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A review of Australian long-horned caddisflies in the *Oecetis pechana*-group (Trichoptera: Leptoceridae), with descriptions of thirteen new species

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Abstract

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This final paper in a series reviewing Australian members of the long-horned caddisfly genus *Oecetis* McLachlan (Trichoptera: Leptoceridae) deals with 21 species, 13 of them new, and all assigned here to the *pechana*-group, so-named for the most common and widespread of Australian *Oecetis* species. This group is diagnosed as having fork 1 in the forewing sessile and, in the male, scale patches on the forewing and a single internal paramere in the phallus, although in several species one or other of these male features is absent. Keys are given to the *Oecetis* species groups recognised in Australia and to species in the *pechana*-group. Established *pechana*-group species are diagnosed and new species are described. Male genitalic features are illustrated for all species save *O. lurida* Kimmins which was described from a female and is probably a doubtful name. A homonym created in the name *O. dilata* Wells, 2004 is replaced with the name *Oecetis kimberleyensis* nom. nov., and *Oecetis cepaforma* Wells, 2004 is synonymised with the widespread Oriental-Australian *O. hemerobioides* McLachlan, 1866. Seventy-four *Oecetis* species are now recognised in the Australian fauna.

Keywords

Taxonomy, Trichoptera, Leptoceridae, *Oecetis pechana*-group, new species, Australia

Contents

Introduction

Among Australian representatives of the long-horned caddisfly genus *Oecetis* McLachlan (Trichoptera: Leptoceridae), a persistent taxonomic problem has been the precise determination of the scope of the species known as *Oecetis pechana* Mosely, 1953. The name has been applied to almost all *Oecetis* specimens having patches of scales on the male forewing, collected Australia-wide, including the water bodies and even stock watering troughs of the arid inland. However, close inspection of males of many of the putative *O. pechana* specimens reveals a range of forms sharing all or some of a suite of character states. Here the *Oecetis pechana*-group is recognised for a set of 21 species, 13 of which are newly described, and is defined to include a number of species that lack scales on the male forewing, but share other synapomorphies.

Oecetis pechana was described originally from the south-west of Western Australia, and subsequently was redescribed and figured by Neboiss, 1977. Neboiss illustrated his work with new figures of *O. pechana* from Tasmania, showing a key feature of the species: the very elongate phallus. This feature is also seen in a newly recognised species, *O. suteri* sp. nov., but is absent in superficially similar specimens that are recognised here as representing several distinct species. *O. pechana* as defined here is the most common and widespread Australian species in the genus *Oecetis*. Adults vary greatly in size, forewing length of those in the northern regions being as little as half that of southern forms. Such a difference in size range probably reflects differences in growth rates, the life cycles being completed far more rapidly in the warm northern waters than in the cooler southern waters. In support of this contention, larger-sized adults were collected in the southern Mt Lofty Ranges of South Australia, where a main late-spring emergence of adults is followed by low numbers of specimens throughout summer, and none in the cool winter months. In contrast, samples from the north of the Northern Territory contain only small-sized adults and, throughout 14 consecutive months of light trap sampling on the Magela Creek at Jabiru (1991–1992), *Oecetis pechana* adults were collected regularly.

Oecetis pechana is often abundant in lentic water bodies such as farm dams and lakes, the larvae in their tubular sand-grain cases probably scavenging on organic material on the substrate. Similarly, all other *pechana*-group species for which larvae have been associated, have cases built of sand grains, including *Oecetis gilva* Neboiss, 1977. This species also occurs in large populations in some farm dams in the Adelaide Hills, South Australia, and has been taken in large numbers from several lakes in Victoria. *Oecetis gilva* as described by Neboiss lacks scales on the male forewing, although conforming with members of the *pechana*-group in other respects. Indeed, membership of this group is confirmed by the fact that light trap collections referable to *O. gilva* taken at two Victorian lakes include males that have scales on the forewing. Quite conceivably, these are simply variants of *O. gilva*, or even hybrids between *O. pechana* and *O. gilva*. For the present, they are accepted as *O. gilva*.

Thus, the *Oecetis pechana*-group is defined by a suite of character states, not all shared by all members: forewing fork 1 without a footstalk, usually with cross veins, forks and anastomoses marked by darkened membrane and hairs; tibial spur formula 1,2,2; in the male, forewing usually with scale patches, phallus usually with a single internal spine or paramere, never with two, abdomen usually with tergites II–IV darkly sclerotised, and genitalia usually with a small setae-lined pouch on inner dorsal side of inferior appendages; and larvae with tubular to conical or cornucopia-shaped cases constructed of sand grains held together by silk secretion. Species of *Oecetis* in the fauna of New Zealand, New Guinea and Java also share the synapomorphies of these *pechana*-group members.

This is the final work in a series of papers (Neboiss, 1989; Wells, 2000, 2004) revising Australian species of *Oecetis*, and raises to 74 the number of species recorded in this genus in Australia. The key provided by Wells, 2004 to distinguish males of the five *Oecetis* groups recognised for Australia is reproduced here with slight modifications, and a key to males of *pechana*-group species is given. The name *dilata* applied to an Australian *Oecetis* species by Wells, 2004, thus creating a homonym, is replaced; and the name *Oecetis cepaforma* Wells, made available in the same work is here suppressed in synonymy.

Methods

Material examined is lodged in the collections of Museum Victoria, Melbourne (NMV), the Australian National Insect Collection, Canberra (ANIC), the Queensland Museum, Brisbane (QM) and the Northern Territory Museum of Arts and Sciences, Darwin (NTM). Other abbreviations used here are BMNH (The Natural History Museum, London, UK); MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA); ARR is used for the Alligator Rivers region, NT; OSS for the Office of the Supervising Scientist, Darwin (previously at Jabiru); and WTH is an NMV code for the Wet Tropics Heritage area of north-eastern Queensland. In the locality data included with the lists of material examined, the Australian political states are abbreviated as follows: NSW (New South Wales); NT (Northern Territory); Qld (Queensland); SA (South Australia); Tas. (Tasmania) ; Vic. (Victoria); and WA (Western Australia).

Many of the scaly-winged species in this group are very difficult to distinguish without dissection of the male abdomen or clearing of the male genitalia to determine the length of the phallus and size and shape of the single internal paramere.

Key to males of *Oecetis* species groups in Australia [Modified from Wells, 2004]

1. Abdominal tergite VIII sculptured, expanded and extended distally, forming shield over terminal abdominal segments and genitalia ..... *reticulata*-group (see Neboiss, 1989: fig. 2)
— Abdominal tergite VIII unmodified 2
2. Wings with veins strongly pronounced, fork 1 without a footstalk (sessile) ..... *longiterga*-group (see Wells, 2004: figs 91, 94)
— Wings with veins not strongly pronounced, fork 1 with or without footstalk 3
3. Phallus simple, lacking parameres ..... *laustra*-group (see Wells, 2004: figs 18, 46, 59)
— Phallus with 1 or more internal or external parameres or spines 4
4. Forewing fork 1 sessile, wing lamina often bearing patches of scales (androconia) (fig. 1); phallus usually with a single internal paramere or spine, never with more than 1 spine associated with the phallus (e.g. figs 3, 7, 8) ..... *pechana*-group (see below)
— Forewing fork 1 stalked, wing never bearing patches of scales; phallus with 1 or more external parameres (spines of the phallotheca) ..... *complexa*-group (see Wells, 2000: figs 25, 26–33)

Key to males of the *Oecetis pechana*-species group in Australia
[excluding *O. lurida* for which males are not associated]

1. Forewing with 1 or more patches of scales (androconia) on lamina (figs 1, 6) 2
— Forewing without scales on lamina (figs 38, 39) 17
2. Inferior appendages in ventral view with length less than twice width at base (figs 13, 31) 3
— Inferior appendages in ventral view with length about twice width at base, or longer (figs 3, 7, 17), ... 4
3. Inferior appendages in ventral view more or less quadrate; phallus in lateral view with paramere about 2–3 times length of abdominal segment VIII, strongly arched dorsally (figs 31, 32) ..... *O. jenniae*
— Inferior appendages in ventral view more or less quadrate; phallus about 3–4 times length of abdominal segment VIII, almost straight (figs 13, 15) ..... *suteri*
4. Inferior appendages in ventral view abruptly angled meso-dorsally at about two-thirds length, rather than smoothly curved, apices truncate (fig. 25) ..... *O. geniculata*
— Inferior appendages not as above 5
5. Pre-anal appendages with length about 3 times width (figs 52, 53) ..... *O. ada*
— Pre-anal appendages with length less than 3 times width (figs 34, 36, 44, 45) 6
6. Inferior appendages in ventral view with a triangular meso-basal lobe dorsally (figs 33, 35) 7
— Inferior appendages without a lobe as above 8
7. Inferior appendages in ventral view with the triangular meso-basal dorsal lobe prominent and proximal to a sharply triangular apico-mesial angle (fig. 35) ..... *O. theischingeri*
Inferior appendages in ventral view with the triangular meso-basal dorsal lobe less prominent and without a sharply triangular apico-mesial angle (fig. 33) ..... *O. mouldsi*
8. Inferior appendages in ventral view with length more than 3 times basal width; phallus short, about length of 1 abdominal segment, sclerotised paramere slender (figs 43, 45) ..... *O. buitenzorgensis*
— Not as above 9
9. Inferior appendages in ventral view fused mesially in basal third; in lateral view with length about 4 times width (figs 49, 50) ..... *O. searica*
— Not as above 10
10. Inferior appendages in ventral view stout, mesial margin excavated in distal half; phallus greater than 4 times length of abdominal segment VIII (fig. 3) ..... *O. pechana*
— Not as above 11
11. Inferior appendages in ventral view stout at base, gradually excavated towards apex, slender distally; phallus in lateral view with sclerotised paramere arched ventrally (figs 22–24) ..... *O. kateae*
— Not as above 12
12. Inferior appendages in ventral view stout throughout length, mesially gradually excavated from base, apices rounded (figs 7, 54) 13
— Not as above 15
13. Phallus with sclerotised paramere equal to about 2–3 times length of abdominal segment VIII 14
Phallus without sclerotised paramere (fig. 54) ..... *O. gilva* (part)
14. Inferior appendages in ventral view dilated lateral at about half length, somewhat sinuous in appearance (fig. 7) ..... *O. walpolica*
— Inferior appendages in ventral view swollen basally, gradually tapered towards apices (Neboiss, 1977: fig. 771) ..... *O. umbra*
15. Inferior appendages in ventral view stout basally, sharply excavated on mesial margin at about two-thirds length, apices rounded; sclerotised paramere of phallus about length of 2 abdominal segments (figs 9, 10) ..... *O. magelensis*
— Not as above 16
16. Inferior appendages about equal width throughout length, sinuous in lateral view, apices rounded to truncate (figs 16, 17) ..... *O. radonensis*
Inferior appendages about equal width for most of length, distally tapered to acute convergent apices (figs 19, 20) ..... *O. humphreyi*
17. Forewing with distinctly spotty pattern; inferior appendages close-pressed meso-ventrally for proximal half, mesial margin excavated in distal half; phallus about length of 2 abdominal segments, with sclerotised paramere strongly arched dorsally, down-turned in distal section, apically acute (figs 27, 28) ..... *O. litua*
— Forewing without distinctly spotty pattern, although usually with crossveins and vein forks and anastomoses marked by dark membrane and hair; inferior appendages not close-pressed for more than one-fifth length; phallus usually shorter than length of 2 abdominal segments, sclerotised paramere strongly reduced, absent or very slender 18
18. Inferior appendages with length longer than basal width (fig. 54) ..... *O. gilva* (part)
— Inferior appendages with basal width greater than length (figs 37, 40, 46) 19
19. Inferior appendages in ventral view with apico-mesial angles acute; phallus with sclerotised paramere finely whip-like distally; a pair of membranous lobes flanking abdominal segment X (fig. 37) ..... *O. australis*
— Not as above 20
20. Abdominal segment X in lateral view with an apically acute ventral process at about half length; inferior appendages in lateral view tapered toward apex (figs 40, 42); antennal segment with brush of long setae on leading edges ..... *O. quadrula*
— Abdominal segment X in lateral view expanded towards apex, lacking a ventral process; inferior appendages in lateral view rod-shaped (fig. 48); each antennal segment with setae all about equal length ..... *O. burtoni*

Oecetis pechana Mosely

Figures 1–6, 56

Oecetis pechana Mosely *in* Mosely and Kimmins, 1953: 302, figs 213–215. —Neboiss, 1977: 143, figs 764–769. —Neboiss, 1986: 267.

Material examined. Holotype. Male, Yanchep, WA, 31°32.9'S, 115°41.2'E (BMNH).

Other material: Some 240 samples from all states of Australia were examined, in collections of NMV, ANIC, QM, NTM.

Diagnosis. Male. Recognised by a combination of wing features, including scale patches, and the general form of the genitalia with inferior appendages in ventral view stoutly clasper-shaped, smoothly curved mesially, and broadly rounded apically; abdominal segment X a simple membranous plate; the phallus long and straight, extending the length of 3–4 abdominal segments, and having the paramere stout and darkly sclerotised. Male forewing (fig. 1) length 5.5–9.6 mm.

Males of closely similar species differ from *O. pechana* as follows: *O. walpolica* has the inferior appendages in lateral view tapered to narrowly rounded apex, phallus shorter, its length equalling about 2 abdominal segments, and the paramere strongly arched dorsally; *O. katae* has inferior appendages in lateral view even more narrowly tapered and curved upwards, phallus shorter, paramere arched ventrally; *O. magelensis* has the inferior appendages shallowly excavated mesially, phallus shorter, about 2–3 abdominal segments in length; *O. gilva* usually has no scales on the forewing, inferior appendages in lateral view attenuate apically, and phallus very short, about length of 1.5 abdominal segments, without paramere.

Distribution. Australia-wide.

Remarks. As defined here, *O. pechana* is difficult to distinguish from closely similar species, since the key diagnostic feature is the length of the male phallus. This feature is surely biologically significant, acting as a reproductive isolating mechanism, determining mating success. Nevertheless, it does appear likely that hybridisation between *O. pechana* and other species occurs, and this may be confirmed if molecular studies are carried out in the future. *Oecetis suteri* similarly has the phallus elongate, but can easily be distinguished by the much reduced inferior appendages. *Oecetis pechana* is often common in both lentic and lotic systems, where its larvae build tube cases of sand.

Oecetis walpolica Neboiss

Figures 7, 8, 57

Oecetis walpolica Neboiss, 1982: 321, figs 123–125. —Neboiss, 1986: 267.

Holotype. Male, Frankland R., Circular pool, 6 km NE of Walpole, WA (NMV: T-6596).

Material examined. Forty-five samples, most from WA, several from NT.

Diagnosis. Male. Closely resembling *O. pechana*, especially in form of the wings, shape of inferior appendages in ventral view, and presence of the basi-dorsal pouch on the inferior appendages. Distinguished from that species by the male genitalia with inferior appendages attenuate apically in lateral view, and phallus about half length of that of *O. pechana* and strongly arched dorsally. Also resembling *O. kateae* sp. nov. in general form, but the phallus of *kateae* is less strongly curved and arches ventrally, and the inferior appendages in ventral view are more widely curved and attenuate apically. Male forewing length 5.7–10 mm.

Distribution. Distributed from south-western WA inland and northwards to the far north of NT.

Remarks. Oecetis walpolica is easily mistaken for *O. pechana* and, similarly, is found in waterholes of the arid inland.

Oecetis umbra Neboiss

Figure 58

Oecetis umbra Neboiss, 1977: 144, figs 770–773. —Neboiss, 1986: 268.

Holotype. Male, Tas., Waldheim, Cradle Mountain National Park (NMV T-5489).

Material examined. Tas.: 1 male, Lake Dobson, 20 Feb 1967, E.F. Riek (ANIC); numerous males, females, Franklin R., Roaring Creek junction, 1 km above Gordon R., 8 Jan 1977, Coleman, Neboiss, Allbrook (NMV); 1 male, Gordon R., 1 km above First Split, 11 Jan 1977, Coleman, Neboiss, Allbrook, Swain (NMV); 2 males, 1 female, swamp near Olga R., 19 km above Gordon R. Junction, 13 Jan 1977, Neboiss and Swain (NMV); 2 males, 2 females, Caves Camp, NE of New R. Lagoon, 2 Jan 1979, S.F. McEvey (NMV); numerous males, females, south coast, Cavers Camp, New R. Lagoon, 3 Jan 1979, S.F. McEvey (NMV).

Diagnosis. Male. Closely resembling *O. pechana* and *O. walpolica* in general features such as scales on the wing and clasper-shaped inferior appendages, but distinguished from both these species by shorter phallus with the paramere only slightly curved, and inferior appendages divergent apically, rather than convergent.

Distribution. Known only from Tas.

Remarks. Neboiss, 1977 compared this species to the New Zealand *Oecetis unicolor* McLachlan and Chatham I. *O. chathamensis* Tillyard and it certainly resembles those species more closely than it does Australian species.

Oecetis magelensis sp. nov.

Figures 9–11, 59

Material examined. Holotype. Male, NT, Alligator R. region, Magela Creek, OSS Site 009, 12°42'S, 132°57'E, 17 Jan 1992, Wells (ANIC).

Paratypes. NT: 24 males, ARR, Magela Creek site 009, 15 Feb 1991, Wells (ANIC); 5 males, 5 females, ARR, Magela Creek at Rum pipeline, 18–19 Feb 1991, P. Dostine (NMV).

Other material. NT: 1 male, Mataranka HS, Roper R., 25 Jan 1977, M.S. and B.J. Moulds (NMV); 1 male, 1 female, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 28–29 Jan 1991, P. Dostine (NTM); 2 males, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 15 Feb 1991, Wells (NTM); 3 males, ARR, Magela Creek at Rum pipeline, 1–2 Apr 1991, P. Dostine (NMV); 3 males, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 1–2 Apr 1991, P. Dostine (NMV); 3 males, 1 female, Jabiru Town Lake, 12°40'S, 132°53'E, 5 Apr 1991, Wells and Webber (NTM); 6 males, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS

Site 009, 24 Apr 1991, Wells and Webber (NTM); 1 male, 1 female, 12°42'S, 132°57'E, Alligator R. Region, Magela Creek, OSS Site 009, 28–29 Apr 1991, P. Dostine (NTM); 1 male, 1 female, Gregory National Park, Limestone Gorge, 25–26 Oct 1991, J. Webber (NTM); 1 male, 1 female, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 3–4 Feb 1992, P. Dostine (NTM); 1 male, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 21–22 Mar 1992, P. Dostine (NTM). WA: 2 males, 2 females, Maggie Creek, 3 Feb 1978, J.E. Bishop (NMV); 3 males, Maggie Creek, 90 km Kununurra-Wyndham, 3 Feb 1978, J.E. Bishop (NMV); 1 male, stream opposite Dead Horse Gap, Lake Argyle, 19 Feb 1977, J.E. Bishop (NMV); 1 male, 4 females, Lily Creek Waterhole, 15 km W of Kununurra, 22 Feb 1977, J.E. Bishop (NMV); 1 male, 1 female, Dunham R. W of Kununurra, J.E. Bishop, 22 Feb 1977 (NMV); 1 male, Ord R. at Kununurra Dam, 22 Feb 1977, J.E. Bishop (NMV).

Diagnosis. Males resemble *O. pechana* and *O. walpolica*, the male genitalia appearing closely similar in ventral view, but are distinguished from the former by the shorter phallus with a strongly arched paramere, and from both *O. pechana* and *O. walpolica* by features of the inferior appendages: in ventral view, the mesial margin is lined proximally with a row of small setae, then excavated to form a small concavity; apically a cluster of short setae; in lateral view the narrower distal section of the inferior appendages is shorter and more closely resembles that of *O. suteri* sp. nov.

Description. Male. Forewing slender, length 5.0–9.0 mm, with short hair on veins, dark spots at vein junctions formed by pigmented membrane and darker vestiture; and a single broad patch of scales. Abdominal segments II–IV with tergites darkly scerotised, IX short, pale, slightly produced mid-dorsally, X a simple, membranous plate, triangular distally. Genitalia (figs 9–11). Pre-anal lobes length about 1.5 times width, apically rounded. Phallus membranous, length equal to 2–3 abdominal segments, apico-ventral portion of phallotheca sharply beak-like and down-turned, paramere darkly sclerotised, in lateral view strongly arched dorsally. Inferior appendages stout throughout length in ventral view, apically rounded, mesial margin lined proximally with short setae, abruptly excavated at about two-thirds length, with a pouch meso-dorsally on basal section; in lateral view stout, with a short, rounded lobe dorsally.

Distribution. Found in the north of WA and the NT.

Remarks. Oecetis magelensis is difficult to distinguish from *O. walpolica*, but has the inferior appendages in lateral view with distal narrower section shorter and in ventral view tending to converge, whereas in *O. walpolica* the inferior appendages tend to turn outward toward apices.

Oecetis suteri sp. nov.

Figures 12–15, 60

Material examined. Holotype. Male, Holmes Jungle NT, 7 Jun 1991, Horak and Wells (ANIC, on slide).

Paratypes. NT: 2 males, Kakadu National Park, Baroalba Springs, 25 Apr 1991, Wells and Webber (ANIC); 2 males, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 28–29 Jan 1992, P. Dostine (NTM); 2 males, same locality, 3–4 Feb 1992, P. Dostine (NTM); 2 males, Litchfield National Park, Walker Creek, 18–19 Apr 1992, Wells (NMV).

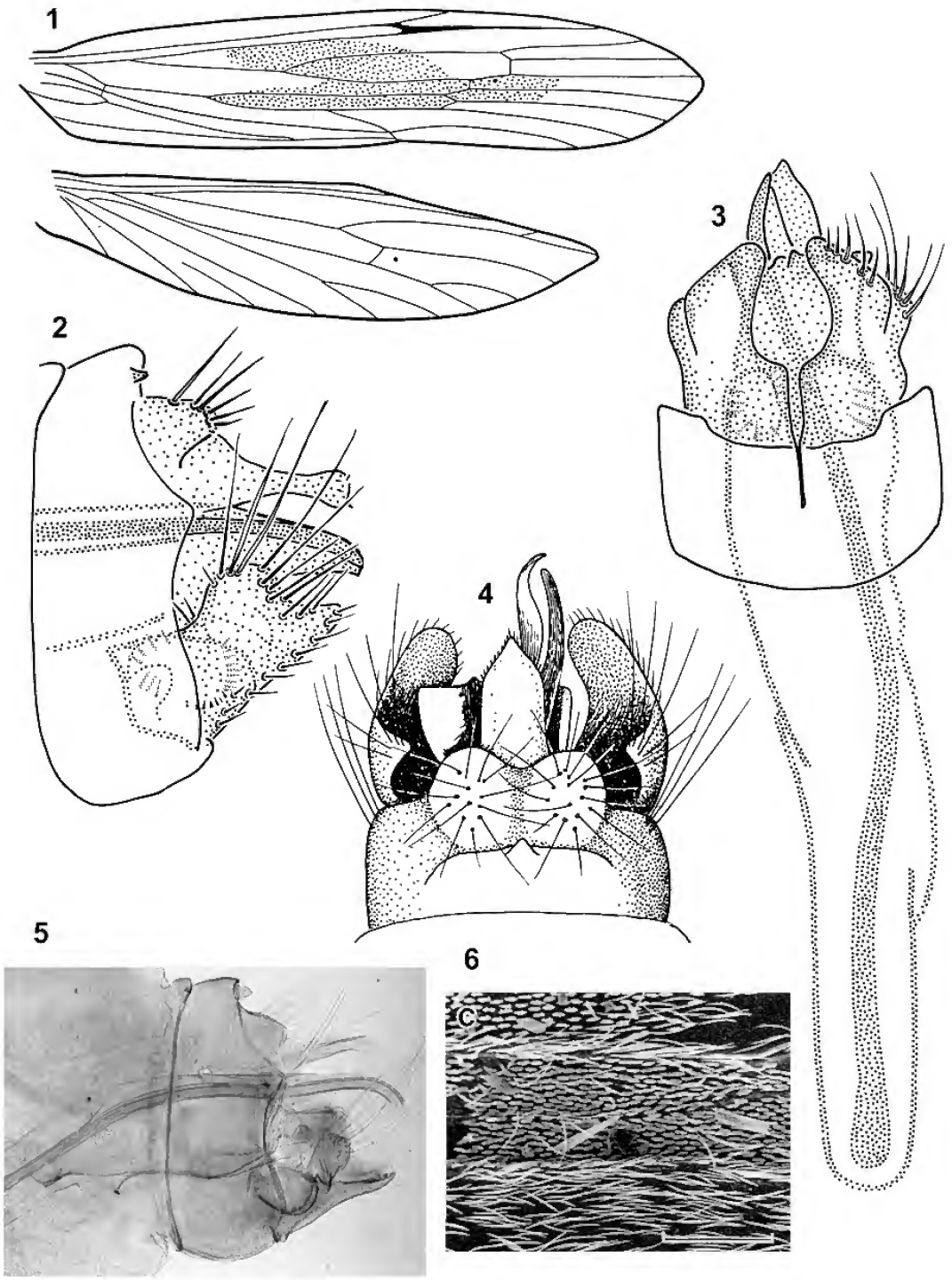
Other material. NT: 2 males, 12°52'S, 132°50'E, Koongarra, 15 km E of Mt Cahill, 15 Nov 1972, J.C. Cardale (ANIC); numerous males, females, 16°40'S, 135°51'E, Bessie Spring, 8 km ESE of Cape Crawford, 25 Oct 1975, J.C. Cardale (ANIC); 1 male, 1 female, 16°40'S, 135°51'E, 8 km ESE of Cape Crawford, 26 Oct 1975, J.C. Cardale (ANIC); 2 males, 1 female, 16°32'S, 136°10'E, Cattle Creek, 54 km S by W of Borroloola, 27 Oct 1975, J.C. Cardale (ANIC); 1 male, 1 female, SAR, 14 Jun 1988, P. Dostine, Site 1 (NTM); 1 male (headless), ARRS, Radon Springs, 13–14 Apr 1989, Suter and Wells (NMV); 2 males, Kakadu National Park, Baroalba Springs, 25 Apr 1991, Wells, Webber and Bickel (NTM); 3 males, 2 females, Berry Springs, 30 Oct 1991, Wells and Webber (NTM); 2 males, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 28–29 Jan 1992, P. Dostine (NTM); 2 males, same locality and collector, 3–4 Feb 1992 (NTM); 2 males, Litchfield National Park, Walker Creek, 18–19 Apr 1992, Wells (NTM). Qld: 1 male, Lockerbie Scrub, Cape York Peninsula, 15 Apr 1975, M.S. Moulds (NMV); 1 male, Cape York Peninsula, upper Jardine R., 11°17'S, 142°35'E, 13 Oct 1979, M.S. and B.J. Moulds (NMV); 2 males, same locality and collectors, 17 Oct 1979 (NMV); 14 males, 6 females, Bertie Creek, 1 km SE Heathlands HS, 4 Feb 1992, D. Cartwright and A. Wells (ANIC); 2 males, 1 female, tributary of Bertie Creek, 250 m SW Heathlands HS, 4 Feb 1992, D. Cartwright and A. Wells (NMV); 1 male, Eliot Creek upstream junction Canal Creek, 6Feb 1992, D. Cartwright and A. Wells (NTM); 4 males, 7 females, Dulhunty R., at Telegraph Crossing, 10 Feb 1992, D. Cartwright and A. Wells (NMV); 17 males, 7 females, tributary of Bertie Creek, 250 m SW Heathlands HS, 11 Feb 1992, D. Cartwright and A. Wells (ANIC, 2 males on slides); 5 males, 3 females, Gunshot Creek at Telegraph Crossing, 14–15 Feb 1992, D. Cartwright and A. Wells (QM); 1 male, 1 female, same locality and collectors, 17 Feb 1992 (QM); numerous males, females, Gunshot Creek at Telegraph Crossing, 4–5 Apr 1992, M. Crossland (ANIC). WA: 1 male, 1 female, Millstream Crossing Pool, 2 Oct 1970, J.C. Cardale (ANIC); 4 males, Drysdale R., upper reaches, 16°09'S, 125°58'E, 7 Sep 1996, I. Edwards (NMV).

Diagnosis. Alone in the *pechana*-group, *O. suteri* lacks fork 1 in the posterior wing; the forewing is more rounded apically than most species in this group and the scale patches narrower. Otherwise it resembles *O. pechana* and *O. magelensis* superficially, but in the male is distinguished from both by the inferior appendages broader than long in ventral view. Like *O. pechana*, *O. suteri* has the phallus about the length of 4 abdominal segments.

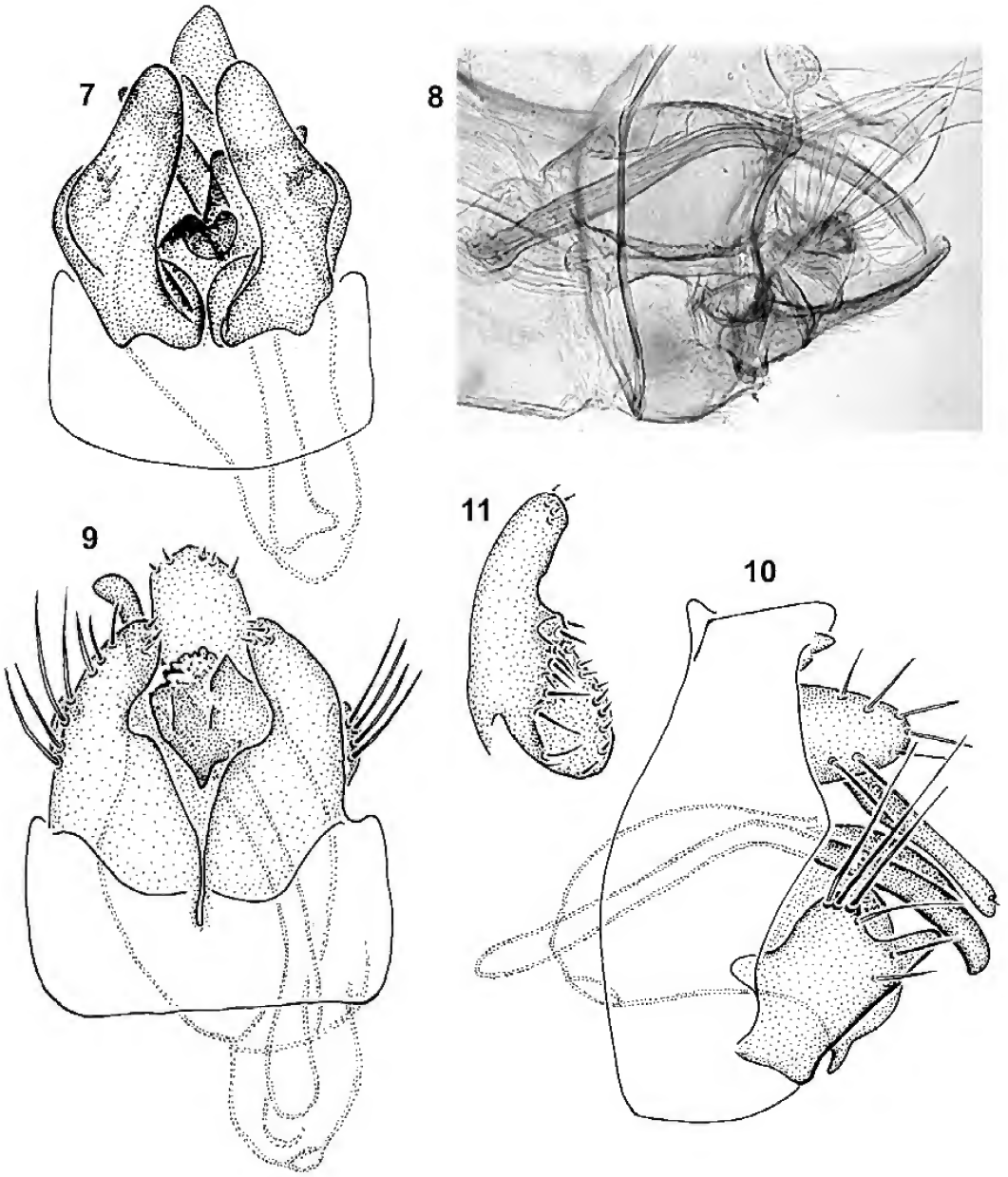
Description. Male. Wings narrower than in *O. pechana*, with dark markings at crossveins, anastomoses and at marginal ends of veins; vestiture short; forewing with a narrow, elongate patch of scales, discoidal and thyridial cells long, narrow, discoidal cell extending distally beyond M-R, M-R distal to thyridial cell; hind wing without fork 1. Forewing length, 4.3–4.6 mm. Abdominal tergites II–IV darkly sclerotised. Genitalia, see figs 12–15. Abdominal segment IX of moderate length, dorsally with paired papillae apico-mesially. Abdominal segment X sub-triangular, short setae scattered apically. Inferior appendages broad basally, slightly extended laterally, in lateral view triangular; a rounded dorsal pouch present. Phallus elongate, about 4 times length of abdominal segment IX, with a long, almost straight paramere.

Distribution. Collected in WA from the Millstream and Kimberley regions, in NT from the north, and in Qld, from the tip of Cape York.

Etymology. Named for Phillip Suter.

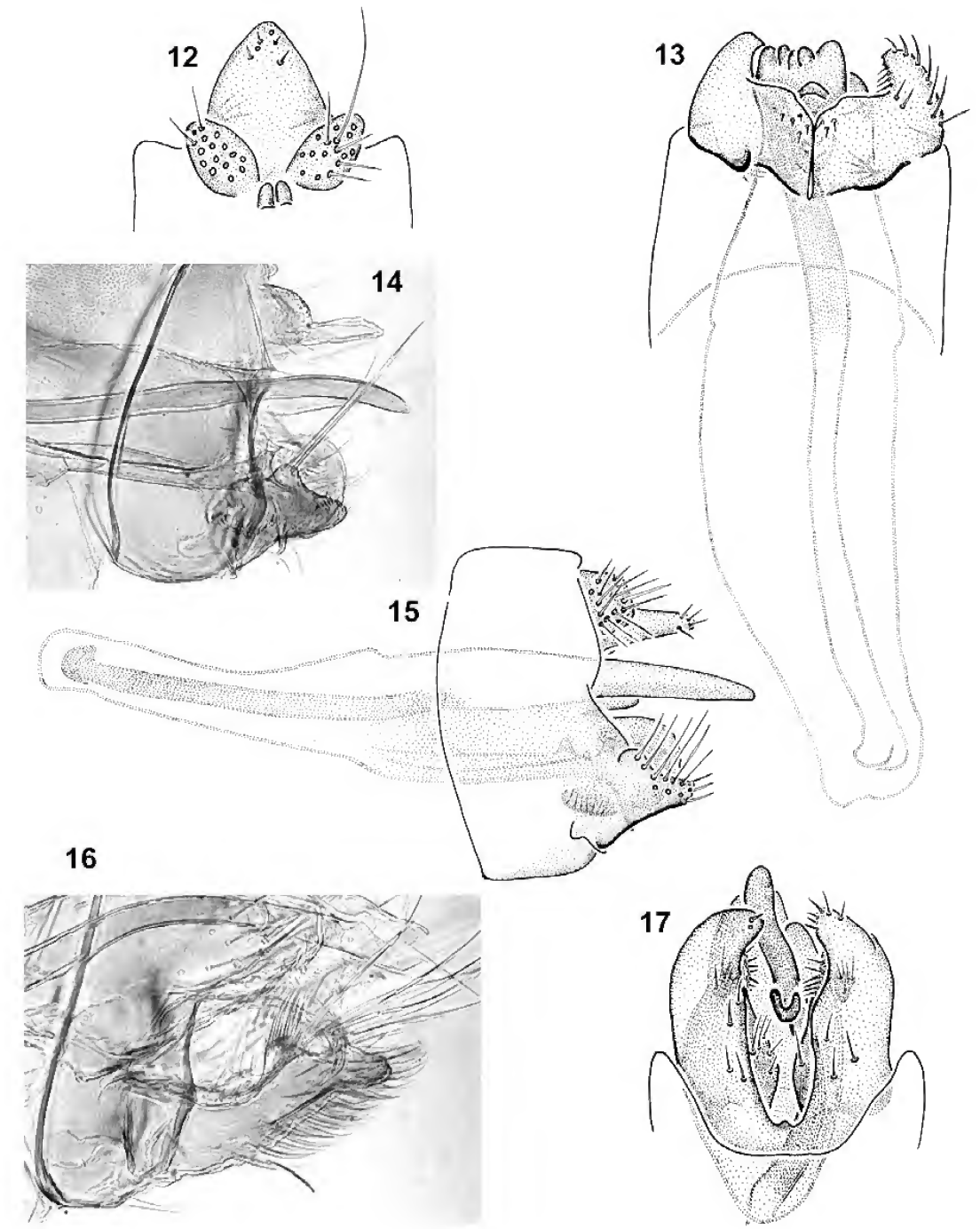


Figures 1–6, *Oecetis pechana* Mosely, male: 1, forewings and hind wings; 2–5, genitalia in lateral, ventral, dorsal and lateral views, respectively (4, after Mosely and Kimmins, 1953; 5, image taken from slide preparation); 6, wing scales (after CSIRO 1991).



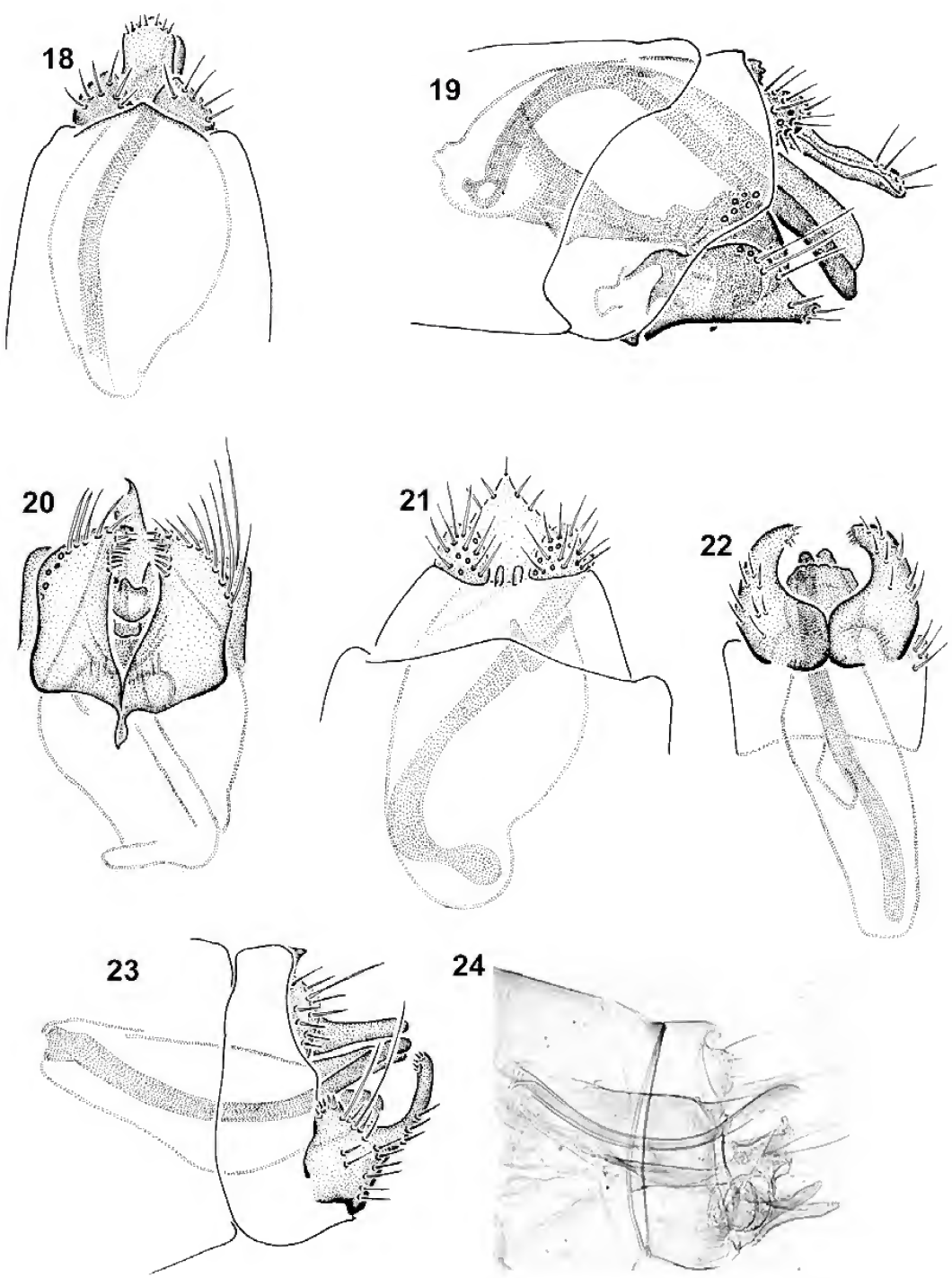
Figures 7, 8, *Oecetis walpolica* Neboiss, male genitalia in ventral and lateral views (8, image taken from slide preparation).

Figures 9–11, *Oecetis magelensis* sp. nov., male genitalia: 9, 10, ventral view and lateral view; 11, dorsal view of right inferior appendage.



Figures 12–15, *Oecetis suteri* sp. nov, male genitalia: 12, dorsal view; 13, ventral view, 14, 15 lateral views (14, image taken from slide preparation).

Figures 16, 17, *Oecetis radonensis* sp. nov., male genitalia in lateral and ventral views (16, image taken from slide preparation).



Figures 18–20, *Oecetis humphreyi* sp. nov., male genitalia in dorsal, lateral and ventral views.

Figures 21–24, *Oecetis kateae* sp. nov, male genitalia in dorsal, ventral and lateral views (24, image taken from slide preparation).

Oecetis radonensis sp. nov.

Figures 16, 17, 61

Material examined. Holotype. Male, NT, Kakadu National Park, Radon Springs, Suter and Wells, 13–14 Apr 1989 (NMV T-18840).

Paratypes. NT: 17 males, 14 females, same data as for holotype (NMV and NTM: 1 male on slide); 4 males, 3 females, Little Baroalba Creek, 25–26 Apr 1991, Wells and Webber (ANIC); 1 male, Kakadu National Park, Baroalba Springs, 12°48'S, 132°49'E, 4 Mar 1992, Wells (NTM).

Other material. NT: 1 male, Radon Creek, Kakadu National Park, 3 Sep 1979, J. Blyth (NMV). WA: 1 male, Mitchell Plateau, 30 Jan 1978, J.E. Bishop (NMV).

Diagnosis. Closely similar to *O. humphreyi* sp. nov. but male distinguished by having inferior appendages in ventral view, stout throughout length, rounded apically, and with 2 small patches of setae at about two-thirds length; phallus longer with paramere only very slightly curved.

Description. Male. Wings narrow, dark markings at crossveins, anastomoses and at marginal ends of veins; vestiture short; with a single elongate patch of scales; forewing length 4.8–5.5 mm. Abdominal segments III and IV with tergites sclerotised; segment IX excavated mid-ventrally and thus appearing to have well-developed lateral lobes; X spatulate in dorsal view, slender and elongate in lateral view. Genitalia, see figs 16, 17. Pre-anal appendages sub-triangular. Phallus about 1.5 segments long; phallotheca with membranous apex sharply down-turned; paramere in lateral view slightly curved. Inferior appendages elongate and in ventral and lateral views almost uniformly stout throughout length; in ventral view with apices in-turned, without a basi-dorsal pouch; dorsally at about two-thirds length a small group of short setae on a raised papilla, another cluster on mesial margin, these possibly homologous with the sets of setae on papillae in the basi-dorsal pouches seen in *O. pechana* and other species.

Distribution. From the Kimberley region of northern WA and the north of the NT, but not a commonly collected species.

Etymology. Named for the type locality, on the edge of Mt Brockman in Kakadu National Park.

Oecetis humphreyi sp. nov.

Figures 18–20, 62

Material examined. Holotype. Male, NT, Radon Springs, 13–14 Apr 1989, Suter and Wells (NMV T-18841).

