reef and patches of sand, 29 April 2005, coll. S. J. Keable (NSW 2778); 1 specimen, AM P.57235, 100 m north-west of Split Solitary Island, 30°14'S 153°10'48"E, 7 March 1992 (NSW 697); male, dissected, 3 slides, AM P.99090, west side of Box Head, Broken Bay, 33°33'S 151°21'E, sponge, 22 November 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 171); many specimens, AM P.99089, west side of Box Head, Broken Bay, 33°33'S 151°21'E, sponge, 22 November 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 171); male, AM P.99092, west side of Box Head, Broken Bay, 33°33'S 151°21'E, sponge *Clathria macropora* with crinoids, 22 November 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 160); 2 specimens, AM P.99093, west side of Box Head, Broken Bay, 33°33'S 151°21'E, bryozoan, 22 November 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 174); 6 specimens, AM P.99091, west side of Box Head, Broken Bay, 33°33'S 151°21'E, 15 m, bryozoan, on rocky substrate, small crinoid, *Antedon incomoda*, 22 November 1982, coll. J. K. Lowry and R. T. Springthorpe (NSW 158).

South Australia: 6 specimens (1 male and 5 females), SAMA C6407, southern Gulf St Vincent, 20–40 m, in prawn trawl, May/June 1987, coll. S. Corigliano, FV *Rivoli Queen*; many specimens, SAMA C6408, west of Aldinga, 33°16'00"S 138°27'00"E, in prawn trawl, 38–41 m, 4–5 May 1987, RV *Rivoli Queen*, K. L. Gowlett-Homes and S. Corigliano; 5 specimens (1 male and 4 females), SAMA C6410, 18.6 miles west norwest of Rapid Head, Gulf St Vincent, 35°31'08"S 138°10'01"E, sponges and bryozoans, in prawn trawl, 23 June 1987, coll. K. L. Gowlett-Homes and S. Corigliano, FV *Rivoli Queen*; many specimens, SAMA C6409, Beacon, Curlew Point, Upper Spencer Gulf, 32°32'21"S 137°46'09"E, 27–30 m, Smith McIntyre grab, 14 January 1988, coll. V. Sergeev and E. Oks.

Victoria: 5 specimens, NMV J66436, Crib Point, 38°21'S 145°14'E, 12 m, 4 March 1997, coll. Marine and Freshwater Research Institute (MAFRI), Victoria; 2 specimens, NMV J66982, Crib Point, 38°21'S 145°14'E 15 m, 4 March 1997, coll. Marine and Freshwater Research Institute (MAFRI), Victoria;1 specimen, NMV J66558, Long Island, Hastings, Western Port 38°19'S 145°18'E 17 m, 4 March 1997, coll. Marine and Freshwater Research Institute (MAFRI), Victoria; 2 specimens, NMV J67096, Long Island, Hastings, Western Port 38°19'S 145°14'E, 17 m, 4 March 1997, coll. Marine and Freshwater Research Institute (MAFRI), Victoria; 3 specimens, NMV J67228, Steel Wharf, Hastings, Western Port 38°18'S 145°11'E, 12 m, 5 March 1997, coll. Marine and Freshwater Research Institute (MAFRI),

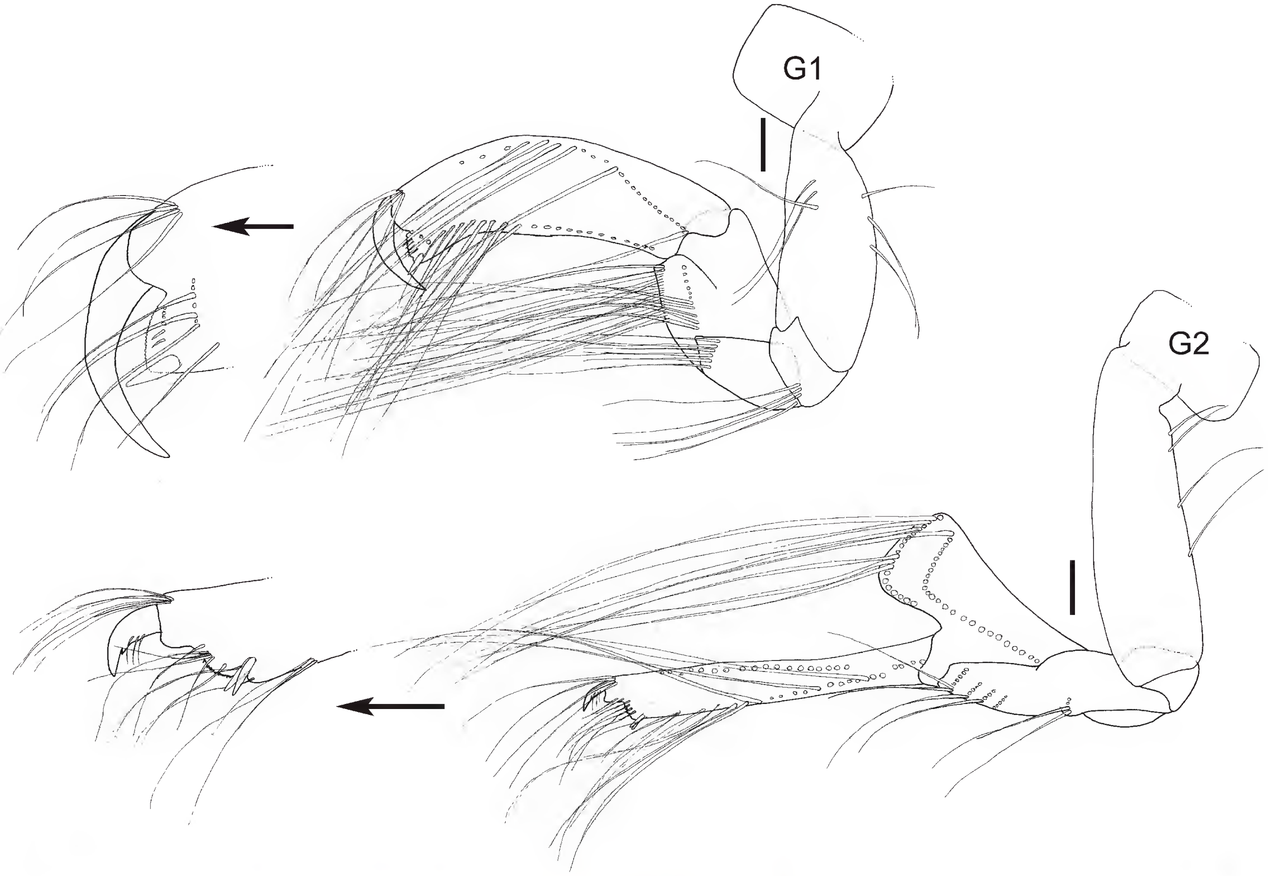

Figure 5. *Xenocheira fasciata* Haswell, 1879, female, 5.8 mm, AM P.99087, east of Red Head, New South Wales (scale 0.1 mm).

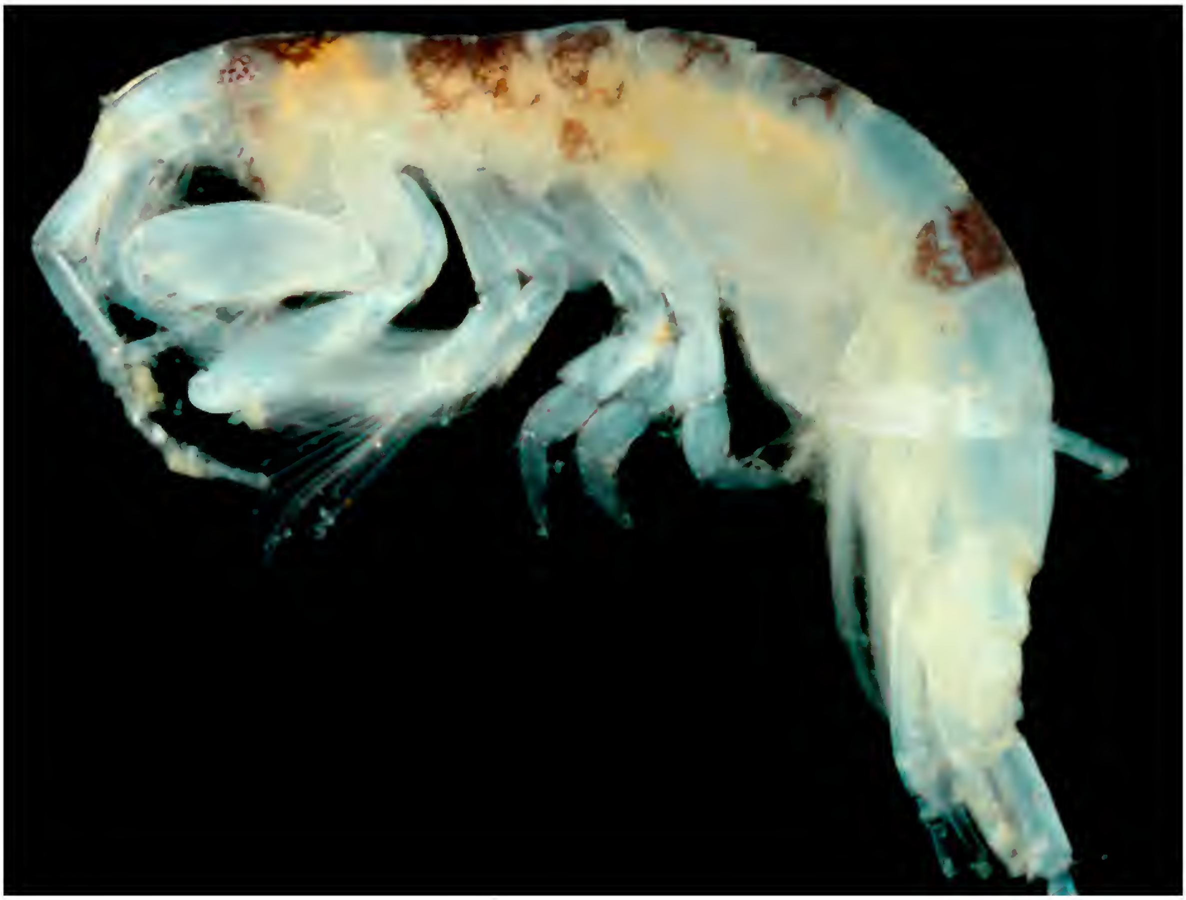

Figure 6. *Xenocheira fasciata* Haswell, 1879, male, 5.9 mm, AM P.80522, south-west side of Boondelbah Island, east of Port Stephens, New South Wales. Image by Roger Springthorpe.

Victoria; 5 specimens, NMV J67251, Steel Wharf, Hastings, Western Port, 38°17'S 145°14'E, 10 m, 5 March 1997, coll. Marine and Freshwater Research Institute (MAFRI), Victoria.

Northern Territory: 1 male and 1 female, AM P.99094, Van Diemen Rise, eastern Joseph Bonaparte Gulf, Timor Sea, 11°38'10"S 129°49'06"E, 27 m, Smith-McIntyre Grab, 12 September 2009, coll. Geoscience Australia (SOL 4934, 31GR49); 5 specimens (1 male and 4 females), NTM Cr015900, Dawson Rock, Bynoe Harbour, 12°42'17.38"S 130°35'33.42"E, 12 m, sponge sample, 9 June 2003, coll. B. Glasby *et al*.

Description. Based on female lectotype, AM P.25466.

Head. Lateral cephalic lobes apically blunt, anteroventral margin shallowly excavate to moderately recessed, anterodistal corner weakly produced. *Antenna 1* peduncle article 1 posterior margin with robust seta; flagellum unknown. *Antenna 2* unknown. *Mandible* molar triturative; accessory setal row with 6–7 setae; palp article 3 subequal 2, length 2.1× width, anterior margin straight with setae of two lengths. *Maxilla 1* inner plate with 1 apical plumose seta; palp 2-articulate, article 2 broad (turned in illustration), distal end with slender setae and 6 apical robust setae.

Pereon. *Pereonites 1–2* each without sternal process. *Gnathopod 1* female simple; basis slender, length 3× breadth, anterodistal margin subquadrate; ischium posterior margin with slender setae; merus 1.8× as long as broad, posterior margin with slender setae; carpus rectilinear, length 0.5× propodus, posterior and midmedial margin with line of long slender setae; propodus length 4× breadth, proximal end with line of long slender setae, posterior margin straight with line of long slender setae, palm weakly developed, defined by subquadrate corner with long robust seta; dactylus 0.3× propodus length, recurved, posterior margin serrate, unguis present. *Gnathopod 2* subchelate; basis anterior margin straight; merus 1.6× as long as broad, posterodistal margin with line of long slender setae; carpus 0.4× propodus length, anterior margin with large flange, anterodistal end with double row of long slender setae, posterior margin with dense cluster of short slender setae; propodus rectilinear, length 4× breadth, anterodistal end with line of long slender setae, posterodistal end with dense cluster of short slender setae, palm transverse, less than one fifth the length of posterior margin, without robust defining seta, dactylus short, recurved, reaching end of palm. *Pereopods 5–7* (P5 based on male AM P.99086) basis margins with plumose setae; ischium and merus slender with patches of slender setae; carpus anterior and posterior margin with short robust setae; propodus posterior margin lined with short robust setae; dactylus recurved, unguis present.

Pleon. *Epimera 1–2* (based on male AM P.99086) posterodistal corner rounded to subquadrate, ventral margin with plumose setae. *Epimeron 3* (based on male AM P.99086) posterodistal margin rounded. *Uropod 1* biramous; peduncle much longer than broad, distoventral interramal spine shorter than peduncle; rami subequal. *Uropod 2* biramous; peduncle subequal to inner ramus length, with distoventral interramal spine less than half length of peduncle; inner ramus longer than outer ramus, apical robust setae short. *Uropod 3* biramous, peduncle short, 0.6× rami length; rami subequal, with slender marginal and apical setae. *Telson* longer than broad, apically excavate with distal slender setae.

Male (sexually dimorphic characters). Based on AM P.99086.

Gnathopod 1 male coxa not produced anterodistally; basis broad, length 1.6× breadth; carpus compressed, length 0.8× breadth, 0.25× propodus length, posterior margin with dense long slender setae; propodus expanded, subovate, length 1.5× breadth, medial surface with line of long slender setae, posterior margin with long slender setae, palm weakly obtuse, proximal shelf long, subquadrate, margin undulating, with excavate v-shaped sinus, defined by subquadrate corner with strong posterodistal spine, without post palmar robust seta; dactylus not reaching end of palm, posterior margin convex.

Remarks. Haswell's original published description of *Xenocheira* did not include specific nomination of type material, but it is significant that only a female specimen was described. Australian Museum collections of *Xenocheira fasciata* thought to be from W. A. Haswell collections include four slides which contain the partial dissection and disjointed carcass of a female. These slides are labelled "types" and "?Macleay Museum", the institute where Haswell had been based. This material has been considered as a probable syntype, AM P.25466 (Springthorpe & Lowry, 1994; Lowry & Stoddart, 2003). Moore (1988) mistakenly cited AM P.25466 as a holotype.

Additionally a female specimen among the Australian Museum Keith Sheard Collection labelled "Co-type. One Co-type mounted. KS" with a second label "*Xenocheira fasciata* Hasw. Port Jackson" was recently discovered (June, 2016). This material is a possible syntype of the set of slides associated with AM P.25466. A lectotype of the more complete female specimen is herein designated to stabilize the species name.

This study extends the known distribution of *X. fasciata* to locations in both southern temperate Australian and tropical northern Australia. Material from Bynoe Harbour indicated that *X. fasciata* is sympatric with *X. pirloti*.

The lobate carpus of gnathopod 2 and long slender seta on the carpus and propodus is seen in *X. fasciata, X. pirloti* and another aorid, *Autonoe seurati* (Chevreux, 1907), which is also reported from tropical northern Australia (Myers, 2009). The absence of long slender setae on the basis of gnathopods 1 and 2 separates *X. fasciata* and *X. pirloti* from *A. seurati*.

Distribution. Australia. New South Wales: Coffs Harbour (current study); Port Stephens (Haswell, 1879; Moore, 1988; current study); Port Jackson (Haswell, 1879; current study); Broken Bay (current study); Twofold Bay (Hutchings, *et al*., 1989). Victoria: Western Port; Corner Inlet; Crib Point, Hastings (Moore, 1988; current study). South Australia: Gulf St Vincent; Upper Spencer Gulf; west of Aldinga (current study). Tasmania: south-western Bass Strait; Variety Bay, Bruny Island, Freycinet Peninsula (Moore, 1988; current study). Northern Territory: Northwest Shelf; Bynoe Harbour (current study).

Xenocheira longisetosa Ren, 2006

Xenocheira longisetosa Ren, 2006: 412–414, fig. 177.

Type locality. Linchang Reef, Hainan Province, South China Sea.

Distribution. Known only from type locality.

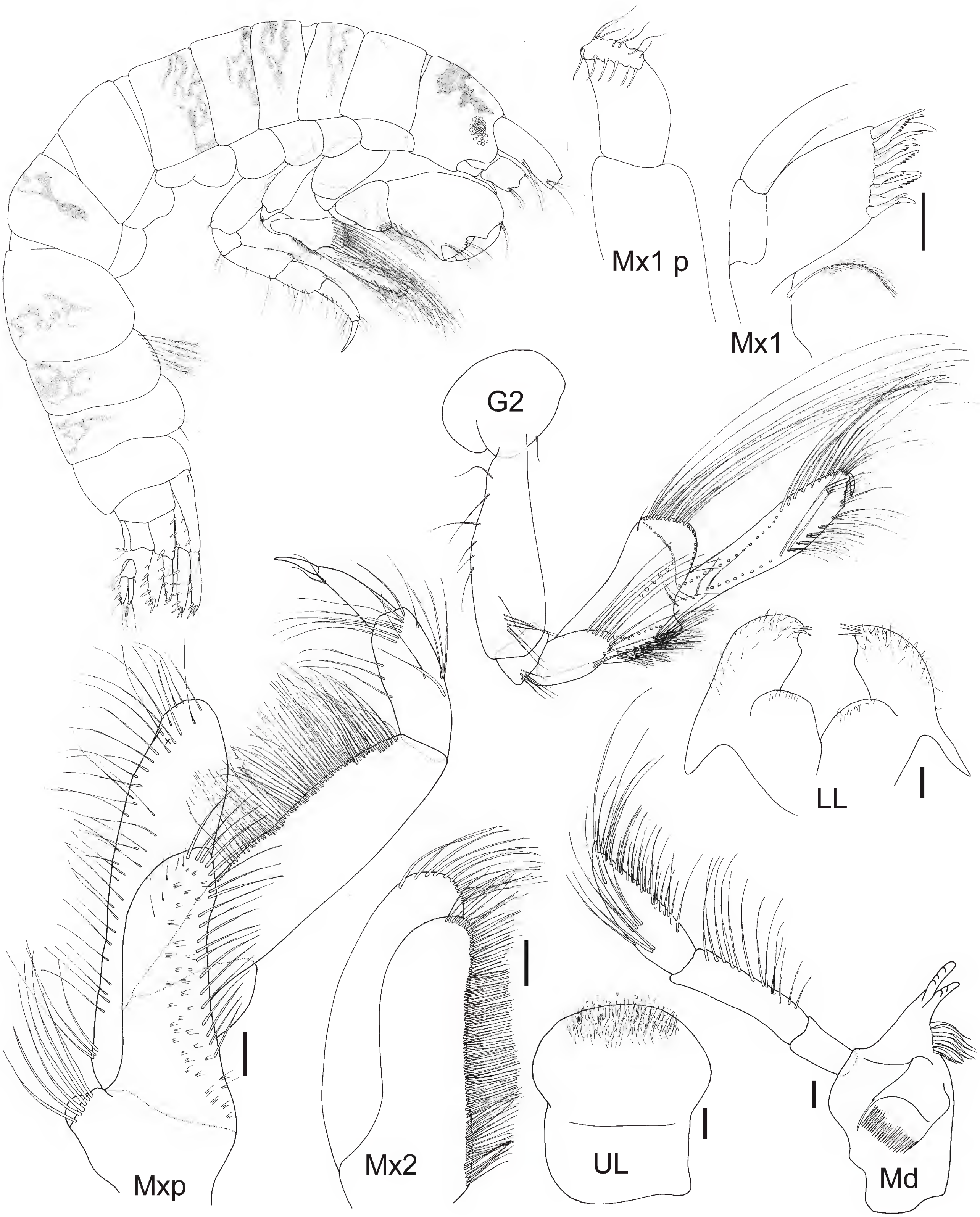

Figure 7. *Xenocheira pirloti* Moore, 1988, male, 9 mm, NTM Cr018976, Dawson Rock, Bynoe Harbour, Northern Territory (scale 0.1 mm).

Xenocheira pirloti Moore, 1988

Figs 7–10

Xenocheira fasciata. —Pirlot, 1938: 335, fig. 150.
Xenocheira pirloti Moore, 1988: 718.

Type material. Stat. 273, Pulu Jedan, Aru Islands [Iles Aru], 23–26 December 1899, shell sand [sable coquillier], 13 m, 3 males. (Material not found, pers. comm. K. Van Dorp January 2016)

Material examined. *Northern Territory*, Australia: 1 a male, 7 mm, dissected, 1 slide, NTM Cr018973; 1 b male, 7.1 mm, dissected, 1 slide, NTM Cr018974; 1 c male, 8 mm, dissected, 1 slide, NTM Cr018975; 1 d male, 9 mm, dissected, 1 slide, NTM Cr018976.; 1 e female, 9.2 mm, dissected, 1 slide, NTM Cr018977; 1 f female, 5.4 mm, dissected, 1 slide, NTM Cr018978; 1 g female, 5 mm, dissected, 1 slide, NTM Cr018979; 12 specimens (4 male and 6 females), NTM Cr015901, Dawson Rock, Bynoe Harbour, 12°42'17.38"S 130°35'33.42"E, 12 m, sponge sample, 9 June 2003, coll. B. Glasby *et al*.. 1 male and 4 females, NTM Cr015886, Table Head, Port Essington, 11°13'30"S 132°10'30"E, algae and reef rock,14 May 1983; 3 male and 2 female specimens, NTM Cr011679, north of Oliver Reef, Vernon Islands, Beagle Gulf, 12°1.02'S 130°58.86'E, 30 m, rocky bottom, 11 October 1993, coll. K. E. Coombes, FV *Kunmunyah* (Beagle Gulf Marine Park Survey).

Western Australia: 1 male, 12 mm, and 1 female, 13.2 mm, WAM C27165, Dampier Archipelago, 20°41'S 116°33'E, 23 July 1999, coll. S. Slack-Smith (DA2/99/68).

Variation. With increasing size, the male gnathopod 1 propodus becomes less elongate and more bulbous, as the posterior margin reduces and the anterior margin becomes more convex (Fig. 8).

Remarks. Pirlot (1936) identified 3 specimens from the Aru Islands as *Xenocheira fasciata* Haswell, 1879. Based on Pirlot's illustrations of gnathopods 1 and 2, Moore (1988) considered the variation in gnathopod 1 propodus length significantly different from *X. fasciata* and established the new species name *X. pirloti* for the Aru Islands material without examining Pirlot's original specimens. Pirlot's material from the Siboga Expedition is currently held by the Department Invertebrates, Naturalis Biodiversity Center, Leiden, The Netherlands. Recent contact with the curator for Crustacea, Chelicerata and Myriapoda Karen Van Dorp confirmed that the type material (either slide or wet preparations) of *X. pirloti* could not be located and for now is considered presumed lost.

Assessment of a large set of tropical Australia collections of *Xenocheira pirloti* included large adult males, gravid females and a range of smaller specimens has revealed the Aru Islands material are juvenile specimens of indeterminate sex and not adult males. A growth series of material is presented here to demonstrate the full development range of *X. pirloti*. This present description of additional material of *X. pirloti* supports this species as distinct from *X. fasciata. Xenocheira pirloti* is known from tropical waters in northern Australia and the Banda Sea in the Indonesian Archipelago while *X. fasciata* occurs in temperate waters along east coast and southern Australia including Tasmania.

Xenocheira pirloti is most similar to *X. fasciata* in the male gnathopod 1 propodus palm with sinus. *Xenocheira pirloti* has an acute gnathopod 1 propodus palm while *X. fasciata* has an obtuse palm. See also remarks for *X. fasciata*.

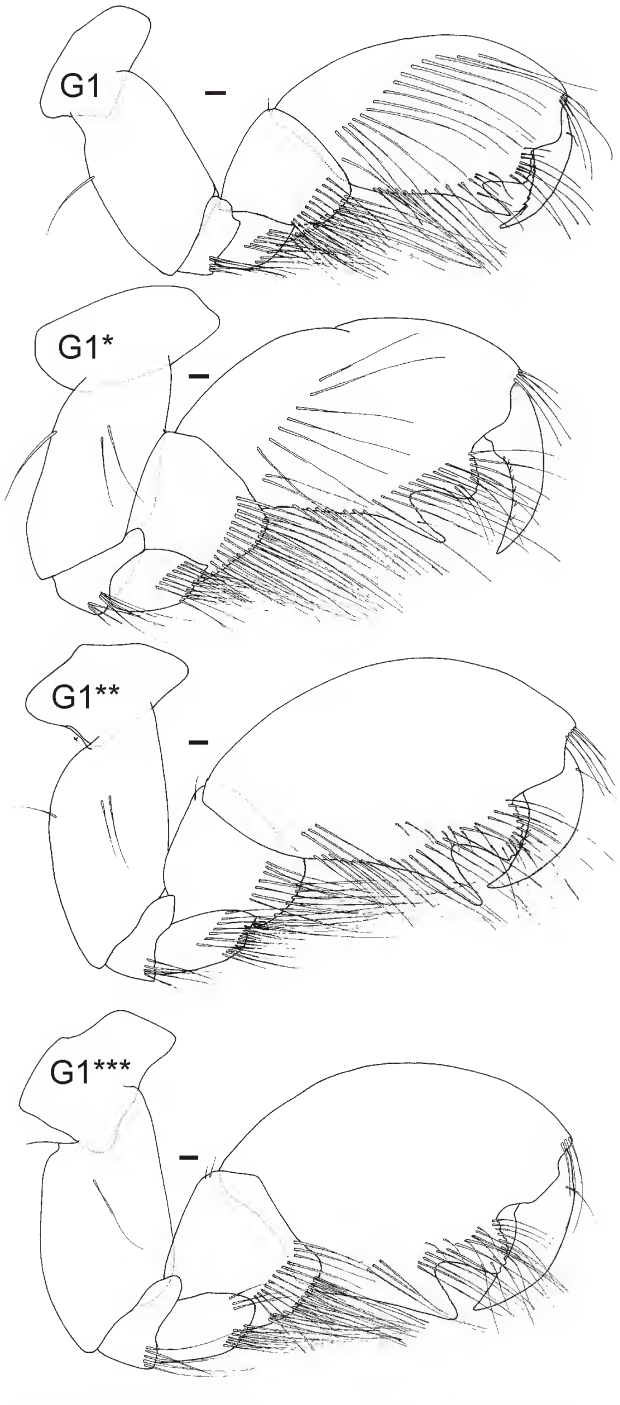

Figure 8. *Xenocheira pirloti* Moore, 1988, male, 7.0 mm, NTM Cr018973, male*, 7.1 mm, NTM Cr018974, male**, 8 mm, NTM Cr018975, male***, 9 mm, NTM Cr018976, Dawson Rock, Bynoe Harbour, Northern Territory (scale 0.1 mm).

Distribution. Indonesia: Pulu Jedan, Aru Islands (Pirlot, 1936). Australia. Northern Territory: Beagle Gulf, Port Essington, Bynoe Harbour, Dampier Archipelago (current study).

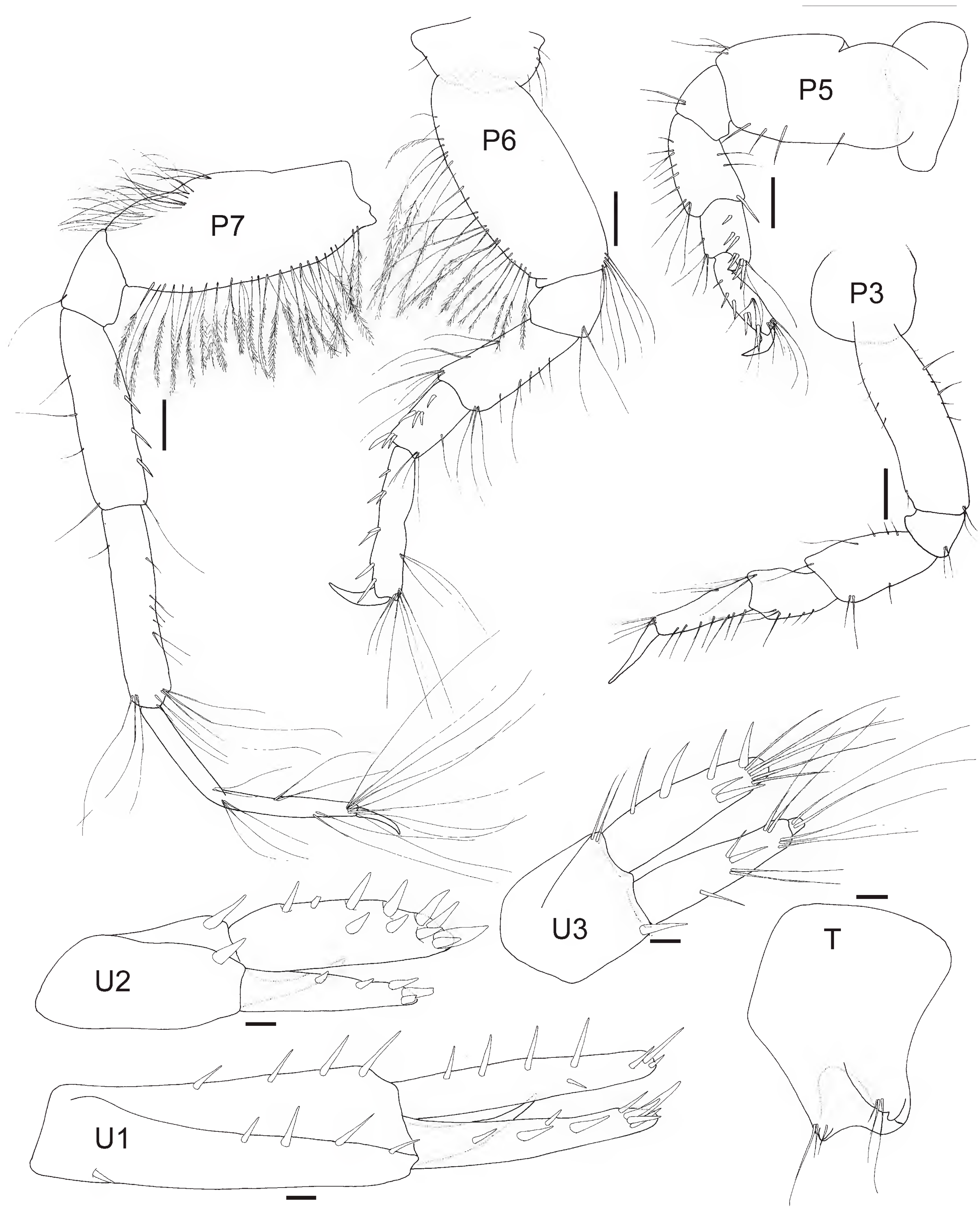

Figure 9. *Xenocheira pirloti* Moore, 1988, d male, 9 mm, NTM Cr018976, Dawson Rock, Bynoe Harbour, Northern Territory (scale 0.1 mm).

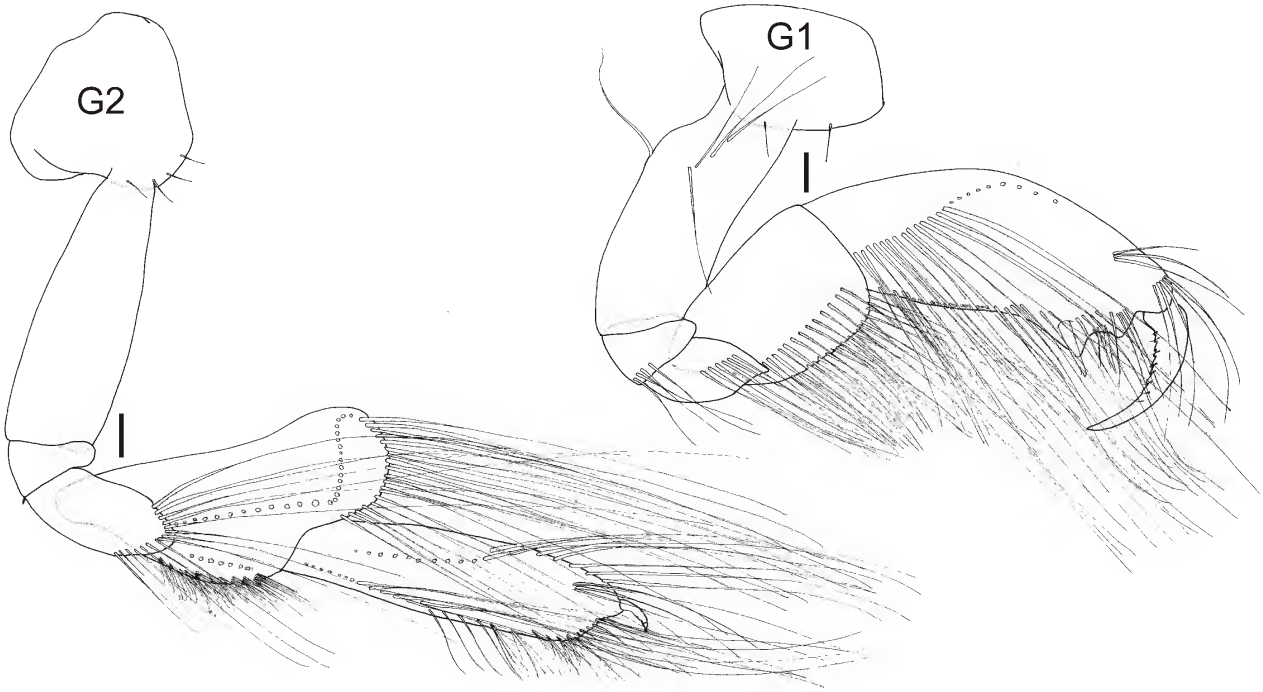

Figure 10. *Xenocheira pirloti* Moore, 1988, e female, 9.2 mm, NTM Cr018977, Dawson Rock, Bynoe Harbour, Northern Territory (scale 0.1 mm).

Xenocheira xandrothrix sp. nov.

Figs 11, 12

Holotype male, 6.4 mm, NTM Cr011636, west of Elizabeth Reef, Cape Hotham, Beagle Gulf, Northern Territory, Australia, 12°04'S 131°20'E, 21 m, shale, 9 October 1993, coll. R. S. Williams, FV *Kunmunyah* (Beagle Gulf Marine Park Survey).

Type locality. West of Elizabeth Reef, Cape Hotham, Beagle Gulf, Northern Territory, Australia.

Etymology. From the Greek, *xandros* for sea monster and the suffix *thrix* meaning hairy.

Description based on holotype male, 6.4 mm, NTM CR011636.

Head. Lateral cephalic lobes weakly truncate, anteroventral margin shallowly excavate to moderately recessed, anterodistal corner subacute. *Antenna 1* peduncle article 1 posterior margin without robust setae; flagellum unknown. *Antenna 2* unknown. *Mandible* molar triturative; accessory setal row with 8 setae; palp article 3 longer than 2, length 3.1× breadth, anterior margin straight with setae of two lengths. *Maxilla 1* inner plate with 1 apical plumose seta; palp 2-articulate, article 2 broad, distal end with slender setae and 6 apical robust setae.

Pereon. *Pereonites 1–2* without sternal process. *Gnathopod 1* male coxa not produced anterodistally; basis broad, length 1.9× breadth; carpus compressed, length 0.8× breadth, 0.25× propodus length, posterior margin with dense long slender setae; propodus expanded, subovate, length 1.5× breadth, posterior margin with long slender setae, palm weakly obtuse, proximal shelf long, subquadrate, margin undulating, distal margin with narrow v-shaped sinus, defined by subquadrate corner with strong posterodistal spine reaching beyond dactylus, without post palmar robust seta; dactylus reaching beyond palm, posterior margin convex with proximal hump. *Gnathopod 2* subchelate; basis proximally narrow, distally broad; merus 1.3× as long as broad; carpus 0.6× propodus length, anterior margin with large flange, anterodistal end with double row of long slender setae, posterior margin with dense cluster of short slender setae; propodus rectilinear, length 4× breadth, anterodistal end with line of long slender setae, posterodistal end with dense cluster of short slender setae, palm transverse, less than one fifth the length of posterior margin, without robust defining seta, dactylus short, recurved, reaching end of palm. *Pereopods 5–7* basis margins with plumose setae; ischium, merus and carpus with patches of slender setae; propodus anterior and posterior margin with short robust and long slender setae; dactylus recurved, unguis present.

Pleon. *Epimera 1–2* posterodistal corner rounded to subquadrate, ventral margin with plumose setae. *Epimeron 3* posterodistal margin rounded with distal notch. *Uropod 1* biramous; peduncle much longer than broad, distoventral interramal spine shorter than peduncle; rami subequal. *Uropod 2* biramous; peduncle subequal to inner ramus length, with distoventral interramal spine less than half length of peduncle; inner ramus longer than outer ramus, apical robust setae of various lengths. *Uropod 3* biramous, peduncle short, 0.6× rami length; rami subequal, with slender marginal and apical setae. *Telson* longer than broad, apically excavate with distal slender setae.

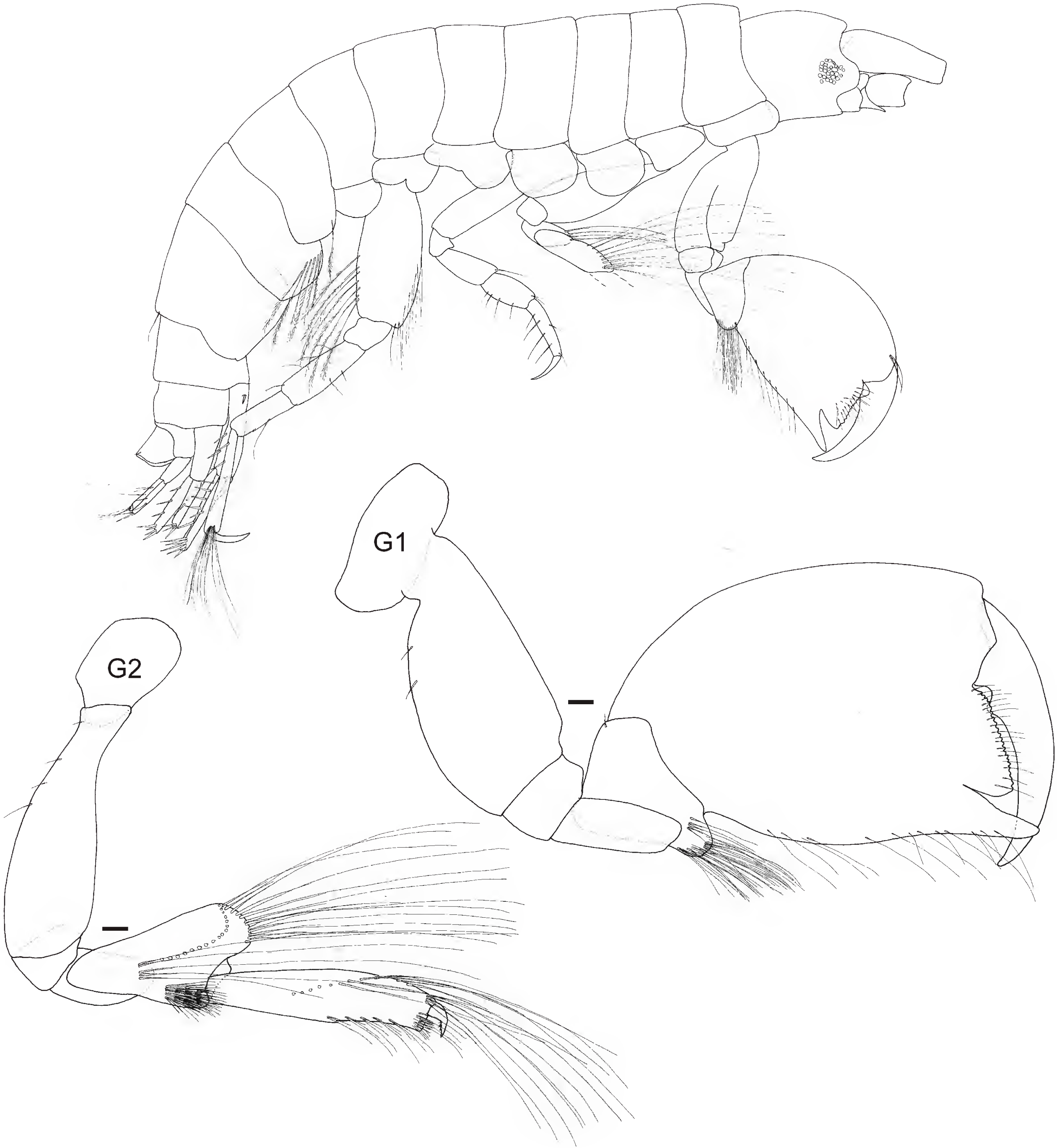

Figure 11. *Xenocheira xandrothrix* sp. nov. holotype, 6.4 mm, NTM Cr011636, west of Elizabeth Reef, Cape Hotham, Beagle Gulf, Northern Territory (scale 0.1 mm).

Remarks. *Xenocheira xandrothrix* sp. nov. and *X. fasciata* have the male gnathopod 1 palm obtuse, separating them from *X. longisetosa* and *X. pirloti* which have a transverse palm. *Xenocheira xandrothrix* sp. nov. has the male gnathopod 1 propodus with the distal spine extending beyond the dactylus which separates it from all other species in the genus. The gnathopod 1 dactylus is slender and has a proximal tooth on the posterior margin which further separates it from other *Xenocheira* species.

Distribution. Known only from type locality.

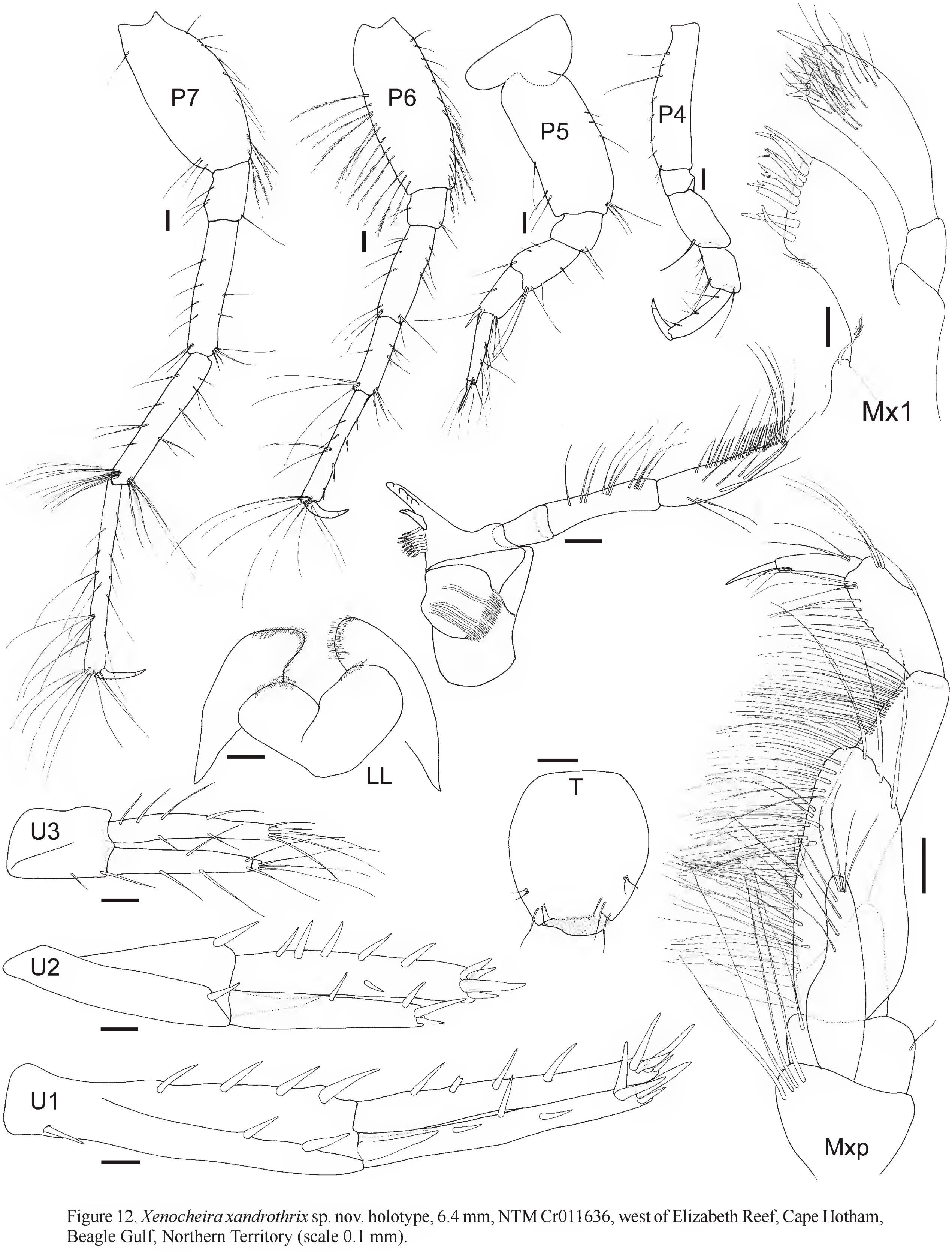

Figure 12. *Xenocheira xandrothrix* sp. nov. holotype, 6.4 mm, NTM Cr011636, west of Elizabeth Reef, Cape Hotham, Beagle Gulf, Northern Territory (scale 0.1 mm).

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Two New Species of *Clinopsalta* Moulds (Hemiptera: Cicadidae) and Additional Distribution Records for *Clinopsalta adelaida* (Ashton), with Notes on their Distinctive Calling Songs

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Abstract. Two new species are described in the genus *Clinopsalta* Moulds. *Clinopsalta autumna* sp. nov. exhibits a warm temperate distribution from south-east Queensland south to Goulburn and Nerriga in eastern New South Wales. *Clinopsalta semilunata* sp. nov. has a patchy distribution in southern Queensland from Binjour Plateau west to near Miles, south to Yelarbon State Forest and Durikai State Forest, both near Inglewood. In addition to the descriptions of these new species, further distribution records are provided for *C. adelaida* (Ashton), which extend its distribution from south-eastern South Australia and northern Victoria to inland central and northern New South Wales. The species of *Clinopsalta* are small–medium sized cicadas (< 20 mm body length) with distinctive calling songs of an intermediate frequency (c. 6 to 18 kHz). The temporal structures of the calling songs follow a similar pattern in each species, comprising an introductory rattle followed by a series of clicking phrases. The call is characteristically accompanied with bouts of prominent wing-snapping, except in one species (*C. semilunata* sp. nov.).

Keywords. Cicadettini; bioacoustics; taxonomy

Popple, Lindsay W., and David L. Emery. 2017. Two new species of *Clinopsalta* Moulds (Hemiptera: Cicadidae) and additional distribution records for *Clinopsalta adelaida* (Ashton), with notes on their distinctive calling songs. *Records of the Australian Museum* 69(4): 237–256. https://doi.org/10.3853/j.2201-4349.69.2017.1673

This stand-alone study forms part of the ongoing taxonomic treatment of Australian cicadas. Many of the smaller cicada species across the world (tribe Cicadettini) exhibit brief seasonal appearances, which can only be intersected by regular and opportunistic fieldwork. The success of such fieldwork has relied heavily upon the readily detectible calling songs produced by these insects (e.g., Ewart, 1988, 1989, 1998, 2005; Simões *et al*., 2000; Ewart & Popple, 2001; Popple & Strange, 2002; Sueur, 2002; Sueur & Aubin, 2004; Pinto-Juma *et al*., 2005; Quartau & Simões, 2006; Seabra *et al*., 2006; Popple *et al*., 2008; Ewart & Popple, 2013a,b). The male calling songs provide an effective and often instantaneous method for identifying known species and a definitive method for revealing new species.

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The genus *Clinopsalta* was introduced by Moulds (2012) as part of a substantial taxonomic revision of Australian cicadas. Two species, previously located in *Cicadetta* Kolenati, were transferred to this genus: *Clinopsalta adelaida* (Ashton, 1914) and *C. tigris* (Ashton, 1914).

In this paper, we describe two new species of *Clinopsalta* and provide new distribution records for *C. adelaida*. A detailed description and comparison of the calling songs of these three species is also presented.

Methods and terminology

Anatomical terminology follows Moulds (2005, 2012) for body structures and wing characters, Moulds (2005) for genitalia, and Dugdale (1972) and Bennet-Clark (1997) for timbals. The long timbal ribs are referred to as long ribs 1 to 5, with long rib 1 being the most posterior (adjacent to timbal plate). The higher classification adopted in this paper follows Moulds (2012). Measurements (in mm) are given as Means and ranges (in parentheses) and include the largest and smallest specimens. Head width spans across the eyes; pronotum width across the extremities of the lateral margins; abdomen width is measured across the outer edges of the auditory capsules.

Material sourced for this taxonomic work is located in collection abbreviated as follows: *AE*, private collection of A. Ewart, Caloundra; *AM*, Australian Museum, Sydney; *DE*, private collection of D. L. Emery, Sydney; *MC*, private collection of M. Coombs, Brisbane; *QM*, Queensland Museum, Brisbane; *MSM*, private collection of M. S. Moulds, Kuranda; *LWP*, private collection of L.W. Popple, Brisbane.

Genitalia preparation. Male genitalia were removed using a pair of surgical scissors and placed in a solution of 10% potassium hydroxide. The solution was either boiled for one hour or left overnight at room temperature to clear the soft tissues and provide a clean dissection. Following clearing, the specimens were washed with ethanol and placed into a solution of either 70% ethanol or glycerol. To facilitate close examination of internal structures, the aedeagus was dissected for each genitalia preparation under 10× magnification. Measurements were taken using a pair of Toledo vernier calipers (accurate to 0.1 mm).

Calling song analysis. The calling song terminology used in this study has been modified from Ewart and Marques (2008). A "pulse" was defined as a single complete movement of the timbals. The term "syllable" was used for the smallest grouping of pulses (typically 5–10 ms duration). Where 2–9 syllables coalesce, this was referred to as a "macrosyllable". Longer durations of continuous sound (≥ 10 syllables) were referred to as an "echeme". A period of silence following a syllable, macrosyllable or echeme is treated as a "gap". Where a series of syllables is produced without coalescence (i.e. with each syllable separated by a gap), this is referred to as a "syllable sequence".

Field recordings have been used throughout. All recordings were made at a distance > 20cm from the calling insect to reduce the chances of near-field effects. None of the recordings showed signs of amplitude clipping due to microphone overload.

The recording systems (RS) used can be detailed as follows: *RS1*, Sony MZR700 minidisc recorder with Sony ECM-MS957 Electret Condenser microphone; *RS2*, Tascam DR-40 digital recorder with a Sennheiser K6/ME66 or ME67 microphone; *RS3*, Marantz PMD670 digital recorder with a Telinga Pro 6 parabolic microphone; *RS4*, Tascam DR-07 digital recorder with an Audio Technica ATR-55 microphone; and *RS5*, Sony WM-D6C Walkman with Sennheiser K6/ME66 microphone.

All recording equipment exhibits a reliable frequency response up to 18 kHz. Processing and analysis of recordings was undertaken with Cool Edit Pro (version 2.1) and Audacity (version 2.1.2) software. Amplitude spectra were generated using a linear frequency axis on a 1024-point Fast Fourier Transform with a Hamming window function.

Systematics

Family Cicadidae Latrielle, 1802

Subfamily Cicadettinae Buckton, 1889

Tribe Cicadettini Buckton, 1889

Genus *Clinopsalta* Moulds, 2012

Diagnosis follows Moulds (2012).

Clinopsalta autumna sp. nov.

Figs 1–4

Cicadetta sp. nr *adelaida* 214: Emery et al. (2005).

Holotype: 1♂, Mt Annan Gardens, Narellan, NSW, 31°18.14'S 149°02.05'E, 29.ix.2009, N. Emery (AM, K.504498). **Paratypes**: 1♂, southeast Queensland, 28°03'S 152°22'E, Cunninghams Gap, via Aratula, 26.xii.1997, C. J. Burwell, QM reg. no. T237102 (QM); 1♂, 3 km E Wedderburn, NSW, 15.xi.2003, D. Britton; 2♂♂1♀, Beach Road, Harley Hill nr Berry, NSW, 34°46.40'S 150°44.01'E, 24.xii.1994, D. Emery (AM, K.504499–501); 1♂, same location, 27.xii.2002, S. and D. Emery; 2♀♀, same location, 2.xi.1997, S. and D. Emery; 1♀, same location, 30.xii.2002, S. and D. Emery; 1♂, Burragorang Rd, The Oaks, NSW, 34°04.10'S 150°28.28'E, 400 m, 14.xi.2003, S. and D. Emery; 3♂♂1♀, Prospect Reservoir, NSW, 33°48.48'S 150°54.48'E, 14.xi.1997, D. Emery; 2♂♂, same location, 5–11.xi.1998, D. Emery; 1♀, same location, 2.xi.1997; 1♀, same location, 17–21.xi.1997; 2♂♂1♀, same location, 5.i.1998, D. Emery; 4♂♂, same location, 11–26.xi.1998, D. Emery; 2♂♂2♀♀, Hume Highway, Pheasants Nest nr Bargo, NSW, 34°16.58'S 150°38.20'E, 1.xii.2003, D. Emery and L. Popple; 2♂♂, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 4.xii.2000, N. Emery; 1♀, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 5.xi.2000, N. Emery (all DE); 1♂, Prospect Res, 11.xi.1998, D. Emery, 214-0001; 1♀, Prospect Res, 26.x.1998, D. Emery, 214-0002; 1♂, Cunningham's Gap, southeast Queensland, 6.Jan.2001, L. Popple, J. Moss, 214-0003; 1♂1♀, same data as previous, 12.xi.2001, 214-0004, 214-0006; 1♂, same data as previous, 31.i.1999, 214-0005; 3♂♂1♀, Australia NSW, Bargo, *Ac*[*acia*] *parramattensis*, 1.Dec.2003, L. Popple, D. Emery, 214-0008–214-0011 (all LWP); 1♂, Milperra, NSW, 7.xii.1976, G. R. Brown; 1♂1♀, Harley Hill, 18.xii.1995, D. Emery; 2♂♂2♀♀, Menai, W. of Sutherland, Sydney, NSW, 14.xi.1983, R. Eastwood (all MSM).