Paratypes. NT: 2 males, same data as for holotype (NMV); 1 male, 12°48'S, 132°49'E, Kakadu National Park, Baroalba Springs, 25 Apr 1991, Wells and Webber (NTM); 4 males, females, same locality and collectors, 29 May 1991 (NTM); 2 males, same locality and collectors, 4 Oct 1991 (NTM); 1 male, Berry Springs, edge of *Melaleuca* nr Billabong, 8–9 Apr 1991, Wells and Horak (NTM); 1 male, Berry Springs, 4 Oct 1991, Wells (NTM).

Other material. NT: 3 males, 1 female, Butterfly Gorge, Katherine Gorge National Park, 27 Jan 1977, M.S. Moulds (NMV); numerous males, females, ARR Magela Creek OSS site 009, 15 Feb 1991, A. Wells (NMV); 2 males, ARR Magela Creek 009, 15 Mar 1991, Wells and Webber (NTM); numerous males, females, 12°40'S, 132°53'E, Jabiru, Town Lake, 2 Apr 1991, Wells and Webber (NTM); 1 male, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, at Rum Pipeline, 6–7 May 1991, P. Dostine (NMV); 1 male, 1 female, Gregory National Park, Limestone Gorge, 25–26 Oct 1991, J. Webber (NTM); 1 male, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 14 Apr 1992, Wells and Webber (NTM); 1 male, same locality, 21–22 Apr 1992, P. Dostine (NTM). WA: 1 male, 1 female, Dead Horse Springs, Lake Argyle, 19 Feb 1977, J.E. Bishop (NMV); 1 male, Fine Springs Creek, on road between Lake Argyle tourist village and Duncan Highway, 23 Feb 1977, J.E. Bishop (NMV).

Diagnosis. Closely similar to *Oecetis radonensis*, but male with inferior appendages distally more strongly tapered to sharper apices, a row of setae on the inner margin sub-apically; abdominal segment X triangular; and phallus of medium length with paramere, in lateral view, strongly arched dorsally.

Description. Male. Wings with vestiture short; forewing with a broad scale patch. Anterior wing length, 4.6–4.7 mm. Abdominal tergites II–IV darkly sclerotised; segment IX strongly excavated ventrally, with a pair of small apico-dorsal papillae; segment X broad-based, triangular in dorsal view, elongate and slender in lateral view. Genitalia, see figs 18–20. Pre-anal appendages well separated, in dorsal view, triangular. Phallus of moderate length, apically beak-like in lateral view; paramere strongly twisted at base in ventral view, in lateral view strongly arched dorsally. Inferior appendages in lateral view tapered towards apex, in ventral view stout with apices convergent, short setae on inner subapical margin, basi-dorsal pouch small and rounded.

Distribution. Collected from the north of the NT and the Kimberley Region of northern WA.

Etymology. Named for Chris Humphrey.

Oecetis kateae sp. nov.

Figures 21–24, 63

Material examined. Holotype. Male, NT, 12°40'S, 132°53'E, Jabiru, Town Lake, 16 Feb 1991, Wells (ANIC).

Paratypes. NT: 2 males, 14 females, same data as for holotype (NTM, ANIC); 22 males, 38 females, 12°42'S, 130°58'E, Berry Springs, 9 Apr 1991, A. Wells and M. Horak (NTM, NMV); 14 males, 23 females, 13°03'S, 130°47'E, Litchfield National Park, Florence Falls, 6 Jun 1991, Wells and Webber (ANIC).

Other material. Ninety-seven samples from NT, Qld, NW WA and NE NSW.

Diagnosis. Recognised by inferior appendages more slender and smoothly curved than those of *O. pechana* and *O. walpolica*, and by the ventrally arched paramere of the phallus.

Description. Male. Wings with short hair, darkly pigmented hair and membrane at anastomoses of veins and crossveins; forewing with a single large patch of scales. Forewing length, 5.1–5.9 mm. Abdominal tergites II–IV darkly sclerotised, segment IX narrow, almost a regular annulus, dorsally slightly pointed apico-mesially, segment X narrow, tapered towards apex. Genitalia, see figs 21–24. Pre-anal appendages short, wider than long. Inferior appendages stouter basally than distally but almost C-shaped in ventral view, in lateral view broad-based, slender, upturned distally, basi-dorsal pouch present. Phallus about length of 3 abdominal segments, membranous ventral phallotheca small, not down-turned, paramere arched ventrally.

Distribution. A widely distributed species that is often abundant in light trap samples from the Kimberley of WA, through the north of the NT to northern Qld, and south east to the border of Qld and NSW.

Remarks. Superficially males of this species resemble those of *O. walpolica* save that the inferior appendages are distally more slender, but close examination of the male genitalia confirms the unique state of the paramere of the phallus, arching in the opposite direction from that of *O. walpolica*, and far less strongly curved.

Etymology. Named for Kate Humphrey.

Oecetis geniculata sp. nov.

Figures 25, 26, 64

Material examined. Holotype. Male, NT, Litchfield National Park, Billabong, 18–19 Apr 1992, A. Wells (ANIC).

Paratypes. NT: 21 males, 33 females, same data as for holotype (NTM and ANIC); 17 males, 15 females, Humpty Doo, Solar Village, 9 Apr 1991, Horak and Upton (NMV).

Other material. Forty-five samples from the north of NT.

Diagnosis. Readily distinguished by the almost jointed appearance of the inferior appendages in ventral view, the unusually slender wings, and markings on the forewings.

Description. Male. Wings with vestiture short; forewing with a patch of scales, but scales appear to be readily dehiscent so that often specimens are collected without scales. Forewing length 4.6–5.0 mm. Abdominal segments II–IV darkly sclerotised, segment IX of moderate length, segment X sub-triangular. Genitalia, see figs 25–26. Pre-anal appendages almond-shaped. Inferior appendages stout, elongate, ridged and turned inward at about two-thirds length, giving a jointed appearance; without a basi-dorsal pouch. Phallus about 1.5 abdominal segments long, paramere straight.

Distribution. Often abundant in samples from the north-west of NT.

Etymology. The name derives from the Latin *geniculatus* — knotty, for the somewhat jointed appearance of the inferior appendages.

Remarks. This species is small and pale, its narrow wings lacking the usual dark markings of the *pechana*-group. It is commonly collected at billabongs or other stillwater bodies.

Oecetis litua sp. nov.

Figures 27–29, 65

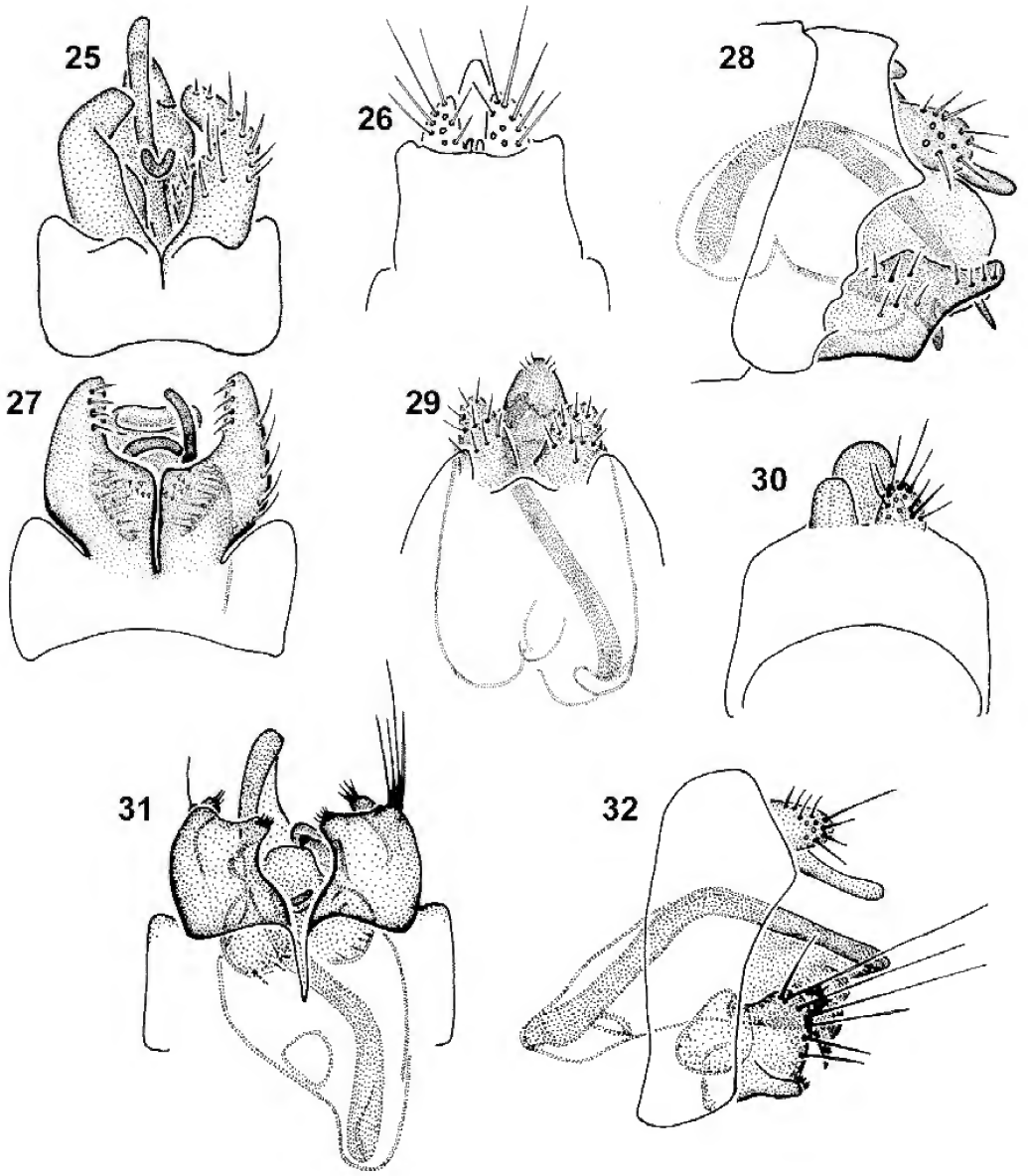
Material examined: Holotype. Male, 12°40'S, 132°53'E, Jabiru, Town Lake, 30 May 1991, Wells and Webber (ANIC).

Paratypes. NT: 46 males, 9 females, East Alligator R. at Cahill's Crossing, Wells and Suter, 27 May 1988 (NMV).

Other material. NT: 2 males, 12°17'S, 133°20'E, Cooper Creek, 11 km SW of Nimbuwah Rock, 3–4 Jun 1973, J.C. Cardale (ANIC); 3 male, 3 females, 12°06'S, 133°04'E, Cooper Creek, 19 km SE of Mt Borrodaile, 5–6 Jun 1973, J.C. Cardale (ANIC); 1 male, 12°25'S, 132°58'E, 1 km of Cahills Crossing (East Alligator R.), 7–8 Jun 1973, J.C. Cardale (ANIC); 3 males, 12°52'S, 132°50'E, Koongarra, 15 km E of Mt Cahill, 12–13 Jun 1973, J.C. Cardale (ANIC); 1 male, 12°52'S, 132°47'E, Nourlangie Creek, 8 km E of Mt Cahill, 14–15 Jun 1973, J.C. Cardale (ANIC); 2 males, 12°57'S, 132°33'E, Jim Jim Creek, 19 km WSW of Mt Cahill, 17 Jun 1973, J.C. Cardale (ANIC); 1 male, 1 female, 15°58'S, 136°21'E, 12 km NNE of Borroloola, 1 Nov 1973, J.C. Cardale (ANIC); numerous males, females, Katherine R. Gorge Nat. Pk, 13 Aug 1979, J. Blyth (NMV); numerous males, females, Adelaide R., 15 km E of Stuart Highway, 15 Aug 1979, J. Blyth (NMV); 5 males, 1 female, South Alligator R., UDP Falls [Gunlom], 7 Sep 1979, J. Blyth (NMV); 5 males, junction of Arnhem Highway and Oenpelli Rd, 26–27 Jun, 1980, M.B. Malipatil (NMV); 2 males, UDP Falls [Gunlom], 18–19 Jul 1980, M.B. Malipatil (NMV); 2 males, ARRS, South Alligator R. at Gimbat OSS Station, 28 Apr 1988, P. Dostine (NMV); 1 male, Magela Creek, Stoned Billabong, 15 May 1988, Wells and Suter (NMV); 2 males 3 females, ARRS, Radon Springs, 18 May 1988, A. Wells and P. Suter (NMV); 3 males, Coonjimba Billabong, 19 May 1988, P. Suter and A. Wells (NMV); 1 male, Magela Creek at Ranger pipe outlet, 20 May 1988, A. Wells and P. Suter (NMV); 1 male, ARRS, Ranger Mine RP1, 20 May 1988, A. Wells and P. Suter (NMV); 2 males, Magela Creek at Ranger pipe outlet, 23 May 1988, A. Wells and P. Suter (NMV); 1 male, 1 female, ARRS, South Alligator R. below Fisher Creek junction, 24 May 1988, A. Wells and P. Suter (NMV); 2 males, ARRS, South Alligator R. at Gimbat OSS Station, 24 May 1988, A. Wells and P. Suter (NMV); 2 males, South Alligator R. below BHP camp, 25 May 1988, P. Suter and A. Wells (NMV); 1 male, 1 female, South Alligator R., 14 Jun 1988, P. Dostine, site 1 (NMV); 2 males, 12°36'S, 132°53'E, ARRS Gulungul Creek, inlet to Gulungul Billabong, 20 Apr 1989, A. Wells and P. Suter (NMV); 1 male, Litchfield National Park, Florence Falls, 9 Apr 1991, Horak, Wells and Upton (NTM); 1 male, 12°42'S, 130°58'E, Berry Springs, 9 Apr 1991, Wells and Horak (NTM); numerous males, females, 12°42'S, 132°57'E, Kakadu National Park, Magela Creek, OSS Site 009, 24 Apr 1991, Wells and Webber (NTM); 1 male, Little Baroalba Creek, 25–26 Apr 1991, Wells and Webber (NTM); 4 males, 1 female, Jabiru Town Lake, 13 May 1991, C. Humphrey (ANIC); 1 male, Jabiru Town Lake, 30 May 1991, Wells and Webber (NMV); 1 male, 1 female, 12°48'S, 132°49'E, Kakadu National Park, Baroalba Springs, 16 Aug 1992, Wells and Webber (NTM); 1 male, 13°16'S, 132°49'E, Kakadu National Park, Jim Jim Falls, camp site, 13 Aug 1996, I. Edwards (NMV). WA: 2 males, Drysdale R. National Park via Carson R. Station, 14°37'S, 125°56'E, 31 Aug 1996, I. Edwards (NMV); 2 males, 1 female, Drysdale R. Crossing, Kalumbaru Rd, 15°42'S, 126°22'E, 28 Aug 1996, I. Edwards (NMV). Qld: numerous males, females, Palmer R., 20 Jun 1971, E.F. Riek (ANIC); 1 male, Mulgrave R., W of Gordonvale, 29 Apr 1979, A. Wells (NMV).

Diagnosis. 1 of several Australian species with distinctively spotted wings that give a somewhat moth-like appearance. In general appearance resembling *O. hemerobioides* McLachlan, 1866 and *O. dostinei* Wells, 2004, but distinguished from those 2 *laustra*-group species by having males with stout inferior appendages, and the phallus with a slender internal paramere.

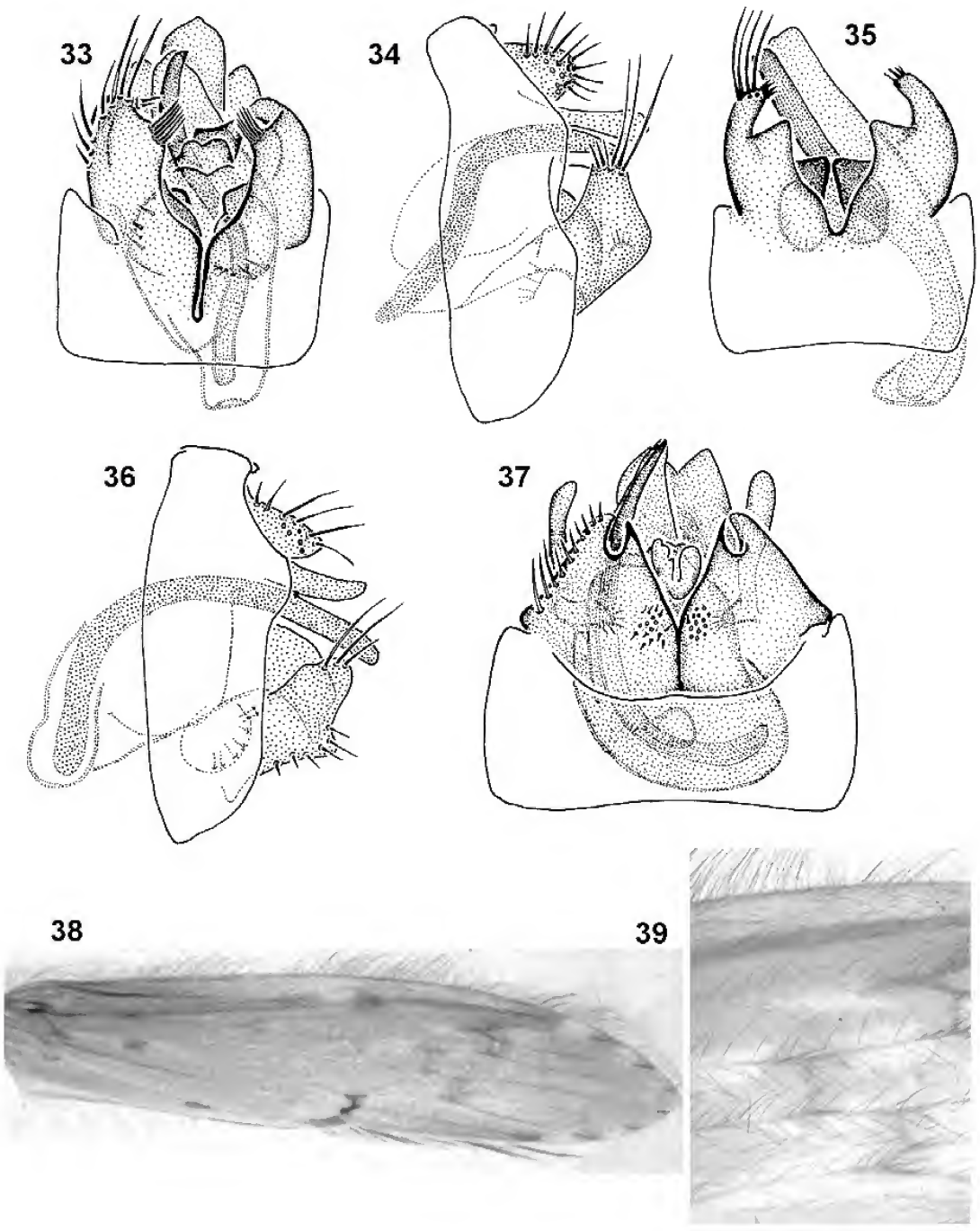
Description. Male. Wings of typical shape, without scales, but with pattern of spots, and long downy hair on veins. Anterior wing length 5.7–6.0 mm. Abdominal segment IX narrow mid-ventrally, with pronounced lateral lobes, segment X broad-based, triangular in dorsal view, slender, tapered in lateral view. Genitalia, see figs 27–29. Pre-anal appendages rounded apically. Phallus stout, short; aedeagus membranous with a sclerotised band apically forming a sharp 'beak' in lateral view; paramere slender, in lateral view strongly curved, slightly sinuous in dorsal and ventral view. Inferior appendages stout at



Figures 25, 26, *Oecetis geniculata* sp. nov., male genitalia in ventral and dorsal views.

Figures 27–29, *Oecetis litua* sp. nov., male genitalia in ventral, lateral and dorsal views.

Figures 30–32, *Oecetis jenniae* sp. nov., male genitalia in dorsal, ventral and lateral views.



Figures 33, 34, *Oecetis mouldsi* sp. nov., male genitalia in ventral and lateral views.

Figures 35, 36, *Oecetis theischingeri* sp. nov., male genitalia in ventral and lateral views.

Figures 37–39, *Oecetis australis* (Banks): 37, male genitalia in ventral view; 38, forewing; 39, downy hair on wing veins.

base, the mesial ventral margins closely adpressed for 1st half length, then abruptly excavated such that the appendages taper to conical lobes distally; in lateral view quite irregular in shape, broadest medially; dorsal pouch reduced to an angled row of stout setae in basal part of appendage.

Distribution. Known from the north of NT and northern Qld, and from 1 sample from northern WA.

Remarks. Within the *pechana*-group, this species is distinctive in its wing pattern and colouration. Yet the paramere and vestiges of the basi-dorsal pocket on the inferior appendages, clearly place it with other *pechana*-group species.

Etymology. The name is derived from the Latin — *lituus*, a curved staff, being descriptive of the paramere of the phallus in lateral view.

Oecetis jenniae sp. nov.

Figures 30–32, 66

Material examined. Holotype. Male, NT, 12°42'S, 130°58'E, Berry Springs, 31 Mar 1992, Wells (ANIC).

Paratypes. NT: 18 males, 17 females, same data as for holotype (ANIC, NMV); 42 males, 22 females, same locality, 17 May 1992, Wells (NTM).

Other material. 105 samples, some comprising numerous specimens, from NT, WA, Qld and NSW (one sample only).

Diagnosis. Oecetis jenniae resembles *O. mouldsi*, having similar male genitalia; however, it lacks a prominent apico-dorsal lobe, and has wing venation of a more normal *pechana* type, the veins not particularly emphasised. In having wing scales and in the pattern of wing markings, *O. jenniae* resembles *O. pechana*, but the male inferior appendages are wider than long and not clasper-shaped, features shared with *O. theischingeri* from which it is distinguished by lacking an apico-mesial lobe on the inferior appendages. The inferior appendages of this species resemble most closely those of *O. burtoni* and *O. quadrula*, but both of those species have long downy vestiture on the male wing and no scales.

Description. Male. Wings with vestiture short, pattern of dark areas at vein anastomoses and at margin; forewing with a patch of scales, which may be narrow or broad. Anterior wing length, 3.9–4.7 mm. Abdominal tergites II–IV darkly sclerotised, segment IX annulate, segment X short, rounded in ventral view, slender in lateral view. Genitalia, see figs 30–32. Pre-anal appendages rounded apically. Phallus about length of 2.5 to 3 abdominal segments; paramere S-shaped in ventral view, in lateral view arched dorsally. Inferior appendages stout, subquadrate in ventral view, with a short dorso-lateral lobe, basi-dorsal pouch present.

Distribution. Widespread in the north of the continent, but also occurring in the south-east of Qld, west of the divide in central NSW, and in the Pilbara region of WA.

Etymology. Named for Jenni Webber.

Remarks. Oecetis jenniae as recognised here is rather variable in features of male genitalia and in the breadth of the scale patches on the male wing. Most specimens from across northern Australia conform to the type specimen from the north of the Northern Territory in having a broad scale patch on the forewing, and the apex of the dorsal lobe of the inferior appendages rounded, rather than acuminate. Some specimens from north-western Western Australia have only a narrow scale patch on the forewing, and the apex of the dorsal lobe of the inferior appendages acuminate, rather than more rounded. For the present a single species is recognised; it is often abundant in light trap collections.

Oecetis mouldsi sp. nov.

Figures 33, 34, 67

Material examined. Holotype. Male, WA, Millstream, Fortescue R., S of Roeborne, 12 Nov 1978, M.B. and B.J. Moulds (NMV T-18842).

Paratypes. WA: 1 male, Drysdale R. headwaters, 30 km NW Mt Elizabeth HS, 30 Sep 1979, J. Blyth (NMV); 1 male, 20°18.48'S, 119°15.16'E, N Pilbara, de Grey R., 25 Apr 1992, P.S. Cranston and P.J. Gullan (ANIC); 5 males, 9 females, 18°06'S, 125°42'E, Geikie Gorge, 5 Oct 1996, I. Edwards (NMV). NT: 1 male, 2 females, 12°40'S, 132°53'E, Jabiru, Town Lake, 17 May 1991 Wells and Webber (ANIC).

Other material. WA: 15°12'S, 128°12'E, Spillway Creek, Ord R. Dam, 20 Feb 1977, J.E. Bishop (NMV); 1 male, 1 female, Spillway Creek, 3 Feb 1978, J.E. Bishop (NMV); 2 females, Limestone Gorge, 16°02'S, 130°23'E, 23–26 Jun 1986, M.B. Malipatil, Operation Raleigh 1986 (NMV); 1 male, Wickham R., 23 km downstream Humbert R. Station, 16°49'S, 131°28'E, 11 Jul 1986, I. Archibald, Operation Raleigh 1986 (NMV); 1 male, 17°01'S, 126°14'E, Bell Gorge, Melaleuca Hole, 13 Sep 1996, I. Edwards (NMV); 1 male, 16°58'S, 125°59'E, Moll Gorge, Hann R., 15 Sep 1996, I. Edwards (NMV). NT: 1 male, 5 km W of King R., SW of Katherine, 5 Feb 1977, M.S. and B.J. Moulds (NMV); 1 male, 1 female, Katherine R. Gorge National Park, 13 Aug 1979, J.E. Blyth (NMV); 1 male, 3 km E of Howard Springs, 17 Aug 1979, J. Blyth (NMV); 3 males, 5 females, Jasper Creek, Victoria R. Downs Rd., 45 km SSE Timber Creek, 17 Sep 1979, J. Blyth (NMV); 4 males, 1 female, UDP Falls [Gunlom], 18–19 Jul 1980, M.B. Malipatil (NMV); 1 male, 4 females, Roderick Creek, Gregory National Park, 15°38'S, 131°22'E, 4–6 Jul 1986, I. Archibald, Operation Raleigh 1986 (NMV); 3 males, ARR, Magela Creek, 15 Feb 1991, A. Wells (NMV). Qld: 9 males, 5 females, Upper Ross R. below weir, S of Townsville, 8 May 1979, A. Wells (NMV); 1 male, 21°07'S, 148°38'E, Finch Hatton Gorge, 14 Nov 1982, T. Hinger (NMV).

Diagnosis. Closely resembling *O. jenniae*, but distinguished from that species by the more pronounced venation of the forewing, and in the male genitalia, by the inferior appendages in ventral view well separated mesially by a triangular apico-mesial process.

Description. Male. Wings with veins more strongly pronounced than usual for *pechana*-group species, with vestiture short and pattern of dark areas at vein anastomoses and at margin; forewing with a large patch of scales, length 6.0–6.3 mm. Abdominal tergites II–IV darkly sclerotised; segment IX annulate, postero-lateral margin produced slightly, forming a short lateral lobe; segment X membranous, slender in lateral view. Genitalia, see figs 33, 34. Pre-anal appendages rounded apically. Phallus about length of 2 abdominal segments, in

lateral view with paramere arched dorsally. Inferior appendages with a basi-dorsal pouch; in ventral view broad-based, with slender dorso-lateral lobe, and a triangular process near base on mesial margin; in lateral view, stout.

Distribution. From north-western WA to the north of the NT, and from 2 localities in north-eastern in Qld.

Remarks. Superficially males of this species resemble those of *O. jenniae*, with which they are often collected, but they are clearly differentiated from that species by the more pronounced wing venation, and narrower inferior appendages.

Etymology. Named for Max Moulds.

Oecetis theischingeri sp. nov.

Figures 35, 36, 68

Material examined. Holotype. Male, Qld, Booloumba Creek, 8 km SW of Kenilworth, 26°39'S, 152°39'E, 12 Dec 1984, G. Theischinger (NMV T-18843, on slide).

Paratypes. Qld: 4 males, same data as for holotype (NMV, 1 on slide); 1 male, Finch Hatton Gorge, 21°07'S, 148°38'E, 14 Nov 1982, T. Hinger (NMV, on slide); 13 males, Strathpine, nr Brisbane, 27°19'S, 153°00'E, 3 Dec 1984, G. Theischinger (NMV, 1 male on slide).

Other material. Qld: 1 male, 1 female, Upper Brookfield nr Brisbane, 4 Apr 1967, N. Dobrotworsky (NMV); 1 male, West Claudie R., 17 Sep 1974, M.S. Moulds (NMV); 1 male, same locality and collector, 30 Sep 1974 (NMV); 1 male, Middle Claudie R., Iron Range, 29 Sep 1974, M.S. Moulds (NMV); 12 males, 1 female, same locality and collector, 2–9 Oct 1974 (NMV); 2 males, same locality and collector, 23 Oct 1974 (NMV); 1 male, Funnel Creek, 53 km SW of Sarina, 4 Jan 1975, M.S. Moulds (NMV); 1 male, 1 female, Bulimba Creek, Site 5, Boorabbin Park, 9 Oct 1979, J.C. Cardale (ANIC); 2 males, Bulimba Creek, near Brisbane, Site R1, Kimmax Street riffle, 23 Oct 1979, [collector not given], (NMV); 4 males, Bulimba Creek, near Brisbane, Site R3, Willowbend lawns, 13 Mar 1980, A. Neboiss (NMV); 1 male, Obi Obi Creek, 8 km SW of Mapleton, 23 Oct 1980, A. Neboiss (NMV); 1 male, 7 females, Coondoo Creek, 30 km NE Gympie, Toolara State Forest, 28 Oct 1980, A. Neboiss (NMV); 1 male, 28°03'S, 152°24'E, Cunninghams Gap, Western Fall, 1 Sep 1984, G. Theischinger (NMV). NSW: 1 male, Kings Gap, S of Sandy Hollow, 5 Dec 1976, G. Daniels (NMV). Vic.: 1 male, Dartmouth R. Survey, Stoney Creek, 14 Feb 1973, Loc VB (NMV) [doubtful record].

Diagnosis. Resembling *O. jenniae* and *O. mouldsi* in having short stout inferior appendages, but distinguished by having the apico-mesial angle of the inferior appendages triangular, and triangular apico-mesial lobes on the inferior appendages. In the latter feature, *O. theischingeri* resembles *O. australis*; but *O. australis* is clearly distinct in having the apico-mesial lobes on the inferior appendages with apices acute and wings with vestiture downy.

Description. Male. Wings with vestiture short, pattern of dark areas at vein anastomoses and at margin; forewing with a large patch of scales. Anterior wing length, 5.0–5.2 mm. Abdominal tergites II–IV darkly sclerotised; abdominal segment IX annulate; segment X elongate-triangular in dorsal view, stout in lateral view, apically capped by a cluster of short setae. Genitalia, see figs 35, 36. Pre-anal appendages almond-shaped. Phallus about length of 2–3 abdominal segments, paramere more sinuous than arched. Inferior appendages wide basally in ventral view with a triangular apico-mesial lobe; in lateral view stoutly rounded dorsally; a basi-dorsal pouch present.

Distribution. Known from north-, central- and south-eastern Qld and from 1 site in NSW. A single specimen bearing locality data of Vic. is undoubtedly this species, but as it is the only specimen from as far south, despite intensive collecting in that area, it is considered a doubtful record until verified by further collecting.

Etymology. Named for Gunther Theischinger.

Oecetis australis Banks

Figures 37–39, 69

Oecetina australis Banks, 1920: 350, pls 1–7. —Mosely and Kimmins, 1953: 305. Neboiss, 1977: 145, figs 777–783. Neboiss, 1979: 840.

Holotype. Male, Vic., Melbourne ('Thorey') (ANIC, ex MCZ), examined.

Oecetis situlus Korboot, 1964: 32, figs 1–7 (synonymised by Neboiss, 1987: 139).

Holotype. Male, Qld, Cedar Creek, Mt Tamborine (QM).

Material examined. Ninety-two samples from Qld, Vic., NSW, Tas., SA and the NT.

Diagnosis. In males closely resembling *O. burtoni* in wing form, and most similar to *O. theischingeri* in form of the inferior appendages, but distinguished from both species by the acute ventro-mesial processes on the inferior appendages and from the latter by the downy vestiture on the inferior appendages, the acute apices on the ventro-mesial processes and the whip-like flagellum into which the paramere of the phallus extends.

Forewing length, 6.4–7.0 mm.

Distribution. Widespread in eastern Australia, from Tas. to northern Qld and also collected from Kangaroo I., SA, and the north-west of the NT.

Oecetis quadrula sp. nov.

Figures 40–42, 70

Material examined. Holotype. Male, NT, Kakadu National Park, UDP Falls, 7 Sep 1979, J. Blyth (NMV T-18844, on slide).

Paratypes. NT: 1 male, Litchfield National Park, Florence Falls, 9 Apr 1991, Horak, Upton and Wells (ANIC); 1 male, Jabiru Town Lake, 13 May 1991, C. Humphrey (ANIC);1 male, Kakadu National Park, Baroalba Springs, 4 Oct 1991, Wells and Webber (NTM); 1 male, same locality, 16 Jan 1992, Wells, Webber and Bickel (NTM); 1 male, Magela Creek Site 009, 3 Mar 1992, A. Wells (NTM).

Other material. NT: 1 male, Muirella Park, 12 Oct 1972, J.C. Cardale (ANIC); 1 male, 12°17'S, 133°13'E, Birraduk Ck, 18 km E by N of Oenpelli, 4–5 Jun 1973, J.C. Cardale (ANIC); 1 male, 12°31'S, 132°54'E, 9 km N by E of Mudginberri HS, 10–11 Jun 1973, J.C. Cardale (ANIC); 1 male, 12°50'S, 132°51'E, 16 km E by N of Mt Cahill, 16 Jun 1973, J.C. Cardale (ANIC); 1 male, 16°25'S, 136°05'E, 45 km SW by S of Borroloola, 5 Nov 1975, J.C. Cardale (ANIC); male, Jim Jim Creek, 3 km below falls, Kakadu National Park, 1 Sep 1979, J. Blyth (NMV, on slide); male, South Alligator R. at

UDP Falls [Gunlom], 7 Sep 1979, J. Blyth (NMV, on slide); 1 male, ARR, creek 5 km W of OSS South Alligator Field Station, 19 Apr 1989, Wells and Suter (NMV); 1 male, Melville I., Andranangoo Creek, 11°31'S, 130°54'E, 8 Oct 1996, G.R. Brown (NTM); 1 male, Melville I., Maxwell Creek, 11°33'S, 130°35'E, 14 Oct 1996, G.R. Brown (NTM); 1 male, same locality and collector, 15 Oct 1996 (NTM). WA: numerous males, females, 15°02'S, 126°55'E, Drysdale R., 3–5 Jul 1975, I.B.F. Common (ANIC); numerous males, females, 15°02'S, 126°55'E, Drysdale R., 3–8 Aug 1975, I.B.F. Common and M.S. Upton (ANIC); male, Mitchell Plateau, Camp Creek, 31 Jan 1978, J.E. Bishop (NMV, on slide); male, Mitchell Plateau, Camp Creek at Crusher, 15 Feb 1979, J.E. Bishop (NMV, on slide); 3 males, Mitchell Plateau, at Mining Camp, 14°49'S, 125°50'E, 9–19 May 1983, J.C. Cardale (ANIC); 1 male, Kimberley, Mt Barnett Station, Manning Gorge, 30 Apr 1992, P.S. Cranston (ANIC); 1 male, 15°55'S, 127°56'E, El Questro Station, Chamberlain R. pool, 26 Aug 1996, I. Edwards, NMV); numerous males, females, 15°42'S, 126°22'E, Drysdale R. Crossing, Kalumburu Road, 28 Aug 1996, I. Edwards (NMV); 2 males, 14°54'S, 126°12'E, King Edward R., 3 Sep 1996, I. Edwards (NMV); 1 male, 16°40'S, 125°56'E, Manning R. near Mt Barnett, 8 Sep 1996, I. Edwards (NMV). Qld: 1 male, The Crater, Atherton Tableland, 25 Apr 1970, S.R. Curtis (ANIC); numerous males, females, Tewah Creek, Tin Can Bay, 17–18 Oct 1971, S.R. Monteith (ANIC); 1 male, Upper Freshwater Creek, Whitfield Range near Cairns, 15 Dec 1974, Moulds (NMV, on slide); 1 male, Mulgrave R. W of Gordonvale, 29 Apr 1979, Wells (NMV); 1 male, 15°12'S, 143°52'E, Hann R. NW by W of Laura, 27 Jun 1986, J.C. Cardale (ANIC). NSW: 4 males, 8 females, Wallagarough R., Princes Highway bridge, 29 Jan 1975, A. Neboiss (NMV). Vic.: 1 male, Wingan R., 8 km S Princes Hwy, 30 Jan 1975, A. Neboiss (NMV, slide); 1 male, Tanjil R. near Old Tanjil, S34, Latrobe C. Survey, 5 Feb 1980 (NMV).

Diagnosis. In the male, resembling *O. australis* and *O. burtoni* in having long downy vestiture on the wings and no scales, but distinguished by absence of acute ventro-mesial processes on the inferior appendages, and inferior appendages short and stout in ventral view, tapered distally in lateral view, phallus short and beak-like, with a short slightly curved paramere. The form of the inferior appendages of this species is similar to *O. jenniae*, but the phallus is far shorter, its paramere short and slender.

Description. Male. Wings rounded apically, with long hair on veins; forewing without scales, length 4.6–7.0 mm. Antennae with a brush of long setae on leading edge of segments. Abdominal segments 3–5 with tergites sclerotised; segment IX narrow, lateral angles produced, segment X elongate cone-shaped in ventral view, in lateral view elongate, rounded apically and with a small triangular ventral process. Genitalia, see figs 40–42. Pre-anal appendages short, rounded, phallus scarcely longer than wide, with membranous apex of aedeagus folded and down-turned; a short, slightly curved paramere present. Inferior appendages in ventral view subquadrate, with apico-lateral lobes short, convergent; in lateral view, simple, straight, tapered at apex, without basi-dorsal pouch.

Distribution. Found across northern Australia, from WA, NT and Qld, and from south-eastern Vic.

Remarks. With a dense brush of setae on the leading edge of the antennae, antennae erect (at least in spirit material), and long maxillary palpi, males of this species look particularly moth-like. Material here referred to *O. quadrula* shows variability in genitalic form, but a conservative approach is taken in assigning all to a single species as examination of more material from the south-east of the continent is required to justify recognition of two distinct morpho-species.

Etymology: Derived from the Latin, *quadra* — square, for the shape of the inferior appendages in ventral view.

Oecetis buitenzorgensis Ulmer

Figures 43–45, 71

> *Oecetis buitenzorgensis* Ulmer, 1951: 459, figs 708–712. Holotype. Java (ZMB).

Material examined. Qld: 7 males, Little Mulgrave R., 28 Jun 1971, E.F. Riek (ANIC); 3 males, West Claudie R., Iron Range, 17 Sep 1974, M.S. Moulds (NMV, 1 male on slide); 1 male, Middle Claudie R., Iron Range, 2–9 Oct 1974, M.S. Moulds (NMV); 1 male, Mcleod R., 15 km W of Mt Carbine, 22–23 Jun 1975, S.R. Monteith (ANIC); 3 males, 1 female, Mulgrave R., W of Gordonvale, 29 Apr 1979, A. Wells (NMV: WTH 1387, 1 male on slide); 2 males, 5 km W by N Rounded Hill nr Hope Vale Mission, 15°17'S, 145°10'E, 7 Oct 1980, J.C. Cardale (ANIC); 1 male, 3 km ENE Mt Tozer, 12°44'S, 143°14'E, 2 Jul 1986, J.C. Cardale (ANIC); 4 males, 2 females, 9 km ENE Mt Tozer, 12°43'S, 143°17'E, 5–10 Jul 1986, J.C. Cardale (ANIC); 3 males, 12°44'S, 143°16'E, Claudie R., Iron Range National Park, 25 km NW Lockhart R., 10 Nov 1988, K. Walker (NMV); 3 males, 21 females, Bertie Creek, 1 km SE Heathlands HS, 4 Feb 1992, D. Cartwright and A. Wells (QM); 1 male, 19 females, Gunshot Creek at Telegraph Crossing, 18 Feb 1992, D. Cartwright and A. Wells (QM); 4 males, 2 females, Kearney Falls, Goldsborough Valley, 26–27 Mar 1997, G. Theischinger and L. Muller (ANIC, 1 male on slide); 7 males, Cape York Peninsula, Iron Range, Rainforest Camping Ground, 6 Oct 2002, G. Theischinger (ANIC).

Diagnosis. Wings with long downy hair and, as in *O. burtoni* and *O. australis*, male forewings lack scale patches. Males are distinguished by genitalic features (figs 43–45): shape of the inferior appendages which are stout and elongate in ventral aspect, in lateral view narrowly tapered apically and with a dorso-mesial expansion; and pre-anal lobes that are broadly almond-shaped. Male forewing length, 3.9–5.5 mm.

Distribution. Known in Australia only from far north-eastern Qld. Described from Bogor (= Buitenzorg), Java, and recorded subsequently from New Guinea (Kimmins, 1962, from Kokoda, Papua New Guinea).

Remarks. *Oecetis buitenzorgensis* is one of several Oriental/New Guinean species recorded from far northern Queensland. Chen, 1992 placing *O. buitenzorgensis* with a group of Palaearctic and Oriental species (African, Indian and Thai), commented that it is a *nomen dubium*, not recognisable from Ulmer's illustrations. However, the north-eastern Australian specimens agree closely with Ulmer's figures, and conform well to other members of the *pechana*-group as recognised here.

Oecetis burtoni Neboiss

Figures 46–48, 72

Oecetis burtoni Neboiss, 1979: 841, figs 37–40.
Holotype. Male, Qld, Fraser I. (NMV T-5749).

Material examined. Qld: 1 male, Mossman Gorge, 16 Jun 1971, E.F. Riek (ANIC); numerous males, females, Tewah Creek, Tin Can Bay, 17–18 Oct 1971, S.R. Monteith (ANIC); 4 males, Iron Range, West Claudie R., 17 Sep 1974, M. Moulds (NMV); 1 male, Iron Range, Middle Claudie R., 19 Sep 1974, M. Moulds (NMV); 1 male, Cap Creek, Mt Finlayson Range, S of Cooktown, 23 Nov 1974, M.S. Moulds (NMV); numerous males, females, Lake Wabby, S end Fraser I., 14 Dec 1975, H. Burton (NMV); 1 male, Bluewater State Forest, S end Paluma Range WNW of Townsville, 31 Jan 1981, M.S. and B.J. Moulds (NMV); 4 males, 5 females, Seary's Creek Rainbow Beach, 25°58'S, 153°04'E, 6 Dec 1984, G. Theischinger (ANIC); 5 males, 6 females, 12°44'S, 143°35'E, Claudie R., Iron Range National Park, 25 km NW Lockhart, 10 Nov 1988, K. Walker (NMV); 3 males, 5 females, 11°45'S, 142°35'E, Heathlands, 15–26 Jan 1992, I. Naumann and T. Weir (ANIC); 6 males, 2 females, Bertie Creek, 1 km SE Heathlands HS, 4 Feb 1992, D. Cartwright and A. Wells (NMV); 3 males, 6 females, Tributary of Bertie Creek, 250 m SW Heathlands HS, 4 Feb 1992, D. Cartwright and A. Wells (NMV); 1 male, Eliot Creek upstream junction Canal Creek, 6 Feb 1992, D. Cartwright and A. Wells (NMV); 1 male, Dulhunty R. at Telegraph Crossing, 11°50'S, 142°30'E, 8–9 Feb 1992, D. Cartwright and A. Wells (NMV); 29 males, 4 females, Dulhunty R., at Telegraph Crossing, 10 Feb 1992, D. Cartwright and A. Wells (NTM); 8 males, 13 females, Tributary of Bertie Creek, 250 m SW Heathlands HS, 11 Feb 1992, D. Cartwright and A. Wells (NMV); 5 males, 7 females, Tributary of Bertie Creek, 250 m SW Heathlands HS, 11 Feb 1992, D. Cartwright and A. Wells (NMV); numerous males, females, Cockatoo Creek and McDonnell Creek junction, 11°39'S, 142°28'E, 13 Feb 1992, D. Cartwright and A. Wells (NMV); 1 male, 1 female, Gunshot Creek at Telegraph Crossing, 18 Feb 1992, D. Cartwright and A. Wells (NMV); 1 male, Cape York Peninsula, Heathlands, Bertie Creek, 23 Mar 1993, M. Crossland (ANIC); 2 males, 3 females, Gunshot Creek at Telegraph Crossing, M. Crossland, 4–5 Apr 1993 (ANIC); numerous males, females, Gunshot Creek at Telegraph Crossing, M. Crossland, 10–11 Apr 1993 (ANIC). WA: 3 males, 1 female, Drysdale R. at Kalumburu Road crossing, Kimberley, 28 Sep 1979, J. Blyth (NMV). NT: 2 males, 2 females, Devil Devil Creek, 70 km SW of Daly R. Mission, 23 Aug 1979, J. Blyth (NMV).