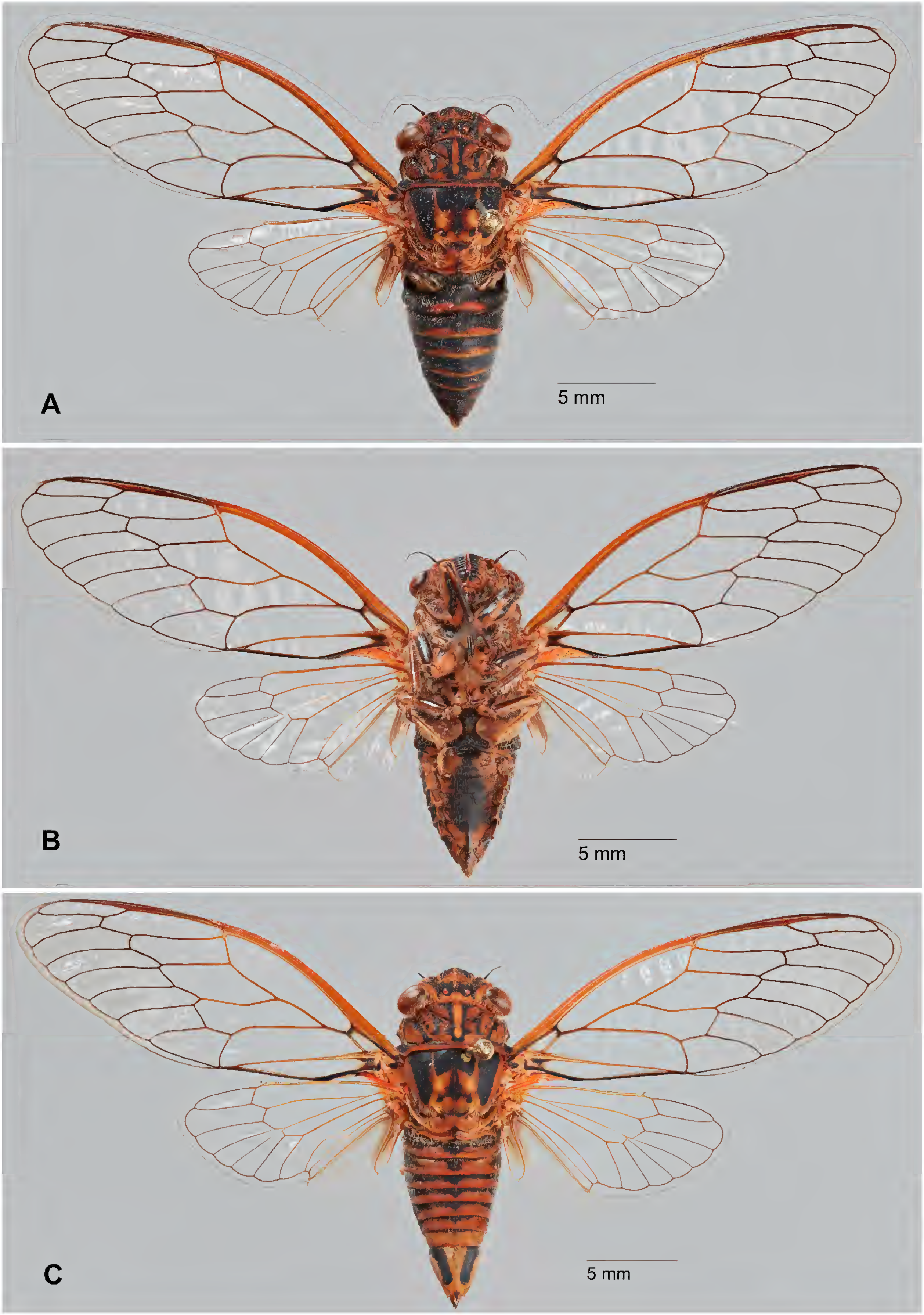

Figure 1. *Clinopsalta autumna* sp. nov. *(A)* male, Narellan (31°18.14'S 149°02.05'E) dorsal habitus; *(B)* male, ventral habitus; *(C)* female, Narellan (31°18.14'S 149°02.05'E), dorsal habitus.

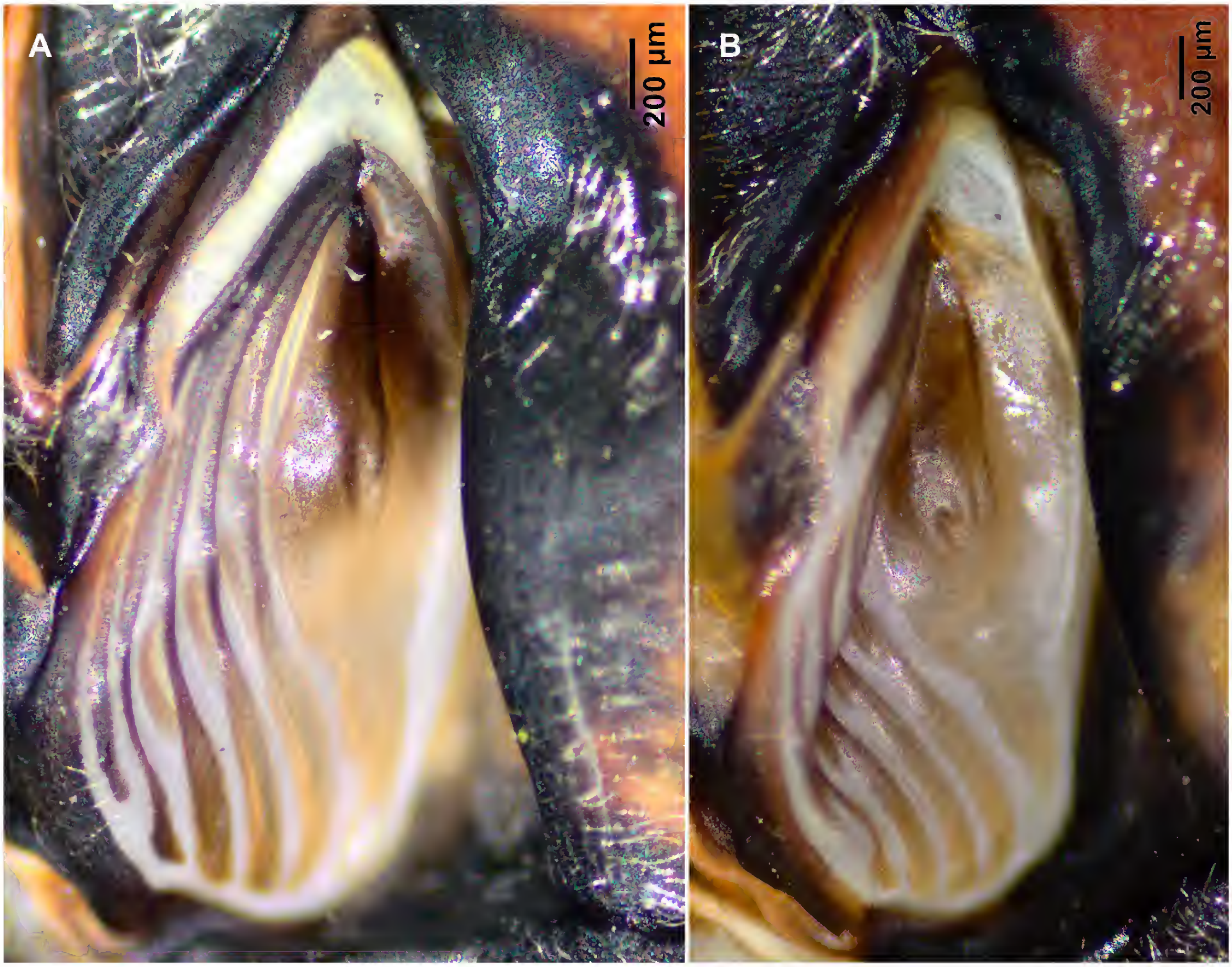

Figure 2. Photos of male left timbals, with dorsal edge at top and posterior margin at right: *(A) Clinopsalta autumna* sp. nov., Narellan (31°18.14'S 149°02.05'E); *(B) Clinopsalta semilunata* sp. nov., Roma (26°33'S 148°47'E).

Other material examined. 1♂, Beach Road, Harley Hill nr Berry, NSW, 34°46.40'S 150°44.01'E, 15.i.1993, T. Emery; 2♂♂, same location, 18–22.xii.1995, D. Emery; 1♂, same location, 1.i.2001, D. Emery; 2♂♂, Prospect Reservoir, NSW, 33°48.48'S 150°54.48'E, 11.x.1998, D. Emery; 3♂♂, Burragorang Rd, The Oaks, NSW, 34°04.10'S 150°28.28'E, 400 m, 18.xi.2003, D. Emery; 3♂♂, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 14.xi.2007, D. Emery; 3♂♂1♀, Mt. Hunter, NSW, 15.xii.2005, D. Emery; 1♂, Mt. Annan Gardens, Narellan, NSW, 31°18.14'S 149°02.05'E, 24.ix.2011, N. Emery; 1♀, same location, 29.x.2009, N. Emery; 1♂, Kentlyn, NSW, 34°02.52'S 150°53.09'E, 1.xi, 2009, N. Emery, 1♂, Endrick River nr Nerriga, 35°05.17'S 150°06.59'E, 1.i.2015, S., N., C., and D. Emery (all DE).

Additional locations with audio recordings. Mountain Rd, Bauple, Qld, 25°48'29"S 152°35'15"E; Razorback Road, West Haldon, Qld, 27°43'44"S 152°06'53"E; Stirling Road Reserve, Rosewood, 27°36'33"S 152°36'36"E; Governor's Chair, Spicers Gap, Qld, 28°05'08"S 152°25'04"E; Redwood Park, Withcott, Qld, 27°33'53"S 151°59'56"E; Carysfield Park, Bass Hill, NSW, 33°54'10"S 150°59'54"E (all LWP).

Description. **Male** (Figs 1A,B; 2A; 3). *Head*. Supra-antennal plate and vertex black, with areas of orange-brown colouration extending laterally from dorsal anteriormost edges of postclypeus; frons black with a contrasting area of brown colouration extending anteriorly from median ocellus; mandibular plates and genae black, each with a narrow orange-brown margin and covered by silver–yellow pubescence; small median orange-brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink to red; compound eyes red when alive, brown to dark brown in stored specimens. Postclypeus predominantly black, orange-brown along margins and between the transverse ridges; anterior median area coloured pale orange-brown or reddish-brown; anteclypeus mainly black; rostrum dark brown; antennae dark brown.

Thorax. Pronotum mainly medium brown, with an orange-brown medial fascia, bordered with black colouration that widens anteriorly of pronotal collar and also towards proximal margin; dorsal and lateral fissures black; pronotal collar reddish-brown to brown, with lateral margins ampliate and often black. Mesonotum with submedial sigilla black, fused anteriorly, with rounded posterior terminations; lateral sigilla black, sharply defined, elongated and narrowing posteriorly; area posterior of submedian sigilla with yellow highlights, often dark brown to black medially; remainder of mesonotum, including lateral edges adjacent to lateral sigilla, area surrounding scutal depressions and length of

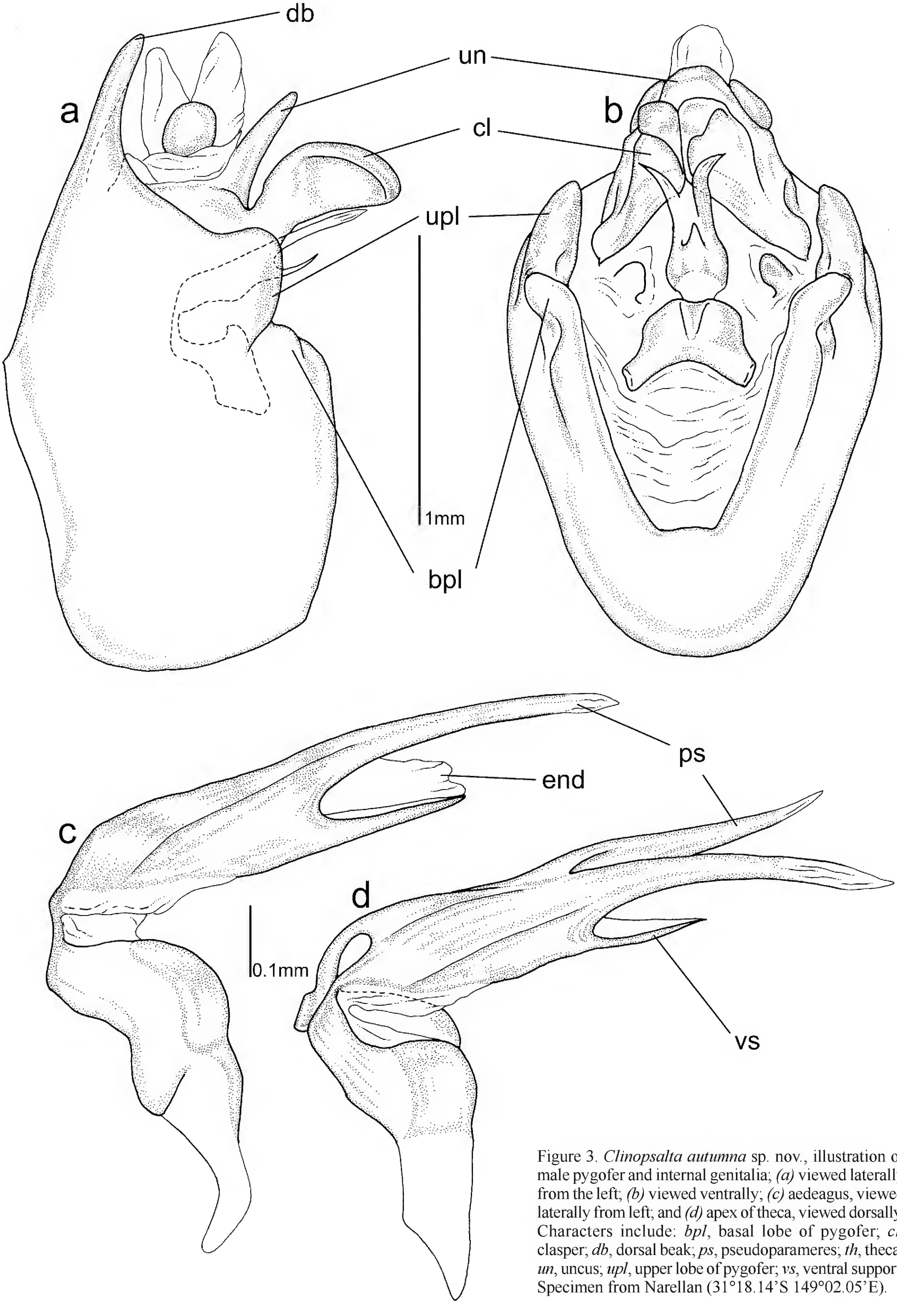

Figure 3. *Clinopsalta autumna* sp. nov., illustration of male pygofer and internal genitalia; *(a)* viewed laterally from the left; *(b)* viewed ventrally; *(c)* aedeagus, viewed laterally from left; and *(d)* apex of theca, viewed dorsally. Characters include: *bpl*, basal lobe of pygofer; *cl*, clasper; *db*, dorsal beak; *ps*, pseudoparameres; *th*, theca; *un*, uncus; *upl*, upper lobe of pygofer; *vs*, ventral support. Specimen from Narellan (31°18.14'S 149°02.05'E).

parapsidal suture between submedian and lateral sigilla, brown; scutal depressions black; cruciform elevation brown to dark brown; mesonotum with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Wings. Fore wing costal vein translucent, orange-brown from base to node, dark brown along remainder; other venation brown, darker proximally; basal membrane orange. Hind wing venation brown, with light brown opaque plaga around margins of anal cell 3, adjacent to vein 3A and vein 2A; six apical cells.

Legs. Coxae and trochanters predominantly pale to medium brown with irregular black fasciae on anterior, lateral and posterior faces; meracantha spikes dark brown with paler lateral margins, slightly overlapping opercula; fore, mid and hind femora medium (or sometimes pale) brown with dark brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore and mid tibiae mainly dark brown; hind tibiae pale brown; tarsi a mixture of pale, medium and dark brown; claws brown, darker apically; spines of fore femora black.

Opercula (Fig. 1B). Broadly rounded; predominantly brown; plates undulating with medial areas slightly depressed.

Timbals (Fig 2A). Five long ribs; ribs 4–5 both unattached to adjacent ribs and shorter than ribs 1–3; ribs 1–3 fused dorsally, but not ventrally.

Abdomen. Tergite 1 dark brown to black; tergite 2 brown on dorsal surface, black laterally; remaining tergites mainly reddish-brown, becoming paler posteriorly, with areas of black colouration anteriorly, extending posteriorly along dorsal midline and along lateral edges, especially on tergite 3; silvery pubescence most prominent along lateral edges of anterior tergites; tergite 8 dark brown to black. Sternite II brown to orange-brown, with median area of black colouration broadening posteriorly; sternites III to VII brown to orange-brown, with broad and prominent black medial triangular areas, pointed anteriorly, weaker, smaller and sometimes restricted to anterior edge of sternite VII; sternite VIII brown; intersegmental membranes brown.

Genitalia (Fig. 3). Pygofer with black colouration dorsally, extending to beak and along anterior lateral edges; medium brown over the remainder; claspers conspicuously elongated, extending posteriorly beyond termination of pygofer, bluntly rounded apically; uncus vertically narrow, relatively short, with rounded termination; pseudoparameres clearly longer than endotheca; endotheca soft and fleshy.

Female. (Fig. 1C). Similar to male in general colouring and patterning, with more extensive areas of paler colouration.

Head. Supra-antennal plate and vertex brown anteriorly, black posteriorly; frons black with brown anterior margins and a contrasting area of brown colouration extending anteriorly from median ocellus; mandibular plates and genae brown; small median orange-brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink to red; compound eyes brown to dark brown. Postclypeus black with median area coloured pale orange-brown or reddish-brown; orange-brown along margins and between the transverse ridges; anteclypeus mainly black, reddish-brown medially; rostrum brown, darker posteriorly; antennae dark brown.

Thorax. Pronotum as in male. Mesonotum with submedial sigilla black, fused anteriorly, with rounded posterior terminations, often shorter than in male; lateral sigilla black, sharply defined, elongated and narrowing posteriorly, as in male; cruciform elevation brown to dark brown; remainder of mesonotum mainly brown, as in male; mesonotum with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Legs. Coxae and trochanters predominantly pale to medium brown with irregular black fasciae on anterior, lateral and posterior faces; fore, mid and hind femora medium (or sometimes pale) brown with dark brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore tibiae mainly dark brown; mid and hind tibiae pale brown; tarsi a mixture of pale, medium and dark brown; claws brown, darker apically; spines of fore femora black.

Abdomen. Tergites 1–8 brown to reddish brown, sometimes dark brown to black anteriorly, with lines of black colouration extending along anterior dorsal and lateral margins; abdominal segment 9 brown to reddish-brown, with a pair of black dorsolateral fasciae, extending from the anterior margin and not reaching the posterior margin and with a localized black spot on posterior lateral surface. Sternite II brown to orange-brown, with median area of black colouration broadening posteriorly; sternites III–VII brown to orange-brown, with broad and prominent black medial, broadly triangular, areas, pointed anteriorly; sternite VIII brown; intersegmental membranes brown. Ovipositor sheath not extending noticeably beyond the posterior termination abdominal segment 9.

Measurements (in mm; range with mean in parentheses: 12 males, 9 females). Body length: male 16.2–17.9 (17.1); female (incl. ovipositor) 15.0–18.8 (18.0). Fore wing length: male 20.3–22.2 (21.4); female 19.1–24.5 (23.0). Forewing length/width ratio: male 2.53–2.79 (2.62); female 2.63–2.81 (2.75). Head width: male 5.9–6.8 (6.3); female 5.9–6.8 (6.3). Pronotum width: male 5.3–6.0 (5.6); female 5.3–6.3 (6.0). Abdomen width: male 5.5–6.3 (5.9); female 5.6–6.6 (6.1).

Distinguishing features. *Clinopsalta autumna* sp. nov. can usually be distinguished from the *C. tigris* species complex by the complete lack of fore wing infuscations. However, on rare occasions, specimens in the *C. tigris* species complex also lack wing infuscations. In this case, *C. autumna* sp. nov. can still be distinguished by having a predominantly dark brown rostrum (cf. mainly brown or olive in paler specimens of *C. tigris*). In addition, *C. autumna* sp. nov. can be distinguished from *C. semilunata* by the broad, black markings on the centre of the sternites. It can be distinguished from the superficially similar *C. adelaida* by the presentation of forewing vein M3+4, which is distinctly kinked at the intersection with the nodal line. By contrast, in *C. adelaida*, forewing vein M3+4 is straight proximal to the nodal line intersection and only subtly curved over the remainder.

Distribution, habitat and behaviour. This species occupies a warm temperate distribution in eastern Australia from Mt Bauple, near Maryborough and the Bunya Mountains in south-east Queensland south along the Great Diving Range and subcoastally to near Goulburn, Nerriga and near Berry in southern New South Wales (Fig. 4). The paucity of records between the Border Ranges and the Greater Sydney regions

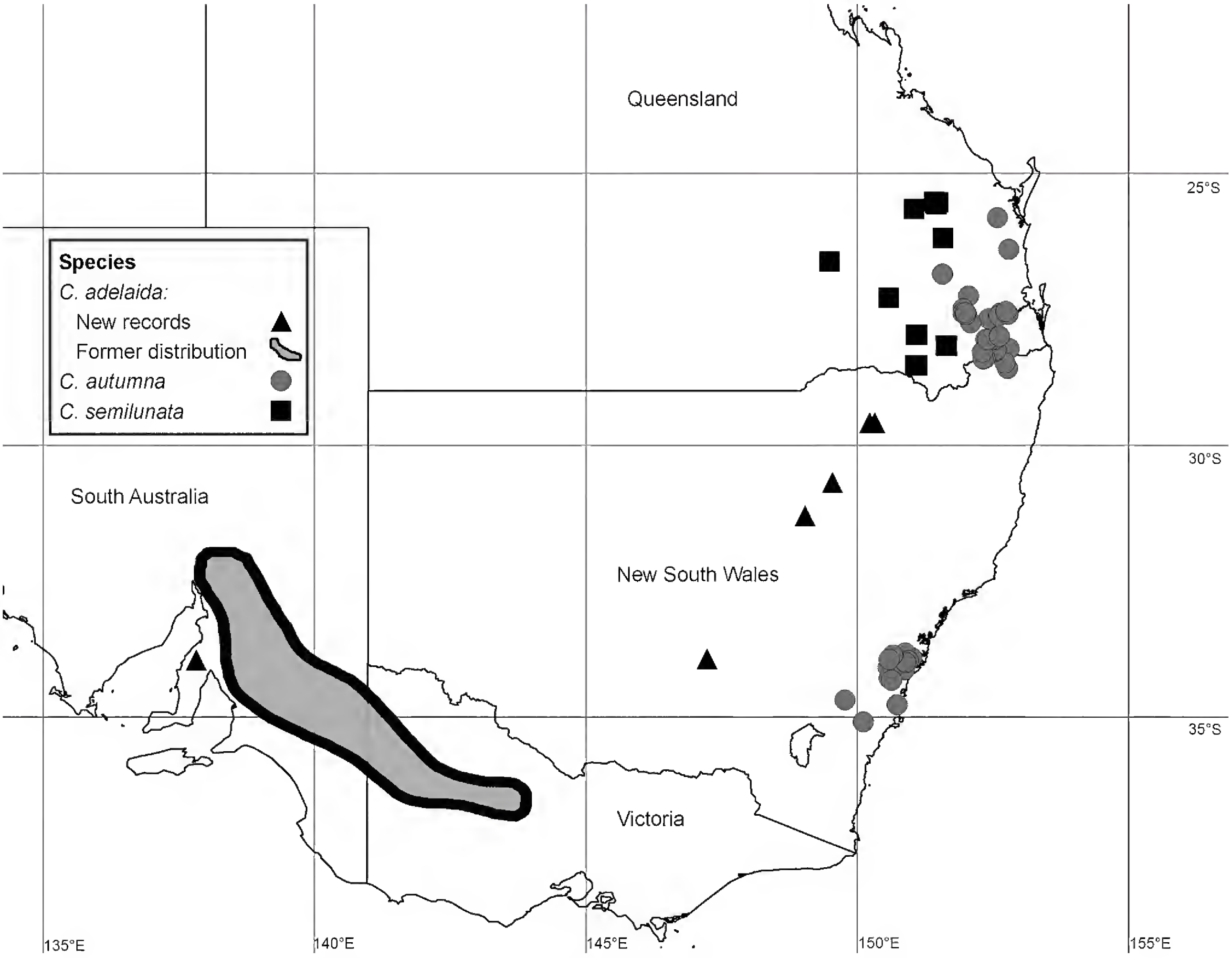

Figure 4. Map of central and eastern mainland Australia showing the geographical distribution of *Clinopsalta adelaida* (black triangles), *C. autumna* sp. nov. (grey circles), *C. semilunata* sp. nov. (black squares). The former distribution of *C. adelaida* is sourced from Moulds (1990).

in New South Wales likely reflect lack of observation or specimen collecting rather than a distribution disjunction, although populations may be patchily distributed. Adults occur in association with wattles, particularly those that retain juvenile foliage (fern-like leaves) as adults, such as *Acacia irrorata* and *A. parramattensis*. Hickory wattles, including *A. falcata* and *A. falsiformis*, are also inhabited in some areas (Emery *et al.*, 2005). Males call from main branches typically in the upper foliage of wattles. Observations suggest that they tend to remain fairly static, but will relocate quickly at the first sign of disturbance. Adults have been observed between early September and early February.

Etymology. From the Latin word *autumnus*, meaning “autumn”. The name is a reference to the various colours of this cicada matching those of autumn leaves in a deciduous forest.

Clinopsalta semilunata sp. nov.

Figs 2B; 4–6

Notopsalta sp. F: Ewart (1998).

Holotype: ♂, AUSTRALIA QLD, Old Thanes Creek Road, Pratten, 1.xi.2015, Recorded, L. W. Popple, 28.0912°S 151.7360°E, 211-0008, QM reg. no. T237103 (QM). **Paratypes**: 1♀ AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0006, QM reg. no. T237104 (QM); 1♂, Jct. Engineer-Auburn Rds., Chinchilla, S. Qld., 10 Oct 1997. Recorded; 1♂, Wongongera Ck., Miles, S. Qld. 26°30.68'S 150°29.30'E, 3 Oct 1997; 1♂, “Red Ridge”, Miles, S. Qld. 26°47.34'S 150°23.85'E, 2 Oct. 1997 (all AE); 2♂♂, 70 km E. Roma, Qld, 26°37.1'S 149°29.40'E, 19.x.2011, N. C. and D. Emery (both DE); 4♂♂ 1♀, AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0001, 211-0003 to 211-0005, 211-0007 (♀); 1♂, same data as holotype (all LWP); 1♂, AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0002 (MSM).

Additional location with audio recordings: Swains Road, Binjour Plateau, Qld, 25°32'00"S 151°29'59"E; Redvale Rd west of Binjour, Qld, 25°31'56"S 151°25'32"E; Yelarbon State Forest, Qld, 28°32'17"S 151°06'22"E (all LWP).

Description. **Male** (Figs 2B; 5A,B; 6). *Head*. Supra-antennal plate and vertex olive-brown anteriorly, black posteriorly; frons brown with contrasting areas of black colouration posteriorly on each side of medial line; mandibular plates and genae mainly olive-brown and covered by silver–yellow pubescence; small median brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink; compound eyes brown. Postclypeus predominantly black, olive-brown along margins and between the transverse ridges; anterior median area coloured brown or reddish-brown; anteclypeus mainly black; rostrum dark brown; antennae dark brown.

Thorax. Pronotum mainly medium brown, with a lighter brown to olive-brown medial fascia, bordered with black colouration that widens anteriorly of pronotal collar and also towards proximal margin; dorsal and lateral fissures narrowly and diffusely black; pronotal collar olive-brown, with lateral margins ampliate and often darker at extreme lateral margin. Mesonotum with submedial sigilla black, fused anteriorly, with rounded posterior terminations; lateral sigilla black, sharply defined, elongated and narrowing posteriorly area posterior of submedian sigilla with yellow to yellow-brown highlights; remainder of mesonotum, including lateral edges adjacent to lateral sigilla, area surrounding scutal depressions and length of parapsidal suture between submedian and lateral sigilla, olive-brown to brown; scutal depressions black; cruciform elevation dark brown to black; with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Wings. Fore wing costal vein translucent, olive-brown from base to node, dark brown along remainder; other venation olive-brown to brown, dark-brown distally; basal membrane orange. Hind wing venation brown to light brown, with light brown opaque plaga around margins of anal cell 3, adjacent to vein 3A and vein 2A; six apical cells.

Legs. Coxae and trochanters pale brown to olive brown; meracanthus spikes pale brown to olive-brown, slightly overlapping opercula; fore, mid and hind femora pale brown with weak brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore, mid and hind tibiae pale brown; tarsi mainly pale brown; claws brown, darker apically; spines of fore femora dark brown.

Opercula (Fig. 5B). Broadly rounded; predominantly brown; plates undulating with medial areas slightly depressed.

Timbals (Fig. 2B). Five long ribs; ribs 4–5 both unattached to adjacent ribs and shorter than ribs 1–3; ribs 1–3 fused dorsally, but not ventrally.

Abdomen. Tergite 1 dark brown to black; tergites 2–7 mainly reddish-brown, often dark brown to black on anterior margins, ochraceous on posterior margins, with a weak discontinuous line of dark colouration extending along anterior dorsal and lateral margins; silvery pubescence most prominent along lateral edges of anterior tergites. Sternites olive-brown, often faded to yellow-brown, sometimes paler medially; intersegmental membranes yellow-brown.

Genitalia (Fig. 6). Pygofer with black colouration dorsally, extending to beak and along posterior lateral edges to upper lobe; ochraceous over the remainder, anal styles light orange; claspers conspicuously elongated, extending posteriorly beyond termination of pygofer, bluntly rounded apically; uncus vertically narrow, relatively short, with rounded termination; Aedeagus trifid, pseudoparameres clearly longer than endotheca; endotheca soft, fleshy.

Female. (Fig. 5C). Similar to male in general colouring and patterning, although often with more extensive areas of paler colouration.

Head. Mainly olive-brown. Supra-antennal plate and vertex pale olive-brown anteriorly, dark brown to black posteriorly; frons olive-brown with contrasting areas of black colouration posteriorly on each side of medial line; mandibular plates and genae pale olive-brown; ocelli pink; compound eyes brown. Postclypeus predominantly olive-brown, tending orange-brown medially, with brown to dark brown longitudinal areas on either side of midline; anteclypeus, rostrum and antennae dark brown.

Thorax. Pronotum as in male, although often with a broader medial fascia. Mesonotum with submedial sigilla brown, separated anteriorly, with slightly darker and rounded posterior terminations, sometimes longer than in male; lateral sigilla dark brown, elongated and narrowing posteriorly, diffuse along margins; area posterior of submedian sigilla with yellow to yellow-brown highlights, as in male; remainder of pronotum, including lateral edges adjacent to lateral sigilla and area surrounding scutal depressions, olive-brown to brown; scutal depressions brown; cruciform elevation dark brown; with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum dark brown.

Legs. Appearance as in male.

Abdomen. Tergite 1 pale brown; tergites 2–8 mainly reddish brown, with dark lines of black colouration along median dorsal margins; abdominal segment 9 brown to pale brown, with a pair of narrow, diffuse, dark brown dorsolateral fasciae, extending from the anterior margin and not reaching the posterior margin. Sternites pale brown to olive-brown; intersegmental membranes orange-brown. Ovipositor sheath barely extending beyond the posterior termination abdominal segment 9.

Measurements (in mm; range with mean in parentheses: 12 males, 2 females). Body length: male 16.1–19.3 (17.9); female (incl. ovipositor) 18.4–18.9 (18.7). Fore wing length: male 19.0–23.5 (22.1); female 22.9–23.9 (23.4). Forewing length/width ratio: male 2.57–2.86 (2.71); female 2.86–2.90 (2.87). Head width: male 5.1–6.3 (5.8); female 5.6–5.9 (5.8). Pronotum width: male 5.0–6.0 (5.6); female 5.5–6.0 (5.8). Abdomen width: male 4.9–4.9 (5.5); female 5.0–5.3 (5.2).

Distinguishing features. *Clinopsalta semilunata* sp. nov. can be distinguished from *C. adelaida* and *C. autumna* sp. nov. by having entirely pale brown to pale green sternites without black markings centrally. In most cases, this feature, and a complete lack of fore wing infuscations, distinguishes *C. semilunata* sp. nov. from the *C. tigris* species complex. However, on rare occasions, specimens in the *C. tigris* species complex may also lack wing infuscations and dark central markings on the sternites. In this situation, *C. semilunata* sp. nov. can still by distinguished by having a predominantly dark brown rostrum (c.f. mainly brown or olive in paler specimens of *C. tigris*).

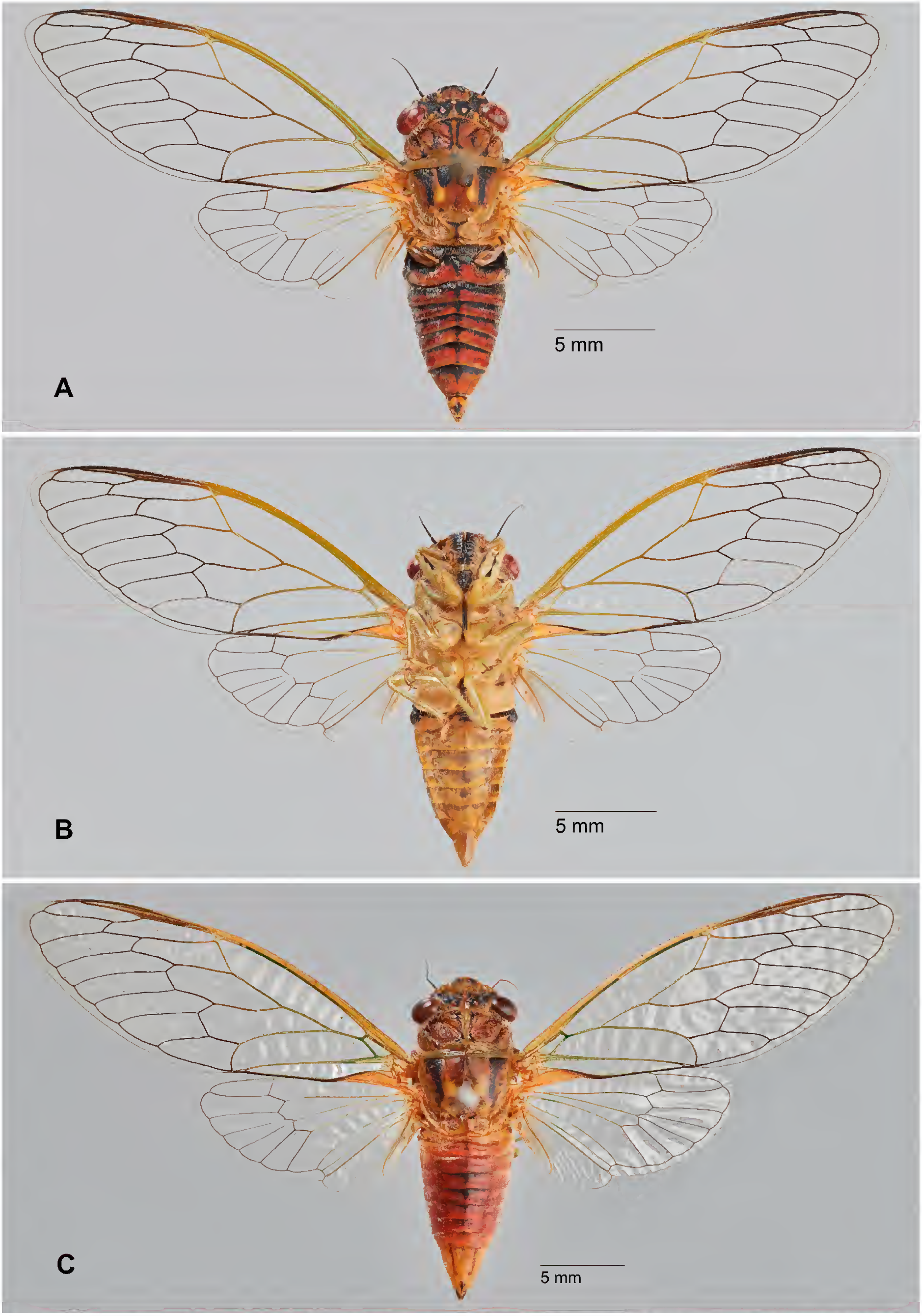

Figure 5. *Clinopsalta semilunata* sp. nov. *(A)* male holotype, Pratten (28.0912°S 151.7360°E) dorsal habitus; *(B)* male, ventral habitus; *(C)* female paratype, 6 km W of Thane (28°09'41"S 151°57'59"E) dorsal habitus.

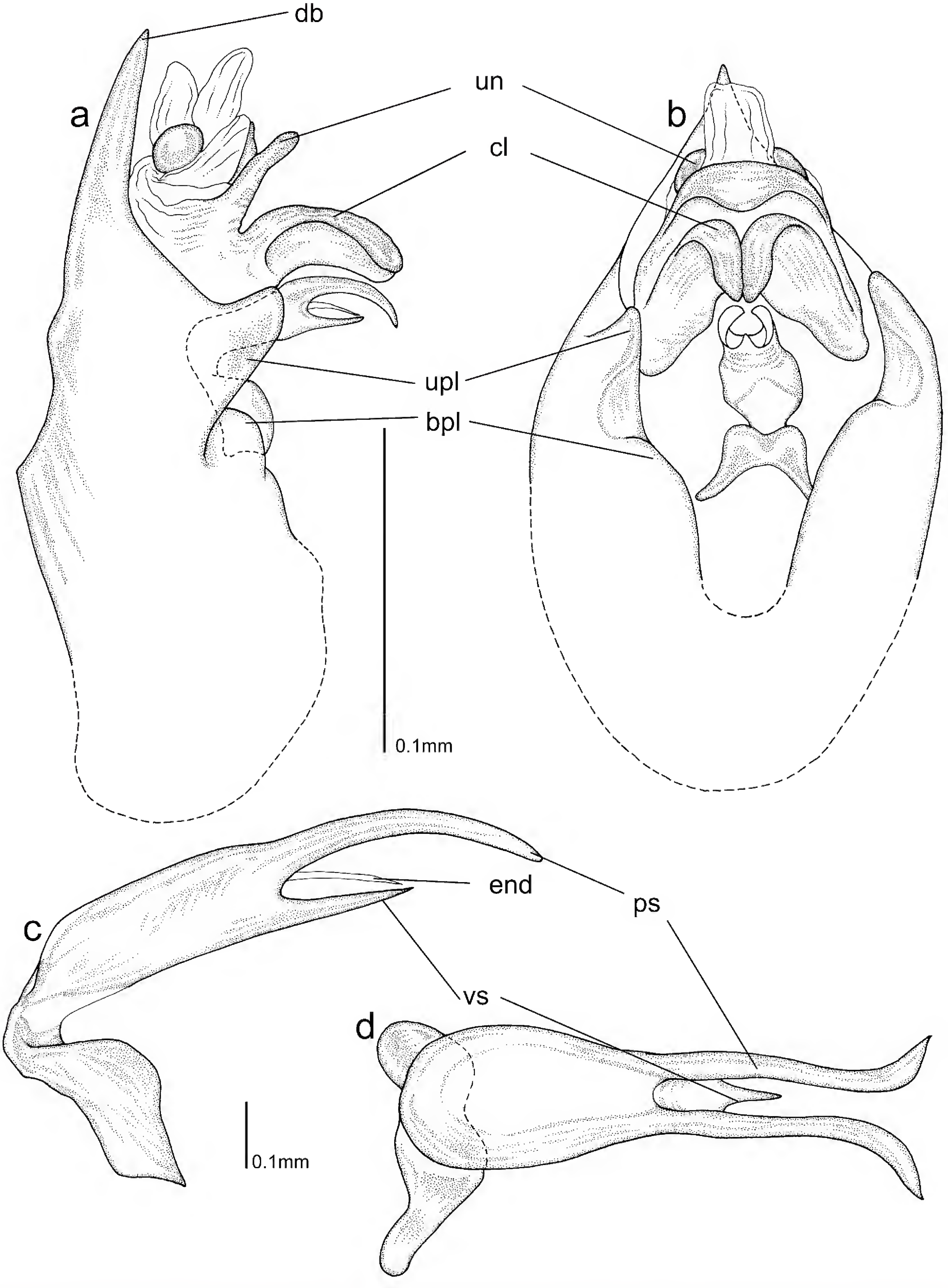

Figure 6. *Clinopsalta semilunata* sp. nov.: illustration of male pygofer and internal genitalia; *(a)* viewed laterally from the left; *(b)* viewed ventrally; *(c)* aedeagus, viewed laterally from left; and *(d)* apex of theca, viewed dorsally. Characters include: *bpl*, basal lobe of pygofer; *cl*, clasper; *db*, dorsal beak; *ps*, pseudoparameres; *th*, theca; *un*, uncus; *upl*, upper lobe of pygofer; *vs*, ventral support. Specimen from 6 km W of Thane (28°09'41"S 151°57'59"E).

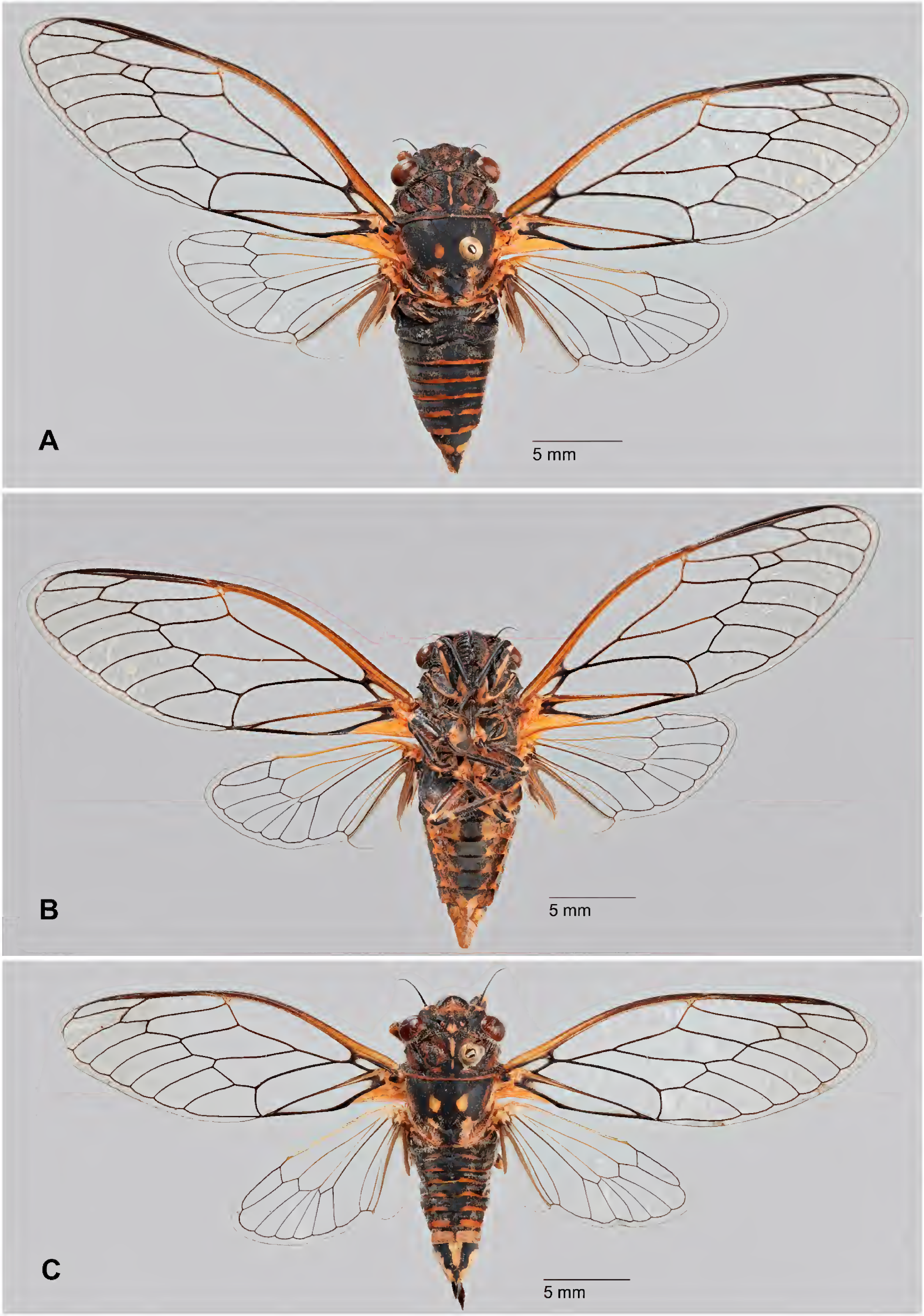

Figure 7. *Clinopsalta adelaida (A)* male, Warrumbungle NPk, NSW (31°18.14'S 149°02.05'E) dorsal habitus; *(B)* male, ventral habitus; *(C)* female, Warrumbungle NPk, NSW (31°18.14'S 149°02.05'E), dorsal habitus.

Distribution, habitat and behaviour. *Clinopsalta semilunata* sp. nov. is restricted to south-east Queensland where it is known from east of Yuleba east to Binjour Plateau and south to near Thane and Yelarbon State Forest (Fig. 4). Populations appear to occur in association with wattles (*Acacia* spp.), which grow in the middle storey of dry open forest. At the type locality near Thane, *C. semilunata* sp. nov. appears to occur principally in association with *Acacia caroleae*. Near Yuleba and in the Gurulmundi area north of Miles, it has been found mainly on *Acacia semilunata*. Adults have been observed between September and December.

Etymology. The name is derived from Latin *lunatus*, meaning "moon", with the prefix *semi-*, meaning "half". This refers to the bright markings on the mesonotum, which can appear as two "half-moons". Additionally, the plant *Acacia semilunata* is one of the species with which this cicada is commonly associated in inland southern Queensland.

Additional distribution records for *Clinopsalta adelaida* (Ashton) (Figs 4, 7). 1♂, Wyalong rest area, NSW, 33°55.33'S 147°14.58'E, 22.xi.2010, L. Popple and D. Emery; 1♂ (visual and aural observation only, no specimen), 9.8 km W. of Paskeville, SA, 34.02631°S 137.80837°E, 3.xi.2016, L. Popple and A. McKinnon (both LWP); 1♂, Pilliga State Forest, 70 km N. of Coonabarabran, NSW, 30°40.52'S 149°32.50'E, 2.xi.2012, N. and D. Emery; 1♂1♀, Whitegum Lookout, Warrumbungle NPk, NSW, 31°18.14'S 149°02.05'E, 680 m, 18.x.2014, N., C. and D. Emery; 1♂, same location, 5.x.2015, N., C. and D. Emery (all DE); 2♂♂, Gravesend, NSW, 21.xi.1998, M. Coombs; 2♂♂, Gravesend, NSW, 21.xi.1998, M. Coombs; 1♂1♀, same data as previous, 22.xi.1998; 1♂, 7 km W. of Gravesend, NSW, 21.xi.1998, M. Coombs; 2♂♂, same data as previous, 22.xi.1998 (all MC).

Calling songs

The calling songs of *Clinopsalta adelaida*, *C. autumna* sp. nov. and *C. semilunata* sp. nov. have clear structural similarities. Each of these species produces a complex day song and a dusk song, although the dusk song of *C. adelaida* has not yet been recorded. The calls broadly consist of regular macrosyllables or echemes, which may or may not be separated by one or more syllables.

The calling song description for *C. adelaida* is based upon a single recording from Telowie Gorge in South Australia (Fig. 8) and two recordings from Wyalong in New South Wales (Fig. 9). The day calling song of this species is the most complex of all described here and has a characteristic sequence. It begins with closely-spaced sets comprising a macrosyllable (0.019–0.023 s duration) followed by three higher amplitude syllables (each 0.007–0.010 s duration), separated by gaps of 0.009–0.015 s duration. This is followed by a sequence of 10–35 syllable doublets (each 0.016–0.019 s duration, punctuated by gaps of 0.015–0.020 s duration). The doublets continue, but are then periodically interrupted by a discrete, higher amplitude macrosyllable (0.040–0.069 s duration) and doublet (or triplet, 0.014–0.022 s duration). This quickly progresses into a stable phrase pattern, with each phrase comprising a high amplitude macrosyllable and doublet followed by a series of three or four lower amplitude doublets. The lower amplitude notes are sometimes augmented with an equivalent number (or fewer) sharp wing-snaps (too subtle in available recordings to allow illustration). These wing snaps may continue for a short time in the gaps between the high amplitude notes even after production of the low amplitude notes has ceased. A short time later, the wing snaps also cease and only the high amplitude notes (macrosyllable and doublet) remain, with each phrase ending in a long gap of 0.074–0.136 s. The phrases then become simplified even further in the final section of the song when the doublets are also dropped, leaving only the macrosyllables, which are then punctuated by even longer gaps of approximately 0.140 s. This final section is typically the longest part of the song (up to 25 s or longer) and it is during this section that the females are expected to respond with a wing-flick (during the gaps), as indicated by the responsiveness of males to simulated wing-flicks (LWP, pers. obs.).

The day calling song of *C. autumna* sp. nov. is similar to *C. adelaida*; however its structure is more simplistic and not so strongly transitional. Illustrations of this song are provided in Figs 10–12. The song commences a burst of strident phrases, which are composed of a macrosyllable (0.027–0.055 s duration, 3–6 syllables) followed by two or three single syllables (0.006–0.012 s duration), each separated by gaps of 0.018–0.074 s duration (all statistics, $n = 16$ individual recordings). These may be interrupted by segments in which the syllables (or sometimes all but one of the syllables) in each phrase are replaced by two prominent wing-snaps (e.g. Fig. 11D). In some instances, the song may progress into a sequence whereby the phrases simplify into a single macrosyllable (0.029–0.056 s duration), a brief silence (0.035–0.071 s), a single syllable, double syllable, or shorter macrosyllable (0.009–0.034 s) and a longer silence (0.104–0.148 s). In the final section, the song winds down to a long series of macrosyllables (each 3–6 syllables, 0.031–0.056 s total duration), each separated by long gaps (0.153–0.268 s duration). From the observations of human observers attracting male cicadas using simulated wing-flicks, it is inferred that the female cicada responds with a single wing-flick during the long gap following each macrosyllable in the final section.

The day calling song of *C. semilunata* sp. nov. is the simplest among the species documented here (see Fig. 13). It typically commences with a brief introduction, which is composed of a short echeme (0.071–0.133 s duration), a gap (0.045–0.194), a short sequence of syllables or occasionally syllable doublets (each 0.006–0.015 s duration, punctuated by gaps of 0.041–0.084 s, total duration 0.691–1.283 s), followed by a long gap (0.108–0.377 s duration; all statistics, $n = 17$ recordings). The brief introduction is succeeded by a long series of echemes (each 0.091–0.158 s duration), each separated by a long gap of 0.255–0.373 s duration. As noted for *C. adelaida* and *C. autumna* sp. nov., observations of simulated attraction of male cicadas indicate that the female cicada responds with a single wing-flick during the long gaps.

Based on examination of a single recording for *C. autumna* sp. nov. and two recordings of *C. semilunata* sp. nov., the dusk calling songs of these species are both equally simple and monotonous (Fig. 14). In each species, repeated phrases consist of a single discrete syllable followed by a macrosyllable (containing 4–5 syllables). In *C. autumna* sp. nov., the gaps between each syllable and macrosyllable (and the following syllable) are all of similar duration (0.051–0.082 s duration), whereas in *C. semilunata* sp. nov. the gap following the syllable (0.055–0.064 s duration) is considerably shorter than the gap that follows

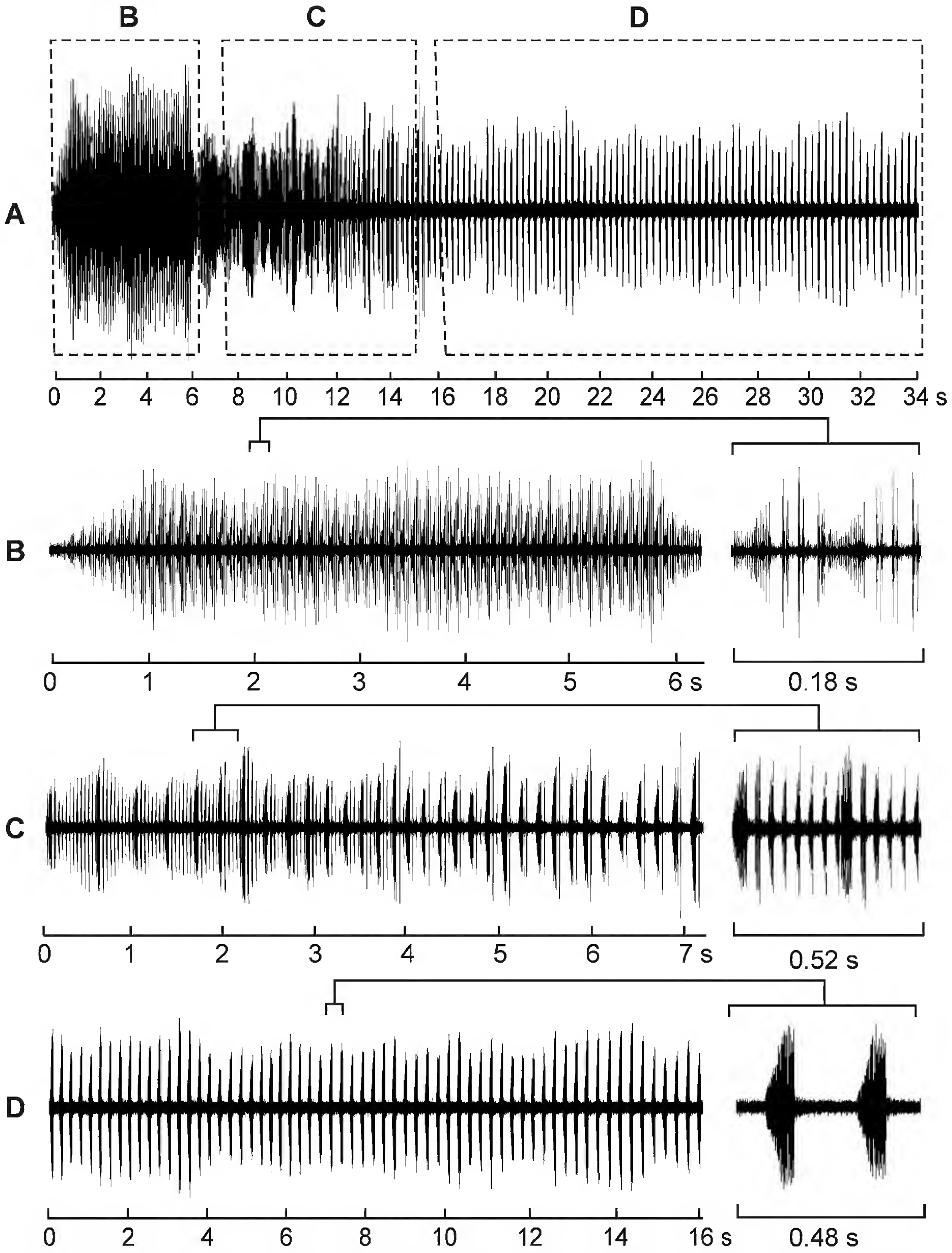

Figure 8. Male calling song structure of *Clinopsalta adelaida*, illustrated in wave plot form. *(A)* a single, complete bout of calling. *(B)* expanded diagram of the commencing section (from *A* above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables, with a magnified example of two sets shown in the excerpt to the right. *(C)* expanded diagram of the middle of the song (from *A*), showing several macrosyllables, each separated by a sequence of syllables, gradually reducing to one syllable; an expanded version showing two macrosyllables, each followed by a syllable sequence is shown to the right of the figure. Wing snaps are detectible in the latter half of this section; however these proved too subtle for illustration. D: expanded diagram of the latter half of the song (from A), showing repeated macrosyllables, these again expanded for convenience of examination to the right of the main figure. The recording was obtained in the field from Telowie Gorge, South Australia (33°01'S 138°06'E) by LWP using RS2 (see *Methods and terminology*).