Diagnosis. In lacking wing scales in the male, but having long downy vestiture on the wings, this species resembles *O. australis*, *O. quadrula* and *O. buitenzorgensis*, but in features of male genitalia it more closely resembles *O. theischingeri* from which it is distinguished by the very short phallus with an equally short paramere, absence of the triangular process apico-mesially on inferior appendages and of the dorso-basal pouch on inferior appendages. Male forewing length, 4.0–4.6 mm.

Distribution. Quite widespread around coastal areas of northern Australia, although not very commonly collected. Possibly records represent more than 1 species, as some variability is recognised in form of the inferior appendages and tergite X. At present this is considered too slight to warrant designation of separate morpho-species.

Oecetis searica sp. nov.

Figures 49, 50, 73

Material examined. Holotype. Male, Qld, Seary's Creek Rainbow Beach, 25°58'S, 153°04'E, 6 Jan 1986, G. Theischinger (NMV T-18845, on slide).

Paratypes. 3 males, same locality and collector as for holotype, 6 Dec 1984 (NMV, 1 on slide).

Diagnosis. One of the species with scales on the male forewing, but distinguished from others by the medium length paramere in the phallus strongly arched dorsally and elongate inferior appendages which, in lateral view, are rod-like, taper gradually toward the apex and lack a dorsal lobe.

Description. Male. Wings with short hair on veins, forewing with a patch of scales. Anterior wing length, 4.3 mm. Abdominal segment IX broader dorsally, with pronounced lateral lobes, segment X triangular in dorsal view. Genitalia, see figs 49, 50. Pre-anal appendages longer than wide. Phallus about length of 1.5 abdominal segments; paramere strongly arched dorsally. Inferior appendages clasper-shaped in ventral view, stout basally, narrow distally, rounded apically, in lateral view elongate, with length almost 4 times as long as basal width, tapered distally, without basi-dorsal pocket.

Distribution. Known only from the type locality in north-eastern Qld.

Etymology. Named for the type locality.

Oecetis ada sp. nov.

Figures 51–53, 74

Material examined. Holotype. Male, NT, Litchfield National Park, Ada Creek, at jump up, 24–25 Jun 1992, Wells and Webber (NTM).

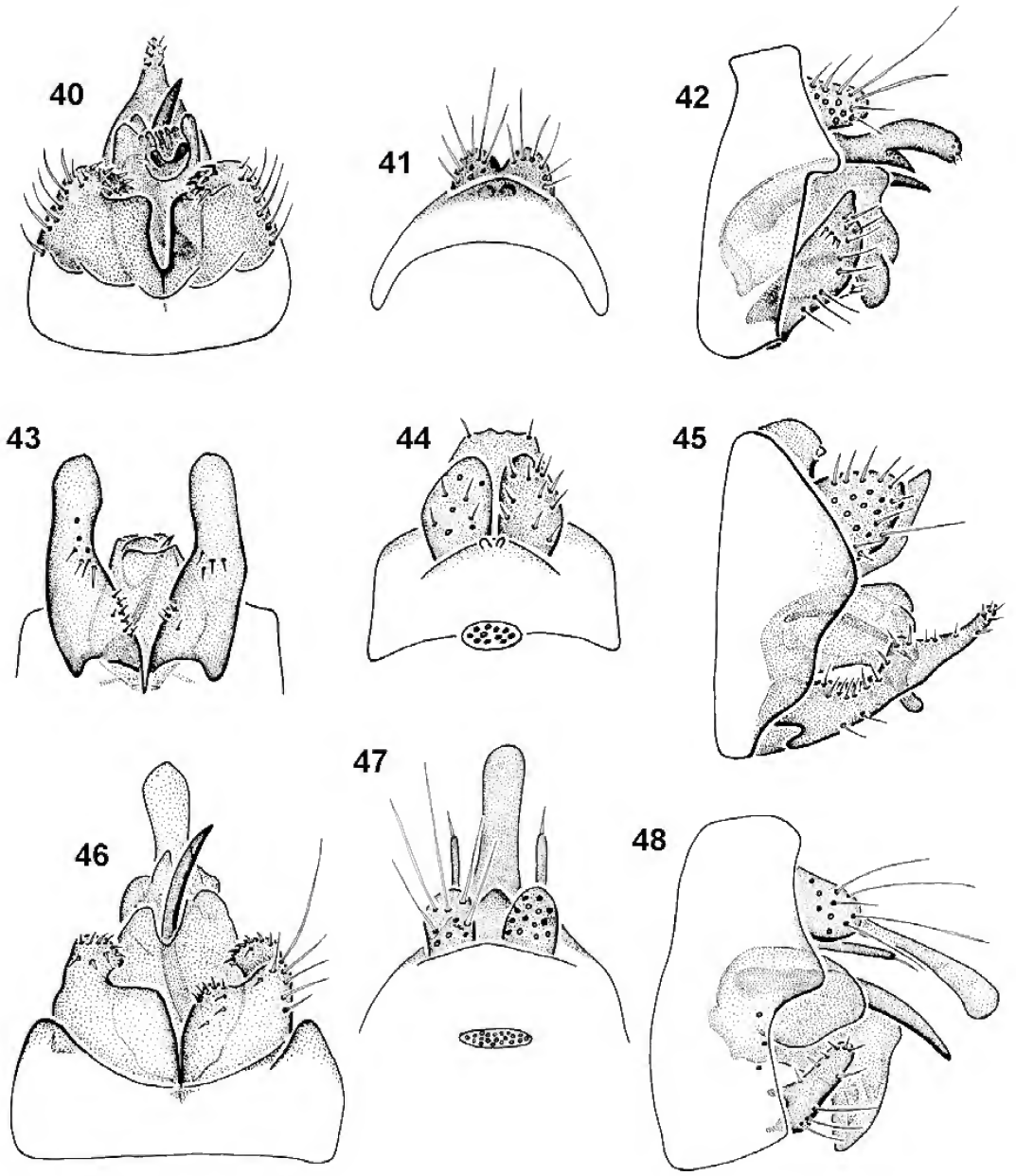
Diagnosis. The patches of wing scales clearly place this species in the *pechana*-group, but, like *O. gilva*, it lacks a paramere in the very short phallus; and the pre-anal appendages are unusually long for a *pechana*-group species, being over 3 times longer than wide.

Description. Wings with short hair on veins, forewing with a patch of scales. Male anterior wing length, 6.6 mm. Abdominal segment IX narrow, lateral angles produced; segment X about as long as pre-anal appendages, slender in dorsal view. Genitalia, see figs 51–53. Pre-anal appendages elongate-ovoid. Inferior appendages stout at base, in ventral view tapered to rounded apices; in lateral view, with a triangular basi-dorsal lobe, and basi-dorsal pouch. Phallus about length of 1 abdominal segment, with a sharply returned, pointed apex; paramere absent.

Distribution. Known only from the holotype male from the north of the NT.

Etymology. Named for the type locality.

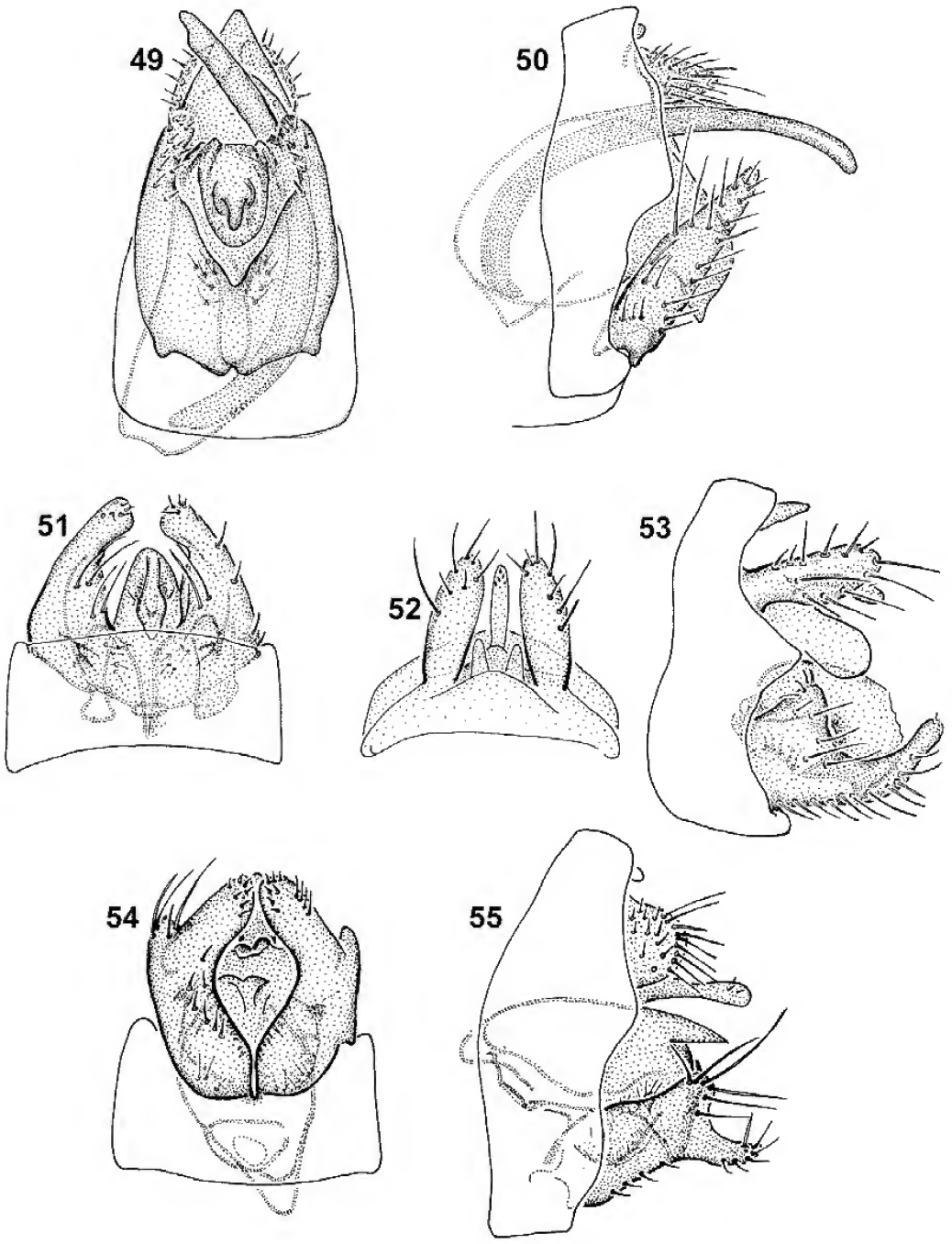
Remarks. Although this species lacks a paramere it clearly groups with *pechana*-group species on the basis of the general form of the phallus, wing venation and presence of scale patches.



Figures 40–42, *Oecetis quadrula* sp. nov., male genitalia in ventral, dorsal and lateral views.

Figures 43–45, *Oecetis buitenzorgensis* Ulmer, male genitalia in ventral, dorsal and lateral views.

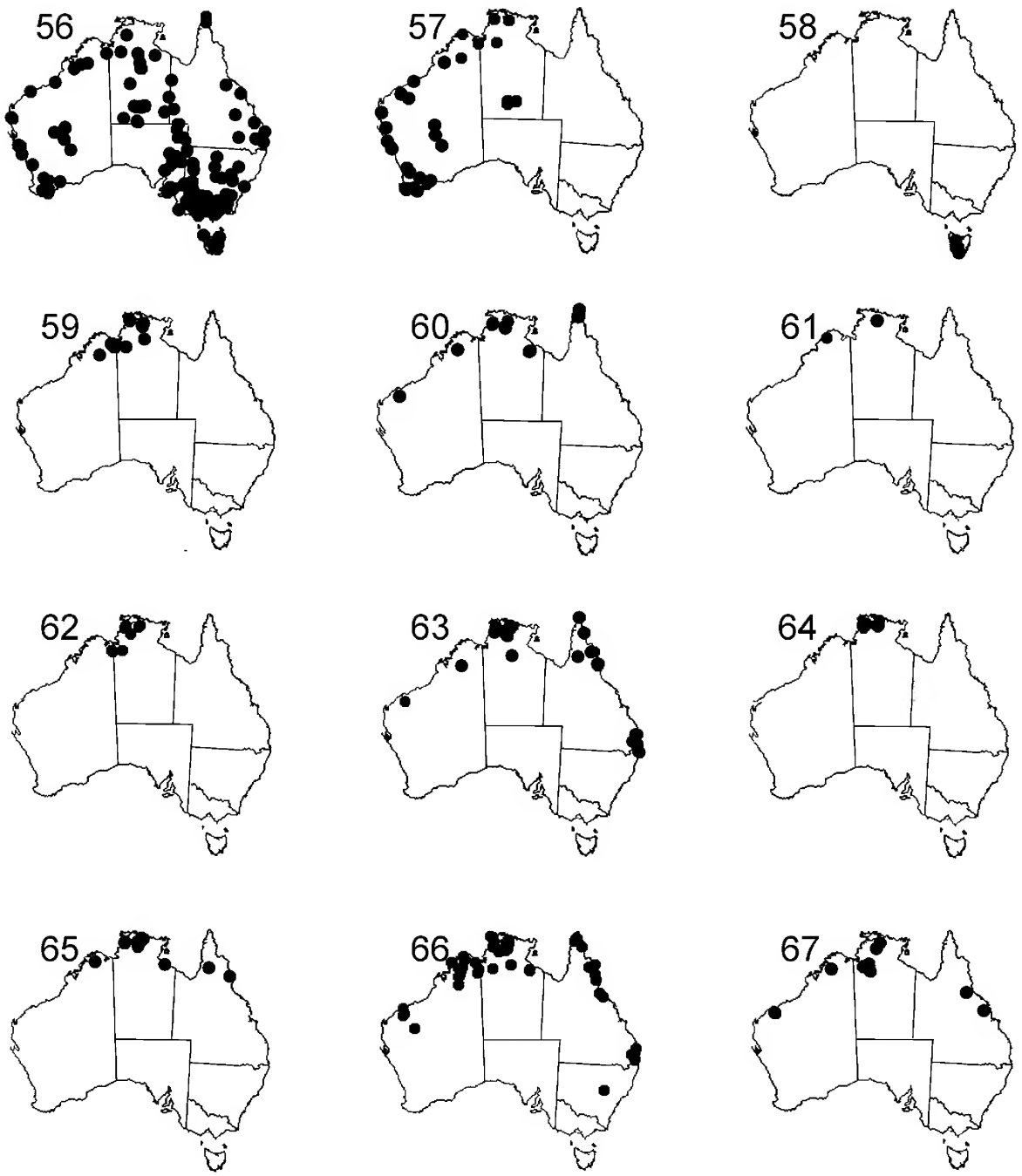
Figures 46–48, *Oecetis burtoni* Neboiss, male genitalia in ventral, dorsal and lateral views.



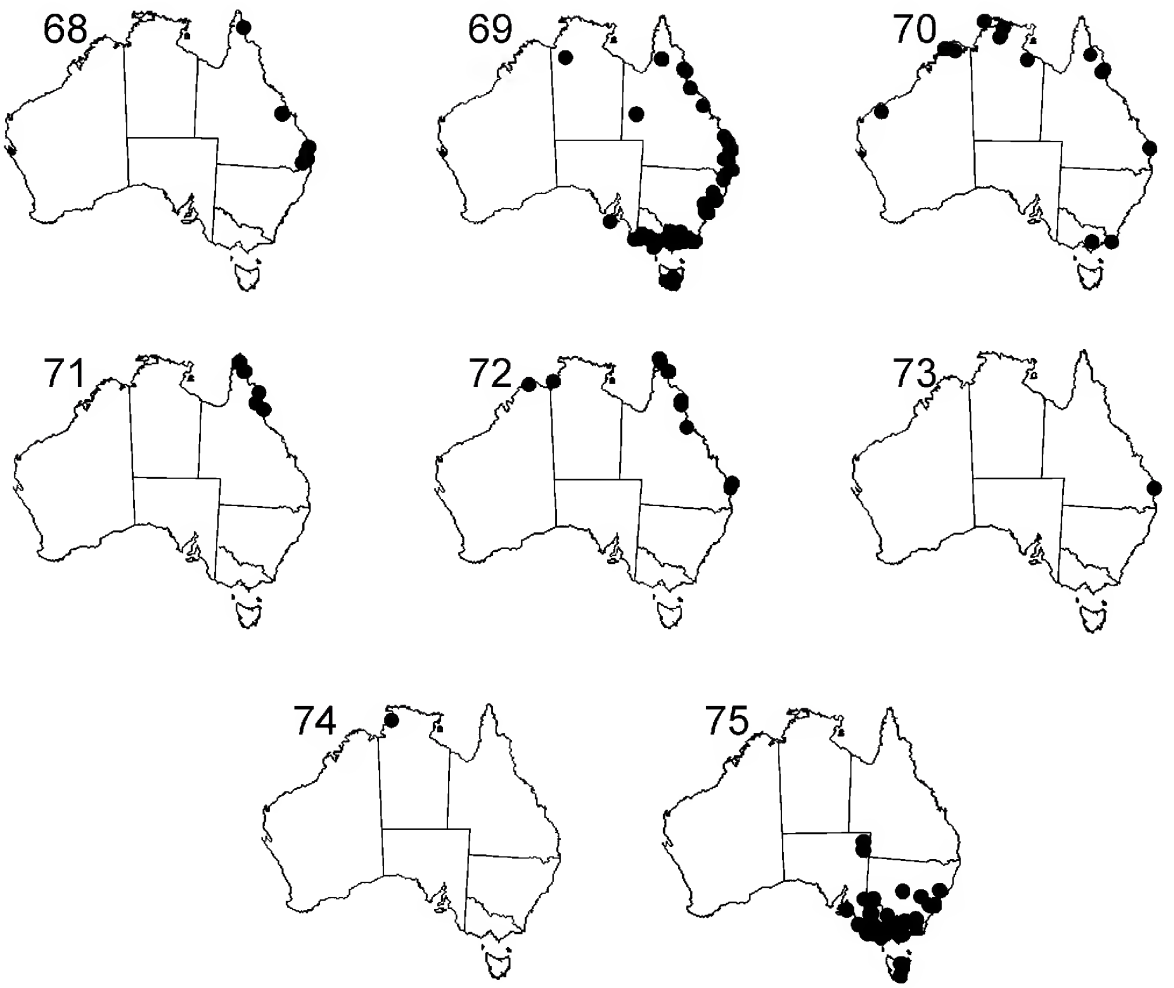
Figures 49, 50, *Oecetis searica* sp. nov., male genitalia in ventral and lateral views.

Figures 51–53, *Oecetis ada* sp. nov., male genitalia in ventral, dorsal and lateral views.

Figures 54, 55, *Oecetis gilva* Neboiss, male genitalia in ventral and lateral views.



Figures 56–67, Distribution of species within Australia: 56, *O. pechana* Mosely; 57, *O. walpolica* Neboiss; 58, *O. umbra* Neboiss; 59, *O. magelensis* sp. nov.; 60, *O. suteri* sp. nov.; 61, *O. radonensis* sp. nov.; 62, *O. humphreyi* sp. nov; 63, *O. kateae* sp. nov.; 64, *O. geniculata* sp. nov.; 65, *O. litua* sp. nov.; 66, *O. jenniae* sp. nov.; 67, *O. mouldsi* sp. nov.



Figures 68–75, Distribution of species within Australia: 68, *O. theischingeri* sp. nov.; 69, *O. australis* (Banks); 70, *O. quadrula* sp. nov.; 71, *O. buitenzorgensis* Ulmer; 72, *O. burtoni* Neboiss; 73, *O. searica* sp. nov.; 74, *O. ada* sp. nov.; 75, *O. gilva* Neboiss.

Oecetis gilva Neboiss

Figures 54, 55, 75

Oecetis gilva Neboiss, 1977: 145, figs 774–776. —Neboiss, 1979: 840, figs 35, 36; Neboiss, 1986: 268.

Holotype. Male, Tas., South Esk R. near Evandale (NMV T-5491).

Material examined. Eighty-seven samples examined, from localities in south-eastern Australia; 2 samples examined from far north-eastern SA.

Diagnosis. In features of wing venation, pattern of markings, and male genitalia resembling *O. pechana* superficially, but wings broader and more rounded apically, and male generally without scales on anterior wing, inferior appendages tapered distally. This species lacks a paramere in the phallus, a feature shared with *O. ada* sp. nov., but unlike that species the phallotheca forms a pale dorsal spine.

Revised description. Wings relatively broad, forewing length 9.1–9.6 mm, rounded apically, male forewing with or without

scales. Abdominal segments III–V with tergites well sclerotised; IX short; segment X narrow, membranous, rounded apically. Male genitalia; figs 54, 55. Pre-anal appendages short, rounded apically. Phallus about twice length of segment IX, beak-like apico-ventrally, without a paramere, but in lateral view extended in a short, pale apico-dorsal spine. Inferior appendages clasper-shaped in ventral view, with basi-dorsal dorsal pouch; in lateral view, expanded and rounded dorsally, tapered to acute apex.

Distribution. A common species in SE Australia, *O. gilva* occurs from northern NSW, throughout Vic., to the Flinders Ranges in SA and south to Tas.

Remarks. The diagnosis of *O. gilva* is expanded here to include the curious scaly winged form that has been collected together with *O. gilva*, *s. str.* from several lakes in Victoria. In all respects other than presence of patches on the wings, these animals appear to be identical. The winged forms could conceivably be hybrids between *O. gilva* and *O. pechana*. *O. gilva* is often abundant in still to slow waters; the larvae build tube cases of sand.

Oecetis lurida Kimmins

Oecetis lurida Kimmins in Mosely and Kimmins, 1953: 298, fig. 210. —Neboiss, 1986: 268.

Material examined. Holotype. Female, Broken Hill, NSW (BMNH).

Remarks. This species was described from a female with uniformly pale, unspotted wings and while it may eventually be found to be a senior synonym of *O. gilva*, which has been found in inland waters, *O. lurida* is probably best considered a doubtful name.

Nomen novum and new synonymy

The name *Oecetis kimberleyensis* nom. nov. is proposed to replace the name, *Oecetis dilata* Wells, 2004: 98, preoccupied by *O. dilata* Yang and Morse, 2000 (J. Morse, in litt.); and, following advice from H. Malicky (in litt.), *Oecetis cepaforma* Wells, 2004 is suppressed in synonymy with *Oecetis hemerobioides* McLachlan, 1866. This action extends into northern Australia the range of *O. hemerobioides*, described from Sulawesi (as Celebes) and recognised previously Chen, 1992 from Thailand and Malaysia through Indonesia and the Philippines to New Guinea. It is probable, too, that *O. oecetinellae* Mey, 1990 from the Philippines is also referable to this species.

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Nannastacidae (Crustacea: Cumacea) from eastern Bass Strait, the south-eastern Australian slope, and Antarctica in the collections of Museum Victoria

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Abstract

Petrescu, I. 2006. Nannastacidae (Crustacea: Cumacea) from eastern Bass Strait, the south-eastern Australian slope, and Antarctica in the collections of Museum Victoria. *Memoirs of Museum Victoria* 63(2): 129–173.

Forty-five species of Nannastacidae were identified in collections in Museum Victoria from eastern Bass Strait and the south-eastern Australian slope. Twenty-eight are described as new: *Campylaspis anae*, *C. angelae*, *C. australiensis*, *C. edenensis*, *C. grossui*, *C. halei*, *C. hirsuta*, *C. latimera*, *C. longidentata*, *C. lynseyae*, *C. nowrae*, *C. poorei*, *C. rectangulata*, *C. sculpta*, *C. serrata*, *C. setifera*, *C. spinifera*, *C. tasmaniensis*, *C. trisulcata*, *Procampylaspis australiensis*, *P. spinifera*, *P. tasmaniensis*, *Styloptocuma australiense*, *S. granulosum*, *S. nodosum*, *S. poorei*, *S. spinosum*, *Styloptocumoides australiensis* and *Vemacumella bacescui*. The new genus *Styloptocumoides* is diagnosed and *Styloptocuma* Băcescu and Muradian, 1974 and *Vemacumella* Petrescu, 2001 are recorded for the first time from Australia. The new species *Procampylaspis poorei* is described from Antarctic waters.

Keywords

Crustacea, Cumacea, Nannastacidae, new taxa, new records

Contents

Introduction

The most important studies on Australian Cumacea were made by the famous specialist, Herbert M. Hale, who dealt with 90% of Australian fauna between 1936 and 1949. He added 32 species of Nannastacidae to the Australian list, 29 being new to science. However, the first species known from this family from Australia were *Cumella cyclaspoides*, *Cumella gibba*, and *Scherocumella nasuta*, described by Zimmer, 1914 from Shark Bay, Western Australia. Foxon (1932) described *Campylaspis pileus* from the Great Barrier Reef. Two other papers have since been published: Băcescu (1991) describing *Campylaspis wardi* and Tafe and Greenwood (1996) adding a new species of *Schizotrema*. Up to now, 40 species of Nannastacidae are known from Australia (Stoddart and Lowry, 2003).

The material in Museum Victoria selected for study was 27 samples collected during two sampling campaigns. One was in eastern Bass Strait at shallow shelf depths (see Coleman et al., 1997 for a discussion of the fauna of this sampling program). The second was on the south-eastern Australian continental slope between Sydney, New South Wales and eastern Tasmania (see Poore et al., 1994, for discussion of the diversity of isopods from these deep-water samples). Only nine of numerous samples were searched for nannastacids. Forty-five species of Nannastacidae including 28 new species, one in a new genus, were identified, bringing the total for Australia to 68. One additonal new species was described from Antarctica.

Specimens are now registered in Museum Victoria, Melbourne (NMV) and representatives are in the "Grigore Antipa" National Museum of Natural History, Bucharest, Rumania (MGAB). Type localities are given in full but other records are given only by station number, and are expanded in the appendix.

Campylaspis Sars, 1865

Campylaspis Sars, 1865: 200.—Băcescu, 1992: 178–179.—Stoddart and Lowry, 2003: 373–418.
Bacescua Muradian, 1979: 105.
Sarsicuma Muradian, 1979: 104.

Type species. *Cuma rubicunda* Liljeborg, 1855.

Remarks. Species of *Campylaspis* are cumaceans with a bulky carapace, longer than 0.4 of total length, having a mandible with large pars incisiva and lacinia mobilis, acute pars molaris, and maxilliped 2 with a 3-toothed dactylus. Fifteen species are previously known from Australia; another 20 taxa are added from this study (19 of them being new to science).

Key to species of *Campylaspis* from Australian waters

1. Eye lenses present 2
— Eye lenses absent 14
2. Carapace smooth without tubercles, spines, carinae or lateral sulcus 3
— Carapace with tubercles, spines, carinae or a lateral furrow or sulcus 4
3. Uropodal peduncle 3 times as long as its endopod ..... *C. thompsoni* Hale, 1945
— Uropodal peduncle 2.3 times as long as its endopod ..... *C. similis* Hale, 1945
4. Carapace with lateral sulcus, without ridges 5
— Carapace without lateral sulcus, with ridges and carinae 7
5. Dactylus of pereopod 2 dilated distally ..... *C. latidactyla* Hale, 1945
— Dactylus of pereopod 2 not dilated distally 6
6. Dactylus of pereopod 2 as long as carpus plus propodus ..... *C. unisulcata* Hale, 1945
— Dactylus of pereopod 2 shorter than carpus plus propodus ..... *C. minor* Hale, 1945
7. Carapace with single, lateral rounded carina ..... *C. uniplicata* Hale, 1945
— Carapace with tubercles, spines, depressions and ridges 8
8. Carapace with ridges and lateral depressions 9
— Carapace with tubercles, spines and ridges 10
9. One ridge delimiting 1 large lateral excavation and 2 in posterior half ..... *C. rupta* Hale, 1945
— Three lateral ridges delimiting 2 curved depressions ..... *C. triplicata* Hale, 1945
10. Carapace covered with spiniform projections, spines on rest of body ..... *C. echinata* Hale, 1945
— Carapace coverd with small tubercles 11
11. Carapace with very small tubercles anteriorly and dorsolaterally ..... *C. roscida* Hale, 1945
— Carapace with conical tubercles 12
12. Maxilliped 3, 3 times as long as wide ..... *C. pustulosa* Hale, 1945
— Maxilliped 3, 2 times as long as wide ..... *C. aspera* Hale, 1945
13. Dactylus of maxilliped 2 with 3 long teeth, twice as long as propodus ..... *C. longidentata* sp. nov.
— Dactylus of maxilliped 2 with teeth shorter or as long as propodus 14
14. Carapace with lateral depressions 15
— Carapace without lateral depressions 34
15. Carapace without ridges or carinae 16
— Carapace with ridges or carinae 29
16. Carapace with sulcus open on anterior extremity of carapace 17
— Carapace with sulcus not reaching the anterior extremity of carapace 25
17. Carapace smooth, excepting lateral depression 18
— Carapace with tubercles 19
18. Uropodal peduncle robust, with median crest, twice as long as exopod ..... *C. anae* sp. nov.
— Uropodal peduncle slender, no median crest, 1.4 times as long as exopod ..... *C. rectangulata* sp. nov.
19. Uropods long, elongated 20
— Uropods short, robust 22
20. Carapace with several rows of tubercles ..... *C. tasmaniensis* sp.nov.
— Carapace with 1–2 tubercles 21
21. Carapace with 1 pair of tubercles at basis of frontal lobe ..... *C. lynseyae* sp. nov.
— Carapace with 1 pair of tubercles at basis of frontal lobe, 2nd under sulcus ..... *C. spinifera* sp. nov.

22. Dactylus of pereopod 2 long 23
— Dactylus of pereopod 2 short 24
23. Pseudorostral lobes meeting for distance of 3 times length of ocular lobe ..... *C. thetidis* Hale, 1945
— Pseudorostral lobes meeting for distance of half ocular lobe ..... *C. sculpta* sp. nov.
24. Uropods with terminal short setae with oval structures ..... *C. wardi* Băcescu, 1991
— Uropods with terminal short setae without oval structures ..... *C. grossui* sp. nov.
25. Carapace with tubercles 26
— Carapace without tubercles 27
26. Integument with acute tubercles ..... *C. australiensis* sp. nov.
— Integument with spiny tubercles ..... *C. hirsuta* sp. nov.
27. Maxilliped 3 and pereopod 1 with large and concave merus ..... *C. latimera* sp. nov.
— Maxilliped 3 and pereopod 1 without large and concave merus 28
28. Pereopod 2 with digitiform dactylus tip ..... *C. halei* sp. nov.
— Pereopod 2 with straight dactylus tip ..... *C. poorei* sp. nov.
29. Carapace with transversal dorsal carinae 30
— Carapace without transversal dorsal carinae 31
30. Carapace with 1 transversal dorsal carina ..... *C. johnstoni* Hale, 1937
— Carapace with 2 transversal dorsal carinae ..... *C. nowrae* sp. nov
31. Carapace with dorsal tubercles ..... *C. angelae* sp. nov.
— Carapace without tubercles 32
32. Pseudorostrum long, lobes meeting for a distance of sixth carapace length ..... *C. pileus* (Foxon, 1932)
— Pseudorostrum short, lobes meeting for a distance shorter than eighth carapace length 33
33. Carapace with 2 lateral ridges delimiting 1 depression ..... *C. edenensis* sp. nov.
— Carapace with 4 lateral ridges delimiting 3 depressions ..... *C. trisulcata* sp. nov.
34. Carapace integument smooth ..... *C. setifera* sp. nov.
— Carapace with long club-like setae, body and appendices highly serrated ..... *C. serrata* sp. nov.

Campylaspis anae sp. nov.

Figures 1, 2

Material examined. Holotype female, NSW, off Nowra, 34°59.52'S, 151°05.94'E, 204 m, coarse shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 1), NMV J52946.

Diagnosis. Carapace with long lateral sulcus, rectangular in dorsal view. Maxilliped 3 with large merus and carpus. Uropod peduncle more than 2.5 times as long as pleonite 6; exopod a little shorter than endopod.

Description. Body with smooth integument. Length: 3.5 mm.

Antenna 1, basal article of peduncle longest, median and apical articles equal; main flagellum 3-articulate, accessory flagellum minute, uniarticulate.

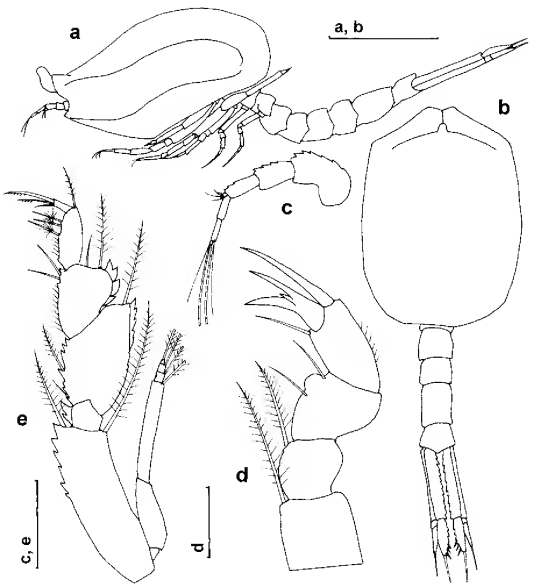

Figure 1. *Campylaspis anae* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, e, 0.25; d, 01.

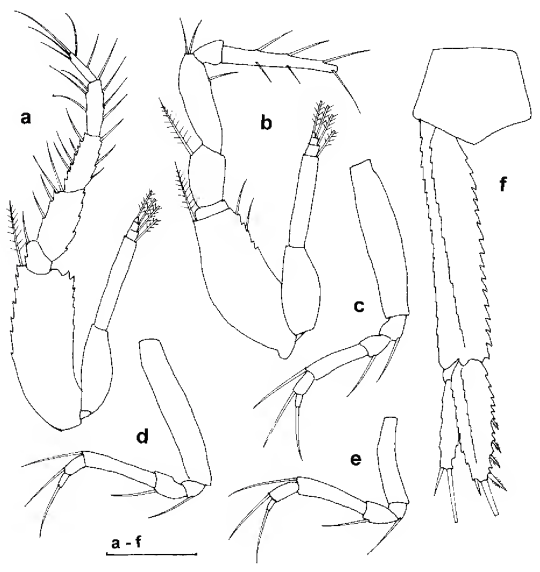

Figure 2. *Campylaspis anae* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.25.

Maxilliped 2 basis (fused with ischium) and merus with long plumose seta on distal inner corner, carpus produced bluntly between 2 simple setae on inner margin, propodus longer than carpus, as long as its distal outer strong seta, dactylus with 3 teeth shorter than propodal seta. Maxilliped 3 basis less than half as long as appendage, with serrated inner margin, with plumose seta on inner and outer distal corners, without outer process; ischium small; merus much bigger (second longest article), with serrated margins and plumose seta on outer distal corner; carpus as long as its distal outer strong seta, dactylus with 3 teeth shorter than propodal seta. Maxilliped 3 basis shorter than half length of appendage, with serrated inner margin, with plumose seta on inner and outer distal corners, without outer process; ischium small; merus larger (second longest article), with serrated margins and plumose seta on outer distal corner; carpus 0.65 of merus length, large, with strong serration on outer margin, 1 plumose seta on outer distal corner; propodus little shorter than carpus, much thinner; dactylus less than half of propodus, with 2 microserrate terminal setae twice dactylus length.

Pereopod 1 basis less than half as long as appendage, with serrated margins; merus 2.6 times as long as ischium; carpus to dactylus progressively shorter, with numerous simple setae on both margins, dactylus with long terminal simple setae. Pereopod 2 basis less than half as long as appendage, with a plumose seta on inner distal corner; merus 4 times as long as ischium, with long plumose seta on inner margin; carpus 1.4 times as long as ischium and merus combined, 2 simple setae on its inner distal corner; dactylus with broken tip, 4 times as long as propodus, with several simple setae marginally. Pereopod 3 basis longer than rest of appendage, ischium as long as merus, ischium and merus with simple seta on inner distal corner; carpus twice as long as merus; dactylus with long stout terminal seta. Pereopods 4 and 5 with shorter basis and longer carpus than pereopod 3. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle more than 2.5 times as long as pleonite 6, with strong serrated inner margin and median crest, twice as long as exopod; exopod shorter than endopod, with subterminal and terminal (much longer) stout setae; endopod with median crest, with 4 microserrate setae on inner margin and a long stout terminal seta.

Etymology. The species is dedicated to my lovely daughter, Ana-Maria.

Distribution. Off Nowra, NSW; 204 m depth.

Remarks. Campylaspis anae has a large lateral sulcus that does not reach the posterior extremity of the carapace. No other species previously known from Australia or from the western Pacific has such a sulcus. The shape of the carapace is similar to that of *C. ovalis* Stebbing, 1912 from South Africa which has an even larger sulcus that is confluent with the posterior extremity of the carapace. Of the 16 new species with a lateral sulcus described herein, *C. anae* is closest to the immature male holotype of *C. rectangulata*. It differs from *C. rectangulata* in possessing longer teeth on maxilliped 2, the merus of maxilliped 3 without a concavity and larger, the dactylus of maxilliped 3 with shorter setae, the uropod with a longer and wider peduncle with a longitudinal median crest, shorter rami, and an endopod with four microserrate setae on its inner margin (3 similar setae in *C. rectangulata*).

Campylaspis angelae sp. nov.

Figures 3, 4

Material examined. Holotype female, NSW, off Nowra, 34°59.52'S, 151°05.94'E, 204 m, coarse shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 1), NMV J52960.

Paratype: 1 female, dissected, type locality, NMV J52961.

Diagnosis. Carapace with a lateral sulcus, 2 dorsal parallel rows of tubercles on carapace, without eyes. Lateral keel on pleonites 1–5 and 2 parallel dorsal keels on pereonite 5 and pleonites 1–4, unique on last 2 pleonites. Antenna 1 short, robust. Maxilliped 3 with enlarged merus to propodus. Pereopod 1 with long ischium. Dactylus of pereopod 2 with finger-like tip. Serrated uropod with a median keel on peduncle.

Description. Body with smooth, highly calcified integument. Length: 2.55 mm.

Carapace almost half of body length, 1.8 times as long as high, with a large lateral sulcus delimited by a transverse crest on anterior part, meeting ventral undulated crest that unites anteroventral corner and oblique posterior crest on each side of carapace; 2 dorsal parallel rows of small tubercles, 1 tubercle on top of ocular lobe, another on pseudorostrum; antennal notch marked, anteroventral corner serrated, ventral margin smooth; prominent ocular lobe without eyes. Parallel dorsal crests on pereonite 6, pleonite 1–4, and single dorsal serrated crest on pleonites 5–6. Pleonites 1–4 produced laterally, pleonite 5 weakly produced laterally.

Antenna 1 short, robust, articles of peduncle decreasing in length distally, main flagellum 3-articulate ending with short aesthetascs; accessory flagellum tiny, uniarticulate.

Maxilliped 2 basis fused with ischium, with stout inner plumose seta, similar seta on merus, carpus with tooth and 2 simple setae on inner margin, propodus with strong robust seta on outer distal corner near articulation with short 3-toothed dactylus. Maxilliped 3 basis less than half as long as appendage, without outer process, with 2 long plumose setae on outer distal corner, ischium to propodus with serrated inner margins, merus second longest article, with 3 teeth and plumose seta on outer margin, carpus 0.66 merus length, with 3 long teeth and long plumose seta on outer margin, propodus as long as carpus, dactylus less than half as long as propodus, with terminal setae longer than dactylus.

Pereopod 1 basis longer than rest of articles combined, basis to propodus with serrated margins, short ischium with inner plumose seta, merus, carpus and propodus enlarged, merus second largest article, longer than carpus and propodus combined, dactylus and propodus subequal. Margins of merus-propodus serrated on both margins. Pereopod 2 basis less than half as long as appendage, with short simple seta on distal inner corner, merus 5 times as long as ischium, with simple seta on inner margin, carpus 1.66 times as long as merus, with short simple setae on distal inner corner, dactylus

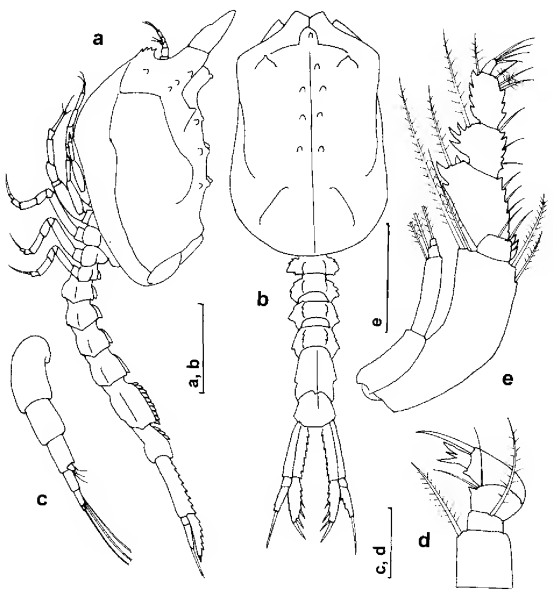

Figure 3. *Campylaspis angelae* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 0.5; c, d, 0.1; e, 0.2.

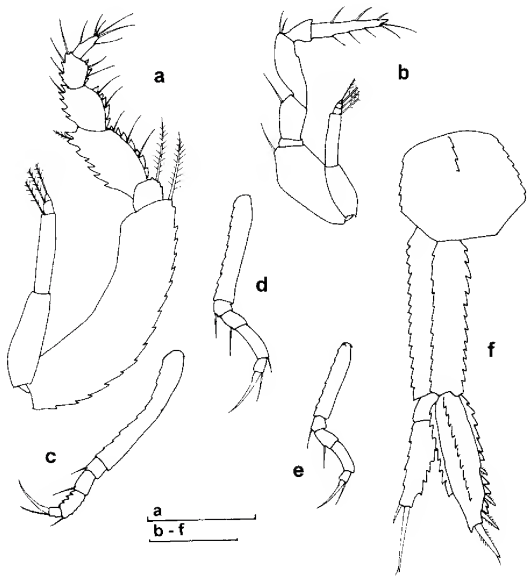

Figure 4. *Campylaspis angelae* sp. nov. female holotype: A, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; E, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a, 0.2; B–f, 0.25.

3 times as long as propodus, bluntly produced terminally, with 2 subterminal short simple setae, no evidence of terminal setae. Pereopod 3 basis longer than rest of articles combined, carpus little longer than merus, with only hair-like distal seta, dactylus fused with its terminal short stout seta. Pereopods 4 and 5 with progressively shorter basis than in pereopod 3, carpus twice as long as merus. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod with robust peduncle, 1.6 times as long as pleonite 6, with median serrated crest and serrated margins, 1.3 times as long as endopod; exopod little shorter than endopod, with strong serrated margins, 2 terminal robust setae, 1 long, endopod 1.15 times as long as exopod, with serrated margins and serrated median crest, 3 stout setae on inner margin and terminal robust microserrate seta.

Etymology. This species is dedicated to my wonderful, lovely and highly devoted wife, Angela.

Distribution. NSW, off Nowra, shelf break, 204 m.

Remarks. This new species has a carapace with a lateral sulcus posteriorly bordered by an oblique crest as in *C. pileus* Foxon, 1932. It differs mainly by a shorter pseudorostrum, small tubercles on the carapace, and shorter and more robust uropods with serrated margins. *C. angelae* is also more similar than other species of the genus to *C. calmani* Petrescu, 1995 from Indonesia, which also has a lateral sulcus with a transverse crest on the anterior part (close to the ocular lobe) and small tubercles. However, tubercles just border the sulcus in *C. calmani* and are otherwise disposed in *C. angelae*, the dactylus of pereopod 2 is with a digitiform extremity only in *C. angelae*, and there is a longitudinal serrated crest on the uropodal peduncle in *C. angelae*, missing in *C. calmani*. The new species is also related to *C. edenensis* sp. nov., which has an almost similar lateral sulcus but without tubercles, similar to pereopod 2 but with longer dactylar teeth than maxilliped 2, and uropodal peduncle without a longitudinal crest.