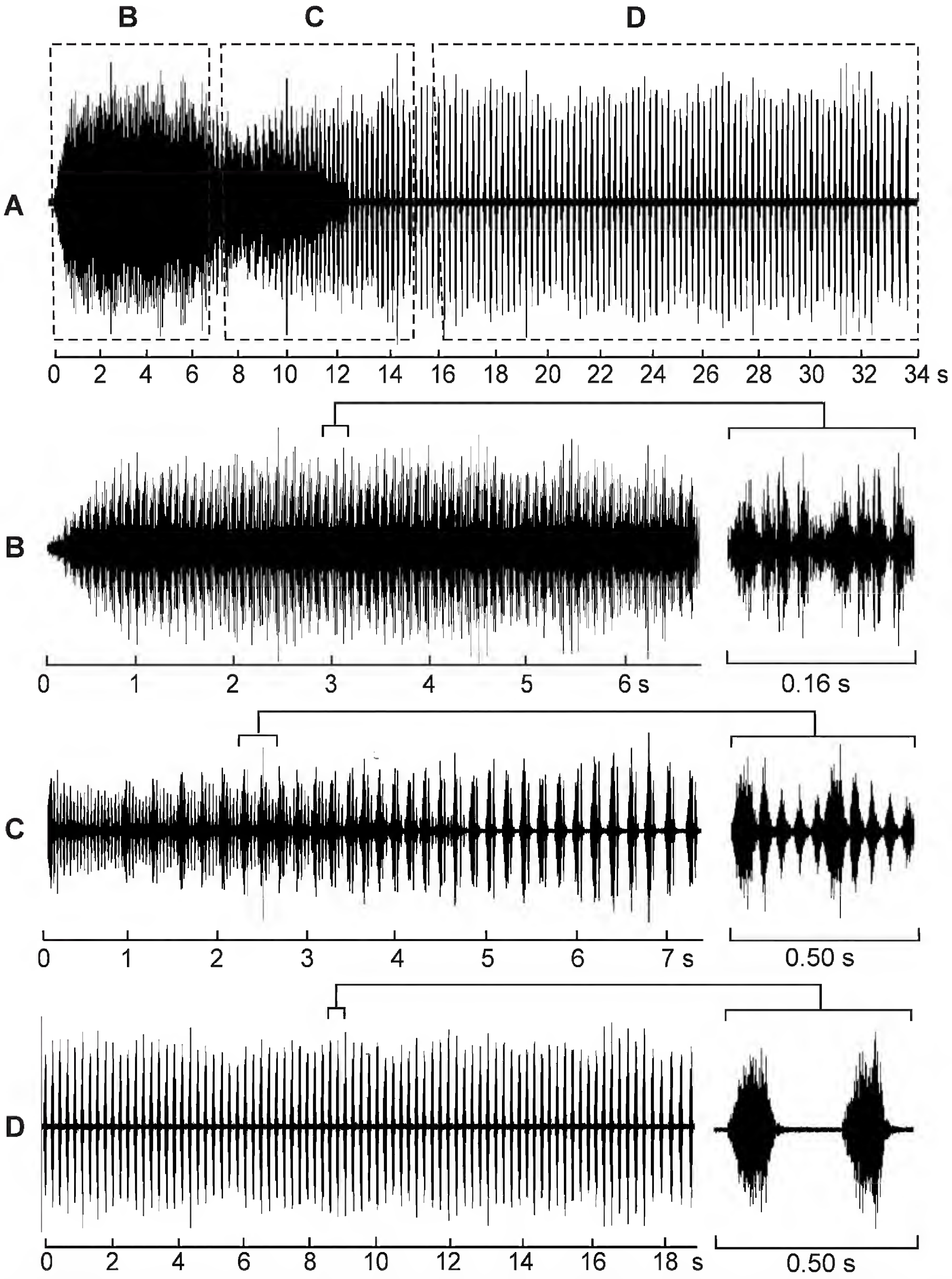

Figure 9. Male calling song structure of *Clinopsalta adelaida*, illustrated in wave plot form. *(A)* a single, complete bout of calling. *(B)* expanded diagram of the commencing section (from *A* above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables, with a magnified example of two sets shown in the excerpt to the right. *(C)* expanded diagram of the middle of the song (from *A*), showing several macrosyllables, each separated by a sequence of syllables, gradually reducing to one syllable; an expanded version showing two macrosyllables, each followed by a syllable sequence is shown to the right of the figure. Wing snaps are detectible in the latter half of this section; however these proved too subtle for illustration. *(D)* expanded diagram of the latter half of the song (from *A*), showing repeated macrosyllables, these again expanded for convenience of examination to the right of the main figure. The recording was obtained in the field from Wyalong, New South Wales (33°55'S 147°14'E) by LWP using RS4 (see *Methods and terminology*).

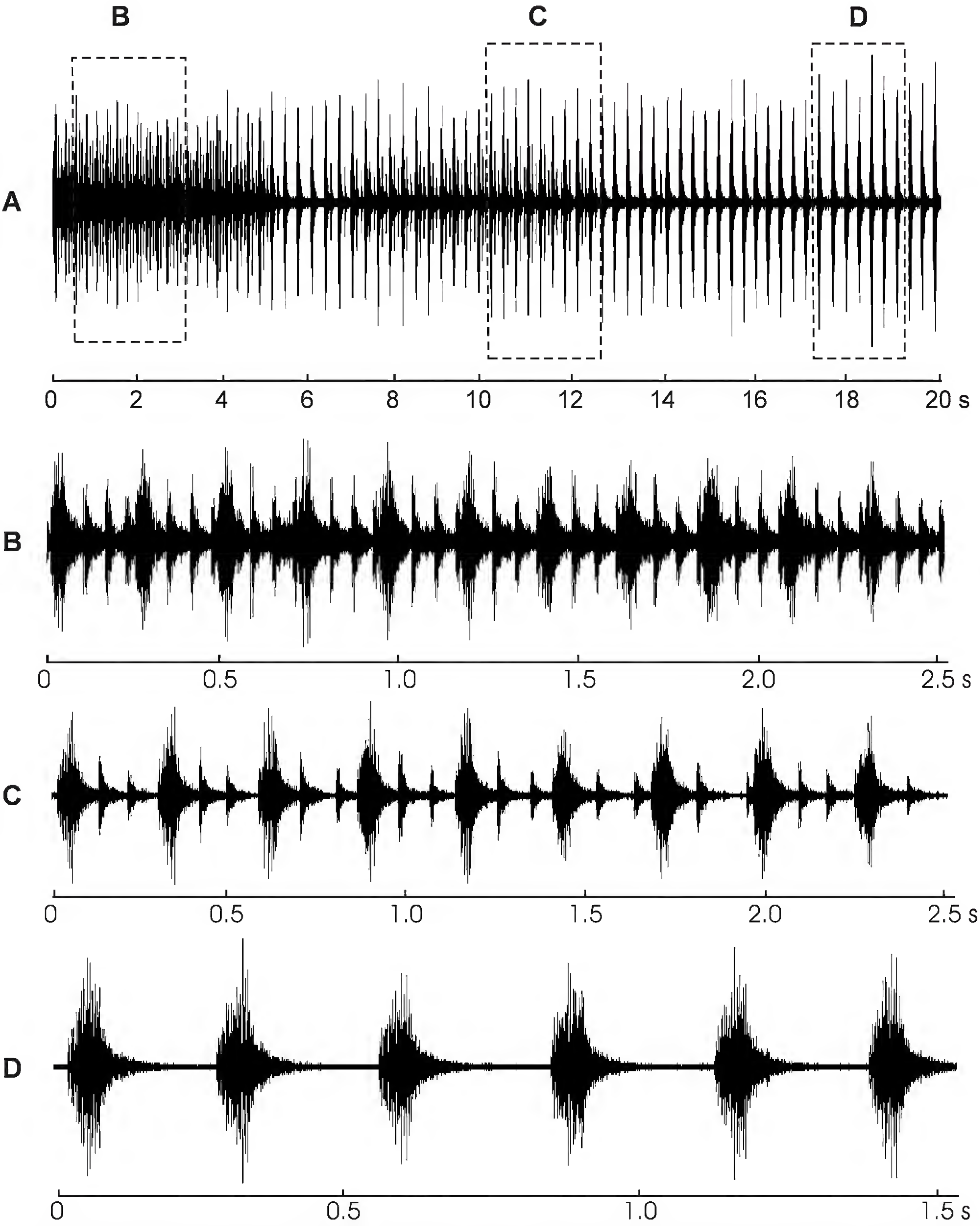

Figure 10. Male calling song structure of *Clinopsalta autumna* sp. nov., illustrated in wave plot form. *(A)* a single, complete bout of calling. *(B)* expanded diagram of the introductory section (from *A* above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables. *(C)* expanded diagram of the middle of the song (from *A*), showing several macrosyllables, each separated by 1–2 syllables. *(D)* expanded diagram of the latter half of the song (from *A*), showing repeated macrosyllables. The recording was obtained in the field from Berry, NSW (34°46'S 150°44'E) by LWP using RS1 (see *Methods and terminology*).

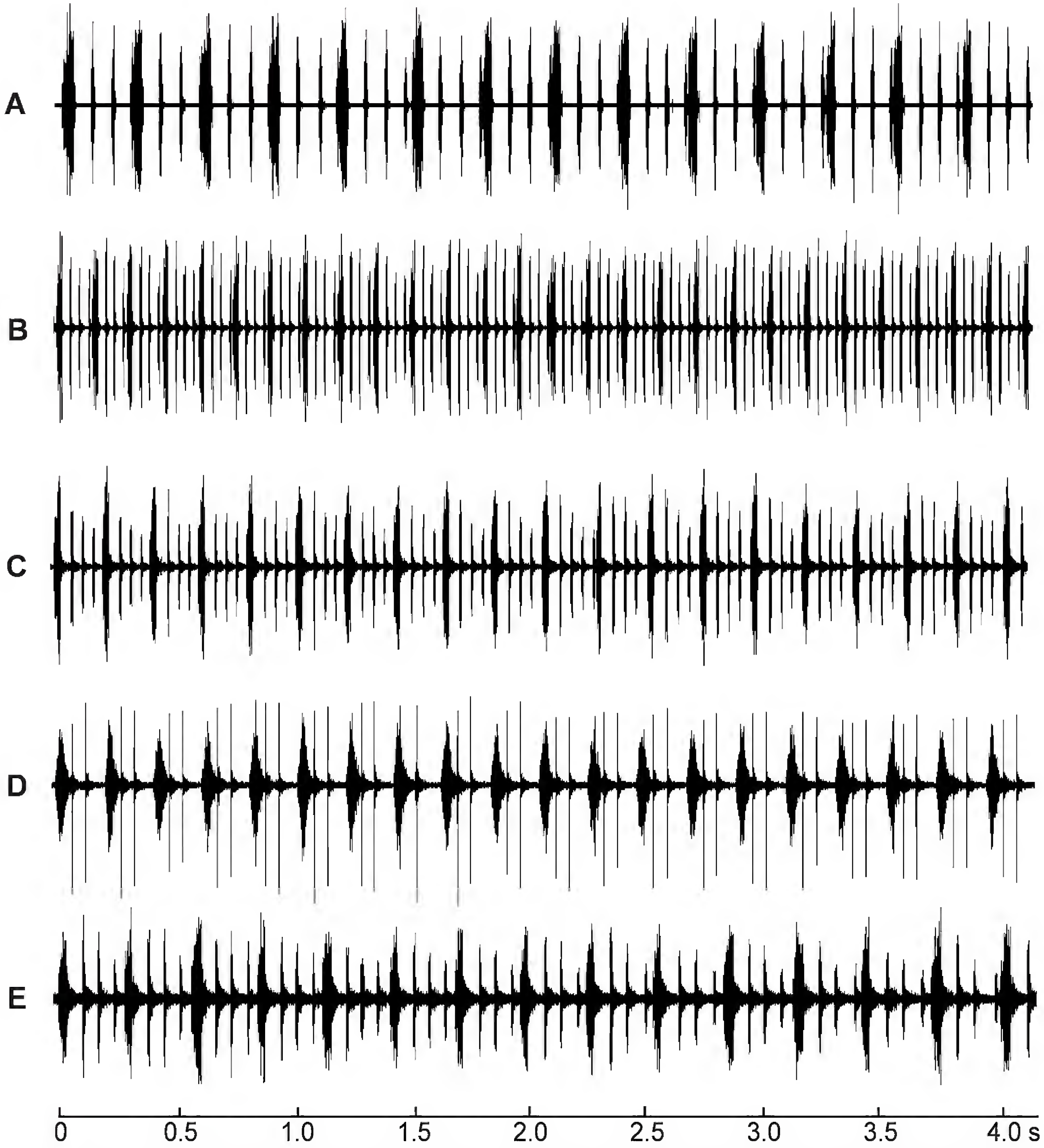

Figure 11. Wave plots illustrating the structure of the complex, introductory part of the male calling song of *Clinopsalta autumna* sp. nov. from *(A)* Bargo, New South Wales (34°17'S 150°35'E), *(B)* Spicer's Gap, Queensland (28°05'S 152°25'E), *(C and D)* Rosewood, Queensland (27°37'S 152°37'E), and *(E)* Berry, New South Wales (34°46'S 150°44'E). *D* provides an example of where timbal-derived syllables (as shown in *C*) have been replaced with timed wing-snaps. All recordings were obtained in the field by LWP using RS1 *(A* and *E)*, RS4 *(B)*, or RS2 *(C* and *D)* (see *Methods and terminology*).

the macrosyllable (0.123–0.240 s duration). It is considered likely that *C. adelaida* also produces a dusk call even though this has not yet been observed or recorded. The function of the dusk calling songs remains unclear, although the repetitive broadcasting of notes could effectively be interpreted as a simplified version of the day calling song. Therefore, it is likely to plays some role in attracting females from the surrounding habitat.

The three species exhibit similar highest amplitude frequency plateaus in their calling songs (Fig. 15). Based on the available recordings, *C. adelaida* has a plateau spanning from 8.8–11.7 kHz (dominant frequency between 10.4 and 11.6 kHz), *C. autumna* sp. nov. has a slightly higher plateau ranging from 9.0–13.6 kHz (dominant frequency between 9.8 and 12.1 kHz) and *C. semilunata* sp. nov. has a plateau of 8.3–12.3 (dominant frequency between 8.9 and 12.2

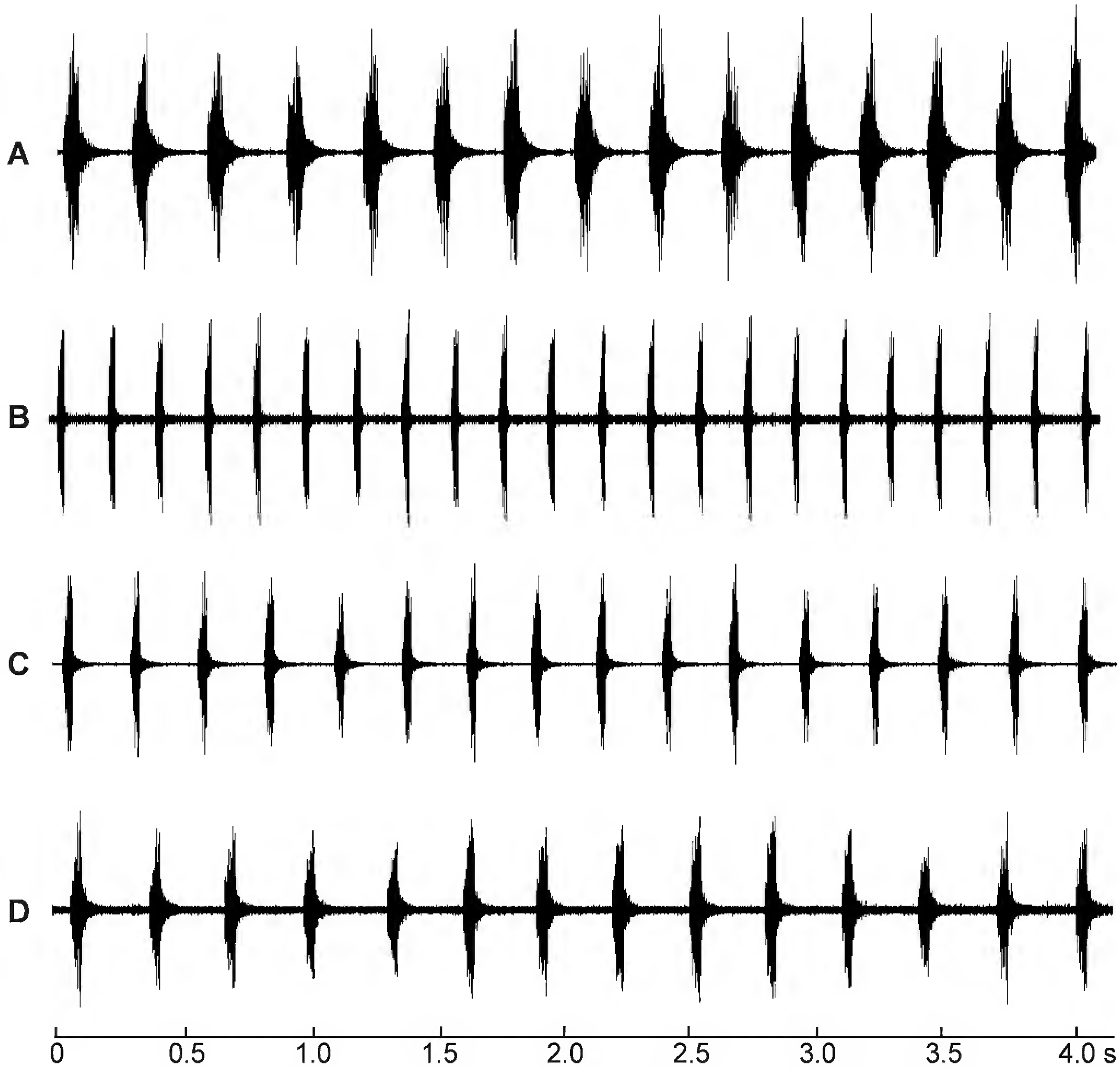

Figure 12. Wave plots illustrating the structure of the simple part of the male calling song of *Clinopsalta autumna* sp. nov. from *(A)* Berry, New South Wales (34°46'S 150°44'E), *(B)* Spicers Gap, Queensland (28°05'S 152°25'E), *(C)* Rosewood, Queensland (27°37'S 152°37'E), and *(D)* Bauple, Queensland (25°48'S 152°35'E). All recordings were obtained in the field by LWP RS1 *(A)*, RS5 *(B)* or RS2 *(C* and *D)* (see *Methods and terminology*).

kHz). None of these species exhibits frequency modulations between the day and dusk calling songs or within the different sections of the more complicated day calling songs.

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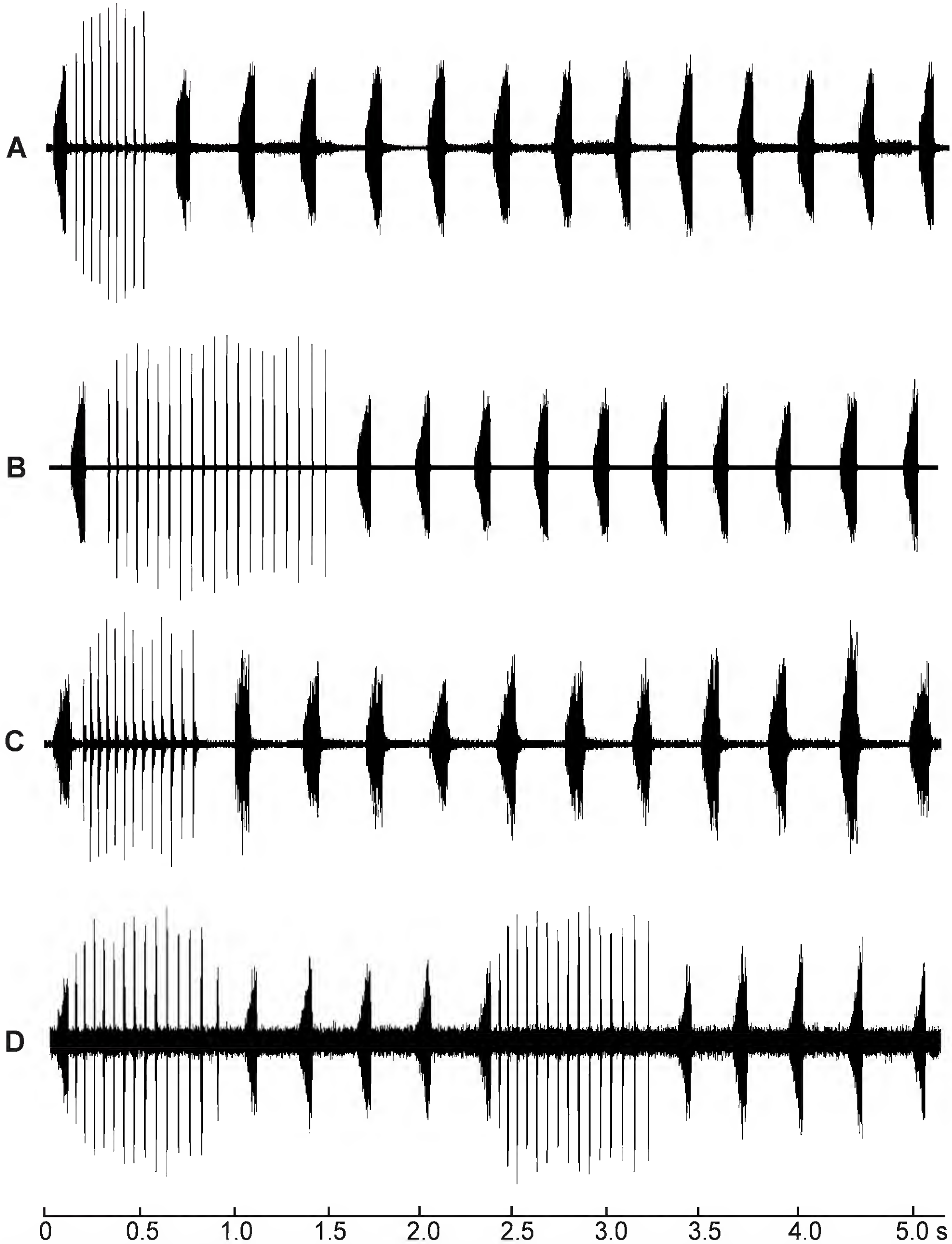

Figure 13. Wave plots illustrating the male calling song of *Clinopsalta semilunata* sp. nov. Each plot shows a separate recording, with a brief introductory echeme and syllable sequence, followed by a series of repeated echemes. Recordings are from *(A)* Pratten (28°05'S 151°44'E), *(B)* Yelarbon State Forest (28°32'S 151°06'E), *(C)* Binjour Plateau (25°32'S 151°30'E), and *(D)* Chinchilla (26°39'S 150°35'E), all in Queensland. All recordings were obtained in the field by LWP using RS2 *(A)*, RS3 *(B)* or RS1 *(C);* or by A. Ewart using RS5 *(D)* (see *Methods and terminology*).

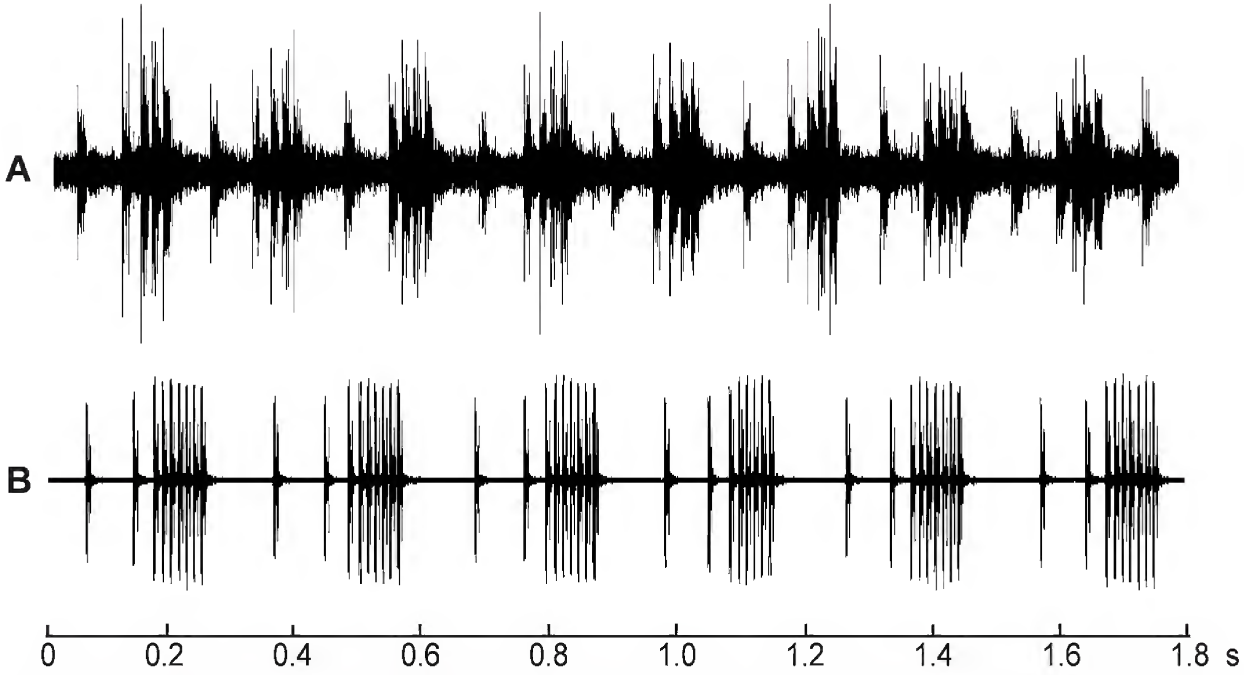

Figure 14. Wave plots illustrating the repeated phrase structure of the male dusk calling song of *Clinopsalta* cicadas, including *(A) C. autumna* sp. nov. from Cunningham's Gap, Queensland (28°03'S 152°22'E), and *(B) C. semilunata* sp. nov. from Yelarbon State Forest, Queensland (28°32'S 151°06'E). Both recording were obtained in the field by LWP using RS1 *(A)*, or RS2 *(B)* (see *Methods and Terminology*).