Campylaspis aspera Hale, 1945

Campylaspis aspera Hale, 1945: 209, figs 45, 46.

Material examined. 8 females, 1 male (stn SLOPE 1), NMV J52964; 2 females, 1 male (stn SLOPE 1), MGAB CUM 1613; 11 females, 7 males (stn SLOPE 45), NMV J52965; 2 females, 1 male (stn SLOPE 46), NMV J52966; 1 female (stn MSL-EG 20), NMV J52967.

Distribution. NSW, 11 m depth.

Remarks. The species was previously recorded by Hale (1945) from Eden, New South Wales, at 70 m depth. The geographic and depth ranges are considerably extended to South Australia, Victoria and Tasmania and from 800 m depth.

Campylaspis australiensis sp. nov.

Figures 5, 6

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J52415.

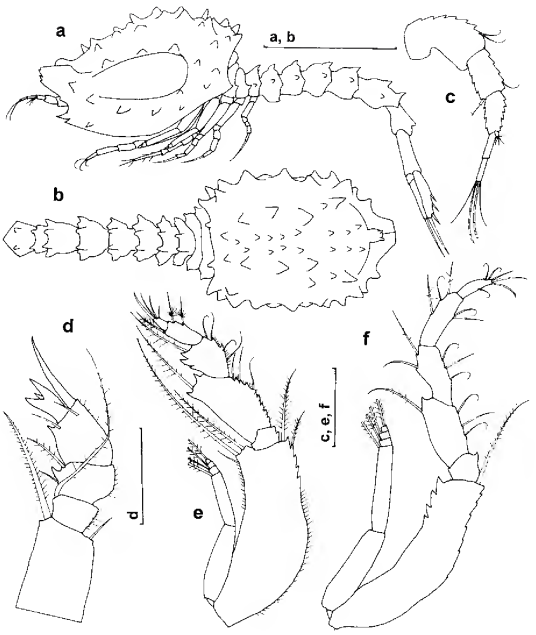

Figure 5. *Campylaspis australiensis* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3; f, pereopod 1. Scale (in mm): a, b, 1; c, e, f, 0.25; d, 0.2.

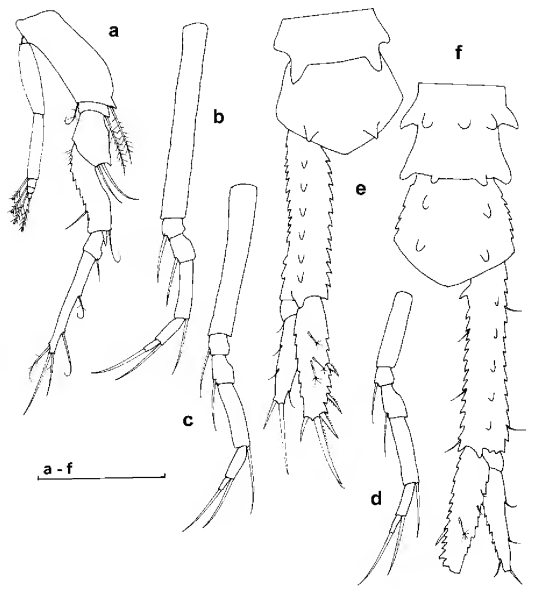

Figure 6. *Campylaspis australiensis* sp. nov. female holotype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and left uropod; f, pleonite 6 and right uropod of other specimen. Scale (in mm): a–f, 0.5.

Paratypes: 5 females, 11 males, type locality, NMV J52933; 1 female, 2 males (stn SLOPE 46), MGAB CUM 1606; 1 manca, 1 female (stn SLOPE 47), NMV J52934; 2 males, 1 manca (stn SLOPE 48), NMV J52419; 1 manca (stn SLOPE 1), NMV J52413; 1 female, 1 male (stn SLOPE 45), NMV J52414; 1 immature male, dissected, NMV J52416.

Diagnosis. Carapace with acute tubercles, with a lateral sulcus. A pair of small dorsal tubercles on pereonite 5 and all pleonites, small lateral tubercle on pereonites 3–5 and pleonites 1–5. Antenna 1 accessory flagellum of 2 articles. Propodus of maxilliped 2 with long robust distal seta, longer than dactylar teeth. Merus and carpus of maxilliped 3 with teeth on outer margin. Dactylus of pereopod 2 3.7 times as long as propodus, with tapering extremity. Dactylus of pereopods 3–5 not fused with terminal seta. Uropod peduncle 1.8 times as long as pleonite 6, 1.4 times as long as endopod, with strongly serrated margins and longitudinal serrated crest, endopod slightly longer than exopod, with 3 microserrate setae on inner margin.

Description. Body with well calcified and hardened reticulated integument. Length: 3.06 mm.

Carapace 0.5 body length, 1.7 times as long as high, with a lateral sulcus, 0.5 of carapace length, open towards anterior part, bordered with acute tubercles, bigger dorsal tubercles, parallel row of smaller dorsal ones, 2 small tubercles on top of eyeless ocular lobe, antennal notch marked, pseudorostral lobes meeting a short distance in front of ocular lobe. Pereonites 3–5 with lateral small tubercle. Pleonites 1–5 with pair of dorsal small tubercles, pleonite 5 with constriction at about posterior one-third, armed with 2 or 3 small dorsal tubercles, lateral tubercle on pleonites 1–5, pleonite 6 with 1 or 2 pairs of small dorsal tubercles.

Antenna 1 peduncle with robust articles, with serrated margins, progressively shorter, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum 2-articulate, shorter than basal article of main flagellum.

Maxilliped 2 with long plumose setae on inner margin of basis and merus, tooth and plumose seta on inner margin of carpus, propodus second longest article, with long robust distal seta, longer than dactylar teeth, with tooth on inner margin, dactylus with 3 short, robust teeth. Maxilliped 3 basis longer than rest of articles combined, with 2 long plumose setae on outer margin, merus second longest article, with 2 teeth and plumose seta on outer margin, carpus shorter than merus, with teeth on both margins and plumose seta on outer margin, propodus shorter than carpus, with 2 pappose setae on inner margin, dactylus half of propodus length, with short simple setae.

Pereopod 1 with slender articles, basis shorter than rest of articles combined, with plumose seta on inner distal corner, merus second longest article, 2.5 times as long as ischium, with small tooth and plumose seta on outer margin, carpus shorter than merus, propodus shorter than carpus, dactylus 0.6 propodus length, with short simple setae. Pereopod 2 basis less than one-third of entire pereopod length, with tooth and plumose seta on inner margin, merus with tooth and 2 simple setae on inner margin, carpus 1.6 times as long as merus, with stout and simple seta on distal margin, dactylus 3.7 times as long as propodus, with tapering tip and short setae. Pereopods

3–5 with progressively shorter basis and longer carpus, propodus longer than merus, dactylus with long stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 1.8 times as long as pleonite 6, 1.4 times as long as endopod, with strongly serrated margins and longitudinal serrated crest, exopod shorter than endopod, with subterminal stout seta and a terminal longer one, endopod with 3 microserrate setae on inner margin and more robust, longer terminal seta.

Etymology. The species bears the name of type locality – Australia.

Distribution. Tas., off Freycinet Peninsula, 600–720 m.

Remarks. The closest species to *Campylaspis australiensis* is *C. sagamiensis* Gamô, 1967 from Japan. Both species have similar tubercles on the carapace, pereon and pleon, and a lateral sulcus, but in *C. sagamiensis* the pleon has lateral ridges rather than tubercles; *C. sagamiensis* also differs in a longer propodus seta, shorter and more robust teeth on the dactylus of maxilliped 2, wider merus and dactylus with shorter terminal setae on maxilliped 3, and shorter more robust uropods.

Similar carapace tubercle patterns around the lateral sulcus also exist on *C. clavata* Lomakina, 1952 from the north-western Pacific, *C. horrida* Sars, 1870 from the Atlantic Ocean, *C. horridoides* Stephensen, 1915 from the Mediterranean and *C. antarctica* Calman, 1907 from Antarctica. *C. clavata* differs in having a longer ocular lobe (reaching the extremity of the carapace versus shorter in *C. australiensis*), shorter dactylus of pereopod 2 and longer uropod peduncle. *C. horrida* differs in having a sulcus not surrounded by acute tubercles, pleonite 6 without tubercles and a longer uropod peduncle. *C. horridoides* differs in fewer dorsal tubercles on the carapace, maxilliped 3 with more teeth on its outer margin and a longer uropod peduncle. *C. antarctica* differs in being without a lateral sulcus on the carapace and its pleonite 6 being without spines.

Campylaspis echinata Hale, 1945

Campylaspis echinata Hale, 1945: 204, figs 41, 42.

Material examined. 1 female (stn SLOPE 1), NMV J52969; 1 immature male (stn SLOPE 47), NMV J52970.

Distribution. NSW, 204 m depth.

Remarks. Hale, 1945 recorded the species from Eden, New South Wales, at 70 m depth; these records represent new geographic and depth extensions (Tasmania, from 600 depth).

Campylaspis edenensis sp. nov.

Figures 7–9

Material examined. Holotype female, NSW, off Eden, 37°07.30'S, 150°20.20'E, 520 m, grey coarse shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 20 Jul 1986 (stn SLOPE 19), NMV J52956.

Allotype: immature male, type locality, NMV J52957.

Paratypes: 3 females (stn SLOPE 19), NMV J52958; 2 females (stn SLOPE 19), MGAB CUM 1612; 1 female, dissected (stn SLOPE 19), NMV J52959.

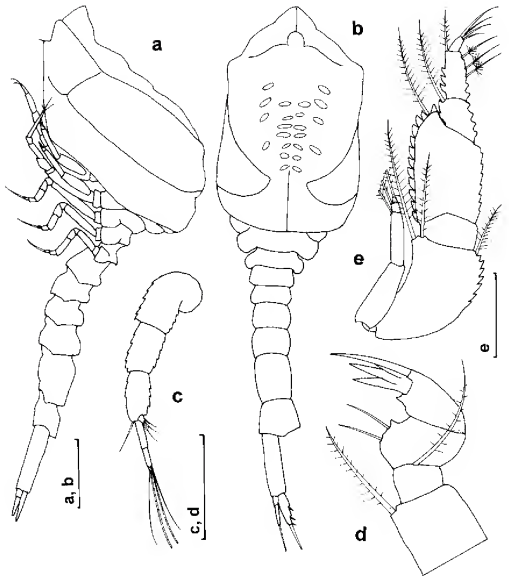

Figure 7. *Campylaspis edenensis* sp. nov. female paratype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 0.5; c, d, 0.2; e, 0.25.

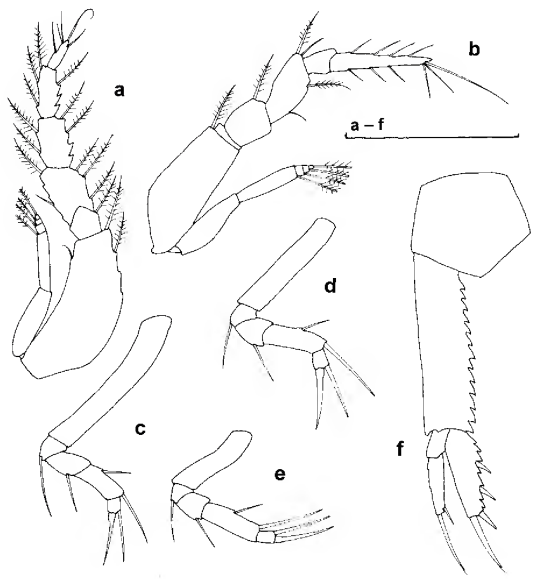

Figure 8. *Campylaspis edenensis* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.5.

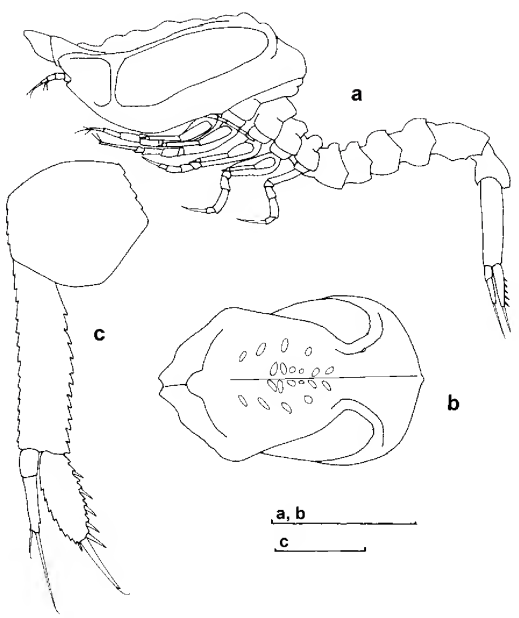

Figure 9. *Campylaspis edenensis* sp. nov. male allotype: a, body, lateral view; b, carapace, dorsal view; c, pleonite 6 and left uropod. Scale (in mm): a, b, 1; c, 0.25.

Diagnosis. Carapace with large, long lateral sulcus not reaching dorsal crest. Median dactylar tooth of maxilliped 2 longer than other two. Maxilliped 3 basis more than one-third of entire appendage. Pereopod 1 with numerous plumose setae on both sides. Pereopod 2 with digitiform tip of dactylus, with long simple subterminal seta. Pereopods 3–5 robust, dactylus fused with terminal seta. Uropod peduncle 1.7 times as long as pleonite 6, subequal rami.

Description of female. Body with well calcified glabrous integument. Length: 3.3 mm.

Carapace half body length, 2.2 times as long as high, large and long lateral sulcus not reaching dorsal crest, upper margin ending on tip of pseudorostrum, transverse ridge on sulcus at base of ocular lobe, large ocular lobe without eyes, numerous dorsal clear lenses, antennal notch small, ventral margin smooth, dorsal crest posteriorly. Pereon with 4 free thoracic segments. Pleon 0.38 body length.

Antenna 1 peduncle with serrated margins, proximal article longest, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum tiny, uniarticulate.

Maxilliped 2 basis fused with ischium, with plumose seta on inner distal corner, similar seta medially disposed on merus, carpus with short tooth and 2 simple setae on inner margin, propodus second longest article, with small tooth on inner margin and outer stronger seta, longer than dactylar teeth, dactylus fused with its 3 teeth, median one the longest. Maxilliped 3 basis more than one-third of entire maxilliped, with plumose seta on inner distal corner and 2 longer setae on outer distal corner, merus second longest article, with serrated margins, stronger on outer margin, with plumose seta on outer distal corner, carpus as long as propodus, with 4 teeth on inner margin and 2 on outer one, propodus with 2 teeth and 4 pappose setae on inner margin, 3 teeth on outer margin, dactylus 0.35 of propodus, with simple short setae.

Pereopod 1 basis more than one-third of entire appendage, with serrated inner margin, plumose setae on basis to propodus, merus twice as long as ischium, carpus as long as propodus, with strong inner serration, dactylus 0.6 of propodus length, with simple short setae. Pereopod 2 basis little less than one-third of appendage, basis and merus with plumose seta on inner distal corner, merus 5 times as long as ischium, carpus 1.3 times as long as merus, with plumose seta and simple seta on distal inner corner, dactylus 3.5 times as long as propodus, with digitiform tip, few simple short setae on both margins, 3 subterminal simple setae, 1 much longer. Pereopods 3–5 with progressively shorter basis and longer carpus, carpus twice as long as merus in last pair, with simple robust seta on distal outer corner, dactylus fused with its terminal robust seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod with robust peduncle 1.7 times as long as pleonite 6, twice as long as rami, with serrated inner margin, exopod slightly shorter than endopod, with terminal longer robust seta, endopod with 2 stout setae on serrated inner margin, robust terminal seta shorter than endopod; terminal setae on rami with single subterminal setule.

Description of male. Body length: 3.5 mm.

Carapace with stronger ridges than in female.

Uropod peduncle 1.5 times as long as pleonite 6, twice as long as endopod, exopod little shorter than endopod, with 2 subterminal setae and a longer, more robust, terminal one, endopod larger than exopod, with terminal robust seta and 5 stout short setae on inner margin.

Etymology. The new species bears the name of Eden, a port town in south-eastern Australia.

Distribution. Off Eden, NSW; 520 m depth.

Remarks. The two species most similar to *Campylaspis edenensis* are *C. calmani* Petrescu, 1995 and *C. angelae*. *Campylaspis edenensis* is differentiated from *C. calmani* by having the sulcus not bordered by small tubercles and the dactylus of pereopod 2 with a digitiform tip. *Campylaspis edenensis* differs from *C. angelae* by a lack of carapace tubercles, dorsal serrated crests on the pereon and pleon, and the longitudinal crest on the uropod peduncle.

Campylaspis grossui sp. nov.

Figures 10, 11

Material examined. Holotype female. Vic., eastern Bass Strait, 11.2 km E of eastern edge of Lake Tyers, 37°51.41'S, 148°13.16'E, 32 m, sand-shell, Smith-McIntyre grab, Marine Science Laboratories, RV *Sarda*, 25 Sep 1990 (stn MSL-EG 27), NMV J27468.

Paratypes: 1 female (stn MSL-EG 27), NMV J27468; 1 female, dissected (stn MSL-EG 27), NMV J52952; 1 female, 1 male (stn MSL-EG 26), NMV J27467; 1 female (stn MSL-EG 26), MGAB CUM 1607; 1 immature male, NMV J 27469; 1 female, NMV J27470.

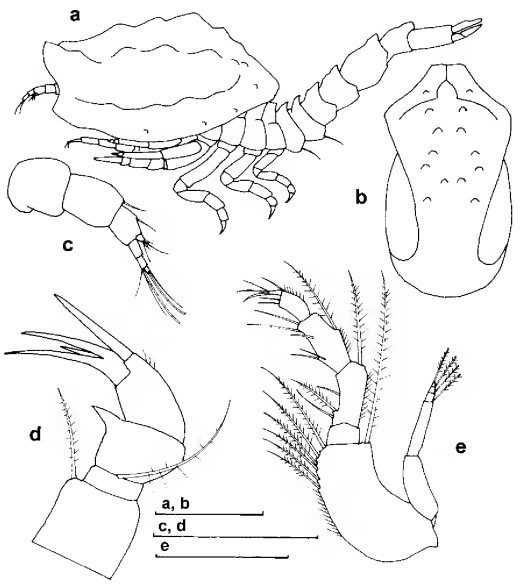

Figure 10. *Campylaspis grossui* sp. nov. female paratype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, d, 0.3; e, 0.5.

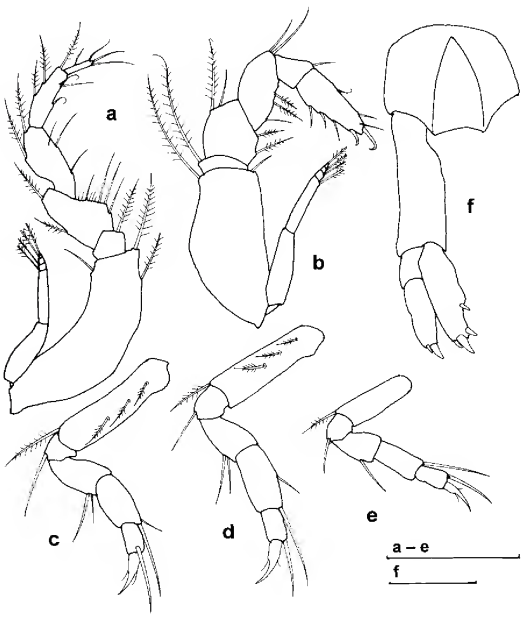

Figure 11. *Campylaspis grossui* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–e, 0.5; f, 0.25.

Diagnosis. Carapace with large lateral sulcus (almost as long as carapace), not meeting on posterior end, with dorsal tubercles. Pleon with short segments. Maxilliped 2 with long dactylar teeth. Pereopod 1 with large merus with an inner concavity. Pereopod 2 with large articles, dactylus wide, with short stout terminal seta. Pereopods 3–5 robust, dactylus fused with short robust, terminal and curved seta. Uropod peduncle 1.4 times as long as pleonite 6, 1.5 times as long as its equal rami, exopod and endopod with very short robust terminal seta, 2 short robust setae on inner margin of endopod.

Description. Body with highly calcified glabrous integument. Length: 3.95 mm.

Carapace 0.5 body length, twice as long as high, with long lateral sulcus, opened towards anterior, not meeting at posterior end, large and small lateral and dorsal tubercles, antennal notch wide, pseudorostrum meeting in front of eyeless ocular lobe. Pereonites 1–4 covered almost completely by carapace. Pleon with anteroposterior compressed segments, shorter than carapace.

Antenna 1 short and robust, median article of peduncle longest, main flagellum as long as distal article of peduncle, 3-articulate, accessory flagellum tiny, uniarticulate.

Maxilliped 2, long plumose seta on inner margin of basis and on distal article of merus, carpus with large tooth on inner margin, propodus second longest article, a long robust distal seta as long as dactylar teeth, dactylus with 3 teeth, 2 of them longer than propodus, median one-half of other two. Maxilliped 3 with wide basis, shorter than rest of articles combined, with 6 long plumose setae on inner margin and 1 on outer margin, ischium to dactylus slender, merus second longest article, with plumose seta on outer distal margin, carpus with plumose seta midway on outer margin, propodus 0.57 of carpus, dactylus short, slender, half of propodus, with short simple terminal setae.

Pereopod 1 basis less than half as long as appendage, with 2 plumose setae on inner margin, wide merus with inner concavity with numerous setae, carpus more slender than merus, second longest article, propodus shorter than merus, dactylus 0.5 of propodus, with short simple terminal setae. Pereopod 2 with short, very robust articles, basis less than half as long as appendage, long plumose seta on inner margin of basis, ischium and merus, carpus 1.2 times as long as merus, with 2 simple setae on distal inner corner, dactylus broad, twice propodus length, with short stout hooked terminal seta. Pereopods 3–5 robust, with progressively shorter basis, and longer carpus, dactylus fused with its robust terminal short seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 1.4 times as long as pleonite 6, 1.5 times as long as its equal rami, exopod and endopod with short robust terminal seta, 2 short robust setae on inner margin of endopod.

Etymology. The species is dedicated to the memory of the late Prof. Dr Alexandru V. Grossu (1910–2004) as a sign of gratitude for his moral and professional qualities as a brilliant scientist and mentor. He was the most important Romanian specialist in malacology, highly appreciated throughout the world, former director of "Grigore Antipa" National Museum of Natural

History (1955–1957), founder of its scientific journal, professor of zoology and Dean of the Faculty of Biology in Bucharest (1957–1962).

Distribution. Eastern Vic.; 32 m depth.

Remarks. Campylaspis grossui is closely related to *C. wardi* Băcescu, 1991 and *C. sculpta*. All three have a similar carapace, and short and robust pereopods and uropods. *Campylaspis grossui* differs from *C. wardi* in several characteristics: fewer tubercles on the carapace; longer teeth on the dactylus of maxilliped 2; more slender carpus of maxilliped 3; uropods with smooth margins; two short stout setae on the inner margin of endopod versus none; and terminal short setae without the oval structures characteristic of *C. wardi*. *Campylaspis grossui* differs from *C. sculpta* in the shape of the carapace in dorsal view, more robust antenna 1, maxilliped 3 and pereopod 1 with more slender articles, pereopod 2 with a much shorter dactylus (twice as long as the propodus in *C. grossui* versus four times in *C. sculpta*) and without a digitiform extremity, and more slender uropod rami with longer setae.

Campylaspis halei sp. nov.

Figures 12, 13

Material examined. Holotype female, Tas., off Freycinet Peninsula, 41°57.50'S, 148°37.90'E, 400 m, coarse shell, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 July 1986 (stn SLOPE 48), NMV J52940.

Allotype male: (stn SLOPE 48), NMV J52941.

Paratypes: 2 females, 1 immature male, 2 mancas (stn SLOPE 1), NMV J52943; 2 females (stn SLOPE 47), NMV J52416; 2 females (stn SLOPE 47), MGAB CUM 1608; 3 females, 1 female, dissected (stn SLOPE 48), NMV J52942; 1 female (stn SLOPE 19), NMV J52420.

Diagnosis. Carapace with a small lateral sulcus. Accessory flagellum of antenna 1 2-articulate. Maxilliped 2 with subequal dactylar teeth. Merus of maxilliped 3 massive, merus, carpus and propodus with teeth on inner margin. Dactylus of pereopod 2 2.8 times as long as propodus, with a digitiform extremity. Uropod peduncle twice as long as pleonite 6 and its endopod, exopod 0.8 length of endopod, endopod with 5 microserrate setae on inner margin.

Description of female. Body with calcified smooth integument. Length: 3.2 mm.

Carapace 0.45 length of entire body, with a small lateral sulcus, large ocular lobe without lenses, antennal notch distinct, anteroventral corner acute, ventral margin smooth. Pleon 0.36 body length.

Antenna 1 peduncle with serrated margins, distal article longer than median one, main flagellum 3-articulate, longer than last article of peduncle, basal article longer than rest of articles combined, accessory flagellum tiny, 2-articulate.

Maxilliped 2 basis fused with ischium, with plumose seta on inner distal corner, merus with similar seta medially, carpus with tooth and 2 long simple setae on inner margin, propodus second longest article, with robust outer seta longer than dactylar teeth, dactylus with 3 subequal teeth.

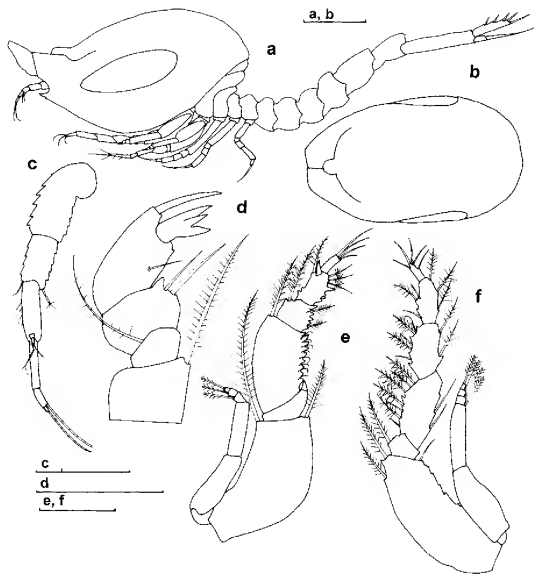

Figure 12. *Campylaspis halei* sp. nov. female paratype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3; f, pereopod 1. Scale (in mm): a, b, 0.5; c, 0.1; d, 0.1; e, f, 0.25.

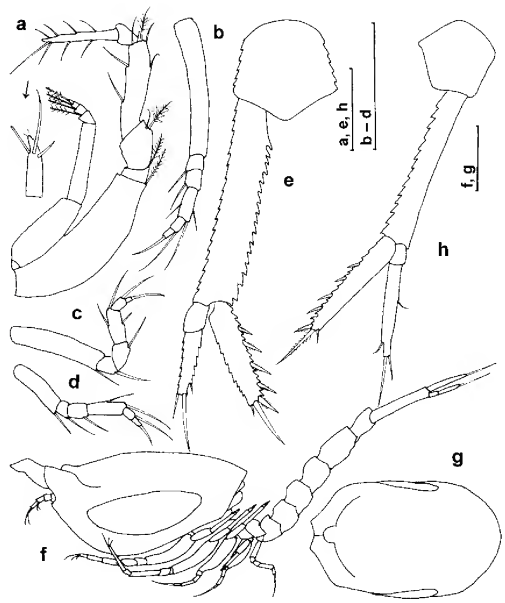

Figure 13. *Campylaspis halei* sp. nov. female paratype: a–e, male f–h: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and left uropod; f, body, lateral view; g, carapace, dorsal view; i, pleonite 6 and right uropod. Scale (in mm): a, e, h, 0.25; b–d, 0.5; f, g, 0.5.

Maxilliped 3 basis less than half as long as appendage, with plumose seta on inner distal corner and longer 1 on outer corner, inner distal corner of ischium with robust seta, merus second longest article, longer than carpus, propodus and dactylus combined, with row of teeth on inner margin and plumose seta on outer distal corner, carpus shorter than propodus, with serrated inner margin and plumose seta on outer distal corner, propodus with teeth on both margins, dactylus shorter than propodus, with terminal simple setae.

Pereopod 1 basis shorter than one-third of appendage length, with 2 plumose setae on inner margin, numerous plumose setae on inner margins of ischium to propodus, merus second longest article, carpus longer than propodus, propodus longer than dactylus, dactylus with simple setae. Pereopod 2 basis more than one-third length of appendage, plumose seta on inner distal corner of basis, ischium and merus, carpus twice as long as merus, with short stout seta, simple and plumose setae on inner distal corner, dactylus 2.8 times as long as propodus, digitiform dactylus tip with subterminal short simple seta. Pereopods 3–5 with progressively shorter basis and longer carpus, carpus and propodus with simple stout seta on outer distal corner, dactylus with stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod with serrated margins, peduncle twice pleonite 6, exopod shorter than endopod, with terminal robust seta shorter than exopod, endopod half peduncle length, with robust terminal seta and 5 microserrate setae on inner margin.

Description of immature male. Body length: 2.8 mm. Carapace less vaulted than in female, with similar sulcus. Antenna 2, pereopods 1–4 and exopods characteristic of an immature stage.

Uropod peduncle with less serrated margins, more slender and proportionally longer than in females, 2.3 times pleonite 6, rami longer than in females, endopod 0.77 peduncle length, rami equal, exopod with smooth margins, endopod with 5 stout setae on inner serrated margin.

Etymology. The species is dedicated to the memory of Herbert Mathew Hale (1895–1963), former director of the South Australian Museum (1928–1960), one of the most important specialists of Cumacea. He described most of the cumacean taxa known from Australian waters.

Distribution. NSW, off Freycinet Peninsula, Tas.; 400–600 m depth.

Remarks. Campylaspis halei has a smooth carapace surface with a relatively small lateral sulcus, extending over about half of the carapace. It resembles *C. latidactyla* Hale, 1945 but with a different extremity of the dactylus of pereopod 2 (digitiform tip in *C. halei*). Its sulcus is smaller than in *C. minor* Hale, 1945, where it is largely opened towards the anterior margin, and has a marked antennal notch absent in Hale's species (which has a much smaller size). *C. halei* is also similar to *C. latimera*, a species with a characteristic large merus on pereopod 1 and to *C. poorei* which has a narrower sulcus, slender pereopods 1 and 2 and a straight tip on the dactylus of pereopod 2 (digitiform in *C. halei*).

Campylaspis hirsuta sp. nov.

Figures 14, 15

Material examined. Holotype male, Vic., south of Point Hicks, 38°25'S, 149°00'E, 1500 m, compacted clay, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 22 Jul 1986 (stn SLOPE 27), NMV J52411.

Paratype: 1 immature male (stn SLOPE 46), NMV J52951.

Diagnosis. Carapace with 2 rows of dorsal tubercles provided with strong spines, spines on top of pseudorostrum, external row of tubercles with stronger spines, large lateral sulcus. Dorsal spines on pereon and pleon. Maxilliped 2 with dactylar teeth. Maxilliped 3 with long terminal seta on dactylus. Dactylus of pereopod 2 as long as propodus and carpus combined. Uropod peduncle 1.7 times as long as pleonite 6, 1.6 times as long as endopod.

Description. Body with integument strongly calcified. Length: 4.7 mm.

Carapace 0.4 body length, 1.8 times as long as high, with large lateral sulcus, pair of tubercles with strong spines at the posterior corners of the frontal lobe, 3 pairs in the median part and pair of smaller ones on posterior extremity, exterior row of 3 strong tubercles with spines on each side, ocular lobe acute, without eyes, pseudorostral lobes large and rounded, little upturned, with spines and long simple setae at the tip, antennal notch marked, anteroventral corner acute, ventral serration strong, long simple dorsal setae.

Antenna 1, median and distal article of peduncle subequal, shorter than main flagellum 3-articulate, accessory flagellum tiny, uniarticulate.

Maxilliped 2 with strong plumose seta on distal inner corner of basis and merus, ischium not visible, 2 simple setae on inner margin of carpus, propodus second longest article, with robust seta on distal outer corner, longer than dactylar teeth, dactylus with 3 teeth, median one shorter. Maxilliped 3 basis half entire appendage, with 2 short plumose setae and short distal serration on inner margin, 2 long plumose setae on outer distal corner, merus second longest article, with serrated inner margin, with tooth and plumose seta on outer margin, short carpus with serrated outer margin, propodus 1.4 times as long as carpus and twice as long as dactylus, dactylus with terminal simple long seta, 3 times dactylus length.

Pereopod 1 basis little less than half as long as appendage, with 2 long plumose setae on inner margin, serration on both distal sides, ischium with serrated inner margin with long plumose seta, merus second longest article, with numerous setae on both margins, carpus little shorter than merus, densely setose, propodus shorter than carpus, with numerous setae, twice as long as dactylus, dactylus with short simple setae. Pereopod 2 basis less than one-third rest of articles combined, with plumose seta on inner distal corner, simple seta on inner margin of merus, carpus 1.9 times as long as merus, short simple seta and longer plumose seta on its distal inner corner, dactylus 3.5 times as long as propodus, as long as propodus and carpus combined, with simple setae on both margins, subterminal and terminal simple long setae. Pereopod 3 basis large, plumose seta on distal inner corner of ischium and

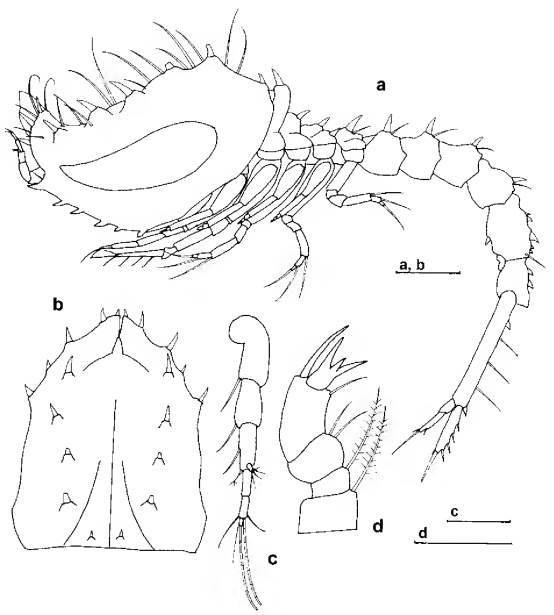

Figure 14. *Campylaspis hirsuta* sp. nov. female holotype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2 Scale (in mm): a, b, 0.5; c, 0.25; d, 0.3.

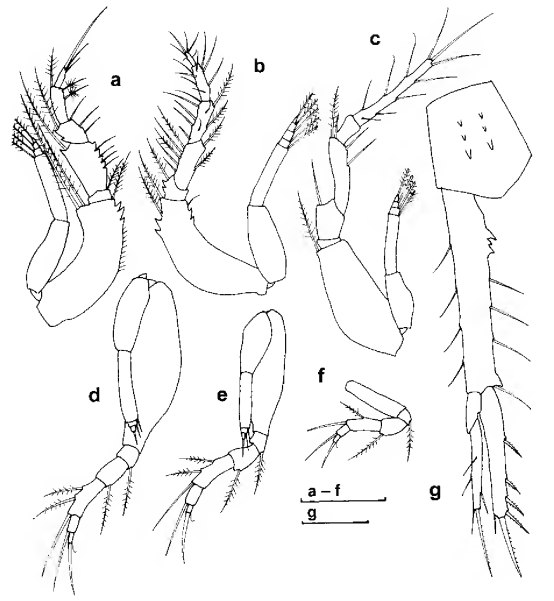

Figure 15. *Campylaspis hirsuta* sp. nov. female holotype: a, maxilliped 3; b, pereopod 1; c, pereopod 2; d, pereopod 3; e, pereopod 4; f, pereopod 5; g, pleonite 6 and left uropod. Scale (in mm): a–f, 0.5; g, 0.25.

merus, carpus little longer than merus, with 2 plumose setae on outer margin and robust seta on outer distal corner, small dactylus with stout terminal seta. Pereopod 4 similar to pereopod 3, with smaller basis and longer carpus. Pereopod 5 with 1 plumose seta on outer margin of carpus. 5 pairs of exopods incompletely developed.

Uropod peduncle 1.7 times as long as pleonite 6, 1.6 times as long as endopod, 3 proximal teeth and 4 simple setae on inner margin, exopod little shorter than endopod, with short simple subterminal seta, another seta on inner margin and robust microserrate terminal seta, endopod with 4 microserrate setae on inner margin, subterminal simple seta and terminal robust microserrate seta.

Etymology. The species is named "*hirsuta*" because of its integument with numerous setae and spines.

Distribution. South of Point Hicks, Vic., off Freycinet Peninsula, Tas.; 720–1500 m depth.

Remarks. Such a combination of characters, tubercles with spines on the carapace, carapace with a lateral sulcus, plus dorsal spines on the pereon and pleon as in *Campylaspis hirsuta*, is unique among species of *Campylaspis*. *C. spinosa* Calman, 1906 from the Mediterranean and the Atlantic Ocean has acute tubercles without spines on the carapace and dorsal spines on the pereon and pleon. The uropod endopod of *C. hirsuta* has four microserrate setae on the inner margin instead of three as in *C. spinosa*

Campylaspis johnstoni Hale, 1937

Campylaspis johnstoni Hale, 1937: 37–56, fig. 2.

Material examined. 4 females, 2 males (stn SLOPE 1), NMV J52975; 1 female, 1 immature male (stn SLOPE 2), NMV J54127; 1 female (stn SLOPE 2), NMV J52963; 1 male (stn SLOPE 46), NMV J52974.

Distribution. Antarctica, Kerguelen Is., south-western Atlantic (Argentina), 204 m depth (Băcescu, 1992); NSW, Tas., 720 m depth.

Remarks. This is the first record of this widespread species from Australian waters and from such a depth (720 m).

Campylaspis latidactyla Hale, 1945

Campylaspis latidactyla Hale, 1945: 194, figs 33, 34.

Material examined. 1 female, 1 male (stn SLOPE 22), NMV J52971.

Distribution. Moreton Bay, Qld, NSW; 200 m depth.

Remarks. The species was first recorded by Hale, 1945 from Moreton Bay, Queensland; its distribution is now extended to the southern New South Wales shelf.

Campylaspis latimera sp. nov.

Figures 16–19

Material examined. Holotype subadult female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J52935.

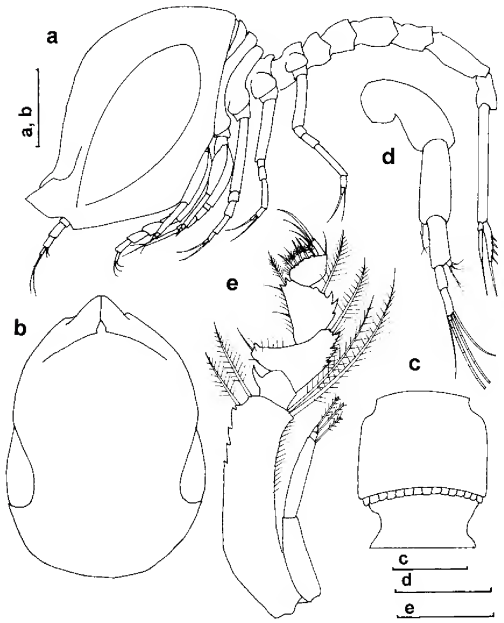

Figure 16. *Campylaspis latimera* sp. nov. female paratype: a, body, lateral view; b, carapace, dorsal view; c, fifth pleonite; d, antenna 1; e, maxilliped 3. Scale (in mm): a, b, 1; c, 0.25; d, 0.25; e, 0.5.

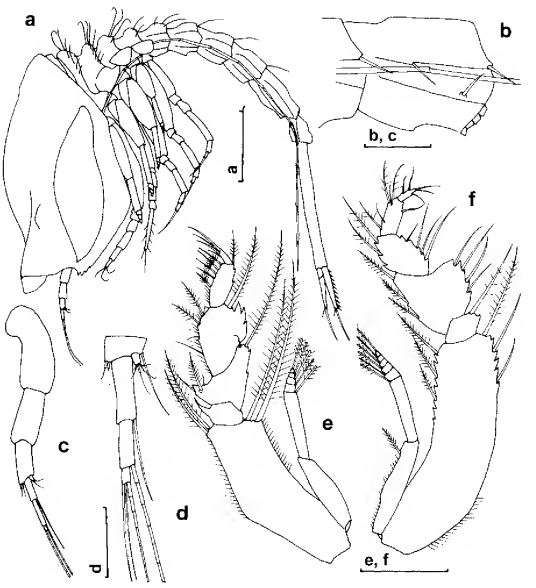

Figure 18. *Campylaspis latimera* sp. nov. male paratype: a, body, lateral view; b, pleonite, magnified; c, antenna 1; d, its flagella, magnified; e, maxilliped 3; f, pereopod 1. Scale (in mm): a, 1; b, c, 0.25; d, 0.1; e, f, 0.5.

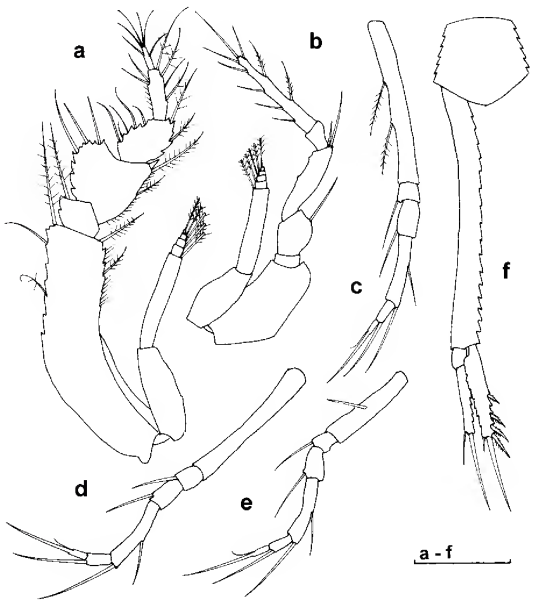

Figure 17. *Campylaspis latimera* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.5.

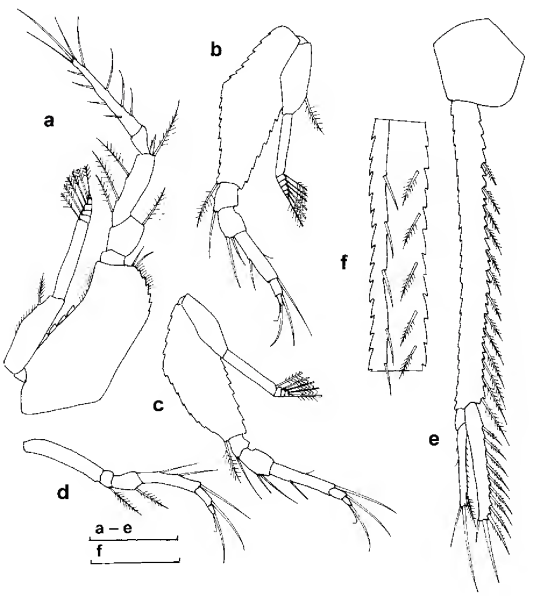

Figure 19. *Campylaspis latimera* sp. nov. male paratype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and left uropod; f, detail of uropodal peduncle, magnified. Scale (in mm): a–e, 0.5; f, 0.25.

Allotype: male (stn SLOPE 45), NMV J52936.

Paratypes: 2 females, 1 manca (stn SLOPE 1), NMV J52937; 1 female (stn SLOPE 1) MGAB CUM 1609; 1 immature male (stn SLOPE 46), NMV J52938; 1 immature male, NMV J45784; 1 female, 1 immature male (stn SLOPE 48), NMV J52939.

Diagnosis. Carapace with a large lateral sulcus, small ocular lobe without eyes. Maxilliped 3 with large concave merus. Pereopod 1 with large merus. Pereopod 2 with long dactylus (3.8 times as long as propodus). Pereopods 3–5 dactylus fused with its terminal seta. Uropod peduncle 3 times as long as pleonite 6 and 2.8 times as long as endopod.

Description of female. Body with calcified, smooth integument. Length: 6.8 mm.

Carapace 0.44 body length, 1.7 times as long as high, large lateral sulcus occupying most of lateral side of carapace (0.7 of its length), ocular lobe small, acute, without eyes, antennal notch small, ventral margin smooth. Pleonites each with toothed posterior margin.

Antenna 1 basal article of peduncle the longest, distal one the shortest, main flagellum shorter than last article of peduncle, 3-articulate, accessory flagellum tiny, uniarticulate.

Maxilliped 3 basis more than half length of appendage, serrated inner margin with 2 plumose apical setae, 2 longer plumose setae on outer corner (not produced), ischium with strong tooth on inner margin, merus large and concave, produced with small tooth, serrated outer margin with plumose seta, carpus shorter than merus, with serrated outer margin and plumose seta, propodus shorter than carpus, with numerous inner plumose setae, dactylus half of propodus, with setae as long as article.

Pereopod 1 basis more than half length of appendage, serrated inner margin with 2 simple setae and long pappose seta on inner distal corner, 2 plumose setae on outer margin, ischium with pappose seta on serrated inner margin, merus large, second longest article, 3 simple setae on serrated inner margin and 2 plumose setae and spine on outer margin, carpus large with serrated margins with simple setae on inner margin and plumose on outer margin, shorter than merus, propodus shorter and thinner than carpus, with numerous plumose setae on outer margin, dactylus 0.5 of propodus, with short simple setae. Pereopod 2 basis less than half length of appendage, simple seta on inner margin of merus, 2 unequal simple setae on outer distal corner, dactylus 3.8 times as long as propodus, with plumose setae on inner margin and simple seta on outer margin, subterminal and terminal simple setae. Pereopods 3–5 with progressively shorter basis and longer carpus (twice as long as merus), dactylus fused with terminal stout seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 3 times as long as pleonite 6 and 2.8 times as long as endopod, serrated inner margin without setae, exopod slightly shorter than endopod, with subterminal simple stout setae, endopod with 4 microserrate setae on inner margin, terminal robust seta shorter than endopod.

Description of male. Body with numerous long simple setae on posterior margin of pereonites and of pleonites 1–4. Length: 6.5 mm. Carapace less vaulted than in female, lateral sulcus smaller, anteroventral corner serrated. Pleonites with lateral groove for protecting the flagellum of antenna, provided with stout setae on its margins keeping flagellum within groove.

Antenna 1 shorter than in female, main flagellum of 3 articles, 1 aesthetasc on articles 2–3. Accessory flagellum tiny, uniarticulate. Maxilliped 3 with similar merus but thinner propodus than in female.

Pereopod 1 as in female. Pereopod 2 basis larger, plumose seta on inner margin of merus, carpus with plumose seta on inner distal corner, dactylus 3.5 times as long as propodus, as in female. Pereopods 3 and 4 basis broad, longer carpus in pereopod 4 (twice as long as merus), dactylus with stout terminal seta. Pereopod 5 carpus second longest article, little longer than in pereopod 4.

Uropod peduncle 3.35 times as long as pleonite 6, longer than in female, 2.65 times as long as endopod, rami little longer than in female, numerous plumose setae on serrated inner margin and a median groove for antenna provided with a lateral row of stout setae and a parallel one with plumose setae, exopod 0.8 length of endopod, with short subterminal stout seta, inner plumose seta and terminal stout long seta (longer than exopod), endopod with 9 microserrate long setae on inner margin and a terminal robust seta shorter than endopod.

Etymology. The species is named "*latimera*" because of the large merus of its maxilliped 3 and pereopod 1.

Distribution. Off Nowra, NSW, off Freycinet Peninsula, Tas.; 204–720 m depth.

Remarks. Campylaspis latimera differs from other species from this area with a lateral sulcus on the carapace by the characteristic shape and large size of the merus of the first pereopod. Maxilliped 3 also has a large merus with a concave inner margin and a large carpus. Both features are present in males and females. *C. anae* also has a large merus and carpus of maxilliped 3 but without the concavity of the merus; pereopod 1 of this species has slender articles. Also, the merus and carpus of maxilliped 3 of *C. rectangulata* are large, the merus with an inner concavity but not as evident as in *C. latimera* and pereopod 1 has only moderately large articles. *Campylaspis microdentata* Ledoyer, 1988 from off Comore Is. has a similar merus to maxilliped 3 but the carapace has no lateral sulcus and pereopod 1 has slender articles, shaped normally.

Campylaspis longidentata sp. nov.

Figures 20, 21

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J52944.

Diagnosis. Carapace with an oblique, concave ridge from dorsal side toward the lower margin, covered with pits and spines. Maxilliped 2 with long terminal teeth, longer than usual, propodus with long robust distal seta and dactylus also with long teeth. Maxilliped 3 with serrated margins. Pereopod 1 with serrated margins on basis to propodus, with slender articles. Pereopod 2 with dactylus 5 times as long as propodus, and with long digitiform extremity. Slender uropod peduncle 2.48 times as long as pleonite 6 and 1.9 times as long as equal rami.

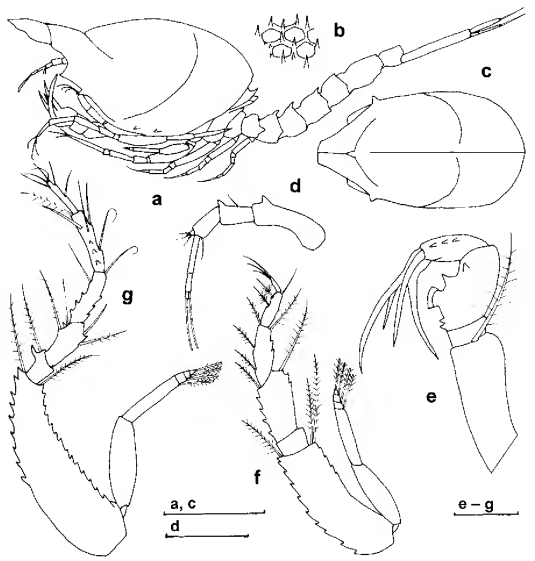

Figure 20. *Campylaspis longidentata* sp. nov. female holotype: a, body, lateral view; b, detail of its integument; c, carapace, dorsal view; d, antenna 1; e, maxilliped 2; f, maxilliped 3; g, pereopod 1. Scale (in mm): a, c, 1; d, 0.25; e–g, 0.25.

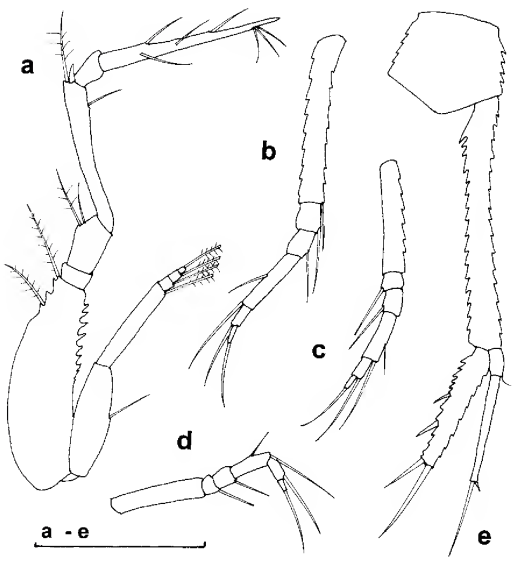

Figure 21. *Campylaspis longidentata* sp. nov. female holotype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and right uropod. Scale (in mm): a–e, 0.5.

Description. Body elongated, with strongly calcified integument. Length: 3.7 mm.

Carapace about half of body, longer than high, covered with numerous pits bordered by little spines, antennal notch obvious, anterolateral corner acute, lower margin with tooth on anterior half, pseudorostral lobes meeting in front of eyeless ocular lobe at a distance longer than length of frontal lobe, concave ridge from dorsal side toward lower margin. A tooth on lateral plate of pereonite 5, a pair of dorsal teeth on pleonites 1–3.

Antenna 1 peduncle articles progressively shorter, basal and median articles with tubercle on inner margin, main flagellum 3-articulate, longer than distal article of peduncle, basal article of flagellum much more than half flagellum length, accessory flagellum tiny, uniarticulate.

Maxilliped 2 basis with plumose seta on distal margin, ischium fused to basis, carpus second longest article, with 4 teeth (2 stronger) and axe-like tooth on inner margin, propodus with long robust distal seta, dactylus with 3 long teeth, median one shorter, twice as long as propodus. Maxilliped 2 visible between pereopod 1 and maxilliped 3 in lateral view. Maxilliped 3 basis shorter than 0.5 of appendage, with serrated margins, 2 plumose setae on outer distal corner, merus second longest article, with serrated margins and plumose seta on outer margin, carpus longer than propodus, with plumose seta on outer margin, propodus twice as long as dactylus, with 2 pappose setae on inner margin, dactylus with short simple terminal setae.

Pereopod 1 with slender articles, basis shorter than rest of articles combined, with serrated margins, plumose seta on distal inner and outer corner, tooth on inner margin of ischium, merus shorter than carpus, carpus shorter than propodus, propodus 1.6 times as long as dactylus, with simple setae. Pereopod 2 with slender articles, basis less than half length of appendage, plumose seta on inner distal corner, simple and plumose setae on inner margin of merus, carpus 2.8 times as long as merus, with robust short seta and plumose seta on its distal inner corner, dactylus 5 times as long as propodus, with long digitiform extremity, and simple setae on both margins. Pereopods 3–5, with progressively shorter basis and carpus, dactylus with long stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod slender, peduncle 2.5 times as long as pleonite 6 and 1.9 times as long as equal rami, with serrated inner margin, exopod with short stout terminal seta, endopod with 3 stout setae on inner margin and robust longer terminal seta.

Etymology. The name of the species is derived from the Latin "*longa*" – "long" and "*dentata*" – "with teeth", due to the long teeth of maxilliped 2.

Distribution. Off Freycinet Peninsula, Tas.; 720 m depth.

Remarks. The texture of the carapace integument with pits and spines is as in *C. sagamiensis* Gamô, 1967 from Japan. It differs mainly in maxilliped 2 and pereopod 2 with a digitiform tip to the dactylus. The presence of such long dactylar teeth on maxilliped 2 is a unique feature within the genus *Campylaspis*.

Campylaspis lynseyae sp. nov.

Figures 22, 23

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°02.20'S, 148°38.70'E, 800 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 45), NMV J52962.

Paratypes: 2 immature males, 1 manca (stn SLOPE 45), NMV J52963.

Diagnosis. Carapace with large lateral sulcus, 0.53 body length, 1.7 times as long as high, large lateral sulcus (0.8 of carapace length). Small dorsal teeth on first 2 pleonites. Antenna 1 slender. Robust seta of propodus of maxilliped 2 as long as dactylar teeth. Maxilliped 3 slender, dactylus with long terminal simple setae. Pereopod 1 with merus twice as long as propodus, few setae on both margins. Pereopod 2 with digitiform tip of dactylus. Dactylus of pereopods 3–5 fused with its terminal stout seta. Uropod peduncle little more than twice pleonite 6 length, 1.7 times as long as endopod.

Description. Body with calcified smooth integument. Length: 2.36 mm.

Carapace 0.53 body length, 1.7 times as long as high, large lateral sulcus (0.8 of carapace length, 4.6 times as long as high), not meeting the dorsal side, frontal lobe with large base, pair of small tubercles at base of this lobe, ocular lobe with acute top, without eyes, long pseudorostrum not upturned, large siphon, small antennal notch, anteroventral corner acute, short serration of ventral margin in anterior part. Pleonites 1 and 2 with a pair of dorsal teeth and a lateral tubercle. Pereonite 6 with small tooth on posteroventral corner.

Antenna 1 basal article of peduncle the longest, with 2 long simple setae, main flagellum, 3-articulate, longer than distal article of peduncle, accessory flagellum minute.

Maxilliped 2 with plumose seta on distal inner corner of basis and median part of merus, tooth and 2 simple seta on inner margin of carpus, propodus second longest article, with robust seta on outer distal corner as long as dactylar teeth and tooth on inner margin, dactylus fused with its forked-like teeth, median one much shorter. Maxilliped 3 basis less than half as long as appendage, with 2 plumose setae on inner and outer margin, no outer process, long and slender merus, second longest article, with small inner concavity, and plumose seta on both margins, carpus half merus length, with 3 teeth on outer margin, propodus longer than carpus, dactylus shorter than propodus, with simple terminal setae much longer than propodus. Pereopod 1 basis less than half as long as appendage, merus 3 times as long as ischium, second longest article, carpus 0.6 length of merus, 1.25 of propodus, propodus twice as long as dactylus, few setae on ischium to dactylus, dactylus with simple short setae. Pereopod 2 basis less than half as long as appendage, plumose seta on inner margin of merus, carpus 1.4 times as long as merus, with simple and plumose seta on inner distal corner, dactylus 5 times as long as propodus, with few setae on both margins and a pronounced digitiform tip with 2 simple subterminal setae. Pereopods 3–5 with progressively shorter basis and longer carpus (carpus more than twice merus), dactylus fused with its terminal stout seta. Exopods in maxilliped 3 and pereopods 1, 2.

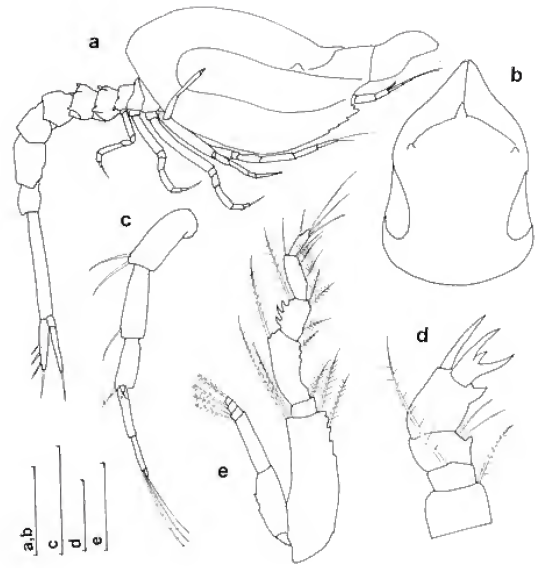

Figure 22. *Campylaspis lynseyae* sp. nov. female holotype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 0.5; c, 0.2; d, 0.1; e, 0.25.

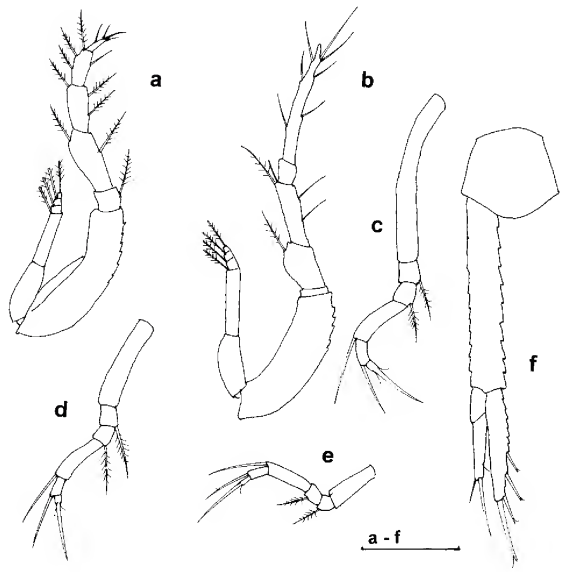

Figure 23. *Campylaspis lynseyae* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.25.

Uropod peduncle little more than twice length of pleonite 6, 1.7 times as long as endopod, serrated inner margin, without any setae, exopod 0.8 of endopod length, with short stout subterminal seta and much longer terminal one, endopod with 3 stout setae with subterminal setule on inner serrated margin and terminal robust seta.

Etymology. The species is dedicated to Lynsey Poore as a sign of gratitude for the kindness shown during my short visit to Melbourne.

Distribution. Off Freycinet Peninsula, Tas.; 800 m depth.

Remarks. The new species has a large lateral sulcus like *C. anae* and *C. rectangulata*. It differs from these species by presence of a pair of small tubercles on the base of the ocular lobe, longer antenna 1, slender maxilliped 3 and pereopod 1 and digitiform extremity of the dactylus of pereopod 2 (extremity broken in *C. anae*). *C. spinifera* also has a similar sulcus, a pair of tubercles on the base of the ocular lobe but with a supplementary tubercle with a spine on top on the lower margin of the sulcus near the anterolateral corner, a shorter, larger merus of maxilliped 3, and pereopod 2 with a tapering extremity to the dactylus.

Campylaspis nowrae sp. nov.

Figures 24, 25

Material examined. Holotype female, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, WHOI epibenthic sled, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986 (stn SLOPE 6), NMV J J52945.

Diagnosis. Carapace with large lateral sulcus and 2 dorsal transverse ridges. Robust antenna 1. Maxilliped 3 with slender articles, dactylus with long terminal seta. Pereopod 1 with merus, carpus and propodus subequal, dactylus with long plumose subterminal seta. Pereopod 2 with digitiform extremity of long dactylus. Dactylus fused with its terminal seta in pereopods 3–5. Short uropods, peduncle 1.3 times as long as pleonite 6 and 1.7 times as long as equal rami, endopod with 2 stout setae on inner margin.

Description. Body with highly calcified integument, smooth. Length: 5.1 mm.

Carapace 0.49 body length, 2.3 times as long as high, with a large lateral sulcus posteriorly continued by a large concavity up to the median part, 2 dorsal transverse ridges in median part that reach upper side of sulcus, 2 small tubercles on lateral side of pseudorostrum, minute ocular lobe with a large base, without eyes, antennal notch large, no lateral and lower serration. Pleonites 1–4 with lateral acute expansions, pleonite 6 the longest.

Antenna 1 with robust articles, articles of peduncle progressively shorter toward the distal extremity, main flagellum 3-articulate, shorter than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 3 basis little shorter than rest of articles combined, with hairy margins, plumose setae on outer and inner distal corners, merus with small inner concavity, with plumose seta on outer margin, carpus shorter than merus, with plumose seta on outer serrated margin, propodus second longest article, dactylus half of propodus, with long simple terminal seta.

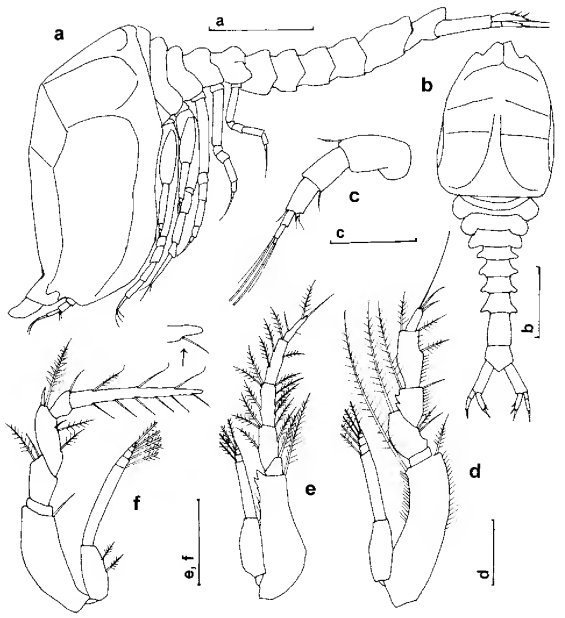

Figure 24. *Campylaspis nowrae* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 3; e, pereopod 1; f, pereopod 2. Scale (in mm): a, 1; b, 1; c, d, 0.25.

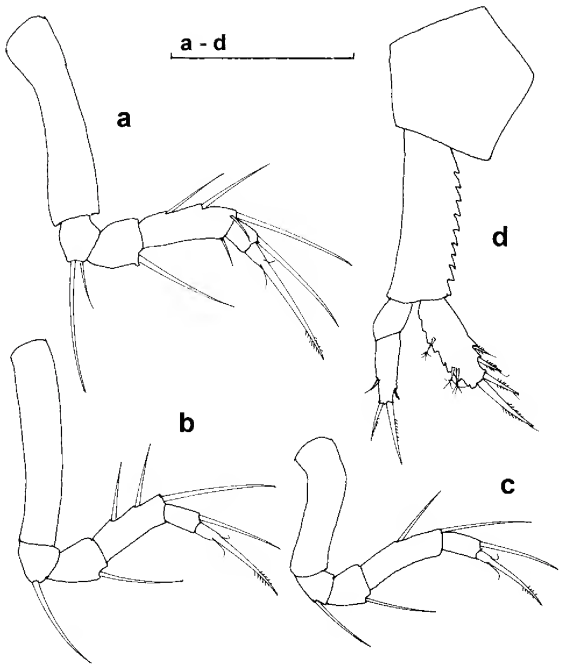

Figure 25. *Campylaspis nowrae* sp. nov. female holotype: a, pereopod 3; b, pereopod 4; c, pereopod 5; d, pleonite 6 and left uropod. Scale (in mm): a–d, 0.5.

Pereopod 1 basis less than half as long as appendage, with serrated outer margin and plumose seta on inner distal corner, merus, carpus and propodus subequal with numerous plumose setae on both margins, dactylus shorter than propodus, with plumose terminal seta. Pereopod 2 basis less than half as long as appendage, simple and plumose setae on inner margin of merus, carpus 1.7 times as long as merus, with stout seta and pappose seta on distal inner corner, dactylus 4.6 times as long as propodus, as long as merus, carpus and propodus combined, with lateral setae and digitiform short tip provided with short simple seta. Pereopods 3–5 with progressively shorter basis and longer carpus (carpus of 5th pair twice as long as merus), simple stout long setae on outer margin of carpus, 1 seta on its outer distal corner, dactylus fused with its terminal stout microserrate seta. Exopods on maxilliped 3 and pereopods 1, 2; with 2nd article very long.

Uropod peduncle 1.3 times as long as pleonite 6 and 1.7 times as long as equal rami, with serrated inner margin, exopod 2-articulate, with subterminal microserrate seta and a terminal longer one, endopod with 2 stout microserrate setae on inner margin, single subterminal setules and longer terminal seta (shorter than endopod), and 3 pedunculate setae.

Etymology. The species bears the name of a town in NSW near the type locality.

Distribution. Off Nowra, NSW; 770 m depth.

Remarks. The carapace of *C. nowrae* has two pairs of transverse dorsal crests in the median region similar to the carapace of form B of *C. johnstoni* Hale, 1937 found by Ledoyer (1993) in the Weddell Sea and *C. bulbosa* Jones, 1974 from the Atlantic coasts of south-western Africa. It differs in the posterior extremity of the carapace with a different arrangement of ridges, in much shorter uropods, and an endopod with two setae on its inner margin.

Campylaspis pileus Foxon, 1932

Cumella pileus Foxon, 1932: 393, figs 9, 10.

Material examined. 6 females (stn SLOPE 45), NMV J52976; 1 female (stn SLOPE 46), NMV J52977.

Distribution. Great Barrier Reef, Qld, Tas.; 22–800 m depth.

Remarks. These records extend the range of the species much further south, to Tasmania, and to greater depth (800 m).

Campylaspis poorei sp. nov.

Figure 26

Material examined. Holotype female, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, WHOI epibenthic sled, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986 (stn SLOPE 6), NMV J52417.

Diagnosis. Carapace with long, thin narrow sulcus. Antenna 1 long. Maxilliped 2 with 3 short dactylar teeth, median one small. Merus of maxilliped 3 the 2nd longest article, dactylus with microserrate terminal setae. Pereopod 1 with slender and less setulated articles. Dactylus of pereopod 2 without digitiform extremity. Uropod peduncle 1.6 times as long as pleonite 6 and 1.3 times longer than endopod, exopod shorter than endopod, endopod with 4 short microserrate setae on inner margin.

Description. Body with smooth integument. Length: 3.1 mm.

Carapace 0.43 of entire body length, twice as long as high, with long, thin lateral sulcus, big ocular lobe without eyes, antennal notch small, ventral margin smooth.

Antenna 1 long, proximal article of peduncle longest article, distal one longer than median article, main flagellum, 3-articulate, as long as last 2 articles of peduncle, accessory flagellum, minute, uniarticulate.

Maxilliped 2 basis with strong inner plumose seta, small tooth and 2 simple setae on inner margin of carpus, propodus second longest article, with robust seta on outer distal corner, longer than dactylar teeth, dactylus fused with 3 short teeth, median one minute. Maxilliped 3 basis half of appendage, 2 plumose setae on outer and inner distal corner, no outer process, merus second longest article, with serrate inner margin with plumose setae, long plumose seta on distal outer corner, carpus less than half merus, with strong serration and plumose seta on outer margin, propodus 1.5 times longer than carpus, with 2 pappose setae on inner margin, dactylus half of propodus, with microserrate setae longer than article.

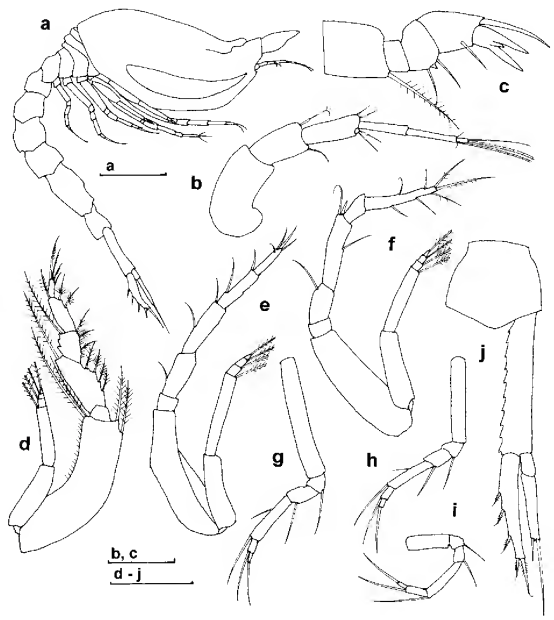

Figure 26. *Campylaspis poorei* sp. nov. female holotype: a, body, lateral view; b, antenna 1; c, maxilliped 2; d, maxilliped 3; e, pereopod 1; f, pereopod 2; g, pereopod 3; h, pereopod 4; i, pereopod 5; j, pleonite 6 and right uropod. Scale (in mm): a, 0.5; b, c, 0.1; d–j, 0.25.

Pereopod 1 basis shorter than rest of articles combined, margins smooth, merus 3 times as long as ischium, with simple seta on outer margin, carpus second longest article, with 2 simple curved setae on inner margin, propodus 0.8 of carpus length, with simple setae on inner margin, dactylus 0.7 propodus length, with simple short setae. Pereopod 2 basis shorter than rest of articles combined, simple seta on inner margin of merus, carpus 1.8 times as long as merus, with short stout seta and longer simple one on distal inner corner, dactylus 2.6 times as long as propodus, shorter than carpus, with few simple setae on both margins, subterminal and terminal plumose setae. Pereopods 3–5 with progressively shorter basis and longer carpus (carpus 3 times as long as merus in last pair), carpus with simple stout long seta on outer distal corner, dactylus with long stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2, with 2nd article long.

Uropod peduncle 1.6 times as long as pleonite 6 and 1.3 times as long as its endopod, with serrated inner margin, exopod 0.8 length of endopod, with long terminal robust seta, endopod with 4 short microserrate setae on inner margin and short microserrate terminal seta.

Etymology. The species is dedicated to Gary Poore, Museum Victoria, Melbourne, Australia, well-known specialist in Peracarida, as a sign of gratitude for offering me the opportunity to study this collection in his laboratory.

Distribution. Off Nowra, NSW; 770 m depth.

Remarks. The new species most resembles *C. minor* Hale, 1945. It differs in the lateral sulcus not reaching the anterior margin of the carapace, pereopod 1 has slender articles, without plumose setae, there are fewer plumose setae on pereopod 2, and the uropod endopod has three setae on the inner margin instead of two.

Campylaspis pustulosa Hale, 1945

Campylaspis pustulosa Hale, 1945: 207, figs 43, 44.

Material examined. 1 female, 1 male (stn SLOPE 1), NMV J52978; 1 female (stn SLOPE 2), NMV J52979; 2 females, 2 males (stn SLOPE 47), NMV J52980; 1 female, 1 male (stn SLOPE 47), MGAB CUM 1614; 2 females, 1 male (stn SLOPE 48), NMV J52981.

Distribution. Off Eden, NSW, Tas.; 70–600 m depth.

Remarks. New discoveries extend the range of this species from New South Wales to Tasmania and to 600 m depth.

Campylaspis rectangulata sp. nov.

Figures 27, 28

Material examined. Holotype immature male, NSW, off Nowra, 34°57.90'S, 151°08'E, 503 m, bryozoa and shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 2), NMV J54123.

Diagnosis. Carapace with large lateral sulcus, rectangular in dorsal view, with short thoracic and abdominal segments. Maxilliped 2 with short dactylar teeth, shorter than robust seta of propodus. Merus of maxilliped 3 with inner concavity,

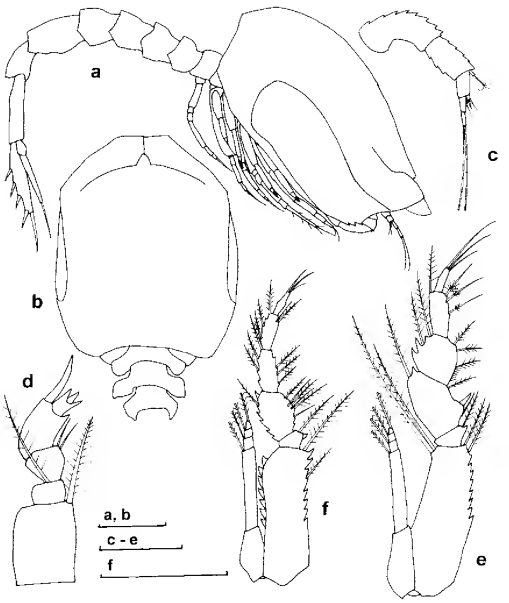

Figure 27. *Campylaspis rectangulata* sp. nov. female holotype: a, body, lateral view; b, carapace and pereon, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3; f, pereopod 1. Scale (in mm): a, b, 0.5; c–e, 0.25; f, 0.5.

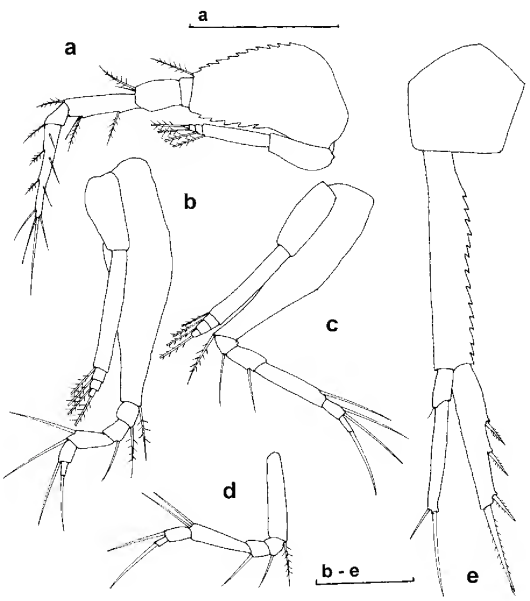

Figure 28. *Campylaspis rectangulata* sp. nov. female holotype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and left uropod. Scale (in mm): a, 0.5; b–e, 0.25.

enlarged merus and carpus. Pereopod 1 with short articles (except enlarged merus), with numerous plumose setae. Dactylus of pereopod 2 without digitiform extremity. Uropod peduncle twice as long as pleonite 6 and 1.4 times as long as its equal rami, without setae, exopod with long robust terminal seta, endopod with 3 microserrate setae on inner margin and longer, more robust, terminal seta.

Description. Body with highly calcified smooth integument. Length: 3.5 mm.

Carapace 0.51 body length, covering first 4 pereonites in lateral view, 1.8 times as long as high, with large lateral sulcus (0.6 of carapace length, 3 times as long as high), frontal lobe with large base and small ocular lobe without eyes, antennal notch almost absent, anterolateral corner with short serration. Pleon elongated, 0.45 body length.

Antenna 1 peduncle with short and robust articles, with serrated margins, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum tiny, uniarticulate.

Maxilliped 2 basis with strong plumose seta on inner margin, similar seta medially on distal margin of merus, carpus with 2 simple setae on inner margin, propodus second longest article, with robust curved seta on outer distal corner, longer than dactylar teeth, dactylus fused with 3 short, equal, teeth. Maxilliped 3 basis less than half as long as appendage, with serrated inner margin, with 2 plumose setae on inner distal corner and another 2 longer on outer distal corner, ischium with tooth and plumose seta on inner margin, merus second longest article, with inner concavity with setae, tooth and long plumose seta on outer margin, carpus enlarged, shorter than merus, with 2 teeth and 2 plumose setae on outer margin, propodus shorter than carpus, thinner, with 3 pappose setae on inner margin, dactylus 0.58 propodus length, with 3 long simple terminal setae.

Pereopod 1 basis less than half as long as appendage, with serrated margins (outer margin stronger), with 2 plumose setae on inner distal corner, short and robust articles with serrated margins and numerous plumose setae excepting dactylus with short simple ones, merus second longest article, carpus longer than propodus, propodus longer than dactylus. Pereopod 2 bulky, basis less than half as long as appendage, with serrated margins, short plumose seta on inner distal corner, 1 simple and 1 plumose seta on inner distal corner of merus, short carpus (1.5 times as long as merus), with short plumose seta on distal inner corner, dactylus 3 twice as long as propodus, with a right-angled extremity, with simple and plumose setae on margins, long stout terminal seta, shorter than dactylus. Pereopods 3–5: pair 3 and 4 with enlarged basis, progressively shorter, carpus progressively longer (3 times as long as merus in 5th pair), dactylus with robust long terminal seta. Exopods, 5 pairs incompletely developed (characteristic of immature specimen).

Uropod peduncle twice as long as pleonite 6 and 1.4 times as long as equal rami, without setae, with serrated inner margin, exopod with long robust terminal seta, endopod with 3 microserrate setae on inner margin and longer, more robust, terminal seta.

Etymology. The name "*rectangulata*" describes the carapace in dorsal view, almost square.

Distribution. Off Nowra, NSW; 503 m depth.

Remarks. Campylaspis rectangulata is similar to *C. anae* (in the form of the carapace and similar antenna 1). It differs in having a maxilliped 2 with shorter teeth on the dactylus, a shorter robust distal seta on the propodus, merus of maxilliped 3 with an inner concavity and a stout seta (versus none) and shorter uropods with slender peduncle, longer subequal rami (versus exopod shorter than endopod in *C. anae*), and three microserrate setae on the inner margin of the endopod instead of four. Pereopods are sexually dimorphic.

Campylaspis sculpta sp. nov.

Figures 29, 30

Material examined. Holotype immature male, dissected, Vic., eastern Bass Strait, 7.3 km SSW of Cape Conran, 37°52.67'S, 148°42.06'E, 48 m, sand-shell, Smith-McIntyre grab, Marine Science Laboratories, RV *Sarda*, 28 Sep 1990 (stn MSL-EG 62), NMV J23259.

Paratypes: 1 immature male (stn MSL-EG 108), NMV J27471; 1 manca (stn MSL-EG 57), NMV J23258, 1 manca (stn MSL-EG 62), NMV J52955.

Diagnosis. Carapace highly sculptured, with short thoracic and abdominal segments. Maxilliped 3 and pereopod 1 with enlarged articles, except dactylus, propodus 2nd longest article after basis. Pereopod 2 with enlarged articles, with long dactylus, longer than basis, with digitiform tip. Pereopods 3–5 with short and robust articles, dactylus fused with robust terminal seta. Short and robust uropods, uropod peduncle 1.25 times as long as pleonite 6 and 1.3 times as long as equal rami. Exopod and endopod (wider than exopod) with rounded tips, with fine short setae.

Description. Body with strongly calcified and smooth integument. Length: 6.08 mm.

Carapace 0.49 body length, 1.9 times as long as high, with large, blunt tubercles around large lateral sulcus (0.8 of carapace length), pseudorostrum short, ocular lobe large, without lenses, pair of tubercles and transverse ridge at its base, antennal notch small, anterolateral corner continued towards ocular lobe by an oblique ridge.

Antenna 1 peduncle with short and robust articles, median article as long as distal one, main flagellum with 3 short and robust articles, shorter than last article of peduncle, median and distal article with an aesthetasc, accessory flagellum tiny, uniarticulate.

Maxilliped 3 basis half of appendage, with 2 plumose setae on inner distal corner and another longer 2 on distal outer corner, merus longer than carpus and ischium, shorter than propodus (0.7), with long plumose seta on outer margin, carpus about half propodus, with small tooth and plumose seta on outer margin, propodus 2nd longest article, with short plumose seta on outer margin and 2 fine setae on inner margin, dactylus 0.2 length of propodus, enlarged, with fine terminal seta.

Pereopod 1 basis half of appendage, with 3 long plumose setae on inner margin, enlarged ischium to dactylus, ischium with tooth and long plumose seta on inner margin, merus widest article, with plumose setae on inner margin, carpus as

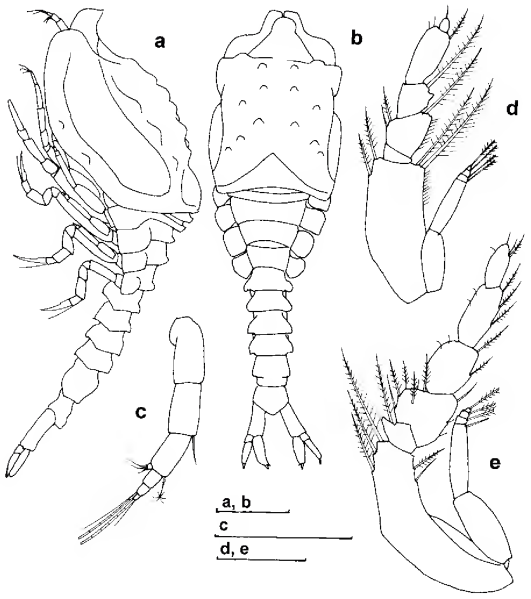

Figure 29. *Campylaspis sculpta* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 3; e, pereopod 1. Scale (in mm): a, b, 1; c, 0.5; d, e, 0.5.

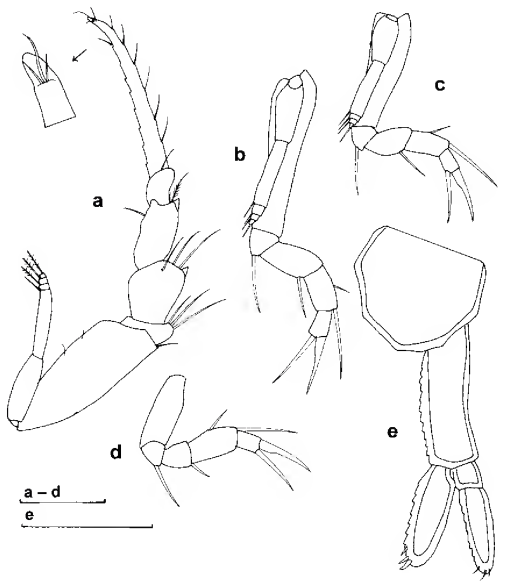

Figure 30. *Campylaspis sculpta* sp. nov. female holotype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and right uropod. Scale (in mm): a–d, 0.5; e, 0.5.

long as merus, with plumose seta on outer margin, propodus, 2nd longest article, 1.1 times as long as carpus, with 3 plumose setae on outer margin, oval dactylus 0.7 of propodus length, with fine terminal seta. Pereopod 2 basis shorter, less than 3rd of appendage length, ischium with 3 simple setae on inner margin, robust merus, the widest article, with small tooth and 3 simple setae on inner margin, carpus little longer than merus, with small tooth and short plumose seta on inner distal corner, long, curved and with digitiform dactylus, 4.6 times as long as propodus, longest article, with 3 fine subterminal setae. Pereopod 3 basis more than half of appendage, merus twice as long as ischium, carpus 0.7 of merus length, with stout long seta on outer margin, propodus 0.6 of carpus length, with robust distal seta, dactylus fused with robust terminal seta. Pereopod 4 basis shorter than in previous pair, merus subequal to carpus, propodus little longer than in previous pair. Pereopod 5 with shorter basis, carpus 1.8 times as long as merus. Exopods, 5 pairs.

Pleonite 6 and uropod with hyaline fringes. Uropod short and robust, uropod peduncle 1.25 times as long as pleonite 6 and 1.3 times as long as equal rami, serrated inner margin, exopod and endopod (wider than exopod), with rounded tips and serrated inner margins, exopod with 3 fine terminal setae, endopod with 3 stout short setae, terminal one little longer.

Etymology. The name "*sculpta*" refers to the sculptured carapace.

Distribution. Eastern Vic.; 48–50 m depth.

Remarks. Campylaspis sculpta is similar to *C. wardi* Băcescu, 1991 and *C. grossui.* They have similar carapaces, short and robust pereopods and uropods. *C. sculpta* differs from *C. wardi* in: fewer tubercles on the carapace; larger sulcus; larger propodus (second longest article) and rounded dactylus of maxilliped 3; larger propodus and dactylus; rounded dactylus of pereopod 1; much longer dactylus of pereopod 2; and the uropod exopod with few terminal fine setae and the endopod with three stout ones, versus the endopod with terminal short setae with the oval structures characteristic of *C. wardi.* The shape of the carapace in dorsal view is different from *C. grossui.* The species also differ in: stronger antenna 1, tiny rounded dactylus of maxilliped 3 and enlarged and rounded dactylus of pereopod 1, versus slender antenna 1 and maxilliped 3 and pereopod 1 with larger articles and dactylus in *C. wardi* and *C. grossui.* Pereopod 2 has a much longer dactylus, four times as long as the propodus in *C. sculpta*, and with a digitiform extremity, versus twice as long in *C. wardi* and *C. grossui,* which have a normal extremity. The uropod rami are stronger than in *C. grossui* and it also has finer setae.

Campylaspis serrata sp. nov.

Figures 31, 32

Material examined. Holotype female, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, WHOI epibenthic sled, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986 (stn SLOPE 6), NMV J45786.

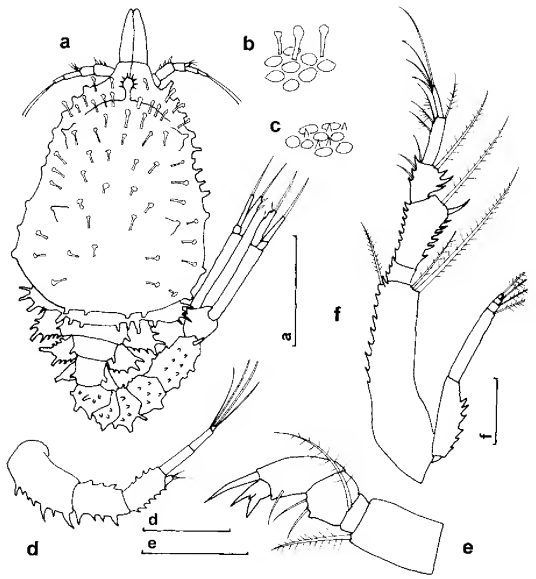

Figure 31. *Campylaspis serrata* sp. nov. female holotype: a, body, dorsal view; b, detail of integument from carapace; c, detail of integument of pereon and pleon; d, antenna 1; e, maxilliped 2. Scale (in mm): a, 1; d, 0.25; e, 0.2; f, 0.25.

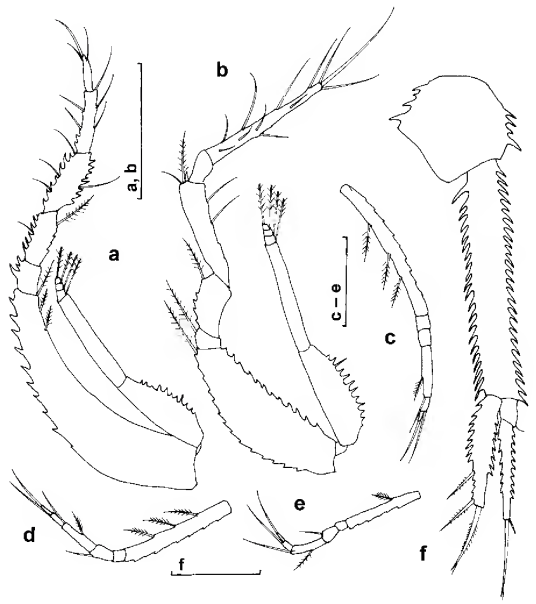

Figure 32. *Campylaspis serrata* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and right uropod. Scale (in mm): a, b, 0.5; c–e, 0.5; f, 0.25.