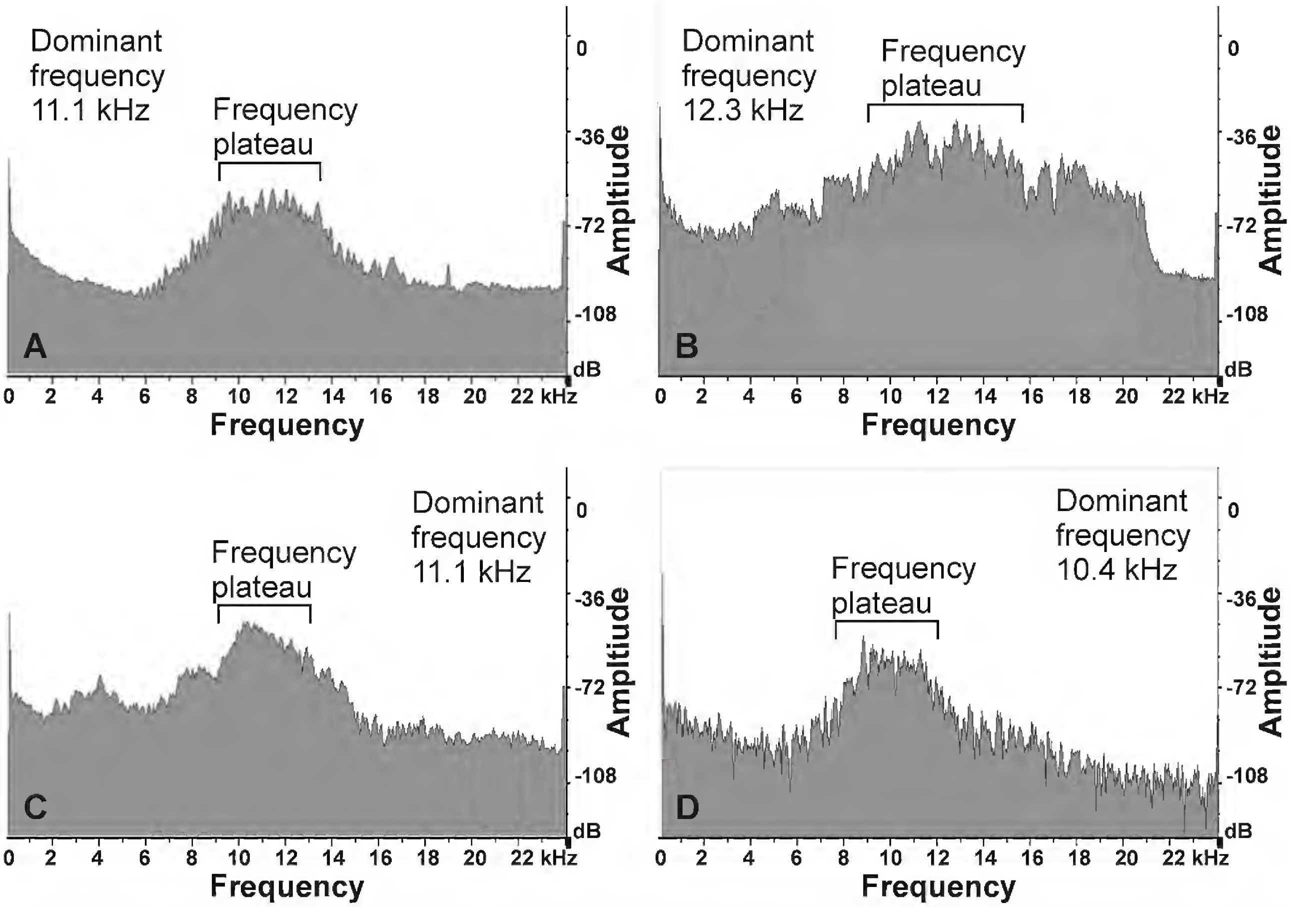

Figure 15. Frequency spectra comparisons between *Clinopsalta* cicadas, including *(A) C. adelaida* (from Wyalong, NSW 33°55'S 147°14'E), *(B) C. autumna* sp. nov. (from Bargo, New South Wales: 34°17'S 150°35'E), *(C) C. autumna* sp. nov. (from Redwood Park, Queensland: 27°34'S 152°00'E) and *(D) C. semilunata* sp. nov. (from Pratten, Queensland: 28°05'S 151°44'E). The horizontal bars show the ranges of each highest amplitude frequency plateau (bounded by the 90th percentile of each amplitude spectrum). Recordings were obtained using RS4 *(A)*, RS1 *(B* and *C)* or RS2 *(D)* (see *Methods and terminology*).

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Supplementary audio data

Audio recordings (WAV files) of the following three species are available (Popple, 2017): *Clinopsalta adelaida* (from Telowie Gorge, Wyalong, and Bauple); *C. autumna* sp. nov. (from Berry, Cunningham Gap at dusk, Rosewood and Spicers Gap); and *C. semilunata* sp. nov. (from Binjour Plateau, Chinchilla, Pratten, Yelarbon and Yelarbon at dusk).

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Anaspidesidae, a new family for syncarid crustaceans formerly placed in Anaspididae Thomson, 1893

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Abstract. The anaspidacean syncarid shrimps of the genera *Anaspides* Thomson, 1894, *Allanaspides* Swain, Wilson, Hickman & Ong, 1970, and *Paranaspides* Smith, 1908, have long been placed in the family Anaspididae Thomson, 1893. Anaspididae Thomson, 1893, however, was formed on a homonymous type genus, *Anaspis* Thomson, 1893, preoccupied by *Anaspis* Geoffroy, 1762 (Insecta: Coleoptera), and is therefore invalid. Anaspididae is also a junior homonym of Anaspidinae Mulsant, 1856 (Coleoptera), and is likewise invalid. There being no synonyms available in place of Anaspididae, we establish a new family, Anaspidesidae, to accommodate taxa previously placed in Anaspididae.

Keywords. Crustacea; Anaspidacea; Anaspididae; Anaspidinae; Tasmania; freshwater; nomenclature.

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The endemic freshwater Tasmanian shrimps of the family Anaspididae Thomson, 1893, are best known from the iconic *Anaspides tasmaniae* (Thomson, 1893), often thought of as a "living fossil" (Ahyong, 2016). *Anaspides* Thomson, 1894 was initially thought to reside among the now defunct Schizopoda, in proximity to mysidaceans (Thomson, 1893, 1894). Calman (1897, 1904), however, recognized the syncarid affinities of *Anaspides*, for which he erected the order Anaspidacea Calman, 1904.

Thomson (1893) originally described *Anaspis tasmaniae* in a new genus, *Anaspis*, and a new family, Anaspidae. Unfortunately, *Anaspis* Thomson,1893, being preoccupied by *Anaspis* Geoffroy, 1762 (Insecta: Coleoptera), rendered Thomson's new genus name invalid. Likewise, the name Anaspidae Thomson, 1893, is also invalid, having been formed on a homonymous type genus (Article 39, International Code of Zoological Nomenclature; hereafter, the Code, ICZN, 1999) and being at the same time a homonym of Anaspidinae Mulsant, 1856 (based on *Anaspis* Geoffroy, 1762). On advice from T. R. R. Stebbing, Thomson (1894: 38) proposed a replacement genus name, selecting *Anaspides* "so that the name of the new order may not have to be changed". Thomson (1894) was incorrect in retaining the spelling Anaspidae, corrected by subsequent authors (Smith, 1908) to Anaspididae, the family-group name now in use for more than a century for Thomson's taxon. Although Thomson (1894) replaced *Anaspis* Thomson, 1893, with *Anaspides*, he did not act to create a new family in place of

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his invalid Anaspidae, nor can it be inferred that it was his intention. Therefore, Thomson's invalid Anaspidae (and its corrected spelling Anaspididae) dates to 1893, rather than 1894 as assumed by some sources. Being preoccupied by Anaspidinae Mulsant, Anaspididae Thomson is invalid and no family-group synonyms are available to take its place. Therefore, a new family, Anaspidesidae, is proposed herein to accommodate taxa previously placed in Anaspididae Thomson. Following Recommendation 29A of the Code (ICZN, 1999), the new family takes the full name of its type genus, *Anaspides*, as its stem.

Taxonomy

Anaspidesidae fam. nov.

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Diagnosis. Rostrum broadly triangular. Cephalon and pereonite 1 fused; cervical groove distinct. Pereonites 2–8 shorter than pleonites; terga smooth. Pleonites with smooth terga; pleonite 6 unarmed or with short spines along posterior margin. Telson longitudinally subquadrate to subtriangular, dorsoventrally flattened, apex bluntly angular to subtruncate. Eyes pedunculate. Antenna 2 with lamellar scaphocerite. Mandible with palp. Thoracopod 1 forming maxilliped; exopod liguliform; epipods present or absent. Thoracopods 2–7 endopod similar; 2 epipods; exopods 2–6 slender, flagellum multiannulate; exopod 7 simple, lamellate or absent. Thoracopod 8 without exopod or epipods. Pleopods 1–5 exopod multiannulate. Pleopods 1–2 endopod modified as gonopods in males. Pleopods 3–5 endopod reduced or absent, simple. Uropodal rami lamellar, exopod with weak, partial diaeresis. Uropods lamellar, forming tailfan with telson.

Type genus. *Anaspides* Thomson, 1894.

Composition. *Anaspides* Thomson, 1894: *A. clarkei* Ahyong, 2015; *A. eberhardi* Ahyong, 2016; *A. jarmani* Ahyong, 2015; *A. richardsoni* Ahyong, 2016; *A. spinulae* Williams, 1965; *A. swaini* Ahyong, 2015; *A. tasmaniae* (Thomson, 1893).

Allanaspides Swain, Wilson, Hickman & Ong, 1970: *Al. helonomus* Swain, Wilson, Hickman & Ong, 1970; *Al. hickmani* Swain, Wilson & Ong, 1971.

Paranaspides Smith, 1908: *P. lacustris* Smith, 1908; *P. williamsi* Ahyong, Schwentner & Richter, 2017.

Remarks. Eleven species in three genera are recognized in Anaspidesidae fam. nov., all endemic to Tasmania, Australia (Ahyong, 2016; Ahyong *et al*., 2017). Although the taxonomic position and composition of the new family is congruent with that of Thomson's Anaspididae, we take the opportunity to update contemporary diagnoses applicable to Anaspidesidae (e.g., Lake *et al*., 2002; Coineau & Camacho, 2013, as Anaspididae). Namely, in anaspidesids, the telson is distally truncate to bluntly angular (rather than pointed or spinular), the maxillipedal exopod is flattened (instead of tubular), and the maxilliped is not clearly eight-segmented, with the demarcation between the proximal two articles usually scarcely discernable.

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The Tasmanian Lake Shrimps, *Paranaspides* Smith, 1908 (Crustacea, Syncarida, Anaspidesidae)

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Abstract. The Tasmanian Lake Shrimps of the genus *Paranaspides* Smith, 1908 (Syncarida: Anaspidesidae) are endemic to lakes on the eastern Central Plateau, Tasmania, namely Great Lake, Shannon Lagoon, Penstock Lagoon, Arthurs Lake and Woods Lake. Prior to the present study, only the type species, *P. lacustris* Smith, 1908, was recognized. Reconsideration of *Paranaspides* from throughout its range, however, showed that *Paranaspides* from Arthurs Lake and Woods Lakes are referrable to a new species, *P. williamsi* sp. nov. Morphometric differences in the uropodal exopod and maxilliped, and subtle differences in the morphology of the male pleopods 1 and 2, and colour-in-life distinguish the two species. Genetic divergence (*p*-distance) between the two species exceeds 10% in mitochondrial COI and 3% in 16S. Both species are described and illustrated, and a lectotype fixed for *P. lacustris*. Although *P. lacustris* and *P. williamsi* occur in relatively close proximity, they occupy different drainages. The Great Lake-Shannon Lagoon-Penstock Lagoon system drains to the southeast, and the Arthurs Lake-Woods Lake system to the northeast. The distributions of *P. lacustris* and *P. williamsi* precisely parallel those of a cognate pair of galaxiid fishes, *Paragalaxias eleotroides* and *Paragalaxias mesotes*. Given the geological history of the Central Plateau and molecular divergence estimates for *Paragalaxias*, *Paranaspides* may also have diverged prior to the Pleistocene glaciations. Species of *Paranaspides* are dependent on their shallow water algal bed habitat, making them highly susceptible to sudden or significant fluctuations in lake water levels as a result of hydroelectric operations. Both species of *Paranaspides* have small areas of occupancy and are prone to the effects of hydroelectric activities on their lake habitats; under IUCN Red List criteria, their conservation status corresponds to Vulnerable (D2).

Keywords. Crustacea; Anaspidacea; *Paranaspides*; Tasmania; freshwater; shrimp.

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The Tasmanian syncarid shrimp family Anaspidesidae comprises three genera: *Anaspides* Thomson, 1894, *Paranaspides* Smith, 1908, and *Allanaspides* Swain, Wilson, Hickman & Ong, 1970. Although these genera were formerly placed in Anaspididae Thomson, 1893, Ahyong & Alonso-Zarazaga (2017) showed Thomson's family name to be preoccupied, warranting creation of the new family, Anaspidesidae. Anaspidesids are notable for their sometimes relatively large size and usual occupation of epigean habitats; though some are subterranean or pholeteric, none are interstitial like most other extant syncarids. As a result, they show little structural reduction and have a near complete complement of appendages and associated rami. Anaspidesid taxonomy has received little attention since the 1970s. Ahyong (2015, 2016) recently revised *Anaspides*, and *Paranaspides* is treated herein.

The type species of *Paranaspides*, *P. lacustris* Smith, 1908, was described from Great Lake on the eastern part of the Tasmanian Central Plateau, hence its common name, the Great Lake Shrimp. *Paranaspides lacustris* was subsequently discovered in neighbouring Shannon and Penstock Lagoons at the south end of the lake (Evans, 1942, Nicholls, 1947), and later reported from Arthurs and Woods Lakes (Fulton, 1982, 1983). Reconsideration of *Paranaspides* from throughout its range based on morphological and molecular data shows that populations from Arthurs and Woods Lakes represent an undescribed species. The new species is formally described, and *P. lacustris* redescribed and figured based on type and topotypic material.

Materials and methods

Morphological terminology follows Ahyong (2016). The two species of *Paranaspides* are very similar, sharing most morphological features. Therefore, a diagnosis and extended description are given at genus level, and a shorter description provided for each species. Measurements of specimens are of total body length, measured from the apex of the rostrum to the tip of the telson. Abbreviations: above sea-level (asl); indeterminate (indet); juvenile (juv.). Specimens are deposited in the collections of the Australian Museum, Sydney *(AM)*; Museum Victoria, Melbourne *(NMV)*; Oxford University Museum of Natural History *(OUMNH)*; Queen Victoria Museum and Art Gallery, Launceston *(QVM)*; Tasmanian Museum and Art Gallery, Hobart *(TMAG)*; National Museum of Natural History, Smithsonian Institution, Washington DC *(USNM)*; Western Australian Museum *(WAM)*; and Zoological Collection, Universität Rostock *(ZSRO)*.

To assess inter- and intraspecific genetic variation between the two species, mitochondrial cytochrome oxidase subunit I (COI) and 16S ribosomal RNA (16S) markers were sequenced for selected series of mostly freshly collected individuals from Great Lake (Swan Bay, 3 specimens; Tods Corner, 4 specimens) and Arthurs Lake (11 specimens). Sequenced specimens are deposited in the ZSRO (*P. lacustris*: ZSRO CR21–22); *P. williamsi*: ZRSO CR23, ZSRO CR392). DNA was extracted either following the HotSHOT protocol (modified after Montero-Pau *et al.*, 2008; Schwentner *et al.*, 2014) with a final volume of 60 µl or the DNeasy Blood and Tissue kit (Qiagen), following the manufacturer's instructions. The PCR reactions had a total volume of 30 µl and contained 3 µl of each primer (each 10 µM), 3 µl 10× Buffer (Molzym), 3 µl dNTP mix (2 mM, Fermentas), 1.05 µl $MgCl_2$ (50 mM), 0.15 µl MolTaq polymerase (Molzym), 12.3 µl ultrapure water and 4.5 µl of the DNA extract. COI primers were LCO2 (5' TCN ACH AAY CAT AAA GAY ATT GGA AC 3') (Schwentner *et al.*, 2011) and HCO2198 (5' TAA ACT TCA GGG TGA CCA AAA AAT CA 3') (Folmer *et al.*, 1994) and 16S primers were 16Sa (5' CGC CTG TTT ATC AAA AAC AT 3') (Xiong & Kocher, 1991) and 16sb (5' CTC CGG TTT GAA CTC AGA TCA 3') (Xiong & Kocher, 1991). PCR amplifications programs comprised an initial denaturation step at 95°C for 4 min, followed by 40 amplification cycles of 95°C for 30 s, 48°C for 30 s, 72°C for 1:30 min and a finial elongation step at 72°C for 5 min. PCR products were visualized by gel electrophoresis, using 5 µl of the PCR product on a 1.5% agarose/TAE gel stained with 0.01% ethidium bromide. PCR products were cleaned with paramagnetic beads (Agencourt AMPure XP, Beckman Coulter) following the manufacturer's instructions with a final volume of 30 µl. Sequencing reactions were performed with the Big Dye Terminator Cycle Sequencing Kit (Applied Biosystems) using PCR primers. Sequencing with the respective forward and reverse primers was conducted on an ABI 3110 xl (Applied Biosystems). The resulting chromatograms were checked and adjusted with Geneious 8.1.4 (Biomatters Limited) or Bioedit (Hall, 1999); new sequences are deposited in GenBank. The only available 16S *Paranaspides* sequence on GenBank derived from a specimen from Shannon Lagoon (accession number AF133682; Jarman & Elliot, 2000) was included in the subsequent genetic distance analysis. All sequences were aligned with ClustalW (Thompson *et al.*, 1994) implemented in Bioedit and uncorrected *p*-distances were calculated in MEGA7 (Kumar *et al.*, 2015).

Results

Molecular data

Thirty-six new sequences were generated from 12 specimens of *P. williamsi* from Arthurs Lake (COI: KX923369, KX923370, KX923380–923383, MF158850–158852, MF593633, MF593634; 16S: KX923497, KX923498, KX923511–923515, MF158858–158860) and seven specimens of *P. lacustris* from Swan Bay, Great Lake (3 specimens; COI: MF158844–158846; 16S: MF158853) and Tods Corner, Great Lake (5 specimens; COI: MF158847–158849, MF593631, MF593632; 16S: MF158854–158857). Sequence alignment was unambiguous; the COI alignment was free of stop-codons. Maximum intraspecific uncorrected *p*-distances were 1.5% for COI and 0.2% for 16S, while interspecific distances were 10.4–11.8% for COI and 3.2–3.7% for 16S. All three studied populations of *P. lacustris* had identical 16S sequences, including the specimen sequenced by Jarman & Elliott (2000) from Shannon Lagoon. This pattern of genetic distances supports the delimitation of these two species and does not suggest further cryptic species within the genetically studied populations.

Systematics

Syncarida Packard, 1885

Anaspidacea Calman, 1904

Anaspidesidae Ahyong & Alonso-Zarazaga, 2017

Paranaspides Smith, 1908

Paranaspides Smith, 1908: 470 (type species: *Paranaspides lacustris,* 1908, by monotypy).

Diagnosis. Rostrum prominent, well-developed. Cephalothorax without *fenestra dorsalis*. Body subcylindrical in cross-section, with prominent obtusely angled flexure at pleonite 1, appearing obtusely bent in lateral view. Free pereonites length subequal, shorter than pleonites. Pleonites 1–5 lower midlateral surface with vertical or near vertical row of minute spines; pleonite 6 lower mid-lateral surface with arcuate row of prominent spines. Pleonite 6 longer than twice length of pleonite 5. Telson dorsoventrally compressed; longer than wide, subquadrate; posterior margin and posterior half of lateral margin spinose. Antennal peduncles unarmed. Scaphocerite with lateral spine. Thoracopod 1 (maxilliped) with epipods. Thoracopod 7 with exopod. Uropodal endopod about two-thirds length of exopod; exopod with row of fixed spines proximal to diaraesis.

Description. Body subcylindrical in cross-section; prominent, obtuse flexure at pleonite 1. Rostrum triangular, apex blunt, slightly deflexed ventrally; few distal setae, arising submarginally. Head (cephalothorax) comprising fused cephalon and pereonite 1; cervical groove distinct; dorsal organ present on dorsal midline anterior to cervical groove; midlateral surface posterior to cervical groove with shallow diagonal groove. Pereonites 2–8 length slightly increasing posteriorly, subparallel, shorter than pleonites. Female gonopore (spermatheca) on pereonite 8 sternum between coxae; bulbous, directed anteriorly, anterior surface with genital orifice as narrow transverse slit.

Pleonite 1 enlarged, wedge-shaped in lateral view, dorsal margin rounded, forming prominent, obtuse flexure; longer than pleonite 2. Pleonites 2–5 length subequal; subparallel, dorsal margin straight. Pleonites 1–5 lower lateral tergal surface with vertical row of minute, close-set spines. Pleura 1–5 rounded; pleuron 1 margin unarmed, those of 2–5 posteriorly multispinose. Pleonites 1–2 upper posterior tergal margins unarmed, of pleonites 3–5 multispinose. Pleonite 6 longer than twice length of pleonite 5; lower midlateral surface of integument with arcuate row of prominent, well-spaced posteriorly directed spines, extending from slightly below mid-height almost to ventral surface; upper posterior margin multispinose; posterolateral angle spinose; posteroventral angle anterior to uropod articulation multispinose. Pleonal sternites 3–5 with low, broadly curved to truncate median processes between pleopod bases.

Telson elongate, subquadrate, dorsoventrally compressed, with low, broad median prominence proximally; posterior margin truncate to slightly concave; posterior margin and posterior half of lateral margins prominently spinose, lengths uneven.

Eyes pedunculate; cornea well-developed, rounded, distinctly wider than peduncle, dorsoventrally compressed; peduncle slightly longer than cornea, distally divergent.

Antennular peduncle 3-articulate, unarmed, dorsoventrally compressed; article 1 with statocyst, longer than article 2; article 2 longer than article 3, with rounded distomesial lappet; biflagellate, mesial (= accessory) flagellum shorter than lateral, similar in both sexes.

Antenna uniflagellate, flagellum slightly shorter than lateral antennular flagellum; protopod 2-articulate, coxa with splayed row of spines on lateral margin, basis with 2 lateral spines; exopod (scaphocerite) laminar, longer than wide, subovate, reaching end of antennular peduncle, distinct lateral spine, mesial and distal margin setose to base of lateral spine; endopod peduncle 2-articulate, unarmed, proximal article longer than distal article.

Labrum with shallow proximal constriction; distal margin slightly concave, finely setose.

Mandibular corpus (apophysis) robust; molar process and incisor process well-developed; molar with elongate, ovate, triturating surface, surrounded by spiniform setae; incisor process diagonal to axis of mandibular corpus. Left incisor process with 8 triangular teeth in sinuous row, proximal tooth largest; proximally with spine row between proximal incisor tooth and molar process. Right incisor process similar to left except with 6 triangular teeth, proximalmost tooth usually apically bifid, widely separated from adjacent tooth. Palp 3-articulate, setose, article 1 short, subquadrate, with 2 setae, article 2 slender, longer than articles 1 and 3.

Paragnaths widely separated by deep V-shaped incision, without lobes, distal half finely setose, especially mesially.

Maxillule with 2 endites; proximal endite distally setose; distal endite spinose distally, lateral surface with small conical palp.

Maxilla with 4 endites, proximal 2 endites with plumose setae, distal 2 endites densely arrayed with serrulate setae.

Thoracopods 1–8 protopod with coxa, basis, preischium, ischium, merus, carpus, propodus and dactylus; flexure at carpus-merus articulation.

Thoracopod 1 (maxilliped) coxa mesial margin with setose coxal endites, lateral margin with 2 lamellar epipods, proximal wider than distal; basis with slender, flattened, liguliform exopod; coxa-basis demarcation often ill-defined; preischium rectangular, more than quadruple length of quadrate ischium, expanded mesially, projecting beyond mesial margin of ischium; merus slightly tapering distally, distinctly longer than ischium; carpus triangular, longer than high, half length of merus; propodus slender, as long as merus; dactylus short, terminating in slender claw, with 2 slender movable spines on either side.

Thoracopods 2–8 (pereopods) as ambulatory legs. Thoracopods 2–6 structurally similar, distal 4 articles with tufts of setae, primarily along flexor margins, dactylus strongly setose; thoracopods 4–5 longest; coxa lateral margin with 2 ovate, lamelliform epipods, proximal epipod more pointed distally than distal epipod; coxa mesial margin in adult females with setose endite; basis short, partially fused with preischium; exopod articulating with lateral margin of basis, with elongate basal article and setose multi-annulate flagellum; ischium about as long as basis-preischium; merus elongate, slightly tapering distally, about twice ischium length; carpus triangular, longer than high, about half merus length or slightly less; propodus elongate, slender, shorter than merus; dactylus short, terminating in long, slender claw, with slender movable spine on lateral side, 2 movable spines on mesial side. Thoracopod 7 similar to thoracopods 2–6 except epipods proportionally more slender; exopod a single narrow lamella; dactylus with movable spine on either side. Thoracopod 8 structurally similar to preceding thoracopods but lacking epipods or exopod; basis and preischium indistinguishably fused; longer than thoracopod 7; dactylus with movable spine on either side.

Pleopods 1–5 exopod long, slender, setose, multi-annulate. Pleopods 1–2 endopod always present; unmodified endopod ovate, lamellar, short, length subequal to first exopod annulation in females and juvenile males; endopod always present on pleopods 3, present or absent on pleopods 4–5; adult male pleopods 1–2 endopod modified as copulatory structures (petasma). Adult male pleopod 1 elongate, directed anteriorly, reaching beyond thoracopod 8 coxa; slender proximally, expanded distally, hollowed mesially, deepest near midlength; distally bluntly rounded to subtruncate, lateral margin thin, lamellate; dorsomesial margin with short row of retinacula near midlength and distally; proximo-mesial surface with long scattered setae and spinules; midventral margin bluntly triangular, incurved mesially; left and right pleopods united by retinacula, together forming scoop-like structure. Male pleopod 2 endopod of 2 articles, slightly longer than pleopod 1, directed anteriorly, reaching to thoracopod 8 coxa; proximal article slightly longer than distal article, mesial proximal margin with row of retinacula; distal article straight, mesially hollowed, with short scattered spinules, apex blunt.

Uropods forming tail-fan with telson. Uropodal exopod elongate, spatulate, distolateral spine row of fixed graded spines; indistinct, partial diaeresis extending from base of distalmost spine; spine row preceded by straight margin; mesial margin and lateral margin distal to spine row setose. Uropodal endopod distinctly shorter than exopod, reaching to distal two-thirds of exopod; mesial margin to distal half of lateral margin setose.

Remarks. *Paranaspides* is readily distinguished from *Anaspides* and *Allanspides* by the distinct flexure at pleonite 1, the presence of a vertical row of minute spines on the lower midlateral surface of pleonites 1–5, an arcuate row of prominent spines on the midlateral surface of pleonite 6, a spinose basal antennal article, a more pronounced distomesial lobe on the maxilliped ischium, absence of sexually dimorphic antennules, a proportionally larger, more elongate scaphocerite, presence of the triangular ventromesial lobe of the male pleopod 1 endopod, a rectangular versus polygonal or linguiform telson, and more elongate uropods. In other respects, *Anaspides* and *Paranaspides* closely agree. Note that Ahyong (2016) inadvertently described *Anaspides* as having a 3-articulate antennal protopod; both *Anaspides* and *Paranaspides* have only two free protopod articles. Like *Anaspides*, *Paranaspides* further differs from *Allanaspides* by lacking the *fenestra dorsalis* on the cephalothorax.