Diagnosis. Carapace covered with spines, small tubercles and long club-like setae interspersed with pits. Integument of pereon and pleon with pits and small spines. Antenna 1, maxilliped 3, pereopods 1 and 2 and uropods with densely serrated margins. Maxilliped 3 with merus second longest article, with long outer spine, carpus with 3 outer teeth, dactylus with long simple setae longer than article. Pereopod 1 with slender articles, with few setae. Pereopod 2 with long dactylus with straight tip. Uropod peduncle 2.25 times as long as pleonite 6 and 1.9 times as long as exopod, exopod little longer than endopod.

Description. Body with integument densely pitted, with bludgeon-like setae, small tubercles and spines on carapace and with small spines on rest. (The only specimen, holotype, is not in good shape, being a little dorsally compressed and twisted). Length: 4.5 mm.

Carapace about half body length, 1.3 times as long as wide, almost triangular in dorsal view, pair of small tubercles in median region, bigger one on branchial part and larger ones with spine on top at base of frontal lobe, integument densely pitted, with long spines and club-like setae, ocular lobe with spoon-like tip with crown of small spines, without eyes, pseudorostral lobes straight. Lateral plates of pereon with long spines, integument covered with pits and small spines. Pleon with pits and spines (longer ones are broken).

Antenna 1 peduncle with strongly serrated articles, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 with strong plumose setae on inner margin of basis and distally on merus, carpus with small tooth and 2 simple setae on inner margin, propodus 2nd longest article, with robust seta on outer distal corner, longer than dactylar teeth, dactylus with 3 teeth, median one minute. Maxilliped 3 with slender articles, basis less than half as long as appendage, with plumose seta on inner margin and 2 longer ones on outer distal corner, no outer process of basis, merus second longest article, with strong tooth and plumose seta on outer distal corner, carpus shorter than merus, with 3 teeth on outer margin, propodus little longer than carpus, with 3 pappose setae on inner margin, dactylus 0.75 of propodus length, with long simple setae, longer than dactylus.

Pereopod 1 with slender articles, basis longer than rest of articles combined, with 3 plumose setae on outer margin, ischium with 3 teeth (one larger) on inner margin, merus little shorter than carpus, with plumose seta on outer margin, carpus 2nd longest article, with simple setae, propodus subequal to merus, with simple setae, dactylus 0.57 of propodus length, with long simple setae. Pereopod 2 basis more than 3rd of appendage length, with plumose seta on distal inner corner, ischium and merus with similar seta, carpus 1.7 times as long as merus, with small tooth and long plumose seta on inner distal corner, dactylus 3.75 times as long as propodus, with numerous simple setae, and 1 terminal longer simple stout seta. Pereopods 3–5 with serrated margins, progressively shorter, with plumose setae, progressively shorter carpus (3 times as long as merus in 3rd pair), with plumose seta on inner margin and stout simple one on distal corner, dactylus with long stout simple terminal seta. Exopods on maxilliped 3 and pereopods 1, 2; with serrated bases.

Uropod peduncle 2.25 times as long as pleonite 6 and 1.9 times as long as exopod, with highly serrated margins, exopod little longer than endopod, with serrated margins and robust terminal seta, endopod with serrated margins, with 2 long microserrate setae on inner margin and a longer, more robust, terminal one.

Etymology. The name of the species describes the serrated appendages.

Distribution. Off Nowra, NSW; 770 m depth.

Remarks. Another species of *Campylaspis* with such highly serrated appendages is *C. echinata* Hale, 1945 (described only from the male). *C. serrata* has a differently textured carapace integument, densely pitted, with long spines and bludgeon-like setae, an ocular lobe with a spoon-like tip with a crown of small spines, uropods with the exopod slightly longer than the endopod, and the endopod with two microserrate long setae on the inner margin instead of one.

Campylaspis setifera sp. nov.

Figures 33, 34

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J52953.

Paratypes: 1 female, 1 dissected female (stn SLOPE 46), NMV J52954; 1 female (stn SLOPE 46), MGAB CUM 1611.

Diagnosis. Carapace high and smooth. Antenna 1 with long main flagellum. Dactylus of maxilliped 2 with short teeth. Maxilliped 3 with enlarged articles, merus 2nd longest article. Pereopod 1 with elongated articles with numerous plumose setae, merus second longest article. Pereopod 2 with long carpus, 2.5 times as long as merus, short dactylus with digitiform extremity. Dactylus of pereopods 3–5 fused with terminal stout seta. Long uropods, uropod peduncle 2.4 times as long as pleonite 6 and twice as long as endopod, with 8 microserrate setae on inner margin, endopod little longer than exopod, with 12 microserrate setae on inner margin.

Description. Body with highly calcified smooth integument. Length: 4.7 mm.

Carapace bulky, 0.51 body length, 1.3 times as long as high, oval in dorsal view, with short straight truncated pseudorostrum, ocular lobe with large base and minute tip, without lenses, antennal notch minute, lower margin smooth. Pereon 0.07 of entire body length, last 2 segments more visible. Pleon 0.41 body length, elongate.

Antenna 1 peduncle basal article the longest, rest progressively shorter, main flagellum 3-articulate, longer than last 2 articles of peduncle combined, accessory flagellum tiny, uniarticulate.

Maxilliped 2 basis and merus with strong plumose seta, ischium visible, carpus with tooth and simple seta on inner margin, propodus with inner tooth and simple seta, outer robust seta on distal corner, dactylus with 3 equal teeth shorter than propodal seta. Maxilliped 3 with enlarged articles, massive basis less than half as long as appendage, with 2 pappose setae on

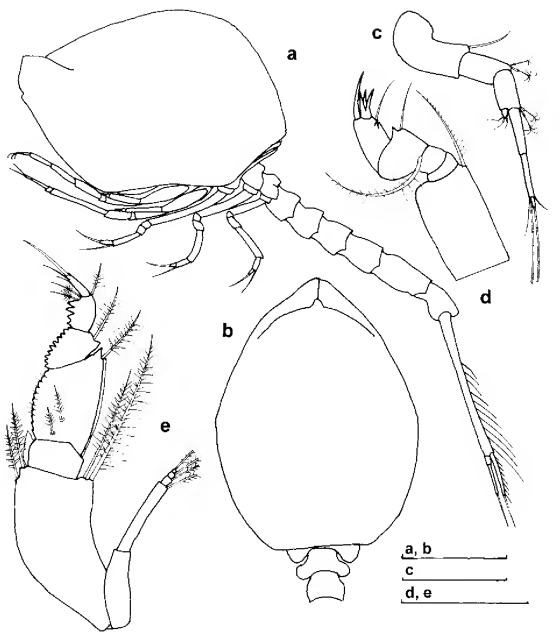

Figure 33. *Campylaspis setifera* sp. nov. female paratype: a, body, lateral view; b, carapace and pereon, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, 0.2; d, e, 0.5.

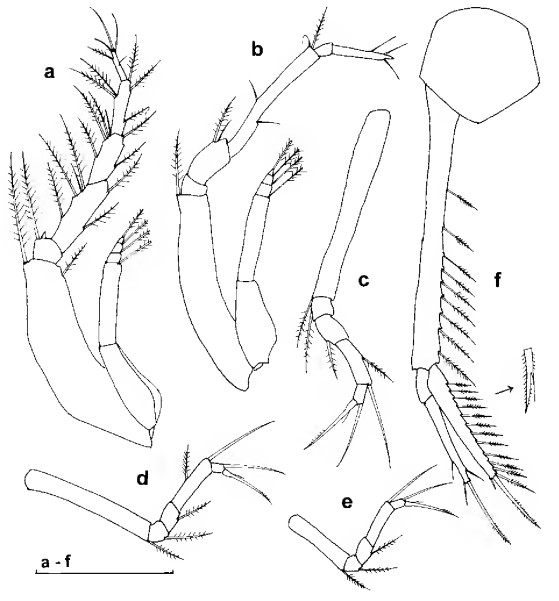

Figure 34. *Campylaspis setifera* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.5.

inner distal corner and an other 2, longer, on outer corner, ischium with hyaline outer crest, merus 2nd longest article, with 2 plumose setae medially, serrated inner margin, tooth and pappose seta on outer margin, carpus shorter than merus, with stronger serration on inner margin, tooth and pappose seta on outer margin, propodus shorter than carpus, with 4 teeth on inner margin, dactylus shorter than propodus, with simple setae.

Pereopod 1 basis longer than half of appendage, with long plumose seta on inner distal corner, ischium with tooth and long plumose seta on inner margin, merus 2nd longest article, with plumose setae on both margins, carpus as long as propodus, with plumose setae on both margins, propodus with plumose setae, dactylus almost half of propodus, with simple and plumose setae. Pereopod 2 basis less than half as long as appendage, with plumose seta on inner distal corner, merus with a similar one, carpus long, 2.5 times as long as merus, short dactylus (4 times as long as propodus), with digitiform extremity with few simple short setae. Pereopods 3–5 basis longer than half of appendage in 3rd pair, progressively shorter in next 2, carpus progressively longer, twice as long as merus in 5th pair. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 2.4 times as long as pleonite 6 and twice as long as endopod, with 8 microserrate long setae on inner margin, exopod with a long microserrate stout seta, endopod 8 little longer than exopod, with 12 microserrate setae on inner margin and longer terminal seta.

Etymology. The species is named "*setifera*" because of the unusual feature for a female.

Campylaspis, numerous setae on the uropods typical of males.

Distribution. Off Freycinet Peninsula, Tas.; 720 m depth.

Remarks. The new species is closer to *C. thompsoni* Hale, 1945 than to other species of the genus. It is strongly vaulted above the carapace, has a massive maxilliped 3 with numerous teeth on the margins of the merus and carpus, the pereopod 1 with numerous plumose setae, the merus being the second longest article, and the dactylus of pereopod 2 has a digitiform tip, and long uropods. *C. setifera* differs in: the ocular lobe is without lenses; antenna 1 has a longer main flagellum; maxilliped 2 has three dactylar teeth instead of four; the propodus of maxilliped 3 also has inner teeth, longer carpus and shorter dactylus in pereopod 2; and the uropod is totally different, almost male-like, with numerous microserrate setae on its peduncle and endopod (no setae on the peduncle and four setae on the endopod in *C. thompsoni*). *C. setifera* is the only species from this material without a sulcus, tubercles or spines on the carapace.

Campylaspis spinifera sp. nov.

Figures 35, 36

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J52931.

Paratypes: 14 females, 10 immature males, 1 female, dissected, NMV J52932; 2 females (stn SLOPE 46), MGAB CUM 1610.

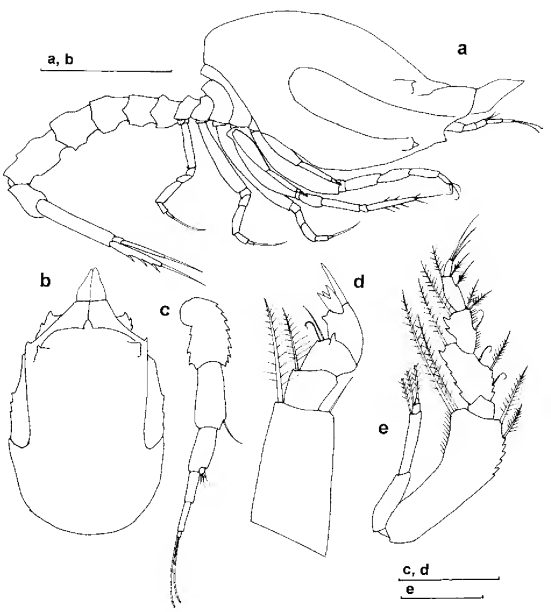

Figure 35. *Campylaspis spinifera* sp. nov. female paratype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, d, 0.2; e, 0.25.

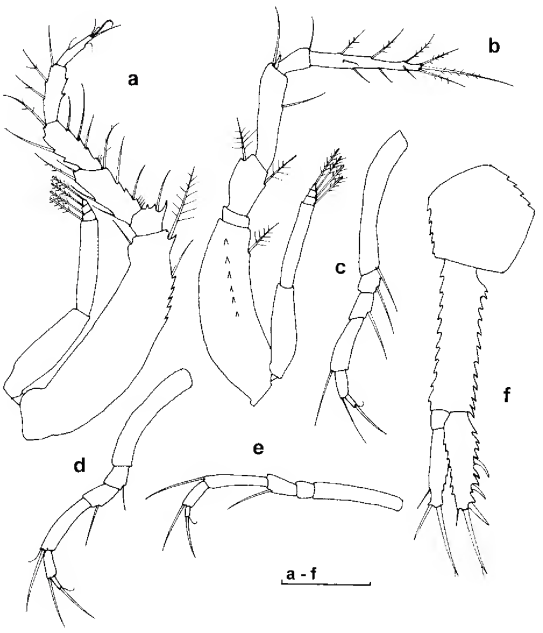

Figure 36. *Campylaspis spinifera* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.25.

Diagnosis. Carapace with a lateral sulcus, tubercles with spines at the base of frontal lobe and near the anterolateral corner, ocular lobe without lenses. Pereopod 1 basis less than half as long as appendage, with slender articles. Pereopod 2 carpus 1.8 times as long as merus and with straight extremity of dactylus. Uropod peduncle 1.4 times as long as pleonite 6 and its endopod, with serrated margins, exopod little shorter than endopod, with terminal robust long seta, endopod with 3 stout setae on inner serrated margin and robust long terminal seta.

Description. Body elongated, with smooth integument. Length: 3.9 mm.

Carapace 0.47 of entire body length, longer than high, with lateral sulcus, pair of tubercles provided with apical strong spines at base of frontal lobe and near pointed anterolateral corner, antennal notch small, ocular lobe small, without lenses, pseudorostrum straight.

Antenna 1 peduncle with progressively shorter articles, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 plumose long seta on inner margin of basis and merus, 2 simple setae and tooth on inner margin of carpus, propodus with robust seta on outer margin, longer than dactylar teeth, dactylus with 3 equal teeth. Maxilliped 3 basis half of appendage, with 2 plumose setae on distal inner and outer corners, merus second longest article, with tooth and plumose seta on outer margin, shorter carpus, with 2 teeth and plumose seta on outer margin, slender propodus as long as carpus, with 2 pappose setae on inner margin, dactylus half of propodus, with simple terminal setae longer than dactylus.

Pereopod 1 basis less than half as long as appendage, with slender articles, 6 strong serrations on inner margin of ischium, merus and carpus, with fewer simple and plumose setae, merus 2nd longest article, progressively shorter articles from carpus to dactylus, dactylus with short simple setae. Pereopod 2 basis longer than one-third of rest of articles combined, merus with plumose seta on inner and outer margin, carpus 1.8 times as long as merus, with short robust seta and a simple one on inner distal corner, dactylus 3.4 times as long as propodus, with simple and plumose setae and straight extremity. Pereopods 3–5 with slender articles, progressively shorter basis and longer carpus, twice as long as merus in 5th pair. Exopods on maxilliped 3 and pereopod 1, 2.

Uropod peduncle 1.4 times as long as pleonite 6 and its endopod, with serrated margins, exopod little shorter than endopod, with terminal robust long seta, endopod with 2 stout setae on inner serrated margin and robust long terminal seta. Terminal setae with 1 subterminal setule in both rami.

Etymology. The name of the species reflects the presence of characteristic spines on the carapace.

Distribution. Off Freycinet Peninsula, Tas.; 720 m depth.

Remarks. This species is more similar to *C. lynseyae* than to others. It differs in: a pair of tubercles with a spine on top near the anterolateral margin of the carapace; shorter dactylar teeth of maxilliped 2; larger merus of maxilliped 3; a tapering dactylus of pereopod 2; and shorter and stronger serrated uropods.

Campylaspis tasmaniensis sp. nov.

Figures 37–39

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°02.20'S, 148°38.70'E, 800 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 45), NMV J52947.

Allotype: male (stn SLOPE 45), NMV J52948.

Paratypes: 1 female, 2 mancas (stn SLOPE 45), NMV J52949.

Diagnosis. Carapace, pereon and pleon with numerous tubercles. Basal article of main flagellum of antenna 1 enlarged. Dactylar teeth of maxilliped 2 as long as robust seta of propodus, median tooth much smaller. Maxilliped 3 basis short, dactylus with long terminal simple setae. Pereopods with slender articles. Pereopod 1 propodus as long as merus, longer than carpus. Pereopod 2 with long dactylus with straight extremity. Uropod peduncle 2.3 times as long as pleonite 6 and endopod, with serrated margins, exopod little shorter than endopod, with subterminal microserrate seta and longer robust terminal seta, endopod with 3 stout setae on inner serrated margin, a subterminal and a terminal microserrate robust seta.

Description of female. Body with tubercled reticulated integument, without setae or spines. Length: 5.4 mm.

Carapace half body length, 2.1 times as long as high, with lateral sulcus that rises from anterolateral part and fuses with similar sulcus from other side, 2 parallel dorsal rows of acute tubercles, 2 transverse parallel rows of tubercles at base of frontal lobe, rows of tubercles delimiting the sulcus, 3 spines on upper side of sulcus toward tip of pseudorostrum, small antennal notch, anterolateral corner acute, short serrated ventral margin, ocular lobe minute, without lenses, pseudorostrum long and straight.

Antenna 1 proximal article of peduncle the longest, distal article longer than median one, short main flagellum 3-articulate, basal one enlarged, accessory flagellum minute, 1-articulate.

Maxilliped 2 with plumose long seta on inner margin of basis and merus, 2 simple setae and tooth on inner margin of carpus, propodus with robust seta on outer margin, as long as dactylar teeth, dactylus with 3 teeth, median one much shorter. Maxilliped 3 basis less than half as long as appendage, with 1 plumose seta on distal inner and outer corners, merus 2nd longest article, with long plumose seta on outer margin and simple and plumose setae on inner margin, carpus half of merus, with 3 teeth and long plumose seta on outer margin, slender propodus 1.6 times as long as carpus, dactylus 0.6 of propodus length, with simple long terminal setae (3.5 times as long as dactylus).

Pereopod 1 basis less than half as long as appendage, with slender articles, serration on inner margin of merus and carpus, with fewer simple and plumose setae, propodus and dactylus with simple setae, merus 2nd longest article, propodus as long as merus and longer than carpus, dactylus with short simple setae. Pereopod 2 basis more than one-third of rest of articles combined, with plumose seta on distal inner and outer corner, merus with plumose seta on inner and outer margin, carpus 1.8 times as long as merus, with short robust seta, a plumose long seta on inner distal corner, dactylus 4 times as long as propodus,

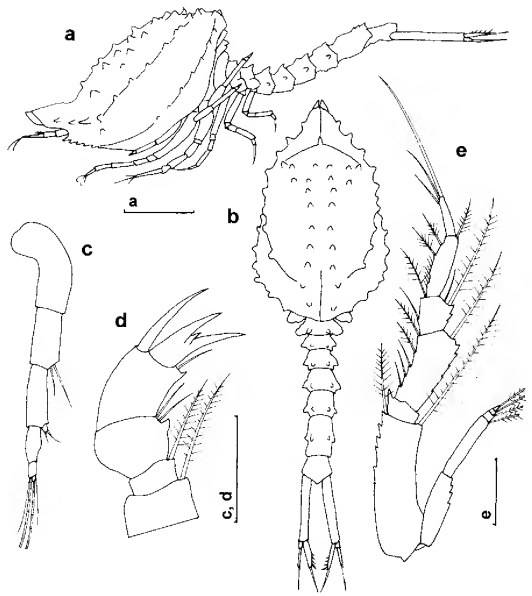

Figure 37. *Campylaspis tasmaniensis* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, d, 0.2; e, 0.25.

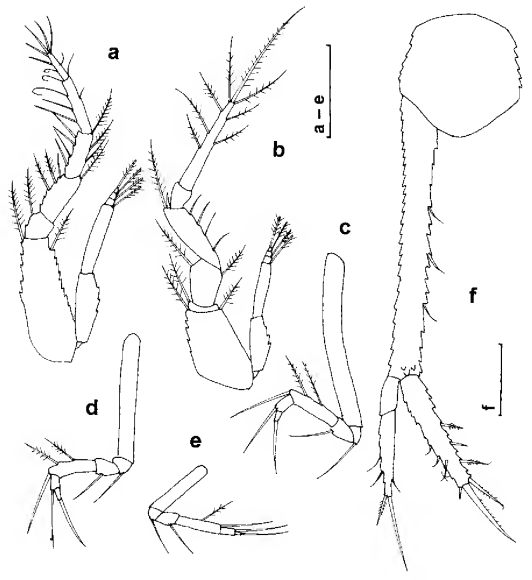

Figure 38. *Campylaspis tasmaniensis* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–e, 0.5; f, 0.25.

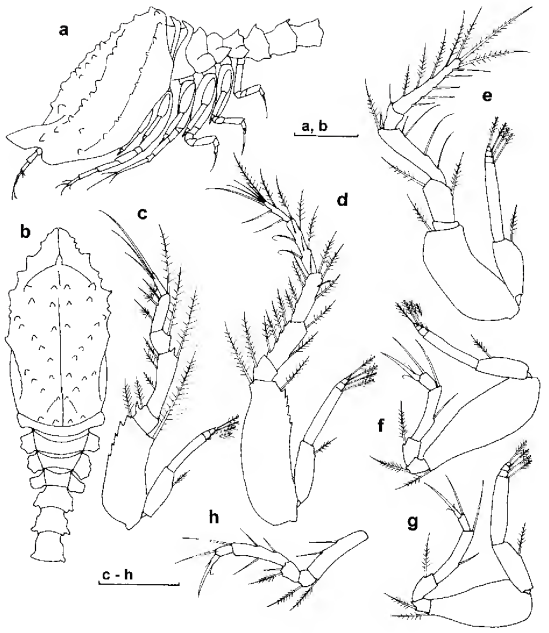

Figure 39. *Campylaspis tasmaniensis* sp. nov. male allotype: a, body, lateral view; b, body, dorsal view; c, maxilliped 3; d, pereopod 1; e, pereopod 2; f, pereopod 3; g, pereopod 4; h, pereopod 5. Scale (in mm): a, b, 1; c–h, 0.5.

with plumose setae and straight extremity. Pereopods 3–5 with slender articles, progressively shorter basis and longer carpus, twice as long as merus in 5th pair, 2 plumose setae on outer margin of carpus in pair 3 and 4, dactylus with stout long terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 2.3 times as long as pleonite 6 and endopod, with serrated margins, exopod little shorter than endopod, with subterminal microserrate seta and longer simple terminal seta, endopod with 3 stout setae on inner serrated margin, subterminal and terminal microserrate robust setae.

Description of male. Body with integument as in female, last 3 pleonites missing. Carapace with more dorsal tubercles, lateral sulcus shorter than in female, sulcus from each side separated, carapace more compressed laterally than in female.

Maxilliped 3 basis shorter, a half of appendage, merus more slender than in female, propodus with longer plumose seta on outer margin, dactylus with long terminal setae as in female.

Pereopod 1 with more numerous plumose setae on all articles including dactylus. Pereopod 2 dactylus shorter than in female, 3 times as long as propodus (versus 4 times), with more setae. Pereopods 3, 4 with large basis characteristic of males, 3–5 with more plumose setae, dactylus fused with terminal robust seta.

Etymology. The species bears the name of the type locality – Tasmania.

Distribution. Off Freycinet Peninsula, Tas.; 800 m depth.

Remarks. The general body shape is reminiscent of *C. sagamiensis* Gamô, 1967 but without pits and spines on the integument, with a larger lateral sulcus, with a bulky basal article of the main flagellum of antenna 1, an accessory flagellum with one article, not with two. *C. tasmaniensis* also is close to *C. mosambica* Ledoyer, 1988 but with more tubercles on the carapace, and the dactylus of maxilliped 3 with a much longer terminal seta.

Campylaspis thetidis Hale, 1945

Campylaspis thetidis Hale, 1945: 212, figs 47, 48.

Material examined. 5 females (stn SLOPE 1), NMV J52982; 1 female (stn SLOPE 21), NMV J52983.

Distribution. Off NSW, 75 m depth.

Remarks. The species is recorded from a greater depth than previously, now down to 209 m depth.

Campylaspis thompsoni Hale, 1945

Campylaspis thompsoni Hale, 1945: 183, figs 24, 25.

Material examined. 2 females, 6 males (stn SLOPE 1), NMV J54121; 1 female, NMV J52984; 3 females, 1 male (stn SLOPE 22), NMV J52985; 6 females (stn SLOPE 27), NMV J52412; 2 females, 1 manca (stn SLOPE 46), NMV J54126; 1 female (stn SLOPE 45), MGAB CUM 1615; 1 female, 2 males (stn SLOPE 47), NMV J52987; 1 female, 1 male (stn SLOPE 48), NMV J52988.

Distribution. NSW, Vic., surface to 80 m depth.

Remarks. The new records extend the species' range into Victoria.

Campylaspis triplicata Hale, 1945

Campylaspis triplicata Hale, 1945: 200, figs 37, 38.

Material examined. 1 female, 1 male (stn SLOPE 6), NMV J52989; 3 females (stn SLOPE 19), NMV J52990; 1 female (stn SLOPE 22), NMV J52991; 1 female, 2 males (stn SLOPE 45), NMV J52992; 2 females, 1 male (stn SLOPE 45), MGAB CUM 1616; 2 females (stn SLOPE 46), NMV J53017.

Distribution. Qld, NSW, Tas.; 12–800 m depth.

Remarks. Previously known from Queensland in shallow water the species' range is extended to New South Wales and Tasmania and to greater depths (800 m).

Campylaspis trisulcata sp. nov.

Figures 40, 41

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°02.20'S, 148°38.70'E, 800 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 45), NMV J52950.

Diagnosis. Carapace large, with 3 lateral sulci. Propodus of maxilliped 2 with robust outer seta longer than dactylar teeth. Maxilliped 3 with 2 long plumose setae on outer distal corner,

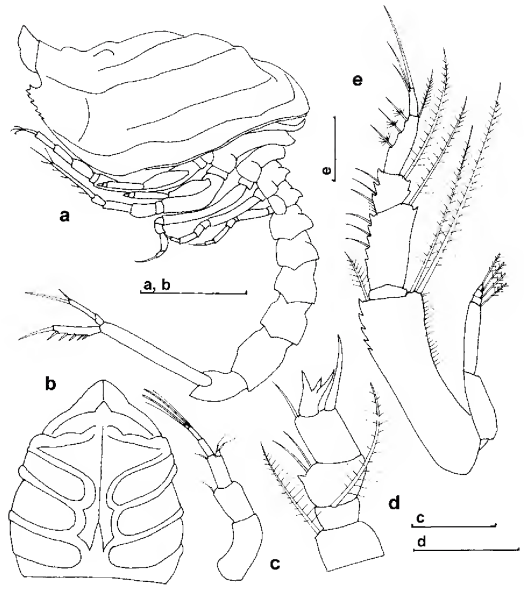

Figure 40. *Campylaspis trisulcata* sp. nov. female holotype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, 0.25; d, 0.3; e, 0.25.

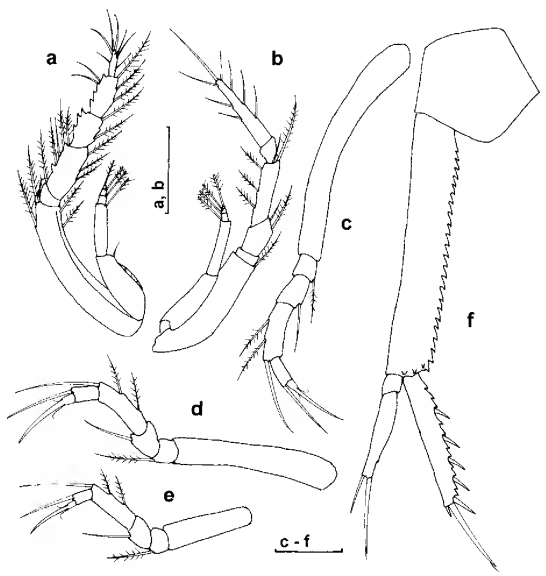

Figure 41. *Campylaspis trisulcata* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a, b, 0.5; c–f, 0.25.

merus 2nd longest article, simple terminal setae twice as long as dactylus. Pereopod 1 with short articles, with numerous plumose setae. Pereopod 2 with carpus 1.3 times as long as merus, dactylus 3 times as long as propodus. Uropod peduncle 2.3 times as long as pleonite 6 and 1.9 times as long as endopod, with serrated inner margin, exopod shorter than endopod, with robust terminal seta, endopod with 5 stout setae on serrated inner margin, long robust terminal seta.

Description. Body with strongly calcified, smooth, integument. Length: 5.1 mm.

Carapace 0.46 body length, twice as long as high, 1.1 times as long as wide, with 3 lateral sulci with strongly elevated margins, transverse lateral ridge at level of base of frontal lobe, ocular lobe without eyes, antennal notch small, anterolateral corner with short serration.

Antenna 1 short, peduncle with progressively shorter articles, main flagellum 3-articulate, little longer than last article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 strong, with long plumose setae on basis and merus, tooth and 2 simple setae on carpus, propodus 2nd longest article, with robust outer seta longer than dactylar teeth, dactylus with 3 teeth, median one shorter. Maxilliped 3 basis little less than half as long as appendage, with 2 long plumose seta on outer distal corner, merus 2nd longest article, strongly serrated on inner margin, with tooth and plumose seta on outer margin, carpus 0.55 of merus length, long plumose seta on outer margin, propodus 0.75 of merus length, with 3 pappose setae on inner margin, simple terminal setae twice as long as dactylus.

Pereopod 1 with short articles, with numerous plumose setae, basis little less than half as long as appendage, merus to propodus with serrated margins, merus 2nd longest article, carpus shorter than merus, propodus longer than carpus and 1.5 times as long as dactylus, dactylus with simple setae. Pereopod 2 basis less than half as long as appendage, plumose seta on inner margin of basis and merus, with carpus 1.3 times as long as merus, with simple seta and plumose seta on distal inner corner, dactylus 3 times as long as propodus, with simple setae, terminal one subequal to dactylus. Pereopods 3–5 basis longer than rest of articles combined, shorter in last pair, carpus twice as long as merus, dactylus fused with terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 2.3 times as long as pleonite 6 and 1.9 times as long as endopod, with serrated inner margin, exopod shorter than endopod, with robust terminal seta, endopod with 4 stout setae on serrated inner margin, single subterminal setule and long robust terminal seta shorter than endopod.

Etymology. The name "*trisulcata*" reflects the presence of three lateral sulci on the carapace.

Distribution. Off Freycinet Peninsula, Tas.; 800 m depth.

Remarks. C. trisulcata is similar to two other species with three or four lateral ridges on the carapace delimiting depressions (sulci): *C. triplicata* Hale, 1945 from Australia and *C. sinuosa* Gamô, 1960 from Japan. *C. triplicata* has four lateral ridges delimiting three depressions, and a massive merus on maxilliped 3. *C. sinuosa* is much closer, with four lateral ridges on the carapace but bordering only two depressions, not three as in *C. trisulcata* (more evident in dorsal view). It also differs in: the dactylus of maxilliped 2 with four teeth (three in *C. trisulcata*); a massive maxilliped 3 with teeth on the propodus and short setae on the dactylus (versus smooth propodus and long terminal setae of dactylus); shorter uropods; and an endopod with two setae on its inner margin (versus four setae in *C. trisulcata*).

Campylaspis uniplicata Hale, 1945

Campylaspis uniplicata Hale, 1945: 189, figs 29, 30.

Material examined. 2 females (stn SLOPE 1), NMV J52993; 2 females (stn SLOPE 1), MGAB CUM 1617; 1 manca (stn SLOPE 2), NMV J52995; 2 females (stn SLOPE 45), NMV J52994; 1 female (stn SLOPE 47), NMV J52996.

Distribution. East of Port Hacking, NSW and Tas.; 100–800 m depth.

Remarks. Originally described from New South Wales, the species is now known in Tasmanian waters and from greater depths (800 m).

Campylaspis unisulcata Hale, 1945

Campylaspis unisulcata Hale, 1945: 187, figs 27, 28.

Material examined. 2 females (stn SLOPE 22), NMV J52997; 1 female (stn SLOPE 45), NMV J54120; 7 females, 2 males (stn SLOPE 46), NMV J52998; 2 females, 1 male (stn SLOPE 46), MGAB CUM 1618.

Distribution. East of Port Hacking, NSW, 100 m depth.

Remarks. The species is now recorded from Tasmania and at greater depth, 800 m.

Procampylaspis Bonnier, 1896

Procampylaspis Bonnier, 1896: 541.—Hale, 1945 : 214.—Băcescu, 1992: 251.—Stoddart and Lowry, 2003: 373–418.

Type species. Procampylaspis echinata Bonnier, 1896.

Remarks. The genus is well-defined by the rake-like dactylus of maxilliped 2 and by a long ischium on pereopod 1. One species is known from Australia but three new species are described in this study.

Key to species of *Procampylaspis* from Australian waters

1. Carapace without dorsal tubercles ..... *P. australiensis* sp. nov.
— Carapace with dorsal tubercles 2
2. Carapace with 1 dorsal tubercle ..... *P. sordida* Hale, 1945
— Carapace with dorsal tubercles in 2 parallel rows (5 in female, 4 in male) ..... *P. spinifera* sp. nov.

Procampylaspis australiensis sp. nov.

Figures 42–44

Material examined. Holotype female, NSW, off Nowra, 34°59.52'S, 151°05.94'E, 204 m, coarse shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 1), NMV J53000.

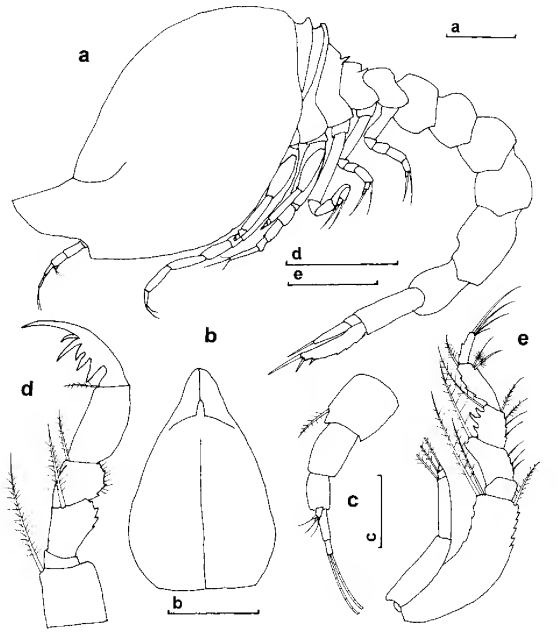

Figure 42. *Procampylaspis australiensis* sp. nov. female paratype: a, body, lateral view; b, carapace, dorsal view; c, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, 0.25; b, 0.5; c, 0.1; d, 0.2; e, 0.25.

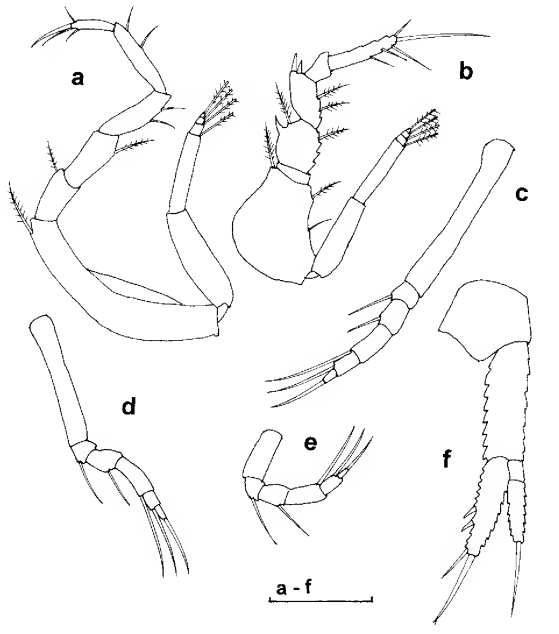

Figure 43. *Procampylaspis australiensis* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and right uropod. Scale (in mm): a–f, 0.25.

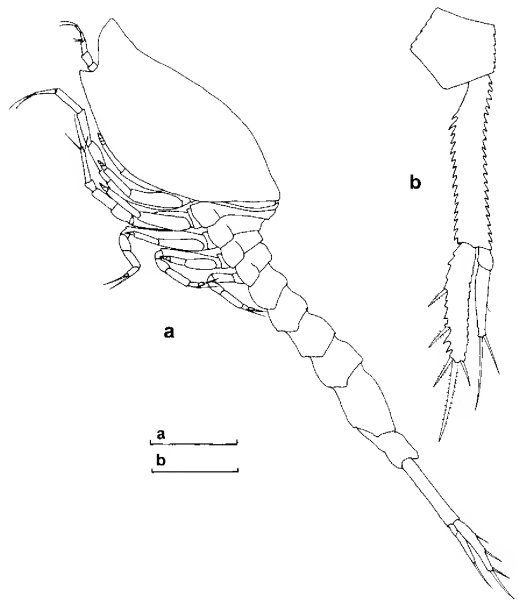

Figure 44. *Procampylaspis australiensis* sp. nov. male allotype: a, body, lateral view; b, pleonite 6 and right uropod. Scale (in mm): a, 0.5; b, 0.25.

Paratypes: 1 immature male, 1 female (stn SLOPE 45), NMV J53001; 1 female, dissected (stn SLOPE 1), NMV J53002.

Diagnosis. Carapace large, with smooth integument. Maxilliped 2 with 6 dactylar teeth. Merus of pereopod 1 as long as carpus, shorter than propodus. Pereopod 2 with short and bulky articles, dactylus twice as long as propodus. Uropod peduncle 1.4 times as long as pleonite 6, 1.1 times as long as its endopod, endopod with 3 inner setae, little longer than exopod.

Description of female. Body with smooth integument. Length: 2.6 mm.

Carapace 0.46 body length, 1.6 times as long as high, with middorsal ridge, short ocular lobe devoid of lenses, pseudorostral lobes 3 times as long as tip of ocular lobe, antennal notch small, ventral margin smooth.

Antenna 1 peduncle with progressively shorter and robust articles, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 basis and merus with pappose seta on inner margin, carpus and propodus with plumose seta on inner margin, propodus second longest article, dactylus fused with its 6 teeth, first 3 teeth progressively shorter toward distal end, 4th tooth longer, 5th tooth half of previous one, curved, 6th tooth the longest, 1.7 times as long as 5th one, barely curved. Maxilliped 3 basis half of appendage, with plumose seta on inner distal corner, 2 longer setae on outer margin, merus with tooth and plumose seta on outer margin, carpus with 3 teeth and plumose seta on outer margin, propodus 2nd longest

article, with 2 pappose setae on inner margin, dactylus half of propodus, with simple long setae.

Pereopod 1 merus as long as carpus, shorter than propodus, dactylus half of propodus, with short simple terminal setae. Pereopod 2 with short and bulky articles, basis 3rd of appendage length, with plumose seta on inner and outer distal corners, merus with tooth and plumose seta on inner margin, carpus little longer than merus, with 2 short stout setae on distal inner corner, dactylus twice as long as propodus with few simple setae. Pereopods 3–5 with progressively shorter basis (as long as rest of articles combined in 3rd pair), dactylus with simple stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 1.4 times as long as pleonite 6, 1.1 times as long as endopod, with serrated margins, exopod shorter than endopod with terminal long stout seta, endopod with 3 inner setae, robust terminal seta.

Description of immature male. Body length: 3 mm.

Carapace, less vaulted than in female, 2.1 times as long as high. Exopods, 5 pairs not fully developed.

Uropod longer than in female, peduncle 2.4 times as long as pleonite 6, strongly serrated, 1.5 times as long as endopod, exopod 0.7 of endopod length, with stout subterminal seta and terminal seta twice as long, endopod with 3 microserrate setae on strongly serrated inner margin, subterminal short microserate seta and a terminal, more robust and longer seta.

Etymology. The name "*australiensis*" refers to Australia.

Distribution. Off Nowra, NSW, off Freycinet Peninsula, Tas.; 204–800 m.

Remarks. The new species differs from other species of *Procampylaspis* in the following combination of female characteristics: the carapace is without spines or tubercles and maxilliped 2 has six teeth on the dactylus. The only known species of *Procampylaspis* from Australian waters is *P. sordida* Hale, 1945 which has a dorsal conical tubercle on the carapace and maxilliped 2 with five dactylar teeth; the first one, more slender than in this species, is longer than the third tooth, and the fifth tooth is shorter.

Procampylaspis poorei sp. nov.

Figures 45, 46

Material examined. Holotype female, Antarctica, Eastern Prydz Bay, off the Larsemann Hills, 68°54.88'S, 76°37.03'E, 667–716 m, epibenthic sled, P.M. O'Loughlin, RSV *Aurora Australis*, 18 Feb 1993 (stn AA93 158), NMV J53009.

Diagnosis. Carapace with 3 dorsal tubercles, a pair medially and 1 in posterior half, ocular lobe eyeless, close to anterior extremity of pseudorostrum, with spine on top. Maxilliped 2 with 1st dactylar tooth longer than 2nd tooth and shorter than 3rd one, 5th tooth twice as long as 3rd tooth. An inner tooth on ischium of maxilliped 3, 2 teeth on outer margin of merus and carpus. Pereopod 1 with slender articles, merus as long as carpus. Dactylus of 2nd pereopod 2 twice as long as propodus, with plumose setae. Uropod peduncle 1.7 times as long as

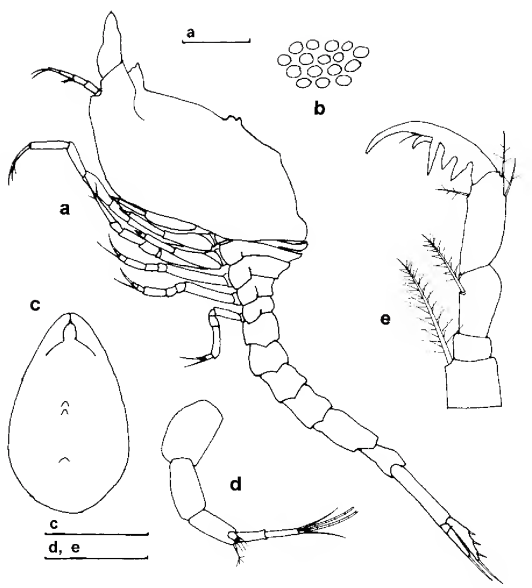

Figure 45. *Procampylaspis poorei* sp. nov. female holotype: a, body, lateral view; b, detail of integument of carapace; c, carapace, dorsal view; d, antenna 1; e, maxilliped 2. Scale (in mm): a, 0.5; c, 1; d, e, 0.2.

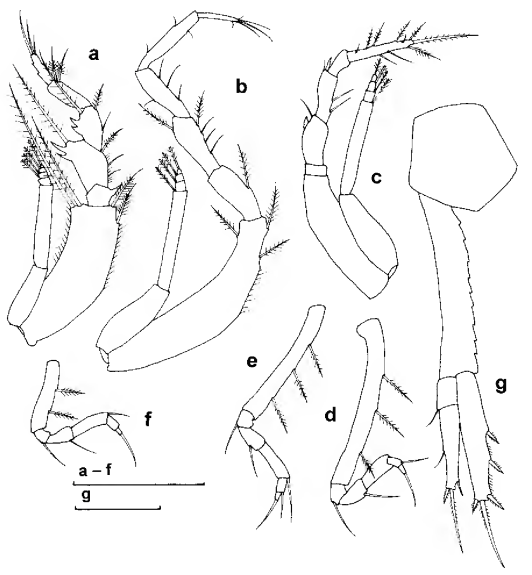

Figure 46. *Procampylaspis poorei* sp. nov. female holotype: a, maxilliped 3; b, pereopod 1; c, pereopod 2; d, pereopod 3; e, pereopod 4; f, pereopod 5; g, pleonite 6 and right uropod. Scale (in mm): a–f, 0.5; g, 0.25.

pleonite 6 and 1.4 times as long as endopod, endopod longer than exopod, with 3 microserrate setae on inner margin.

Description. Body with highly calcified integument. Length: 3.8 mm.

Carapace 0.46 body length, twice as long as high, with 3 dorsal tubercles on midline, a close pair medialy and 1 in posterior half, covered with pitted integument, ocular lobe eyeless, close to anterior extremity of pseudorostrum, with spine on top, antennal notch small, lower margin smooth.

Antenna 1 with progressively shorter articles of peduncle, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 with pappose seta on inner distal margin of basis and carpus, propodus second longest article, with short plumose seta on inner margin, 1st dactylar tooth longer than 2nd tooth and shorter than 3rd one, 5th tooth twice as long as 3rd tooth. Maxilliped 3 with 2 plumose setae on inner and outer distal corner, inner tooth on ischium, 2 teeth and plumose seta on outer margin of merus and carpus, merus 2nd longest article, carpus as long as propodus, dactylus 0.68 times as long as propodus, with long simple terminal setae.

Pereopod 1 with slender articles, basis less than half as long as appendage, merus as long as carpus, propodus twice as long as carpus, second longest article, dactylus half of propodus. Pereopod 2 basis shorter than rest of articles combined, merus with tooth and simple seta on inner margin, carpus slightly longer than merus, with 2 simple setae on inner distal corner, dactylus twice as long as propodus, with plumose setae. Pereopods 3–5 with progressively shorter basis (as long as half of appendage in 3rd and 4th pair), with plumose setae on outer margin, dactylus with long stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 1.7 times as long as pleonite 6 and 1.4 times as long as endopod, exopod shorter than endopod, with subterminal microserrate seta and terminal robust longer seta, endopod with 3 microserrate setae on inner margin and robust, longer, terminal seta.

Etymology. The species is dedicated to Gary Poore, Principal Curator, Museum Victoria, Melbourne, Australia, specialist in Peracarida, as a sign of gratitude.

Distribution. Eastern Prydz Bay, off the Larsemann Hills, Antarctica; 667–716 m depth.

Remarks. The only species of *Procampylaspis* with fewer than five dorsal tubercles or spines on the carapace is *P. compressa* Zimmer, 1907 which has two pairs of spines versus three dorsal median tubercles as in *P. poorei*. The new species also differs from *P. compressa* in: ocular lobe with one median spine on the tip instead of two as in *P. compressa*; antenna 1 with a longer main flagellum; and the first and second dactylar teeth of maxilliped 2 are separated up to the basis (versus not separated) and the maxilliped 3 has fewer teeth on its articles.

Procampylaspis sordida Hale, 1945

Procampylaspis sordida Hale, 1945: 215, fig. 49.

Material examined. 1 female (stn SLOPE 27), NMV J53011; 3 females (stn SLOPE 45), NMV J53012; 7 females, 1 male (stn SLOPE 46), NMV J53013; 2 females (stn SLOPE 46), MGAB CUM 1620.

Distribution. Off Eden, NSW and Tas.; 60–800 m depth.

Remarks. Hale recorded the species from New South Wales. New records are from Tasmania at 800 m depth.

Procampylaspis spinifera sp. nov.

Figures 47–50

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J53003.

Allotype male: (stn SLOPE 45), NMV J53004.

Paratypes: 2 immature males (stn SLOPE 46), NMV J53006; 1 female, dissected (stn SLOPE 45), NMV J53007; 1 male, dissected (stn SLOPE 46), NMV J53008; 1 female (stn SLOPE 46), MGAB CUM 1619.

Diagnosis. Carapace with 5 pairs of dorsal spines, pair of spines on top of ocular lobe, anterolateral margin with strong serration. Pair of dorsal spines on pereonites 3–5 and pleonite 1. Strongly serrated basal article of antenna 1 peduncle. Maxilliped 2 with 5 dactylar teeth, 1st one as long as 3rd, 5th tooth twice as long as 3rd tooth. Maxilliped 3 with strong tooth on outer margin of merus. Pereopod 1 with merus longer than carpus but shorter than propodus. Pereopod 2 with spine on inner margin of merus, dactylus 2.8 times as long as propodus. Dactylus of pereopods 3–5 fused with terminal seta. Uropods with serrated peduncle, 2.27 times as long as pleonite 6, 1.9 times as long as endopod, exopod 0.7 endopod length, endopod with 3 microserrate setae on inner margin.

Description of female. Body without setae on integument. Length: 4.1 mm.

Carapace 0.43 body length, 2.1 times as long as high, with 5 pairs of dorsal spines, pair of spines on top of ocular lobe, ocular lobe long, without eyes, anterolateral margin with strong serration. A pair of dorsal spines on pereonites 3–5 and pleonite 1.

Antenna 1 basal article of peduncle with 3 strong teeth on inner margin, peduncle with progressively shorter articles, main flagellum 3-articulate, much longer than distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 2 with pappose seta on inner margin of basis and merus, merus to propodus with serrated outer margin, propodus 2nd longest article, with plumose seta on outer margin, dactylus with 5 teeth, 1st one as long as 3rd, 5th tooth twice as long as 3rd tooth. Maxilliped 3 basis almost half of appendage, with plumose seta on inner margin and 2 longer setae on outer margin, ischium with tooth on inner margin, strong tooth on outer margin of merus, 3 teeth on outer margin of carpus, propodus shorter than carpus, dactylus shorter than propodus, dactylus with simple long terminal setae.

Pereopod 1 basis less than half as long as appendage, with merus longer than carpus, but shorter than propodus, dactylus with simple terminal setae. Pereopod 2 basis shorter than rest of articles combined, with spine on inner margin of merus, carpus 1.4 times as long as merus, with 3 stout setae on distal

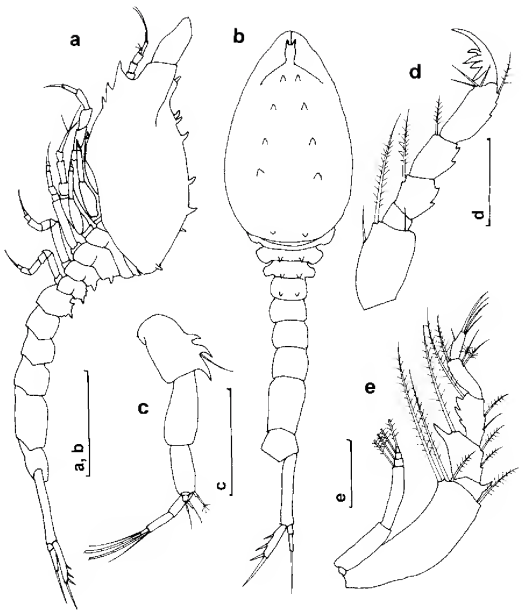

Figure 47. *Procampylaspis spinifera* sp. nov. female paratype: a, body, lateral view; b, body, dorsal view; c, carapace, dorsal view; d, antenna 1; d, maxilliped 2; e, maxilliped 3. Scale (in mm): a, b, 1; c, 0.2; d, 0.25; e, 0.25.

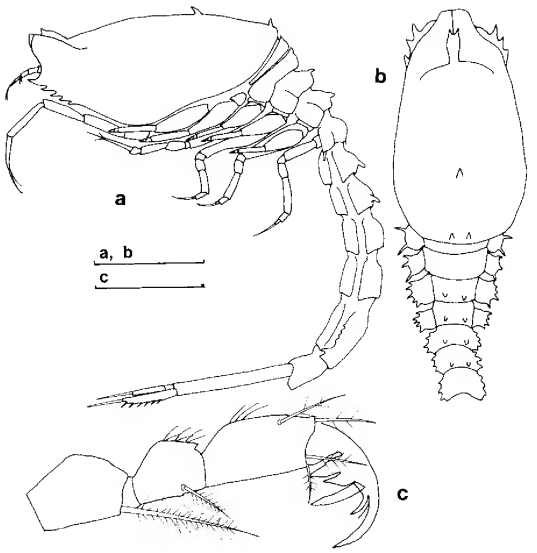

Figure 49. *Procampylaspis spinifera* sp. nov. male allotype: a, body, lateral view; b, body, dorsal view; c, maxilliped 2. Scale (in mm): a, b, 1; c, 0.2.

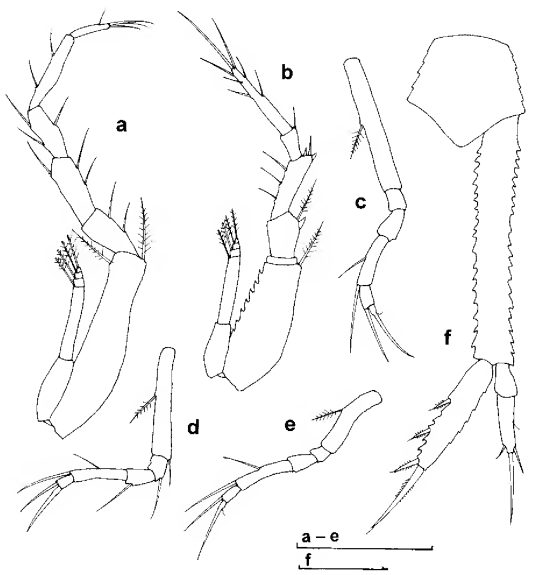

Figure 48. *Procampylaspis spinifera* sp. nov. female paratype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and right uropod. Scale (in mm): a–e, 0.5; f, 0.25.

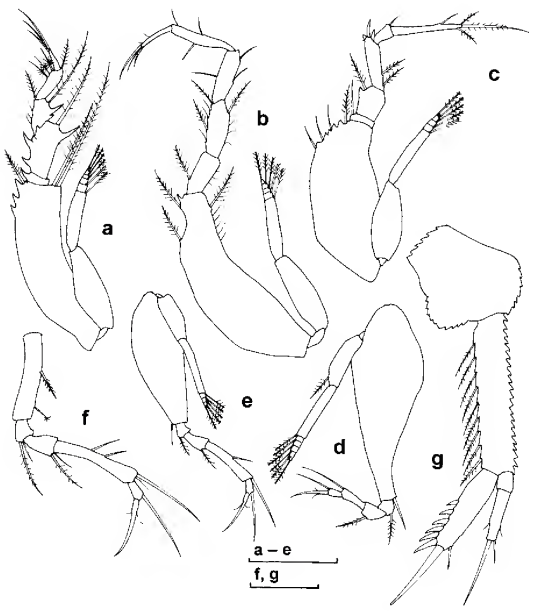

Figure 50. *Procampylaspis spinifera* sp. nov. male allotype: a, maxilliped 3; b, pereopod 1; c, pereopod 2; d, pereopod 3; e, pereopod 4; f, pereopod 5; g, pleonite 6 and right uropod. Scale (in mm): a–e, 0.5; f, g, 0.25.

inner corner, dactylus 2.8 times as long as propodus, with simple setae. Pereopods 3–5 with progressively shorter basis, with plumose seta on outer margin and longer carpus (carpus twice as long as merus in 5th pair), dactylus fused with terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod with serrated peduncle, 2.27 times as long as pleonite 6, 1.9 times as long as endopod, exopod 0.7 endopod length, with short subterminal stout seta and longer terminal robust seta, endopod with 3 microserrate setae on inner margin and more robust and longer terminal seta.

Description of male. Body length: 5.4 mm. Carapace with median dorsal small tubercle and pair of tubercles near posterior extremity, pair of small tubercles on top of eyeless ocular lobe not reaching extremity of pseudorostrum, lower margin shortly serrated in anterior half.

Maxilliped 2 with 3rd tooth of dactylus more slender than in female. Maxilliped 3 with more serrated basis and merus on inner margin, carpus with 2 teeth on inner margin (3 in female).

Pereopod 1 as in female, with larger basis. Pereopod 2 with fewer stout distal setae on carpus, dactylus with terminal plumose seta instead of simple one in female, larger basis. Pereopod 5, with longer carpus than in female. Exopods, 5 pairs.

Uropod peduncle with serrated margins and numerous plumose setae on inner margin, 1.7 times as long as pleonite 6, 1.8 times as long as endopod, exopod 0.8 of endopod length, with subterminal and terminal stout simple seta, endopod with 6 stout setae on inner margin, seta subterminal and robust longer terminal seta.

Etymology. The Latin name "*spinifera*" describes the presence of numerous spines on the body and appendages.

Distribution. Off Freycinet Peninsula, Tas.; 720–800 m depth.

Remarks. P. spinifera is close to *P. spinosa* Petrescu, 2001 from the south-eastern Pacific Ocean (American coast), both having numerous dorsal spines on the carapace. These number five pairs in females of *P. spinifera* and 12 in females of *P. spinosa*. The setae on the dactylus of pereopod 2 are simple in *P. spinifera* while plumose in *P. spinosa*.

Procampylaspis tasmaniensis sp. nov.

Figures 51, 52

Material examined. Holotype male, dissected, Tas., off Freycinet Peninsula, 42°02.20'S, 148°38.70'E, 800 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 45), NMV J53010.

Diagnosis. Carapace with 2 dorsal parallel rows of 4 small tubercles on posterior extremity. Lateral small spines on pereon and pleon. Maxilliped 2 with 1st tooth of dactylus as long as the 3rd one, 5th tooth 1.3 times as long as 3rd tooth, 1st and 2nd teeth enlarged. Maxilliped 3 with teeth on outer margin of merus and carpus. Ischium of pereopod 1 2nd longest article. Pereopod 2 with dactylus 3.7 times as long as propodus. Carpus of 5th pereopod 3.7 times as long as merus. Dactylus of pereopods 3–5 fused with its terminal seta. Uropod peduncle 2.7 times as long as pleonite 6, 2.4 times as long as exopod.

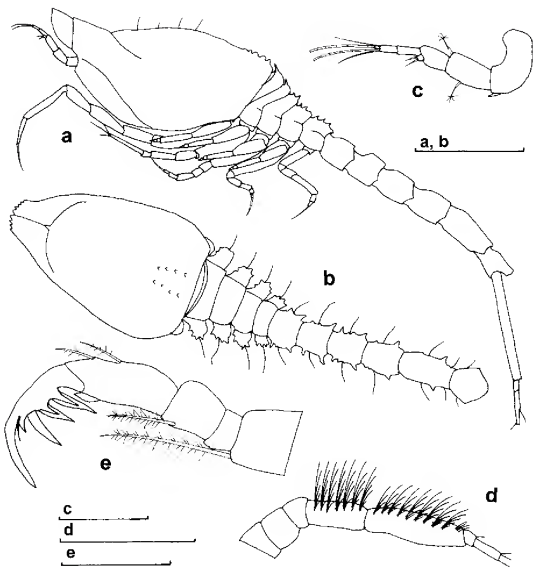

Figure 51. *Procampylaspis tasmaniensis* sp. nov. male holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, antenna 2; e, maxilliped 2. Scale (in mm): a, b, 1; c, 0.25; d, 0.5; e, 0.2.

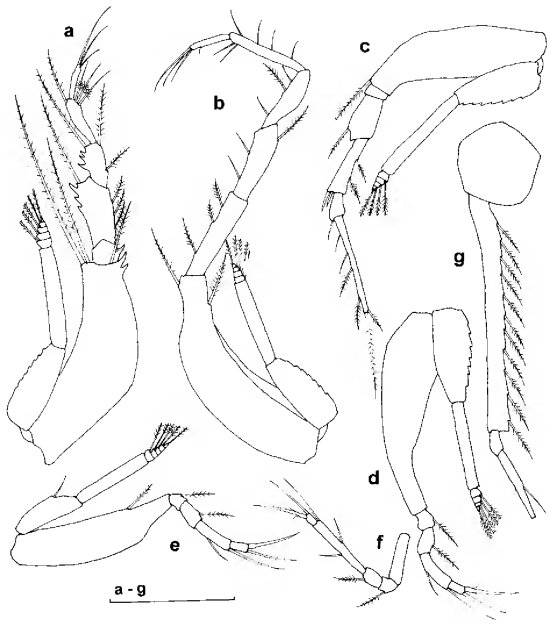

Figure 52. *Procampylaspis tasmaniensis* sp. nov. male holotype: a, maxilliped 3; b, pereopod 1; c, pereopod 2; d, pereopod 3; e, pereopod 4; f, pereopod 5; g, pleonite 6 and left uropod. Scale (in mm): a–g, 0.5.

Description. Body with calcified integument. Length 4.6 mm.

Carapace 0.39 entire body length, twice as long as high, with parallel row of 4 dorsal small tubercles on posterior extremity, a ridge starting behind the pseudorostrum obliquely going backwards medially reaching the lower margin, antennal notch marked, ocular lobe minute, eyeless, few fine setae on integument, smooth lower margin.

Antenna 1 short and robust, articles of peduncle progressively shorter, main flagellum 3-articulate, longer than distal article of peduncle, accessory flagellum minute, uniarticulate. Antenna 2 of with several groups of setae on outer margins of last 2 segments of peduncle.

Maxilliped 2 with strong long pappose seta on inner distal corner of basis and carpus, propodus second longest article, 2 plumose setae on outer margin, 1st tooth of dactylus as long as 3rd one, 5th tooth 1.3 times as long as 3rd tooth, 1st and 2nd teeth enlarged, separated up to basis. Maxilliped 3 basis longer than rest of articles combined, with 2 teeth on inner distal corner, 2 long plumose setae on outer distal corner, merus second longest article, with 3 plumose setae on inner margin, 3 teeth and plumose seta on outer margin of merus and carpus, propodus longer than carpus, dactylus 0.7 of propodus

Pereopod 1 basis less than half as long as appendage, ischium 2nd longest article, merus as long as propodus, carpus shorter than propodus, longer than dactylus, dactylus with stout terminal long seta. Pereopod 2 basis shorter than rest of articles combined, plumose seta on inner distal corner of basis and merus, carpus 1.4 times as long as merus, 2 stout setae on distal inner corner of carpus, dactylus 3.7 times as long as propodus, with long terminal plumose seta. Pereopods 3 and 4 with progressively shorter basis, longer than rest of articles combined, dactylus fused with terminal seta. Pereopod 5 with shorter basis and longer carpus, 3.7 times as long as merus, dactylus fused with terminal seta. Exopods on maxilliped 3 and pereopods 1–4.

Uropod peduncle 2.7 times as long as pleonite 6, with plumose setae on inner margin, 2.4 times as long as exopod, endopod broken off.

Etymology. The species bears the name of the collecting area – Tasmania.

Distribution. Off Freycinet Peninsula, Tas.; 800 m depth.

Remarks. *P. bonnieri* Calman, 1906 from the Mediterranean and eastern Pacific (Petrescu, 2000) share with *P. tasmaniensis* a carapace with spines on the posterior extremity and a minute ocular lobe. The new species has fewer tubercles/spines on the posterior extremity of the carapace, no row of spines near the lower margin of the carapace, dactylar teeth of a different shape, maxilliped 3 without strong teeth on the inner margin of the merus, pereopod 1 with its ischium longer than the propodus, and longer uropods.

Scherocumella Watling, 1991

Scherocumella Watling, 1991b: 754.—Stoddart and Lowry, 2003: 373–418.

Type species. *Nannastacus longirostris* Sars, 1879.

Remarks. The carapace is as in the genus *Nannastacus* and the lenses grouped in two lateral pairs as always in *Nannastacus*. The pseudorostral lobes meet each other in front of the eyelobe, from base to top, similar to the genus *Cumella* and the uropodal peduncle is as long or even longer than pleonite 6, as in *Cumella*. Five species and one subspecies are known from Australia.

Key to species of *Scherocumella* from Australian waters

1. Peudorostral lobes long 2
— Peudorostral lobes short 3
2. Carapace with a dorsal hump behind frontal lobe ..... *S. nasuta camelus* Zimmer, 1914
— Carapace with no dorsal hump ..... *S. nasuta nasuta* Zimmer, 1914
3. Pereon and pleon with dorsal tubercles 4
— Pereon and pleon without tubercles 5
4. Carapace with serrated dorsal and lateral rows ..... *S. vieta* Hale, 1949
— Carapace without serrated rows ..... *S. clavata* Hale, 1945
5. Uropod peduncle longer than pleotelson ..... *S. sheardi* Hale, 1945
— Uropod peduncle shorter than pleotelson ..... *S nichollsi* Hale, 1949

Scherocumella nichollsi Hale, 1949

Nannastacus nichollsi Hale, 1949: 227, figs 1, 2.—Băcescu, 1992: 240.

Scherocumella nichollsi.—Watling, 1991b: 754.—Stoddart and Lowry, 2003: 417.

Material examined. 1 female (stn MSL-EG 77), NMV J26637; 1 male (stn MSL-EG 78), NMV J26638; 1 female (stn MSL-EG 104), NMV J26639.

Distribution. Garden I., WA and Vic.; 6–25 m depth.

Remarks. Previously known from the type locality, the species is now recorded from eastern Victoria, at 25 m depth.

Scherocumella sheardi Hale, 1945

Nannastacus sheardi Hale, 1945 : 156, figs 8, 9.—Băcescu, 1992: 243.

Scherocumella sheardi.—Watling, 1991b: 754.—Stoddart and Lowry, 2003: 417.

Material examined. 3 females (stn MSL-EG 105), NMV J26640.

Distribution. Gulf St. Vincent, SA and eastern Vic.; surface to 4 m depth.

Remarks. The species was described by Hale from specimens collected at Brighton, Gulf St Vincent, SA. The species has now been discovered in eastern Bass Strait, Victoria from 27 m depth.

Schizotrema Calman, 1911

Schizotrema Calman, 1911: 341, 360–361.—Watling, 1991b: 755.—Băcescu, 1992: 259.—Stoddart and Lowry, 2003: 418.

Type species. *Schizotrema depressum* Calman, 1911.

Remarks. In *Schizotrema*, the carapace is high as in *Nannastacus*, higher than in *Cumella*; the eyes are always as in *Nannastacus*, but the pseudorostral lobes are completely separated from base to top, not like in *Nannastacus*, *Scherocumella* or *Cumella*. The uropodal peduncle is as long as or shorter than pleonite 6, as in *Nannastacus*.

Key to species of *Schizotrema* from Australian waters

1. Exopod of uropod at least 0.3 times as long as endopod 2
— Exopod of uropod at least 0.25 times as long as endopod 3
2. Last pereonite and 1st pleonite with a pair of strong dorsal spines ..... *S. aculeatum* Hale, 1936
— Last pereonite and 1st pleonite without spines ..... *S. nudum* Tafe and Greenwood, 1996
3. Carapace with dorsal and lateral spines ..... *S. resimum* Hale, 1949
— Carapace without spines ..... *S. leopardinum* Hale, 1949

Schizotrema aculeatum Hale, 1936

Schizotrema bifrons aculeata Hale, 1936: 430, fig. 18.
Schizotrema aculeta.—Hale, 1945: 168, fig. 16.
Schizotrema aculeatum.—Lowry and Stoddard, 2003: 418.

Material examined. 1 female (stn SLOPE 2), NMV J45780.

Distribution. NSW, Gulf St Vincent, SA and WA: 2–503 m depth.

Remarks. The species' range is extended to New South Wales and to greater depths.

Styloptocuma Băcescu and Muradian, 1974

Styloptocuma Băcescu and Muradian, 1974: 74.—Băcescu, 1992: 262.—Petrescu and Watling, 1999: 306.
Americuma Watling, 1991a: 580–581.
Cumella (*Styloptocuma*).—Watling, 1991b: 752.

Type species. Styloptocuma antipai Băcescu and Muradian, 1974.

Remarks. Styloptocuma is characterised by pseudorostral lobes reaching the extremity of the ocular lobe, the ocular lobe without visual elements, and uropods with long peduncles, twice or even longer than pleonite 6. The genus has not previously been recorded from Australia.

Key to species of *Styloptocuma* from Australian waters (females only)

1. Carapace dorsally and ventrally serrated 2
— Carapace without serration 4
2. Carapace only with ventral serration ..... *S. granulosum* sp. nov.
— Carapace with dorsal and ventral serration 3
3. Carapace with a lateral serrated row ..... *S. spinosum* sp. nov.
— Carapace without lateral serrated row ..... *S. poorei* sp. nov.
4. Dactylus of pereopod 2 twice as long as propodus ..... *S. australiense* sp. nov.
— Dactylus of pereopod 2 quarter length of propodus ..... *S. nodosum* sp. nov.

Styloptocuma australiense sp. nov.

Figures 53, 54

Material examined. Holotype female, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, WHOI epibenthic sled, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986 (stn SLOPE 6), NMV J53062.

Paratype: 1 female (stn SLOPE 6), NMV J53063.

Diagnosis. Carapace short, with long pseudorostrum, lower margin smooth. Integument with few setae on carapace, smooth on rest of body. Pereopod 1 with carpus as long as propodus. Dactylus of pereopod 2 twice as long as propodus. Uropod peduncle 2.8 times as long as pleonite 6, with serrated inner margin 1.3 times as long as endopod, exopod shorter than endopod, endopod with 4 setae on inner margin and robust curved terminal seta.

Description. Body elongate, integument carapace covered with sparse setae. Length: 3.2 mm.

Carapace shorter than one-third body length, 1.7 times as long as high, long pseudorostrum (0.4 of entire carapace length), antennal notch absent, lower margin smooth, ocular lobe eyeless, reaching extremity of pseudorostral lobes, conical in dorsal view. Pleon 0.55 body length.

Antenna 1 peduncle with progressively shorter articles, median article with tubercle with 2 sensory setae, main flagellum 3-articulate, longer than distal article of peduncle, median and distal article with 1 aesthetasc, accessory flagellum minute, uniarticulate.

Maxilliped 3 basis shorter than rest of articles combined, with 2 plumose setae on inner margin and 4 (2 long, 2 short) plumose setae on outer distal corner, short ischium, merus shorter than carpus, merus and carpus with long plumose seta on outer margin, propodus 2nd longest article, with 2 pappose setae on inner margin, dactylus longer than merus, with 2 stout curved terminal setae.

Pereopod 1 basis less than half as long as appendage, ischium shorter than merus, carpus longer than merus, as long as propodus, dactylus 0.4 propodus length, with long simple stout terminal seta. Pereopod 2 less than half as long as appendage, merus with seta on inner margin, carpus almost twice as long as merus, with 1 seta on inner margin and 2 on outer margin, 2 stout setae on distal inner corner, dactylus twice as long as propodus, with simple setae. Pereopods 3–5 with progressively shorter basis and longer carpus (twice as long as merus in 5th pair), propodus longer than merus, dactylus with a long stout terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 2.8 times as long as pleonite 6, with serrated inner margin, 1.3 times as long as endopod, exopod shorter than endopod, with a stout terminal seta, endopod with 4 setae on inner margin and robust curved terminal seta.

Etymology. The species bears the name of type locality – Australia.

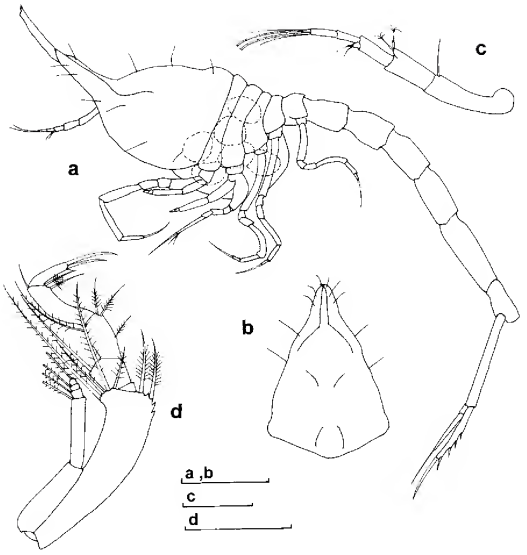

Figure 53. *Styloptocuma australiense* sp. nov. female holotype: a, body, lateral view; b, carapace , dorsal view; c, antenna 1; d, maxilliped 3. Scale (in mm): a, b, 0.5; c, 0.1; d, 0.2.

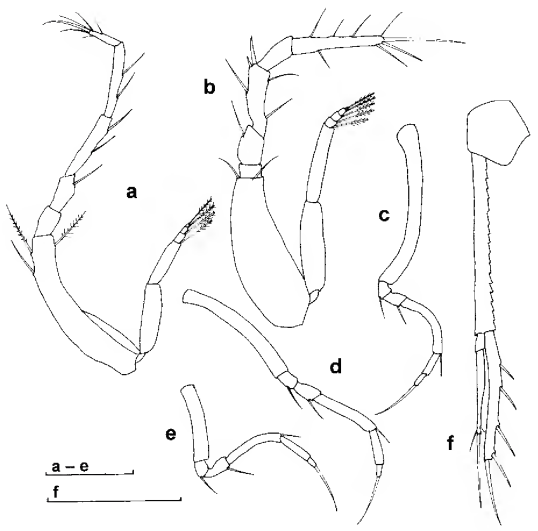

Figure 54. *Styloptocuma australiense* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–e, 0.25; f, 0.5.

Distribution. Off Nowra, NSW; 770 m depth.

Remarks. This is the first record of the genus *Styloptocuma* from Australian waters. It was previously known from the deep Atlantic (Băcescu, 1992) and Eastern Pacific (Petrescu, 1991; Petrescu and Watling, 1999). *Styloptocuma australiense* is morphologically similar to *S. angustatum* Jones, 1984 from the Western Atlantic (Brazil): both have a carapace without spines or tubercles, a similar anterolateral margin and almost similar pereopods 1 and 2. The new species differs in having a longer pseudorostrum, shorter carapace, and uropod endopod with four setae on the inner margin instead of three.

Styloptocuma granulosum sp. nov.

Figures 55, 56

Material examined. Holotype female. Vic., S of Point Hicks, 38°25'S, 149°00'E, 1500 m, compacted clay, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 22 Jul 1986 (stn SLOPE 27), NMV J53067.

Diagnosis. Carapace with short pseudorostrum, antennal notch large, lower margin serrated. Pleon with spines and setae. Antenna 1 with basal article of peduncle longer than rest of articles combined. Merus of maxilliped 3 with tooth on outer margin. Carpus of pereopod 1 longer than propodus, propodus twice as long as dactylus. Carpus of pereopod 2 twice as long as merus, dactylus 3 times as long as propodus. Carpus of pereopod 5 more than 3 times as long as merus. Uropod peduncle 2.1 times as long as pleonite 6, 0.8 endopod length, exopod shorter than endopod, endopod with 6 microeserrate setae on inner margin.

Description. Body with hairy granulous integument. Length: 4.08 mm.

Carapace more than 3rd body length, more elevated on posterior extremity, 1.9 times as long as high, ocular lobe bulky, eyeless, reaching extremity of pseudorostrum, short siphon, antennal notch large, anterolateral corner acute, lower margin strongly serrated, numerous setae.

Antenna 1 proximal article of peduncle 1.65 times length of rest of articles combined, median article without an evident tubercle, main flagellum 3-articulate, twice as long as distal article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 3 basis half of appendage, with 2 plumose setae on inner distal corner and 2 much longer on distal outer corner, merus and carpus with tooth and plumose seta on outer margin, carpus longer than merus, propodus 2nd longest article, dactylus half of propodus, with strong stout curved terminal seta.

Pereopod 1 basis less than half as long as appendage, carpus 2.1 times as long as merus, twice as long as propodus, propodus twice as long as dactylus, dactylus with long robust terminal seta, numerous simple setae especially on propodus and dactylus. Pereopod 2 basis less than half as long as appendage, carpus twice as long as merus, with stout seta on inner distal corner, dactylus 3 times as long as propodus, with long simple stout terminal seta. Pereopods 3–5 with progressively shorter basis and longer carpus (carpus more than 3 times as long as merus in last pair), dactylus fused with

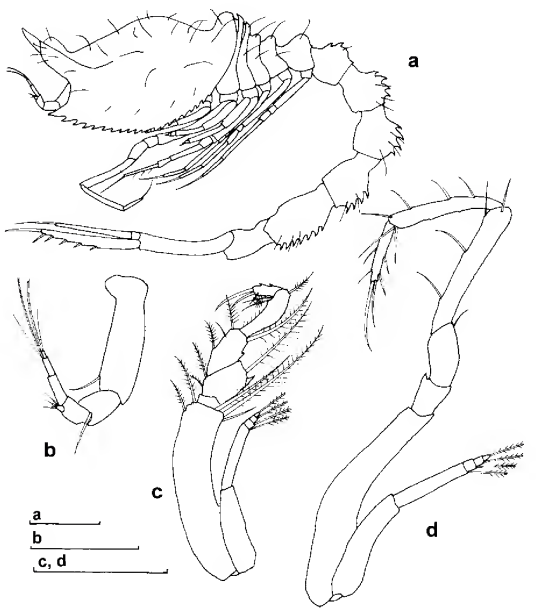

Figure 55. *Styloptocuma granulosum* sp. nov. female holotype: a, body, lateral view; b, antenna 1; c, maxilliped 3; d, pereopod 1. Scale (in mm): a, 0.5; b, 0.2; c, d, 0.5.

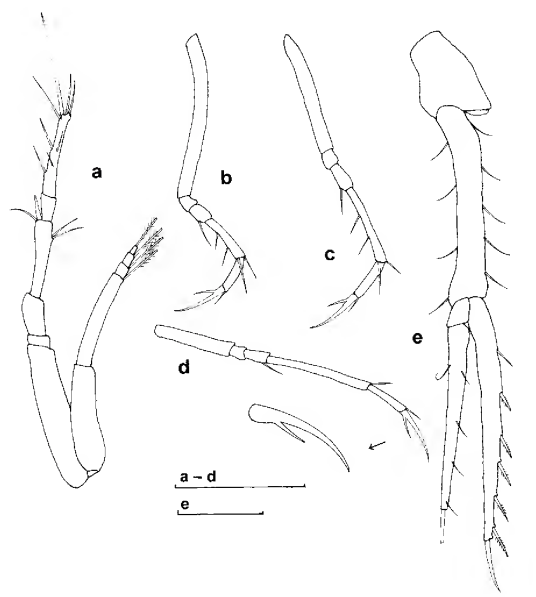

Figure 56. *Styloptocuma granulosum* sp. nov. female holotype: a, pereopod 2; b, pereopod 3; c, pereopod 4; d, pereopod 5; e, pleonite 6 and left uropod. Scale (in mm): a–d, 0.5; e, 0.25.

its stout terminal seta, with inner spine (see detail). Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 2.1 times as long as pleonite 6, with fine setae on both sides, 0.8 endopod length, exopod slightly shorter than endopod, with robust terminal seta (broken), endopod with 6 microserrate setae on inner margin and terminal robust short simple seta.

Etymology. In Latin "*granulosum*" means granular and describes the integument.

Distribution. S of Point Hicks, Vic.; 1500 m depth.

Remarks. Styloptocuma granulosum differs mainly from other species of *Styloptocuma* described in this paper in a longer carapace with a smooth upper margin and serrated lower margin. *Styloptocuma cristatum* Jones, 1984 from the Gulf of Biscay has a longer carapace but with dorsal spines on the carapace, lateral spines on the pleon and uropods with shorter rami.

Styloptocuma nodosum sp. nov.

Figures 57–60

Material examined. Holotype female, Vic., S of Point Hicks, 38°25'S, 149°00'E, 1500 m, compacted clay, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 22 Jul 1986 (stn SLOPE 27), NMV J53064.

Allotype: male (stn SLOPE 27), NMV J53065.

Paratypes: 3 females, 1 immature male, 7 mancas, 1 adult male, dissected (stn SLOPE 27), NMV J53066.

Diagnosis. Carapace with short pseudorostrum, without antennal notch, slightly serrated lower margin. Antenna 1 with tooth on distal article of peduncle. Carpus and propodus of pereopod 1 subequal. Carpus of pereopod 2 3 times as long as merus, dactylus with subterminal long seta. Uropod peduncle 2.9 times as long as pleonite 6 and 1.3 times as long as its equal rami.

Description of female. Body with few hairs on carapace. Length: 4.7 mm.

Carapace third of body length, 1.6 times as long as high, with short upturned pseudorostrum (0.3 of carapace length), with knotty surface and few long setae, antennal notch absent, lower margin slightly serrated, ocular lobe eyeless. Pleon more than half body length.

Antenna 1 slender, basal article of peduncle much longer than rest of articles combined, median article with minute tubercle, distal one with strong tooth, main flagellum shorter than last article of peduncle, accessory flagellum tiny.

Maxilliped 2 with pappose long seta on inner distal corner of basis and merus, carpus 2nd longest article, with pappose setae on inner margin, dactylus half length of propodus, with stout terminal seta. Maxilliped 3 basis longer than rest of articles combined, with 4 plumose setae along distal margin (2 much longer), merus as long as carpus, with plumose seta on outer margin of both, propodus 2nd longest article, dactylus little less than half as long as propodus, with longer stout terminal setae.

Pereopod 1 basis less than half as long as appendage, merus more than twice length of ischium, carpus 1.8 times as long as merus, as long as propodus, twice as long as dactylus, dactylus

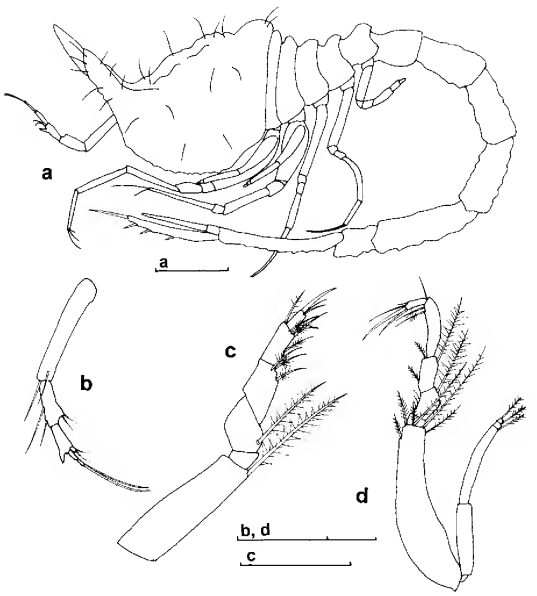

Figure 57. *Styloptocuma nodosum* sp. nov. female holotype: a, body, lateral view; b, antenna 1; c, maxilliped 2; d, maxilliped 3. Scale (in mm): a, 0.5; b, d, 0.5; c, 0.2.

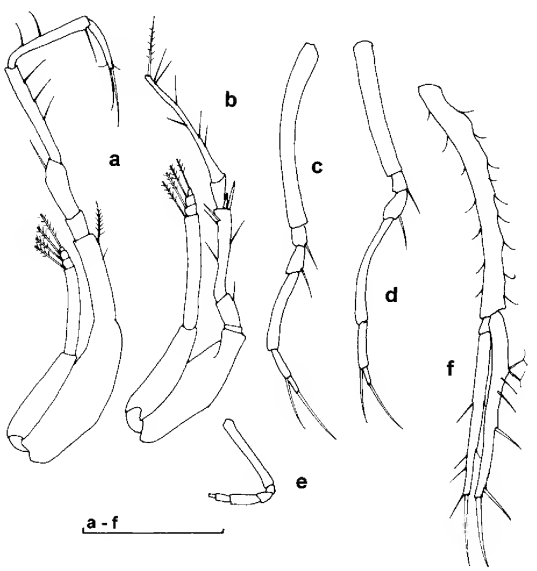

Figure 58. *Styloptocuma nodosum* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and left uropod. Scale (in mm): a–f, 0.5.

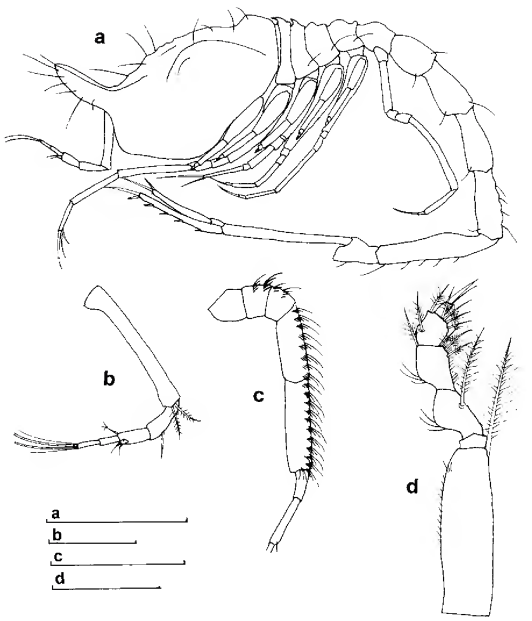

Figure 59. *Styloptocuma nodosum* sp. nov. male allotype: a, body, lateral view; b, antenna 1; c, antenna 2; d, maxilliped 2. Scale (in mm): a, 1; b, 0.25; c, 0.5; d, 0.2.

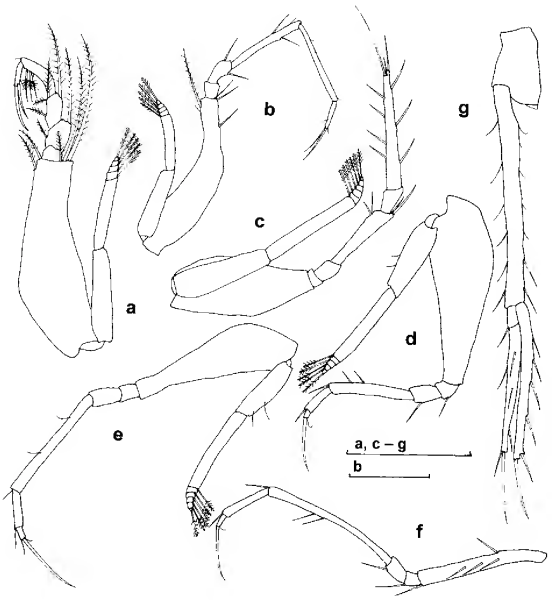

Figure 60. *Styloptocuma nodosum* sp. nov. male allotype: a, maxilliped 3; b, pereopod 1; c, pereopod 2; d, pereopod 3; e, pereopod 4; f, pereopod 5; g, pleonite 6 and left uropod. Scale (in mm): a, c–g, 0.5; b, 0.5.

with terminal stout curved seta. Pereopod 2 basis 3rd of appendage length, fine seta on inner margin of merus, carpus 3 times as long as merus, with 2 stout setae on inner distal corner, dactylus one-fourth as long as propodus, with subterminal long plumose seta (less than half of dactylus). Pereopod 3 basis longer than half of entire pereopod, carpus 3 times as long as merus, propodus little longer than merus, with distal stout seta, dactylus with terminal stout seta. Pereopod 4 with shorter basis and carpus longer than in previous pair. Pereopod 5 much shorter than previous pairs, basis half of appendage, terminal seta missing (limb is regenerated or individual is first molt after manca 2). Exopods on maxilliped 3 and pereopods 1, 2; with 2nd article very long.

Uropod peduncle 2.9 times as long as pleonite 6 and 1.3 times as long as its equal rami, fine setae on both sides, exopod with terminal stout seta (one-third of exopod length), endopod with 2 pedunculate setae, 2 slender simple and 2 stout setae on inner margin and longer terminal seta (as in exopod).

Description of male. Body with knotty surface only on pleonite 4. Length: 5.1 mm. Carapace, pseudorostrum with long setae, large lateral swelling on branchial region, more pronounced anterolateral corner, smooth lower margin.

Antenna 1 with similar peduncle, main flagellum longer than in female. Antenna 2 (fig. 59c) with ranks of setae on articles 2–5 of peduncle.

Maxilliped 2 with larger articles, more setulose. Maxilliped 3 with longer basis.

Pereopod 1 as in female, carpus and propodus equal, longer than in female (3 times as long as merus), with shorter dactylus. Pereopod 2 as in female, subterminal seta of dactylus simple, not plumose. Pereopods 3 and 4 with large basis, longer than rest of appendage in 3rd pair, shorter in 4th, carpus 3 times as long as merus in 3rd pair, 4.5 times longer in 4th pair, long stout terminal seta. Pereopod 5 with shorter and more slender basis than in previous pairs, carpus 5 times as long as merus, propodus 0.4 of carpus. Exopods, 5 pairs, stronger than in female.

Uropod peduncle with straight margins, 2.7 times as long as pleonite 6, 1.4 times as long as endopod, exopod little shorter than endopod, endopod with 5 setae on inner margin.

Etymology. The name "*nodosum*" means "knotty" in Latin and describes the body surface.

Distribution. S of Point Hicks, Vic.; 1500 m depth.

Remarks. Styloptocuma nodosum differs from other species in this paper in its knotty integument, a carapace without spines, its slightly serrated lower margin of the carapace in females, being without an antennal notch and with a more upturned pseudorostrum. It resembles *S. extans* Jones, 1984 from the deep Atlantic but has a shorter pseudorostrum, the integument not knotty, and a spiny pleon.

Styloptocuma poorei sp. nov.

Figure 61

Material examined. Holotype female, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 46), NMV J53068.