When first described, *Paranaspides* immediately attracted controversy with its apparent possession of a biramous mandibular palp, a feature otherwise unknown in malacostracans (Smith 1908, 1909b; Hansen, 1925). Gordon (1961), however, showed Smith's mandibular observations to be based on an aberrant specimen; the palp of *P. lacustris* is uniramous and 3-articulate as in *Anaspides*. Phylogenetic analyses indicate a close relationship between *Anaspides* and *Paranaspides*, as sister groups or with the latter possibly even nested within the former (Jarman & Elliott, 2000).

Species of *Paranaspides* differ ecologically from those of *Anaspides* and *Allanaspides*, which are epibenthic and pholeteric, respectively. Instead, species of *Paranaspides* are frequently natatory and occur only in association with aquatic vegetation, amongst and above which they freely swim. Some morphological differences between *Paranaspides* and other anaspidesid genera, such as the enlarged scaphocerite and more elongated uropods may relate to the primarily pelagic or natatory rather than benthic habits of other anaspidesids.

Subsequent to Smith's (1908, 1909b) accounts of *Paranaspides lacustris*, other studies have examined pleonal musculature (Daniel, 1931), functional morphology and excretion (Cannon & Manton, 1929; Manton, 1930, 1931), internal reproductive organs and the alimentary canal (Nicholls & Spargo, 1932), ommatidial structure (Richter, 1999) and cuticular sclerites (Kutschera *et al.*, 2015).

Paranaspides lacustris Smith, 1908

Figs 1–4, 9A, 10

Paranaspides lacustris Smith, 1908: 470–471, fig. 3–6; 1909a: 63, 71; 1909b: 492, 497, 506, 560–562, fig. 1, 4, 8, 10, 13, 16, 19, 22, 24–29, 49, pl. 11: fig. 2. —Manton, 1930, pl. 1. —Nicholls & Spargo, 1932: 153–155. —Nicholls, 1947: 9, 14. —Riek, 1959: 251. —Gordon, 1961: 214–221, fig. 1–5. —Williams, 1965: 95, 96, 99–105, 122, 123, 125, tab. 5. —Mayrat, 1966: 1542. —Hewer, 1967: 1. —Goede, 1967: 83. —Swain *et al.*, 1970: 6. —Lake & Knott, 1973: 96. —Williams, 1974: 80, tab. 4.1. —Knott, 1975: 157, 177, 183, 184. —Silvey, 1980: 72. —Fulton, 1982: 23–25, fig. 1, 2 [Great Lake, Shannon Lagoon, Penstock Lagoon only]; 1983: tab. 1 [Great Lake]. —Wells *et al.*, 1983: xliii, 275, 277, 278. —Schram, 1984: 191. —Schram & Hessler, 1984: 194. —Michaelis, 1985: 6. —Zeidler, 1985: 75. —Campbell *et al.*, 1986: 92. —Davies & Fulton, 1987: 2, 3, 4 (unnumbered fig.), 9. —Horwitz, 1990: 65–67. —Jarman & Elliott, 2000: 625, 626, 631, 632, fig. 1, tab. 1, 2. —Ovenden *et al.*, 1993: 227. —Richter, 1999: 171, fig. 20. —Lake *et al.* 2002: 12. —Camacho *et al.*, 2002: tab. 1, fig. 1. —Serov, 2002: 8, 15, 16, fig. 46. —Bonham, 2006: 3. —Camacho, 2006: 6. —Driessen & Mallick, 2007: 1173. —Schram, 2008: 131. —Boxshall & Jaume, 2009: 245. —Coineau & Camacho, 2013: 377, 436, figs 50.6C, 50.8A, 50.11A, 50.19A–C, 50.24, 50.33. —Kutschera *et al.*, 2015: 3–4, 17, 24, figs 1N, 3C–E, tab. 3, 4. —Richards *et al.*, 2015: 61, 62, tab. 1. —Ahyong, 2016: 316.

Lectotype: AM P100400, male (11 mm), Great Lake, coll. G. W. Smith, 1907–1908. **Paralectotypes**: OUMNH 5403, 1♂ (11 mm), 12 juvenile ♂♂ (6–10 mm), 1♀ (TL 11 mm), 11 juvenile ♀♀ (6–10 mm), 1 partial cephalothorax, Great Lake, coll. G. W. Smith, 1907–1908; AM P100401, 1♀ (11 mm), Great Lake, coll. G. W. Smith, 1907–1908.

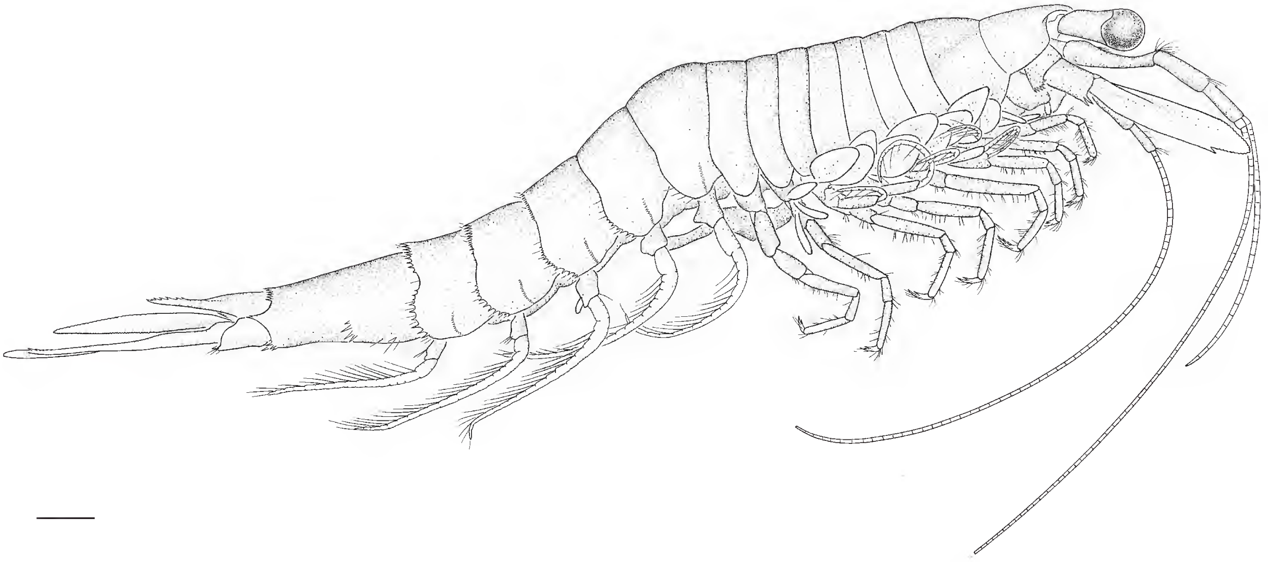

Figure 1. *Paranaspides lacustris* Smith, 1908, male (17 mm), Swan Bay, Great Lake, QVM 10:49151, right habitus. Scale = 1.0 mm.

Other material examined. *Great Lake*: QVM 10:8080, 4♂♂ (12–13 mm), Great Lake, coll. Evans, 1939; USNM 29140, 1♂ (15 mm), Great Lake, coll. F. R. Schram, 26 May 1980; USNM 60112, 2♂♂ (13–15 mm), 4♀♀ (12–18 mm), Great Lake, coll. W. M. Tattersall, 1914; AM P8766, 2♂♂ (14–15 mm), 1♀ (16 mm), Great Lake, pres. J. J. Flynn; AM P56372, 1♂ (15 mm), 1♀ (20 mm), 1 juvenile ♀ (10 mm), Great Lake, #327, coll. J. W. Evans; WAM C58159, 11♂♂ (12–14 mm), 46 juvenile ♂♂ (9–11 mm), 2♀♀ (13 mm), 102 juvenile ♀♀ (9–13 mm), N end Great Lake, dredged near old shore line, coll. G. Nicholls, 25 Jan 1947; WAM C58163, 2♂♂ (11–12 mm), Great Lake, coll. G. Nicholls; WAM C11776, 1♀ (11 mm), NW corner Great Lake, coll. "H.D.", 1 Feb 1945; WAM C11777, 1♂ (11 mm), Brandum Bay [41°48.0'S 146°41.0'E], coll. G. Nicholls, 26 Jan 1947; WAM C11795, 1♂ (11 mm), 1♀ (11 mm), Brownie Bay, Brandum Bay [41°49.84'S 146°41.09'E], coll. G. Nicholls, 26 Jan 1947; WAM C11779, 1♂ (18 mm), 3♀♀ (17–22 mm), N end Breona [41°47'S 146°42'E], near old shore line, coll. G. Nicholls, 25 Jan 1947; WAM C11778, 4 juvenile ♂♂ (10–11 mm), 1♀ (22 mm), 10 juvenile ♀ (9–11 mm), Brownie Bay [41°49.84'S 146°41.09'E], dredged, 12–15 feet, coll. G. Nicholls, 26 Jan 1947; QVM 10:49146, 1♀ (6 mm), Brandum Bay [41°48.0'S 146°41.0'E], level 2, coll. W. Fulton, 4 Dec 1976; QVM 10:49147, 1♂ (13 mm), Brandum Bay [41°48.0'S 146°41.0'E], level 2, coll. W. Fulton, 31 Mar 1975; QVM 10:49148, 1♂ (17 mm), Brandum Bay, level 2, [41°48.0'S 146°41.0'E], coll. W. Fulton, 2 Jun 1975; QVM 10:49149, 1♀ (c. 8 mm, poor condition), Brandum Bay, level 2, [41°48.0'S 146°41.0'E], coll. W. Fulton, 27 Jan 1975; WAM C58155, 1♂ (10 mm), 1 juvenile ♀ (9 mm), Beckett Bay, S end of Great Lake [41°58.06'S146°44.80'E], 1933; QVM 10:49150, 2♂♂ (14–17 mm), Swan Bay [41°58.43'S 146°41.56'E], level 2, coll. W. Fulton, 31 Mar 1975; QVM 10:49151, 1♂ (17 mm), 1♀ (21 mm), Swan Bay [41°58.28'S 146°41.55'E], from weed on anchor (*Chara* sp.), 30 ft, coll. W. Fulton, 7 Nov 1975; AM P100405, 2♀♀ (16–20 mm), Swan Bay, #2, from *Nitella* bed, 6.3–6.7 m, 41°56'16"S 146°41'12"E, on SCUBA, coll. M. Reinhardt & C. Hoepel, 8 March 2017; ZSRO CR20, 2♀♀ (16–17 mm), Swan Bay, #2, from *Nitella* bed, 6.3–6.7 m, 41°56'16"S 146°41'12"E, on SCUBA, coll. M. Reinhardt & C. Hoepel, 8 March 2017; AM P100406, 2♀♀ (13–16 mm), Swan Bay, #3, from *Nitella* & *Chara* bed, 7.0–7.3 m, 41°59'14"S 146°41'16"E, on SCUBA, 8 March 2017; ZSRO CR21, 3♀♀, Swan Bay, #3, from *Nitella* & *Chara* bed, 7.0–7.3 m, 41°59'14"S 146°41'16"E, on SCUBA, 8 March 2017; AM P100408, 2♂♂ (14–15 mm), 1♀ (15 mm), Tods Corner, #1, off northeastern shore, 41°57'24"S 146°47'18"E, 6.3–7 m, sparse *Chara* beds, 11 March 2017; AM P100410, 1♀ (18 mm), Tods Corner, #2, off western shore, 41°57'30"S 146°47'02"E, 3–4 m, dense *Chara* beds, 11 March 2017; AM P100411, 2♂♂ (15 mm), 5♀♀ (14–17 mm), Tods Corner, #2, off western shore, 41°57'30"S 146°47'02"E, 3–4 m, dense *Chara* beds, 11 March 2017; ZSRO CR22, 4♂♂, 3♀♀, Tods Corner, #2, off western shore, 41°57'30"S 146°47'02"E, 3–4 m, dense *Chara* beds, 11 March 2017.

Shannon Lagoon: AM P11898, 3♂♂ (20–22 mm), Shannon Lagoon at Miena, [41°59.25'S 146°44.04'E], coll. J. Waterhouse; QVM 10:49160, 8♂♂ (12–15 mm), 9♀♀ (14–16 mm), Shannon Lagoon, [42°00.86'S 146°44.30'E], coll. W. Fulton, 3 Mar 1973; QVM 10:49060, 3♂♂ (c. 9–10 mm, poor condition), 5♀♀ (c. 7–10 mm, poor condition), Shannon Lagoon, [41°59.50'S 146°44.33'E], coll. J. H. Wilson, 30 Jan 1965; AM P99513, 1♀ (19 mm), Shannon Lagoon, 41°59'10.53"S 146°44'16.9"E, 3 m, weeds, 1015 m asl, coll. S. Jarman; NMV J37892, 7♂♂ (16–20 mm), 5♀♀ (18–20 mm), Shannon Lagoon, 42°S 146°E, coll. B. Knott, 16 November 1972.

Description. Pleonite 6 lower midlateral surface with arcuate row of 2–5 (usually 4) prominent, well-spaced spines; posterolateral angle bispinous (rarely unispinous); posteroventral angle anterior to uropod articulation with cluster of 7–13 spines.

Antennule mesial (accessory) flagellum about 0.2–0.3 × body length (24 articles in figured male); lateral flagellum 0.5–0.7 × body length (58 articles in figured male).

Antennal flagellum 0.5–0.7 × body length (47 articles in figured male); protopod coxa with splayed row of 6–8 spines on lateral margin, basis with 2 (rarely 3) lateral spines.

Labrum anterior proximal surface swollen medially, usually with median point.

Thoracopod 1 (maxilliped) merus length 2.5–3.0 × width.

Pleopod 3 endopod always present; pleopod 4 endopod usually present; pleopod 5 endopod absent. Adult male pleopod 1 margin of dorsodistal half concave. Male pleopod 2 endopod distal article with straight distoventral surface.

Uropodal protopod with cluster of 2 or 3 posterolateral spines. Uropodal exopod elongate, spatulate; lateral margin between incurved anterolateral margin and distolateral spine row, straight or faintly or faintly concave, with 0–6 minute widely spaced setae; spine row of 8–10 fixed graded spines; spine row length 0.3 × length of straight portion of preceding exopod margin.

Colour in life (Fig. 9A). Body transparent, covered in dull red and brown chromatophores forming diffuse transverse bands across pereon and pleon; cephalothorax with red brown patch on lateral surface behind cervical groove. Antennular peduncle article 1 transparent with scattered spots and dark midline; article 2 transparent with longitudinal brown patches; article 3 solid dark brown. Scaphocerite transparent. Eyestalks red-brown. Pereopods and pleopods translucent pale brown. Tailfan transparent with scattered brown spots, densest distally.

Figure 2. *Paranaspides lacustris* Smith, 1908, male (17 mm), Swan Bay, Great Lake, QVM 10:49151. *(A)* anterior cephalothorax; *(B)* right antenna basal article, lateral view; *(C)* right antenna and antennule, ventral view; *(D)* pleonite 6, telson and right uropod; *(E)* pleonite 6 posterolateral margin and Uropodal protopod, right ventral view; *(F)* pleonites 1–6, posterior margin, right lateral view; *(G)* labrum, anterior; *(H)* paragnaths, anterior; *(I)* right maxillule; *(J)* right maxilla; *(K)* right mandible; *(L)* right mandible incisor process; *(M)* left mandible incisor process. Scale: A–F = 1.0 mm, G–M = 0.5 mm.

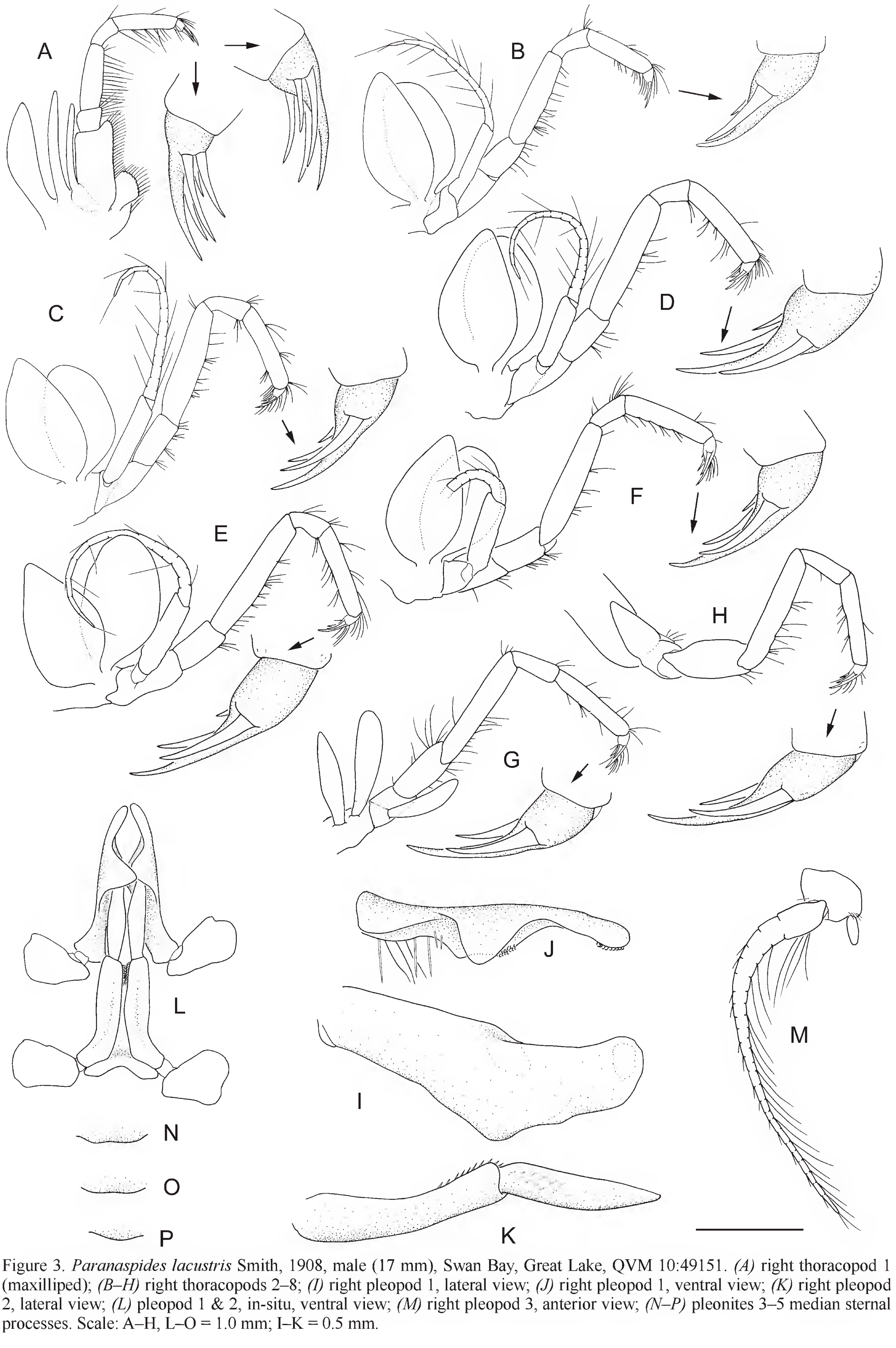

Figure 3. *Paranaspides lacustris* Smith, 1908, male (17 mm), Swan Bay, Great Lake, QVM 10:49151. *(A)* right thoracopod 1 (maxilliped); *(B–H)* right thoracopods 2–8; *(I)* right pleopod 1, lateral view; *(J)* right pleopod 1, ventral view; *(K)* right pleopod 2, lateral view; *(L)* pleopod 1 & 2, in-situ, ventral view; *(M)* right pleopod 3, anterior view; *(N–P)* pleonites 3–5 median sternal processes. Scale: A–H, L–O = 1.0 mm; I–K = 0.5 mm.

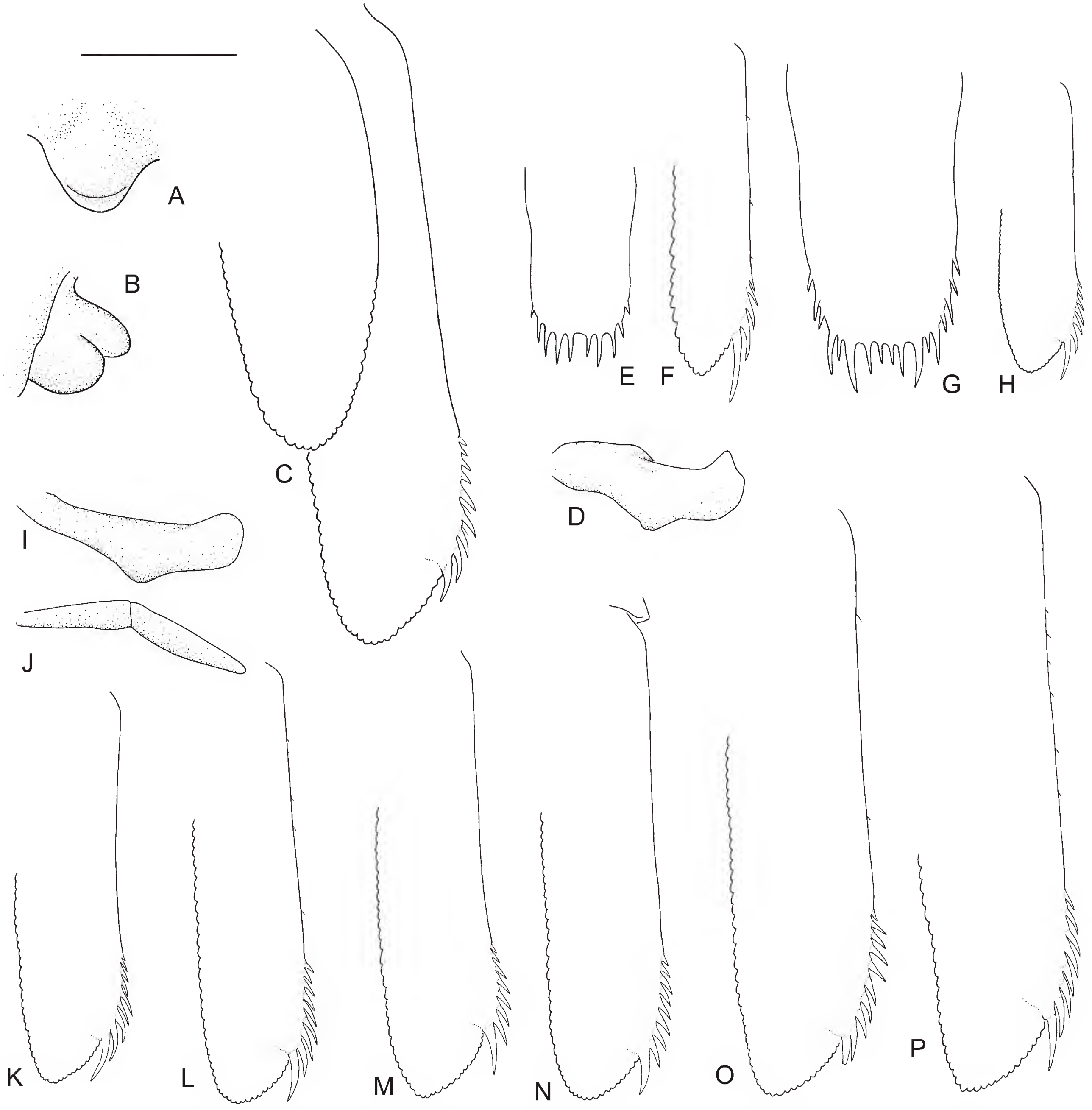

Figure 4. *Paranaspides lacustris* Smith, 1908. *(A–C)* female (21 mm), Swan Bay, Great Lake, QVM 10:49151; *(D)* male (11 mm), Great Lake, WAM C58163; *(E–F)* female (6 mm), Brandum Bay, Great Lake; *(G–H)* QVM 10:49146; male (10 mm), Beckett Bay, Great Lake, WAM C58155; *(I–K)* male lectotype (11 mm), Great Lake, AM P100400; *(L)* male (12 mm), Shannon Lagoon, QVM:10:49160; *(M)* male (13 mm), Brandum Bay, Great Lake, QVM 10:49147; *(N)* female (16 mm), Shannon Lagoon, QVM 10:49160; *(O)* male (17 mm), Swan Bay, Great Lake, QVM 10:49150; *(P)* male (17 mm), Brandum Bay, Great Lake, QVM 10:49148. *A–B*, female gonopore, ventral view and right lateral view; *C*, right uropodal endopod and exopod; *D, I*, right male pleopod 1, lateral view; *E, G*, telson outline; *J*, right male pleopod 2, lateral view; *F, H, K–P*, right uropodal exopod. Scale: 1.0 mm. Scale: A–C, H, K–P = 1.0 mm; D–G, I, J = 0.5 mm.

Measurements. Male (n = 121) 6–22 mm; female (n = 183) 6–22 mm. Fulton (1982) reported specimens up to 25 mm body length.

Remarks. *Paranaspides lacustris* Smith, 1908, was described based on specimens dredged from Great Lake and subsequently discovered in Shannon and Penstock Lagoons (artificially created during the 1920–30s) and connected to the south end of the lake (Evans, 1942; Nicholls, 1947). *Paranaspides lacustris* was also thought to occur in Arthurs Lake, Woods Lake and the Lake River adjacent to the dam outflow at Woods Lake (Fulton, 1982), but these are referrable to *P. williamsi* sp. nov. Distinctions between *P. lacustris* and *P. williamsi* are discussed under the account of the latter. To fix the identity of *P. lacustris*, an adult male syntype (11 mm) from Great Lake is herein selected as the lectotype to fix the identity of the species; the remaining syntypes thus become paralectotypes. Significantly, the paralectotype series includes an 8 mm juvenile of *Anaspides richardsoni* Ahyong, 2016, evidently overlooked by Smith (1908), but representing the first confirmed record of the genus from Great Lake. The occurrence of *Anaspides* in Great Lake itself has often been questioned (e.g., Nicholls, 1947; Williams, 1965; O'Brien, 1990) so the present specimen of *A. richardsoni*, collected together with *P. lacustris*, demonstrates that *Anaspides* was at least a transient resident of the lake. Whether *Anaspides* still occurs there remains to be determined.

Morphological variation in *P. lacustris* is minor; meristic differences in spination usually vary allometrically, with the smallest specimens having fewest spines. The smallest juveniles (c. 6 mm) lack lateral spines on the telson, the pleopod 1–2 endopods are present as tiny buds and the pleopod 3–5 endopods are absent. By c. 8 mm, the lateral telson spines are present, the pleopod 1–2 endopods are evident (albeit as yet unmodified in males) and the pleopod 3–4 endopods appear. The relative length of the spine row on the uropodal exopod is stable across the size range, though the number of spines and relative length of the distal spine changes with body size: five spines are present at 6 mm body length, with the distal spine overreaching the apex of the exopod; by 9 mm, eight or more spines are present with the distal spine reaching the end of the exopod; and above 9 mm, the distal spine distinctly falls short of the end of the exopod. Maturity in both sexes appears to be reached at 10–11 mm body length. The adult male pleopod 1 endopod of *P. lacustris* is concave on the upper margin of the distal half, usually with a bluntly rounded apex. In some males, however, the distal pleopod 1 endopod margin is produced to a triangular lobe. The adult complement of pleopod endopods is variable and overlaps that of *P. williamsi*, being always present on pleopod 3, variable on pleopod 4 and always absent on pleopod 5. In *P. williamsi*, the pleopod 3–4 endopods are present, but variable on pleopod 5.

Although yet to be studied in detail, the life cycle of *P. lacustris* is apparently univoltine, with a single reproductive event and little overlap between year classes. Spawning is believed to take place in summer and hatching in winter, with individuals living for up to 18 months (Williams, 1965; Fulton, 1982).

Distribution. Known only from Great Lake, Shannon Lagoon and Penstock Lagoon; 0.2–10 m depth; 1040 m above sea level.

Paranaspides williamsi sp. nov.

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Figs 4–8, 9B, 10

Paranaspides lacustris.—Fulton, 1982: 23, 25, fig. 1 [Woods Lake, Arthurs Lake, Lake River only]; 1983: 776, tab. 1 [Arthurs Lake].

Holotype: TMAG G8244, male (12 mm), Arthurs Lake, Pumphouse Bay, near pumping station, 41°59'16.3"S 146°51'44.8"E, netted from weeds, < 1 m, coll. S. Richter & C. Wirkner, 28 February 2006. **Paratypes**: AM P99963, 3♂♂ (11–12 mm), 6♀♀ (13–14 mm), collected with holotype; AM P100414, 3♀♀ (11–12 mm), Pumphouse Bay, near pumping station, 41°59'15"S 146°51'42"E, *Nitella* beds, 0.7 m, light trap, coll. S. Ahyong, C. Hoepel, M. Reinhardt, S. Richter, 10 March 2017; QVM 10:49058, 1♀ (15 mm), southern East Lake, Arthurs Lake [41°59.30'S 146°57.19'E], coll. W. Fulton, 17 May 1977.

Other material examined. *Arthurs Lake*: AM P100413, 4♂♂ (11 mm), 1♀ (11 mm), Pumphouse Bay, near pumping station, 41°59'15"S 146°51'42"E, *Nitella* beds, 0.2–0.7 m, hand net, coll. S. Ahyong, C. Hoepel, M. Reinhardt, S. Richter, 8 March 2017; ZSRO CR23, 3♂♂ (12–13 mm), 2♀♀ (11–12 mm), Pumphouse Bay, near pumping station, 41°59'15"S 146°51'42"E, *Nitella* beds, 0.2–0.7 m, netted, coll. S. Ahyong, C. Hoepel, M. Reinhardt, S. Richter, 8 March 2017; QVM:10:49059, 1 damaged ♂, 1♀ (15 mm), 1 exoskeleton, Sand Lake, Arthurs Lake [41°56.46'S 146°57.88'E], coll. W. Fulton, 29 June 1977; QVM 10: 49057, 1♂ (16 mm), 2 damaged ♀♀, southern East Lake, Arthurs Lake [41°59.30'S 146°57.19'E], coll. W. Fulton, 19 April 1977.

Woods Lake: QVM 10:49161, 10♂♂ (14–16 mm), 10♀♀ (13–16 mm), west shore Woods Lake, [42°05.50'S 146°59.82'E], coll. W. Fulton, 22 July 1977.

Description. Pleonite 6 lower mid-lateral surface with arcuate row of 3–5 (usually 4) prominent, well-spaced spines; posterolateral angle bispinous (rarely unispinous); posteroventral angle anterior to uropod articulation with cluster of 6–14 spines.

Antennule mesial (accessory) flagellum 0.1–0.2 × body length (17 articles in holotype); lateral flagellum 0.4 × body length (42 articles in holotype).

Antennal flagellum 0.3–0.4 × body length (40 articles in holotype); protopod coxa with splayed row of 6–9 spines on lateral margin, basis with 2 lateral spines.

Labrum anterior proximal surface swollen medially, without median point.

Thoracopod 1 (maxilliped) merus slightly tapering distally, length twice length of ischium.

Pleopods 3–4 endopod always present in adults; pleopod 5 endopod rarely present. Adult male pleopod 1 margin of dorsodistal half straight to faintly concave. Male pleopod 2 endopod distal article with distoventral surface broadly concave.

Uropodal protopod with cluster of 1–4 posterolateral spines. Uropodal exopod elongate, spatulate; lateral margin between incurved anterolateral margin and distolateral spine row, straight or faintly or faintly concave, with 0–7 minute, widely spaced setae; distolateral spine row of 9–14 fixed graded spines; spine row length 0.4–0.7 × length of straight portion of preceding exopod margin.

Colour in life (Fig. 9B). Body transparent, covered in dull red and brown chromatophores forming diffuse transverse bands across pereon and pleon, most pronounced and darkest across pereonites 2–3, 7 and anterior half of pleonite 6; with dark-brown; cephalothorax with red brown patch on lateral surface behind cervical groove. Antennular peduncle article 1 transparent with scattered spots and dark midline; article 2 transparent with longitudinal brown midline and brown mesial margin; article 3 transparent, with partial pigmentation. Scaphocerite transparent. Eyestalks red brown. Pereopods and pleopods translucent pale brown. Tailfan transparent with scattered brown spots, densest distally.

Measurements. Male (n = 23) 11–16 mm; female (n = 26) 11–16 mm.

Remarks. *Paranaspides williamsi* sp. nov. differs from *P. lacustris* in the following features: the proportionally shorter merus of the maxilliped (length twice the width in the new species versus 2.5–3 times length in *P. lacustris*), the proportionally longer spine row on the uropodal exopod (about half or longer versus one-third length of the preceding straight, unarmed lateral margin), and subtle differences in the adult male pleopods 1 and 2. The adult male pleopod 1 distodorsal margin is straight or, at most, faintly concave in

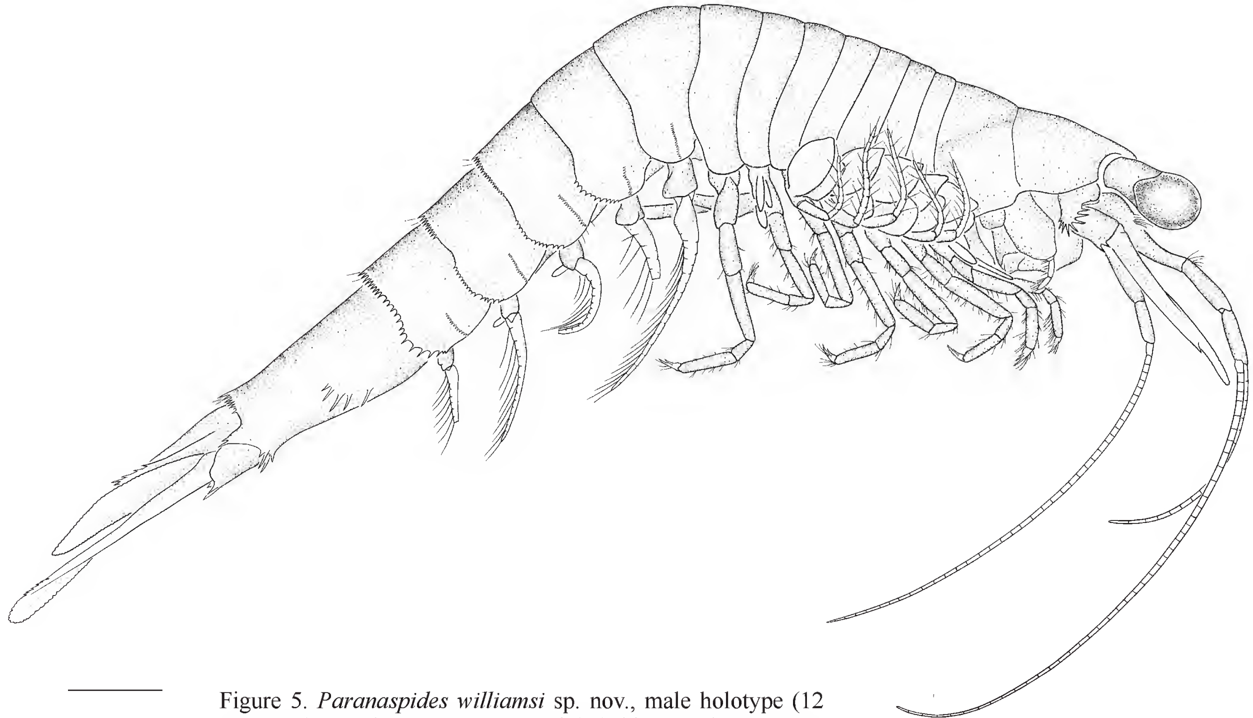

Figure 5. *Paranaspides williamsi* sp. nov., male holotype (12 mm), Arthurs Lake, TMAG G8244, right habitus. Scale = 1.0 mm.

P. williamsi, rather than noticeably to strongly concave in *P. lacustris*. The distoventral margin of the distal article of adult male pleopod 2 is concave in *P. williamsi*, straight in *P. lacustris*. In both species of *Paranaspides*, the number of pleopodal endopods is variable and overlapping, but with different ranges. In *P. lacustris*, the pleopodal endopods are usually present on pleopods 1–4, but may be absent on pleopod 4, even in adults. In *P. williamsi*, endopods are present on pleopods 1–4, and in one specimen, also on pleopod 5 (damaged adult male, QVM 10:49050). Both *P. lacustris* and *P. williamsi* appear to mature at a similar size (c. 10–11 mm), although they differ in maximum known body length (25 mm versus 16 mm, respectively). Whether this size difference reflects reality or limited sampling remains to be determined. Colour-in-life (Fig. 9) is similar between *P. williamsi* and *P. lacustris*, though in the latter, the distal article of the antennular peduncle is solid dark brown versus being partially pigmented, and transverse banding is uniform rather than darkest and most pronounced on pereonites 2–3 and 7, and on pleonite 6.

The distributions of the two species of *Paranaspides* precisely parallel those of a cognate pair of freshwater fishes, *Paragalaxias,* distributed in Great Lake-Shannon Lagoon-Penstock Lagoon (*Paragalaxias eleotroides* McDowall & Fulton, 1978) and Arthurs Lake-Woods Lake-Lake River below Woods Lake dam (*Paragalaxias mesotes* McDowall & Fulton, 1978) (McDowall & Fulton, 1978; Fulton, 1982). Great Lake and Arthurs Lake are geographically close (c. 6 km), and, given the shared cognate species pairs, both lake systems probably shared a common system in the past. Great Lake and Arthurs Lake now occupy different drainages, with the former draining to the southeast towards Hobart via the Shannon River and Derwent River, and the latter draining northeast towards Launceston via Woods Lake, the Lake River and then the Tamar River (McDowall & Fulton, 1978). Great Lake and Arthurs Lake are believed to be preglacial and apparently escaped glaciation during the Pleistocene (Davies, 1974; Kiernan, 1990; Andrew, 2005). McDowall & Fulton (1978) hypothesised that the divergence between the respective cognates of *Paragalaxias* might also be pre-Pleistocene. Molecular divergence estimates of Central Plateau *Paragalaxias* (c. 3–10 ma) (Waters *et al.*, 2000) corroborate the hypothesised pre-Pleistocene divergence of selected Great Lake and Arthurs Lake taxa and isolation of drainages proposed by McDowall & Fulton (1978). Given the striking parallels with species of *Paragalaxias*, the divergence of *Paranaspides* might also be pre-Pleistocene.

Distribution. Arthurs Lake, Woods Lake and the Lake River below Woods Lake dam; 738–952 m asl.

Conservation status

Paranaspides lacustris was abundant in Great Lake amongst the extensive stands of nearshore charophyte algal beds prior to its stepwise modification and damming since the c. 1920s, leading to significant population declines (Manton, 1930). These algal beds typically occur only down to about 10 m depth given light attenuation, so significant increases in lake level are particularly deleterious, especially given the probable univoltine life-cycle making loss of a year-class difficult to recover from. Although preyed on by trout (Richards *et al.*, 2015), the more significant threat to *P. lacustris* is probably habitat loss caused by changing lake levels. Major reductions in *P. lacustris* populations observed in the 1920s, 1930s, 1960s and 1970s are associated with progressive artificial increases in lake level (Wells *et al.*, 1983). Subsequent dam modifications further increased the lake level several times through to the 1980s (Davies & Fulton, 1987; Bonham, 2006). Since the 1920s, *P. lacustris*

Figure 6. *Paranaspides williamsi* sp. nov., male holotype (12 mm), Arthurs Lake, TMAG G8244. *(A)* anterior cephalothorax; *(B)* right antenna basal article, lateral view; *(C)* right antenna and antennule, ventral view; *(D)* pleonite 6, telson and right uropod; *(E)* pleonite 6 posterolateral margin and Uropodal protopod, right ventral view; *(F)* pleonites 1–6, posterior margin, right lateral view; *(G)* labrum, anterior; *(H)* paragnaths, anterior; *(I)* right maxillule; *(J)* right maxilla; *(K)* right mandible; *(L)* right mandible incisor process; *(M)* left mandible incisor process. Scale: A–F = 1.0 mm, G–M = 0.5 mm.

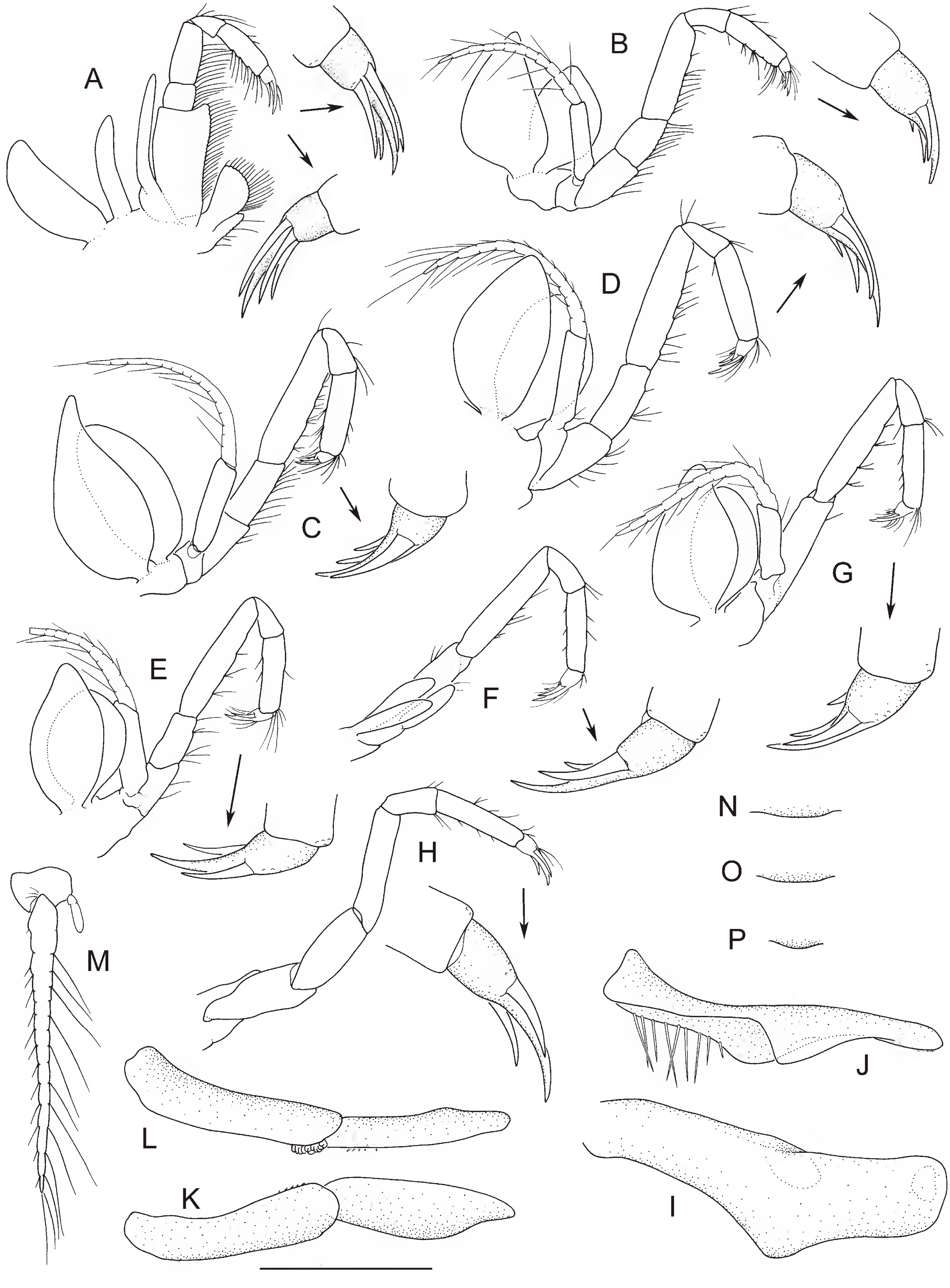

Figure 7. *Paranaspides williamsi* sp. nov., male holotype (12 mm), Arthurs Lake, TMAG G8244. *(A)* right thoracopod 1 (maxilliped); *(B–H)* right thoracopods 2–8; *(I)* right pleopod 1, lateral view; *(J)* right pleopod 1, ventral view; *(K)* right pleopod 2, lateral view; *(L)* right pleopod 2, ventral view; *(M)* right pleopod 4, anterior view; *(N–P)* pleonites 3–5 median sternal processes. Scale: A–H, L–O = 1.0 mm; I–K = 0.5 mm.

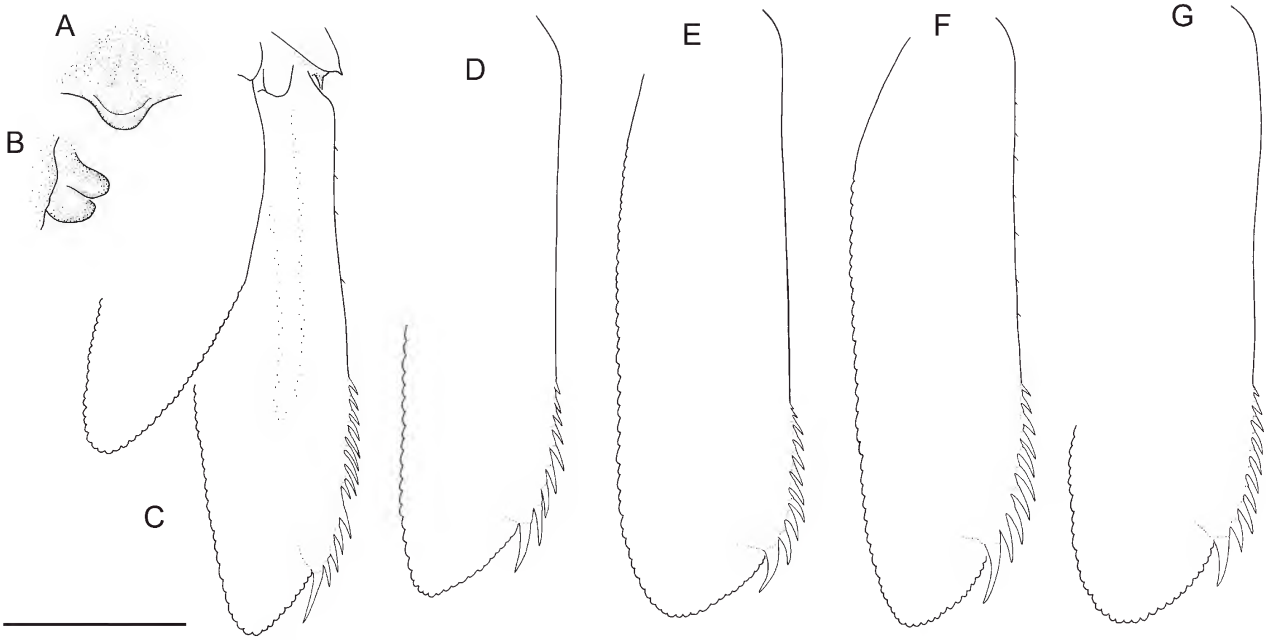

Figure 8. *Paranaspides williamsi* sp. nov. *(A–C)* female paratype (14 mm), Arthurs Lake, AM P99963; *(D)* male (14 mm), Woods Lake, QVM 10:149161; *(E)* female (15 mm), Sand Lake, Arthurs Lake, QVM 10:49059; *(F)* female (15 mm), East Lake, Arthurs Lake, QVM 10:49058; *(G)* male (16 mm), Arthurs Lake, QVM 10:49057. A, B, female gonopore, ventral and right lateral views. C, right uropod; D–G, right uropodal exopod. Scale = 1.0 mm.

Figure 9. Colour in life. *(A) Paranaspides lacustris* Smith, 1908, female, 18 mm, Tods Corner, Great Lake, AM P100410; *(B) P. williamsi* sp. nov., paratype female, 12 mm, Arthurs Lake, AM P100414.

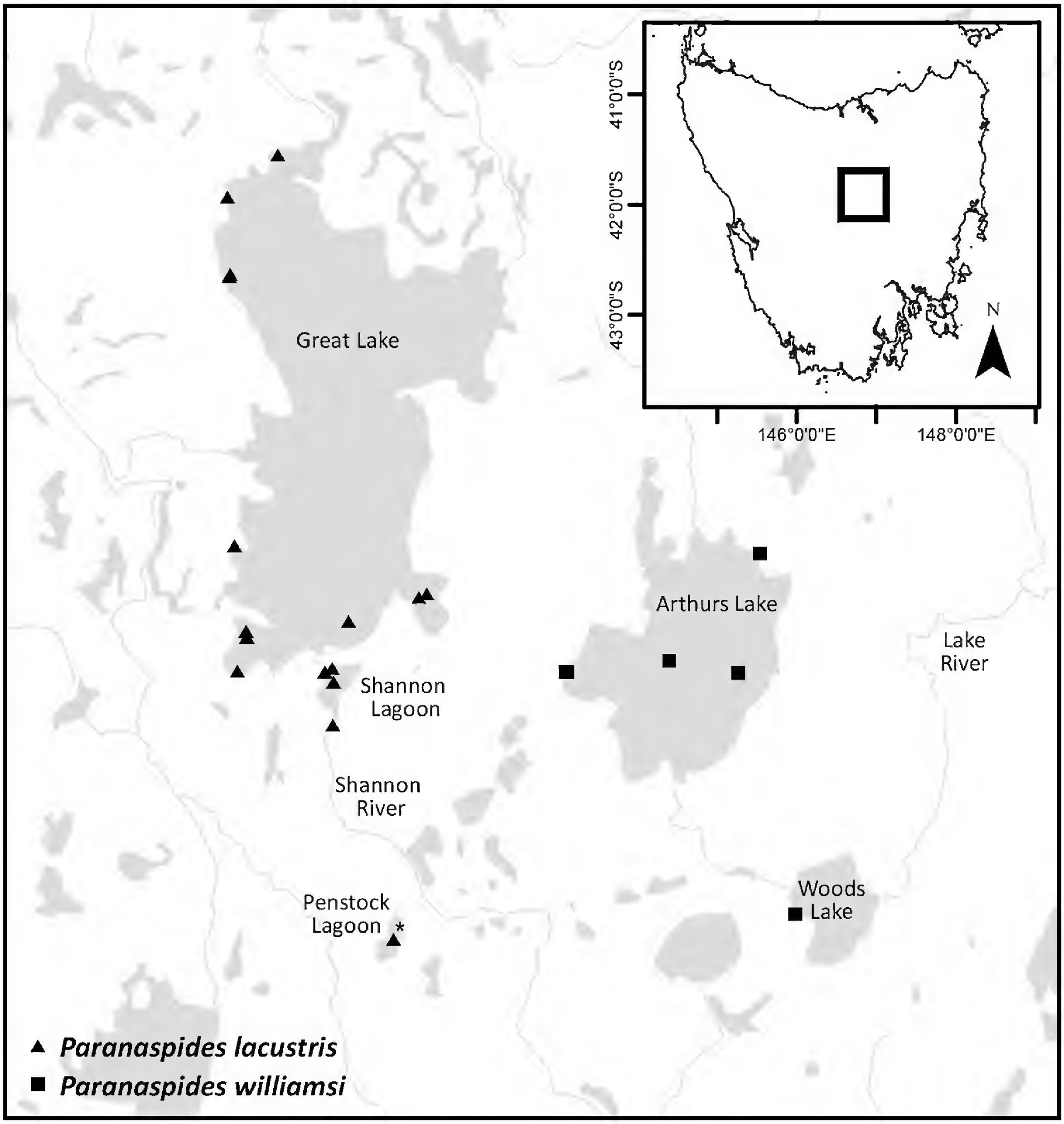

Figure 10. Distribution of *Paranaspides*. * Record from Penstock Lagoon, based on Williams (1965).

Table 1. Uncorrected *p*-distances between species and populations of *Paranaspides*. Intraspecific or intrapopulation distances shown on the diagonal (*COI* distances above, *16S* distances below).

		P. williamsi (Arthurs Lake)	*P. lacustris* (Shannon Lagoon)	*P. lacustris* (Great Lake, Swan Bay)	*P. lacustris* (Great Lake, Tods Corner)
P. williamsi (Arthurs Lake)	COI	0.2–1.5	—	10.4–11.7	11.0–11.8
	16S	0.0–0.2	3.2–3.3	3.2–3.3	3.2–3.7
P. lacustris (Shannon Lagoon)	COI		—	—	—
	16S		—	0.0	0.0
P. lacustris (Great Lake, Swan Bay)	COI			0.0–0.2	0.0–0.3
	16S			—	0.0
P. lacustris (Great Lake, Tods Corner)	COI				0.0–0.2
	16S				0.0

has seldom been found in significant numbers in Great Lake, with the frequent raising and lowering of lake levels for hydroelectric operations believed to retard establishment of the littoral vegetation essential as habitat (Horwitz, 1990).

Little is known of the current population size and dynamics of either species of *Paranaspides*, so conservation assessments have relied largely on area of occupancy and the limited number of locations at which either species occurs. *Paranaspides lacustris* is currently assessed by the *IUCN Red List of Threatened Species* as Vulnerable (D2) (Inland Water Crustacean Specialist Group, 1996) based on its limited area of occupancy, few known locations, and in being prone to the effects of hydroelectric operations. With Arthurs and Woods Lakes now excluded from the range of *P. lacustris*, the area of occupancy is reduced, though the Vulnerable D2 assessment would remain applicable. *Paranaspides williamsi*, being restricted to Arthurs and Woods Lakes (and the Lake River immediately below the Woods Lake dam) has a limited area of occupancy and occurrence at no more than three locations. The dependence of *P. williamsi* on aquatic vegetation (charophyte and macrophyte beds) indicates an area of occupancy in Arthurs Lake of 0.63–8.3 km^2 depending on water level (Lobdale, 2011). Although the proportion of vegetated habitat of Woods Lake is not known, the total surface area is approximately 1.2 km^2 so the total area of occupancy of *P williamsi* (both lakes combined) would not exceed 9.5 km^2. Like *P. lacustris*, *P williamsi* is also subject to artificial lake level fluctuations and stochastic events given its very narrow range. As such, the conservation status of *P. williamsi* under IUCN Red List categories would also correspond to Vulnerable D2. Our efforts to sample *P. williamsi* in Woods Lake in March 2017, however, were unsuccessful and no other recent collections are presently available. Therefore, establishing the population status of *P. williamsi* in Woods Lake should be prioritized, especially given the sharp decline in *Paragalaxias mesotes* observed in Woods Lake over the past two decades (TSSC, 2016). If the Woods Lake population of *P. williamsi* has also significantly declined, it might require a higher level of protection.

Neither species of *Paranaspides* is currently listed on either the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* or the Tasmanian *Threatened Species Protection Act 1995* (Bonham, 2006). It is noteworthy, however, that the galaxiid fishes *Paragalaxias eleotroides* and *Paragalaxias mesotes*, under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Tasmanian *Threatened Species Protection Act 1995*, are currently assessed as vulnerable and endangered, respectively (TSS, 2006). Given that these species of *Paragalaxias* parallel the species of *Paranaspides* in distribution, habitat requirements and in similar threats, they may warrant a similar conservation status under Tasmanian and Commonwealth jurisdictions. Since key proposed conservation priorities for *Paragalaxias* emphasize mitigating habitat deterioration and loss (TSSC, 2014, 2016), their adoption could also benefit *Paranaspides.*

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