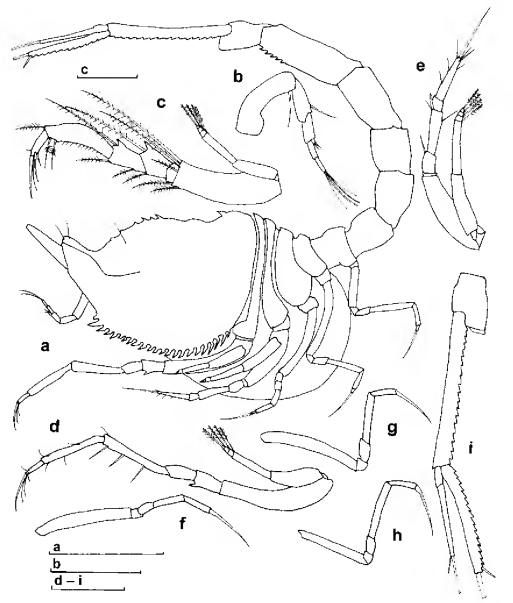

Figure 61. *Styloptocuma poorei* sp. nov. female holotype: a, body, lateral view; b, antenna 1; c, maxilliped 3; d, pereopod 1; e, pereopod 2; f, pereopod 3; g, pereopod 4; h, pereopod 5; i, pleonite 6 and left uropod. Scale (in mm): a, 0.5; b, 0.2; c, 0.1; d–i, 0.25.

Diagnosis. Carapace with short, little upturned pseudorostrum, with several dorsal spines and strongly serrated lower margin. Short serration on pleonite 5. Propodus of maxilliped 3 as long as ischium, merus and carpus combined. Carpus of pereopod 1 longer than propodus. Dactylus of pereopod 2 3.8 times as long as propodus. Uropod peduncle with serrated inner margin, 2.9 times as long as pleonite 6 and 1.3 times as long as endopod, endopod twice as long as exopod, with 1 seta on inner serrated margin.

Description. Body with weakly calcified smooth integument. Length: 2.8 mm.

Carapace 0.31 body length, 1.4 times as long as high, short pseudorostrum (0.18 carapace length), 7 dorsal median spines, 1 near posterior extremity, first 2 on frontal lobe, antennal notch not marked, lower margin strongly serrated.

Antenna 1 basal article of peduncle little longer than other 2 articles combined, median article with small tubercle, main flagellum longer than last article of peduncle, accessory flagellum minute, uniarticulate.

Maxilliped 3 basis less than half as long as appendage, 2 long plumose setae on outer distal corner, a tooth and a plumose seta on outer margin of merus and carpus, propodus 2nd longest article, as long as ischium, merus and carpus combined, dactylus with stout terminal curved seta, longer than dactylus.

Pereopod 1 basis less than half as long as appendage, carpus longer than propodus. Pereopod 2 basis less than half as long as appendage, carpus twice as long as merus, with 2 stout spines on

distal inner corner of carpus, dactylus 3 times as long as propodus, with a stout terminal seta longer than dactylus. Pereopods 3–5 with progressively shorter basis and longer carpus (3.4 times longer carpus than merus in 5th pair), dactylus fused with its terminal seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle with a serrated inner margin, 2.9 times as long as pleonite 6 and 1.3 times as long as endopod, endopod twice as long as exopod, with 1 subterminal seta on inner serrated margin.

Etymology. The species is dedicated to Gary Poore, Principal Curator, Museum Victoria, Melbourne, Australia, well known specialist in Peracarida, as a sign of gratitude.

Distribution. Off Freycinet Peninsula, Tas.; 720 m depth.

Remarks. The new species differs from other species of *Styloptocuma* in this collection in the carapace with a few dorsal spines, a strongly serrated entire lower margin, lacking a lateral row of spines and a relatively smooth pereon and pleon. Such a combination of characters may also be found in *S. subductum* Jones, 1984 from the Atlantic but that species has the lower margin of its carapace serrated only on the anterior half and the uropod endopod has four setae on the inner margin instead of one as in *Styloptocuma poorei*.

Styloptocuma spinosum sp. nov.

Figures 62, 63

Material examined. Holotype female, NSW, off Nowra, 34°57.90'S, 151°08'E, 503 m, bryozoa and shell, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 2), NMV J53018.

Paratype: 1 female (stn SLOPE 2), NMV J53019.

Diagnosis. Carapace with middorsal row of spines, another lateral and lower margin densely serrated. Dorsal serrated crest on pleonites 1–5. Pereopod 1 with propodus 2nd longest article. Pereopod 2 with dactylus 3 times as long as propodus. Last 3 pairs of pereopods slender. Uropod peduncle serrated on inner margin, twice as long as pleonite 6 and 1.5 times as long as its equal rami.

Description. Body elongate, with weakly calcified integument. Length: 2.36 mm.

Carapace 3rd of body length, 1.7 times as long as high, pseudorostrum quarter of carapace length, slightly upturned, siphon longer than carapace, a middorsal row of spines, 1 bigger spine on ocular lobe, ocular lobe eyeless, reaching extremity of pseudorostral lobes, a median row of spines near lower serrated margin, scattered setae. Pereon glabrous. Pleon elongate, 0.58 of body length, with dorsal serrated crest on pleonites 1–5, without setae.

Antenna 1 basal article of peduncle 2.5 times as long as rest of articles combined, median article longer than distal one, without visible tubercle, main flagellum longer than last article of peduncle, accessory flagellum minute.

Maxilliped 3 basis half of appendage, with 2 plumose setae on outer margin, merus and carpus with plumose seta on outer distal corner, propodus 2nd longest article, twice as long as dactylus.

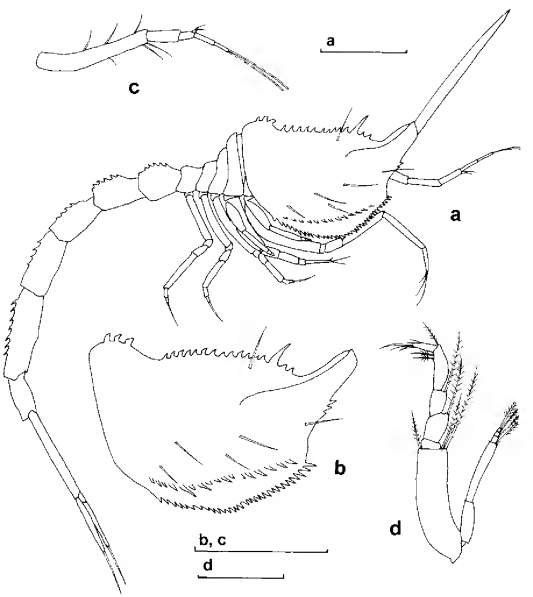

Figure 62. *Styloptocuma spinosum* sp. nov. female holotype: a, body, lateral view; b, carapace, lateral view, magnified; c, antenna 1; d, maxilliped 3. Scale (in mm): a, 0.5; b, c, 0.5; d, 0.25.

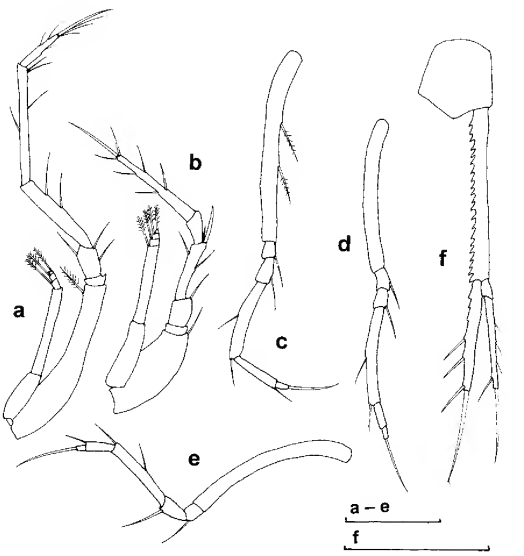

Figure 63. *Styloptocuma spinosum* sp. nov. female holotype: a, pereopod 1; b, pereopod 2; c, pereopod 3; d, pereopod 4; e, pereopod 5; f, pleonite 6 and right uropod. Scale (in mm): a–e, 0.25; f, 0.5.

Pereopod 1 basis shorter than rest of articles combined, ischium with small tooth on inner margin, merus twice as long as ischium, carpus 4 times merus and dactylus combined, propodus 2nd longest article, twice as long as carpus, dactylus with slender terminal long seta. Pereopod 2 basis one-third of appendage length, simple seta on distal inner corner of basis and merus, carpus twice as long as merus, with 2 unequal stout setae on inner distal corner, dactylus 3 times as long as propodus, with simple setae. Pereopods 3–5 slender, basis longer than rest of articles combined in 3rd pair, progressively shorter in pairs 4 and 5, carpus progressively longer in pairs 3–5, carpus 5 times as long as merus in 5th pair. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle serrated on inner margin, twice as long as pleonite 6 and 1.5 times as long as its equal rami, exopod with few fine setae on outer margin and a stout terminal seta, endopod with 3 setae on inner margin and a terminal seta longer and more robust than in exopod.

Etymology. The name of the species reflects the numerous spines of carapace.

Distribution. Off Nowra, NSW; 503 m depth.

Remarks. Some features of the carapace, about 20 dorsal spines, a lateral row of spines near the lower densely serrated margin combined with dorsal serration of the pleon, make *Styloptocuma spinosum* unique within Australian species of the genus. Such carapace armature may also be found in *S. antipai* Băcescu and Muradian, 1974 from the deep western Atlantic and *S. echinatum* Jones, 1984 from the eastern Atlantic. The new species differ in the glabrous pereon, absence of lateral rows of spinules on the pleon and the shorter carpus of pereopod 2.

Styloptocumoides gen. nov.

Type species. Styloptocumoides australiensis sp. nov., here designated.

Diagnosis. Carapace with short pseudorostrum, eyeless ocular lobe reaches its extremity. 5 free pedigerous somites. No trace of exopods in maxilliped 3 or pereopods in females.

Gender. Masculine.

Etymology. The new genus looks like *Styloptocuma* Băcescu and Muradian, 1974.

Remarks. The closest genus to *Styloptocumoides* is *Styloptocuma* Băcescu and Muradian, 1974, especially regarding the carapace, with the ocular lobe reaching the tip of the pseudorostrum. The main difference is the total absence of exopods in the females of *Styloptocumoides*. A second difference is five instead of four free thoracic segments.

Styloptocumoides australiensis sp. nov.

Figure 64

Material examined. Holotype female, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, WHOI epibenthic sled, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986 (stn SLOPE 6), NMV J53060.

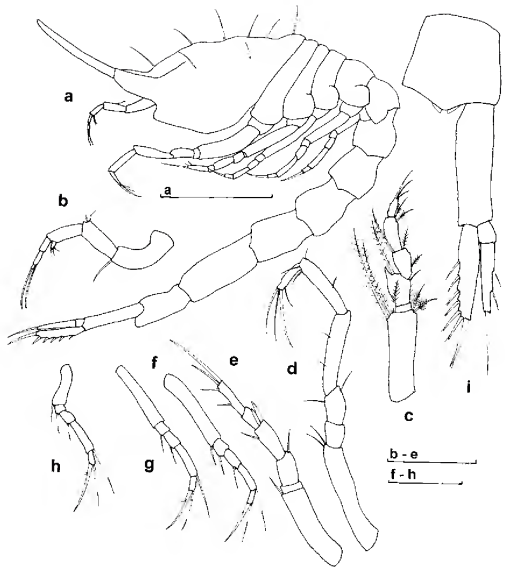

Figure 64. *Styloptocumoides australiensis* sp. nov. female holotype: a, body, lateral view; b, antenna 1; c, maxilliped 3; d, pereopod 1; e, pereopod 2; f, pereopod 3; g, pereopod 4; h, pereopod 5; I, pleonite 6 and right uropod. Scale (in mm): a, 0.5; b–e, i, 0.2; f–h, 0.25.

Diagnosis. Pseudorostrum 0.38 of carapace length, ocular lobe eyeless, reaching its tip, few setae on carapace, no spines on entire body, smooth lower margin of carapace. Basal article of peduncle of antenna 1 shorter than rest of articles combined, short main flagellum. Maxilliped 3 with a strong tooth on outer margin of merus. Pereopod 1 with carpus 2nd longest article, dactylus with long curved robust terminal seta. Pereopod 2 with carpus little longer than merus, with 2 robust short setae on its distal inner corner, short dactylus. Pereopods 3–5 progressively shorter, with dactylus fused with its terminal seta. No exopods. Short and robust uropods, peduncle twice as long as pleonite 6 and its endopod, endopod slightly longer than exopod, with 6 setae on inner margin.

Description. Body with weakly calcified integument. Length: 2.6 mm.

Carapace one-third body length, twice as long as high, with pseudorostrum 0.38 of carapace length, ocular lobe reaches its extremity, with some dorsal undulation viewed from lateral side, with few setae, antennal notch marked, lower margin smooth, siphon long.

Antenna 1 basal article of peduncle shorter than rest of articles combined, main flagellum short, 3-articulate, as long as distal article of peduncle, with short aesthetascs, accessory flagellum minute, uniarticulate.

Maxilliped 3 basis with 2 plumose setae on inner distal corner, 3 on outer one (2 much longer), merus with strong tooth and plumose seta on outer margin, carpus shorter than

merus, with plumose seta on outer margin, propodus slightly longer than merus, with 2 pappose setae on inner margin, short dactylus with stout long terminal seta.

Pereopod 1 basis less than half as long as appendage, carpus 2nd longest article, dactylus little less than half as long as propodus, with terminal long curved robust seta. Pereopod 2 basis less than half as long as appendage, simple seta on inner margin of merus, carpus little longer than merus, with 2 short robust setae on inner distal corner, dactylus 1.6 times as long as propodus, with long robust terminal seta. Pereopods 3–5 with progressively shorter basis and longer carpus (3 times as long as merus in last pair), dactylus fused with its stout terminal seta. Exopods absent in maxilliped 3 and pereopods 1, 2.

Uropod short and robust, peduncle twice as long as pleonite 6 and its endopod, exopod slightly shorter than endopod, with robust terminal seta, endopod with 6 setae on inner margin and terminal robust seta shorter than in exopod.

Etymology. The species bears the name of the collecting place – Australia.

Distribution. Off Nowra, NSW; 770 m depth.

Remarks. The female of *Styloptocumoides australiensis* has pereopods as in *Styloptocuma poorei* but maxilliped 3 has a shorter propodus in *S. australiensis*; maxilliped 3 and pereopods 1 and 2 are without exopods, and obviously shorter and larger uropods.

Vemacumella Petrescu, 2001

Vemacumella Petrescu, 2001: 1675–1677.

Type species. Vemacumella heardi Petrescu, 2001.

Remarks. The genus has the general aspect of *Cumella* but with a higher carapace, eyeless ocular lobe like in *Styloptocuma*, pseudorostral lobes meeting in front of ocular lobe like in *Cumella*, not as in *Styloptocuma*; median article of antennal peduncle with a tubercle as in *Styloptocuma* but absent in *Cumella*.

Vemacumella bacescui sp. nov.

Figures 65, 66

Material examined. Holotype female, Tas., off Freycinet Peninsula, 41°57.50'S, 148°37.90'E, 400 m, coarse shell, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE 48), NMV J53069.

Paratype: 1 female (stn SLOPE 6), NMV J53070.

Diagnosis. Carapace with middorsal row of spines, anterolateral corner strongly serrated, ocular lobe eyeless. Short and robust antenna 1, median article of peduncle with small tubercle. Basis and merus of maxilliped 3 with strong inner serration. Carpus of pereopod 1 2nd longest article, as long as propodus and dactylus combined. Carpus of pereopod 2 with long stout seta on inner distal corner, short dactylus. Uropod peduncle 1.7 times as long as pleonite 6 and 1.3 times as long as endopod, endopod longer than exopod, with 4 stout setae on inner serrated margin.

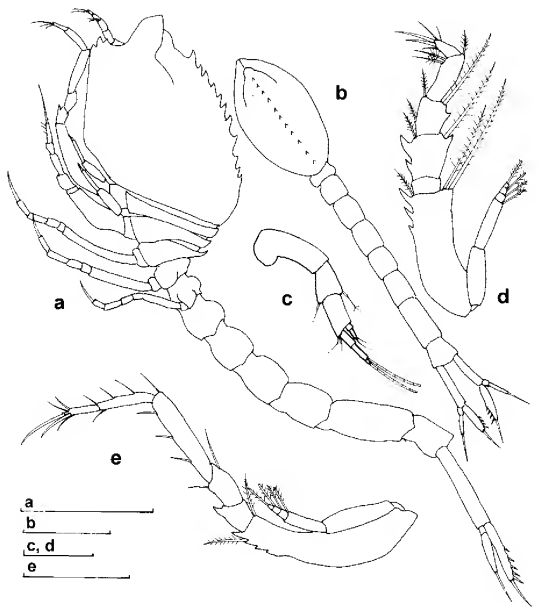

Figure 65. *Vemacumella bacescui* sp. nov. female holotype: a, body, lateral view; b, body, dorsal view; c, antenna 1; d, maxilliped 3; e, pereopod 1. Scale (in mm): a, 0.5; b, 0.5; c, d, 0.1; e, 0.2.

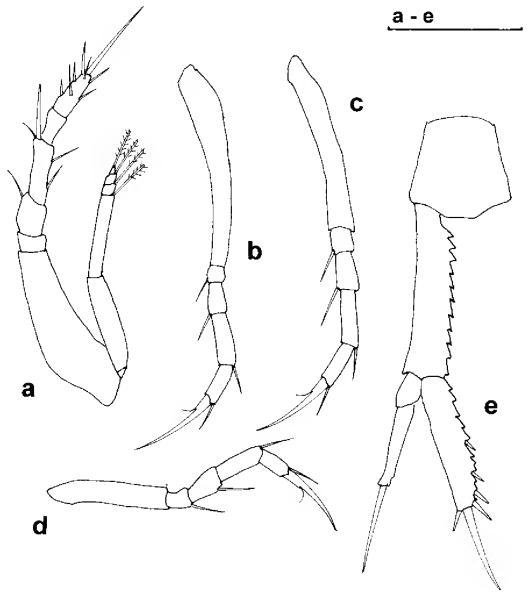

Figure 66. *Vemacumella bacescui* sp. nov. female holotype: a, pereopod 2 ; b, pereopod 3 ; c, pereopod 4 ; d, pereopod 5 ; e, pleonite 6 and left uropod. Scale bar : a–e, 0.2

Description. Body strongly calcified, integument smooth. Length: 2.4 mm.

Carapace 0.33 body length, 1.6 times as long as high, with a median dorsal row of spines reaching frontal lobe, short pseudorostrum meeting in front of ocular lobe, ocular lobe eyeless, antennal notch marked, anterolateral corner strongly serrated, lower margin smooth.

Antenna 1 proximal article of peduncle the longest, median one the shortest, with tubercle provided with pedunculate seta, main flagellum slightly shorter than distal article of peduncle, 3-articulate, accessory flagellum 2-articulate, almost reaching the extremity of basal article of main flagellum.

Maxilliped 3 basis less than half as long as appendage, with 3 strong teeth on inner margin, 2 long plumose setae on outer distal corner, without outer process, merus 2nd longest article, with 2 strong teeth on inner margin, long plumose seta on outer margin of merus and carpus, propodus longer than carpus, with 2 pappose setae on inner margin, dactylus 0.5 propodus length, with 2 stout terminal setae.

Pereopod 1 basis shorter than rest of articles combined, with strong serration on inner margin, tooth on inner margin of ischium, merus longer than ischium, carpus 2nd longest article, as long as propodus and dactylus combined, dactylus with stout slender terminal seta. Pereopod 2 basis shorter than rest of articles combined, merus with simple seta on inner margin, carpus 1.7 times as long as merus, with long stout seta on inner distal corner, dactylus 1.75 times as long as propodus, with numerous short simple setae on both margins, long stout simple terminal seta. Pereopods 3–5 with progressively shorter basis (longer than half of appendage in 3rd pair) and longer carpus (twice as long as merus in 5th pair), dactylus fused with its terminal stout seta. Exopods on maxilliped 3 and pereopods 1, 2.

Uropod peduncle 1.7 times as long as pleonite 6 and 1.3 times as long as endopod, exopod 0.9 times length of endopod, with long robust terminal seta, endopod with 4 stout setae on inner serrated margin and robust terminal seta.

Etymology. The species is dedicated to the memory of the late Mihai C. Băcescu (1908–1999), member of the Romanian Academy, former director of "Grigore Antipa" National Museum of Natural History from Bucharest, one of the highest world authorities on Crustacea Peracarida, as a sign of homage and gratitude for all he offered to his last student.

Distribution. Off Nowra, NSW, off Freycinet Peninsula, Tas.; 400–770 m depth.

Remarks. This is the first record of the genus in the western Pacific (Australia) and second description of a species of *Vemacumella* Petrescu. *Vemacumella bacescui* has in common with *Vemacumella heardi* Petrescu, 2001 (described from the south-eastern Pacific) a carapace longer than one-third of the body length, five free pereonites, antenna 1 with a tubercle on the median article of the peduncle, accessory flagellum 2-articulate, and relatively short uropods with serrated margins and unequal rami. *Vemacumella bacescui* differs in having more numerous dorsal spines on the carapace and the basis of maxilliped 3 without an outer process. Other morphological characters are sexually dimorphic, the Australian species being described from a female while the American one is from a male.

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Appendix.

Station data from Museum Victoria collections. That which is prefixed AA is from Prydz Bay, Antarctica. Those prefixed MSL-EG were collected off East Gippsland, Victoria, by tenth-metre-square Smith-McIntyre grab from RV *Sarda* and donated by the Marine Sciences Laboratories (see Coleman et al., 1997). Those prefixed SLOPE were collected by WHOI epibenthic sled during cruises on RV *Franklin* by Museum Victoria on the south-eastern Australian continental slope (see Poore et al., 1994).

Antarctica

AA93 158, Eastern Prydz Bay, off the Larsemann Hills, 68°54.88'S, 76°37.03'E, 667–716 m, epibenthic sled, P.M. O'Loughlin, RSV *Aurora Australis*, 18 Feb 1993.

Victoria, eastern Bass Strait

MSL-EG 18, 14 km SW of Marlo, 37°54'S, 148°25.7'E, 26 m, sand-shell, 12 Aug 1989.

MSL-EG 20, 23 km SSW of Marlo, 37°49'S, 148°25.7'E, 11 m, sand-shell, 12 Aug 1989.

MSL-EG 26, 7.8 km ESE of eastern edge of Lake Tyers, 37°51.65'S, 148°10.60'E, 38 m, sand-shell, 25 Sep 1990.

MSL-EG 27, 11.2 km E of eastern edge of Lake Tyers, 37°51.41'S, 148°13.16'E, 32 m, sand-shell, 25 Sep 1990.

MSL-EG 28, 15.7 km E of eastern edge of Lake Tyers, 37°51.19'S, 148°16.28'E, 36 m, sand-shell, 25 Sep 1990.

MSL-EG 57, 5.4 km SW of Cape Conran, 37°51.28'S, 148°43.73'E, 50 m, sand-shell, 28 Sep 1990.

MSL-EG 62, 7.3 km SSW of Cape Conran, 37°52.67'S, 148°42.06'E, 48 m, sand-shell, 28 Sep 1990.

MSL-EG 67, 13.3 km E of eastern edge of Lake Tyers, 37°51.70'S, 148°14.60'E, 37 m, coarse sand, 4 Jun 1991.

MSL-EG 77, 11.7 km W of Pt Ricardo, 37°49.89'S, 148°30.13'E, 27 m, coarse sand, 4 Jun 1991.

MSL-EG 78, 11.7 km W of Pt Ricardo, 37°49.89'S, 148°30.13'E, 27 m, coarse sand, 4 Jun 1991.

MSL-EG 104, 11.7 km W of Pt Ricardo, 37°49.89'S, 148°30.13'E, 27 m, coarse sand, Feb 1991.

MSL-EG 105, 11.7 km W of Pt Ricardo, 37°49.89'S, 148°30.13'E, 27 m, coarse sand, Feb 1991.

MSL-EG 108, 15.5 km SW of Pt Ricardo, 37°53.14'S, 148°28.94'E, 45 m, medium sand, Feb 1991.

South-eastern Australian continental slope

SLOPE 1, NSW, off Nowra, 34°59.52'S, 151°05.94'E, 204 m, coarse shell, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986.

SLOPE 2, NSW, off Nowra, 34°57.90'S, 151°08.00'E, 503 m, bryozoa and shell, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986.

SLOPE 6, NSW, off Nowra, 34°51.90'S, 151°12.60'E, 770 m, crinoid dominated, G.C.B. Poore and C.C. Lu, RV *Franklin*, 15 Jul 1986.

SLOPE 19, NSW, off Eden, 37°07.30'S, 150°20.20'E, 520 m, grey coarse shell, G.C.B. Poore et al., RV *Franklin*, 20 Jul 1986.

SLOPE 21, NSW, off Eden, 36°57.40'S, 150°18.80'E, 220 m, muddy shell, G.C.B. Poore et al., RV Franklin, 20 Jul 1986.

SLOPE 27, Vic., S of Point Hicks, 38°25.00'S, 149°00.00'E, 1500 m, compacted clay, G.C.B. Poore et al., RV *Franklin*, 22 Jul 1986.

SLOPE 45, Tas., off Freycinet Peninsula, 42°02.20'S, 148°38.70'E, 800 m, coarse shelly sand, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986.

SLOPE 46, Tas., off Freycinet Peninsula, 42°00.20'S, 148°37.70'E, 720 m, coarse shelly sand, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986.

SLOPE 47, Tas., off Freycinet Peninsula, 41°58.60'S, 148°38.80'E, trawl, 500–600 m, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986.

SLOPE 48, Tas., off Freycinet Peninsula, 41°57.50'S, 148°37.90'E, 400 m, coarse shell, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986.

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A new genus and new species of Desmosomatidae (Crustacea: Isopoda: Asellota) from the deep sea of south-eastern Australia

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Abstract Brix, S. 2006. A new genus and new species of Desmosomatidae (Crustacea: Isopoda: Asellota) from the deep sea of south-eastern Australia. *Memoirs of Museum Victoria* 63(2): 175–205.

A new genus and species, *Chelantermedia composita* sp. nov., and five new species of Desmosomatidae Sars, 1897 (*Paradesmosoma australis* sp. nov., *Oecidiobranchus nowrae* sp. nov., *Disparella kensleyi* sp. nov., *Whoia victoriensis* sp. nov., *Echinopleura cephalomagna* sp. nov.) are described from the deep sea off south-eastern Australia. The species of Desmosomatidae sampled in 1988 are the first record of this family in Australian waters.

Keywords Isopoda, Desmosomatidae, Australia, taxonomy, *Chelantermedia,* new genus, new species

Introduction

The new species described below were collected in the 1980s as part of the SLOPE Program of Museum Victoria and the then Victorian Institute of Marine Sciences. Samples were taken off southern New South Wales and Tasmania and in Bass Strait in 1988 from RV *Franklin*. Poore et al., 1994 analysed depth and geographical diversity patterns of all species of Isopoda. The present paper describes members of the asellote family Desmosomatidae Sars, 1897, common deep-sea benthic isopods with a slender body (Hessler, 1970; Svavarsson, 1984, 1988; Wägele, 1989). In deep-sea areas that are sampled for the first time, the fraction of isopod species new to science ranges from 50–100% (Wilson, 1980; Poore et al., 1994; Park, 1999; Brandt et al., 2004). The species of Desmosomatidae described here are the first record of this family in Australian waters. From a total of 21 desmosomatid species new to science, six new species are described from the material lodged in the Museum Victoria, Melbourne (Poore et al., 1994).

The specimens were compared with relevant type material of similar species. For the drawings a Leitz MI85 compound microscope (Biocenter Grindel and Zoological Museum, Hamburg) and Olympus BX20 (Museum Victoria, Melbourne) with a camera lucida were used. The dorsal and lateral habitus drawings were made from the holotype in glycerine stained with methylene green. All appendages were dissected from a paratype (if not available, from the holotype) and deposited in water-free glycerin jelly, stained and finally sealed. The total body length was measured in dorsal and lateral views from the anterior edge of the head to the posterior medial tip of the pleotelson. Length-to-width ratios refer to the greatest length and width of the limb articles or segments. The terminology used in this study for the most important setal types follows Hessler (1970). Following Wolff (1962) and Hessler (1970) roman numerals refer to pereopods and Arabic numerals for body segments and articles of appendages.

Abbreviations: A1 = antennula; A2 = antenna; MdL = left mandible; MdR = right mandible; Mx1 = maxillula; ip = incisior process; lm = lacinia mobilis; mp = molar process; Mx2 = maxilla; Mxp = maxilliped; Op = operculum; PI–VII = pereopods I–VII; Plt = pleotelson; Plp 1–5 = pleopods 1–5; Prn 1–7 = pereonites 1–7; Urp = uropods; ZMH = Zoological Museum of Hamburg; AM = Australian Museum, Sydney, NMV = Museum Victoria, Melbourne.

Chelantermedia gen. nov.

Type and only species. *Chelantermedia composita* sp. nov.

Diagnosis. Body elongated, length about 5 times longer than width of pereonite 2. Lateral margins of pereonites straight, Pereonites 6, 7 and pleotelson dorsally fused. Pereopod chelate, enlarged, carpus ventrally with 1 slender seta midway and 1 slender seta proximal to claw-seta.

Etymology. The first part of the name refers to the chela of pereopod I. *Chela* (Latin, a claw) and *intermedia* (Latin, in between) reflect the intermediate set of characters between Desmosomatidae and Nannoniscidae – as it occurs for example in the chela of pereopod I.

Discussion. The new genus shows a mixture of characters of Desmosomatidae Sars, 1897 and Nannoniscidae Hansen, 1916, two families that are poorly differentiated. The new species, *C. composita*, will be important in phylogenetic studies leading to better understanding of the relationships within the family Desmosomatidae. It possesses a combination of character states not compatible with any existing genus. No desmosomatid genus has pereonites 6 and 7 and the pleotelson fused as in some nannoniscid genera, for example *Rapaniscus* Siebenhaller and Hessler, 1981. All nannoniscid genera including species with fused pereonites 6 and 7 (*Hebefustis* Siebenhaller and Hessler, 1977, *Rapaniscus*, *Regabellator* Siebenhaller and Hessler, 1981, *Nannoniscoides* Hansen, 1916, *Nannoniscus* Sars, 1870, *Saetoniscus* Brandt, 2002) have an antennula with a bulbous distal article. The new genus does not possess such a specialisation, the flagellar articles of the antennula tapering towards the distal article. Pereopod I resembles most species of *Prochelator* Hessler, 1970, *Chelator* Hessler, 1970 or *Oecidiobranchus* Hessler, 1970. *Prochelator* is the only one of these three that includes species with biramous uropods but none has fused pereonites.

Chelantermedia composita sp. nov.

Figures 1–3

Material examined. Holotype. Female, preparatory, 2.1 mm; NMV J18612. Australia, NSW, off Nowra (34°59.52'S, 151°5.94'E), 204.0 m, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 14 Jul 1986 (stn SLOPE 1).

Paratypes (7 specimens: 3 females, 4 males). Same data as holotype. NMV J186121.

Description. (Holotype female). *Habitus* (fig. 1): body 2.1 mm long, 5.17 times longer than width of pereonite 2. Pereonite 1 width 1.16 times cephalon width in dorsal view. Pereonite 1 length 1.11 pereonite 2 length, 0.96 pereonite 2 width. Pereonite 5 width 0.60 length, anterior margin straight. Pereonite 6 and 7 fused with pleotelson, lateral margins straight. Coxae 1–4 slightly produced, without setae. Pleotelson length as long as wide, without posterolateral spines. Lateral margins straight, posterior margin slightly rounded.

Antennula: 0.23 mm long, length 0.02 body length, 5 articles. Article 1 with 2 broom setae and 1 simple seta. Article 2 length 3.67 width, 1.94 article 1 length; with 2 long articulated broom setae distally and 2 simple seta midway. Article 3 with 1 simple seta, article 4 with 2 long slender setae and article 5 distally with 1 aesthetasc and 2 long slender setae. *Antenna*: length about one-third of body length, with 11 articles. Article 3 with 1 small seta. Article 4 with 2 small setae. Article 5 distally with 3 simple setae, 1 simple seta located midway. Article 6 with 4 simple setae midway, distally with 2 small broom setae and 6 long slender setae. Flagellar articles with few setae.

Mandible: Without palp. Incisior process with 3 lobes. Lacinia mobilis of left mandible with 4 teeth. Spine row containing 4 spines. Molar process triangular with 7 setae. *Maxilliped*: Epipodite lost during dissection. Endite with 2 coupling hooks and numerous fine setae on inner margin and on distal tip. Palp of 4 articles, articles 1 and 2 clearly broader than articles 3 and 4. Article 1 length 1.14 width. Edge of palp article 2 with 4 long slender setae and inner margin with 2 long slender setae. Article 2 about 2 times width, article 3 length 5.00 width, article 4 length 3.50 width. Article 3 with 2 setae, article 4 with 3 setae.

Pereopod I: Chelate. Basis length 3.75 width, proximal to ischium ventrally 1 large seta. Ischium length 1.77 width, with 1 ventral seta. Merus length 2.38 width, ventrally with 1 strong unequally bifid seta, midway 1 slender seta, distodorsally 1 large simple seta. Carpus length 1.38 width, ventrally with claw-seta, penultimate slender seta and 1 slender seta midway. Claw-seta as long as propodus. Propodus length 2.69 width, dorsally with 2 small setae, ventral margin with cuticular membrane and 6 small slender setae. Dactylus length 3.6 width, without setae. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopods II–IV*: Similar. *Pereopod III*: Basis length 4.29 width, with 2 simple setae and 1 broom seta. Ischium length 2.15 width, with 2 simple slender setae. Merus length 1.36 width, ventrally with 2 simple setae, distodorsally 1 simple seta. Carpus length 3.90 width, ventrally 3 distally setulate setae and combs between insertion of setae, distodorsally 1 small simple seta. Propodus length 3.90 width; ventral margin with 2 setae and combs between them. Dactylus length 3.84 width, with 3 small slender seta, unguis (claw) of 1 strong spittle-like formed conate seta and 3 slender setae inserting ventrally. *Pereopods V–VII*: Similar. *Pereopod V*: Basis length 3.00 width, with 7 broom setae in irregular distances and ventrally 1 slender seta near ischium. Ischium length 2 times width, with 1 dorsal and 1 ventral simple seta. Merus length 0.89 width, distodorsally with 2 setae, ventrally 1 seta. Carpus length 2.80 width, with ventral row of 4 long slender distally unequally bifid setae, dorsally 3 slender setae and near propodus 1 small broom seta. Propodus length 5.60 width, dorsally with 3 slender distally unequally bifid setae increasing in length towards dactylus, ventrally with row of 5 slender distally unequally bifid setae increasing in length towards dactylus and 1 simple seta between 4th and 5th seta of ventral row. Dactylus length 4.67 width, (slightly damaged) with unguis (claw) of 1 small robust seta and 1 long conate seta broadened distally, 3 slender setae inserting between them.

Pleopod 2 (operculum): Length 1.15 width. Form nearly rectangular, lateral margins straight, distal margin straight. Ventral surface without setae. Distal margin with 4 slender setae. *Pleopod 3*: Endopod length 1.39 width, distally with 3 long plumose setae. Exopod length 1.46 of endopod length, outer margin hirsute. *Pleopod 4*: Endopod oval and tapering to tip, length 1.62 width. Exopod length 6.90 width, distally with 1 long plumose seta.

Uropods: Biramous. Exopod length 0.58 times endopod length. Endopod 5.14 times longer than wide, 1 small broom seta inserting medially, a bunch of 4 small broom setae and 1 slender seta inserting between the single small broom seta and the tip of the endopod, distally with 3 long broom setae and 2 small simple setae. Exopod length 4.2 width, distally with 2 long slender setae. Protopod length 1.39 width, with 1 small broom seta and 3 simple setae.

Male. *Habitus* similar to female, 5.43 times longer than width of pereonite 2. *Antenna*: 20 articles, flagellum basally swollen, with 14 articles. *Pleopod 1*: 4.93 times longer than distal width, tips triangular with 4 small slender setae on outer side. *Pleopod 2*: sympod length 2.03 times width, outer lateral margin slightly convex, distally with 4 setae. Endopod inserting about 0.50 of sympod length.

Etymology. From the latin word *composita*, composite. The new species is composed of character states that occur in Desmosomatidae and Nannoniscidae and are observed together in the same species for the first time.

Distribution. Off southern NSW, Australia.

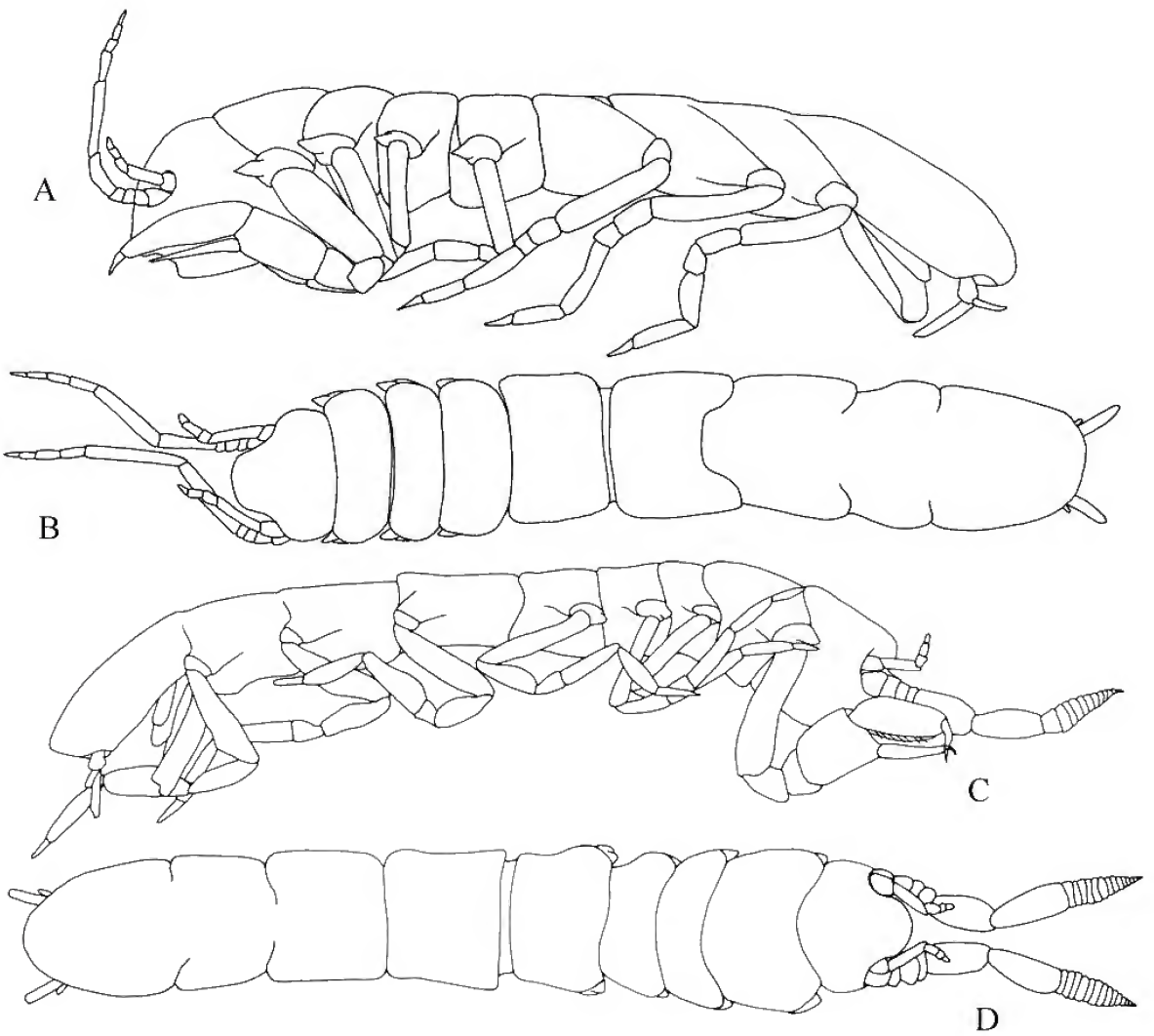

Figure 1. *Chelantermedia composita* sp. nov. Holotype female. NMV J18612. Dorsal and lateral views (A, B). Allotype male. NMV J186121. Dorsal and lateral views (C, D).

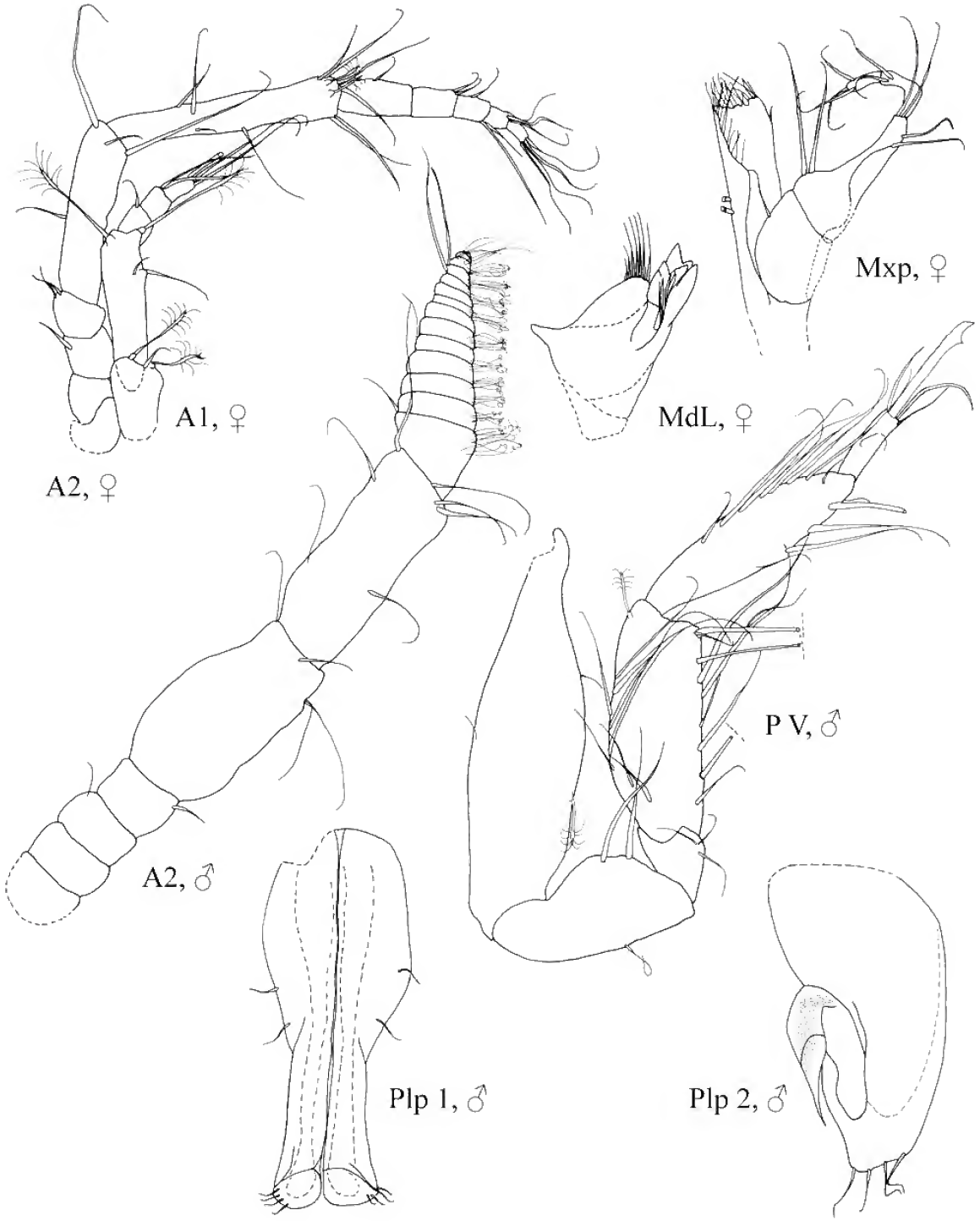

Figure 2. *Chelantermedia composita* sp. nov. Paratype female, Allotype male. NMV J186121. Antennae, mouthparts, pereopod V, male pleopods.

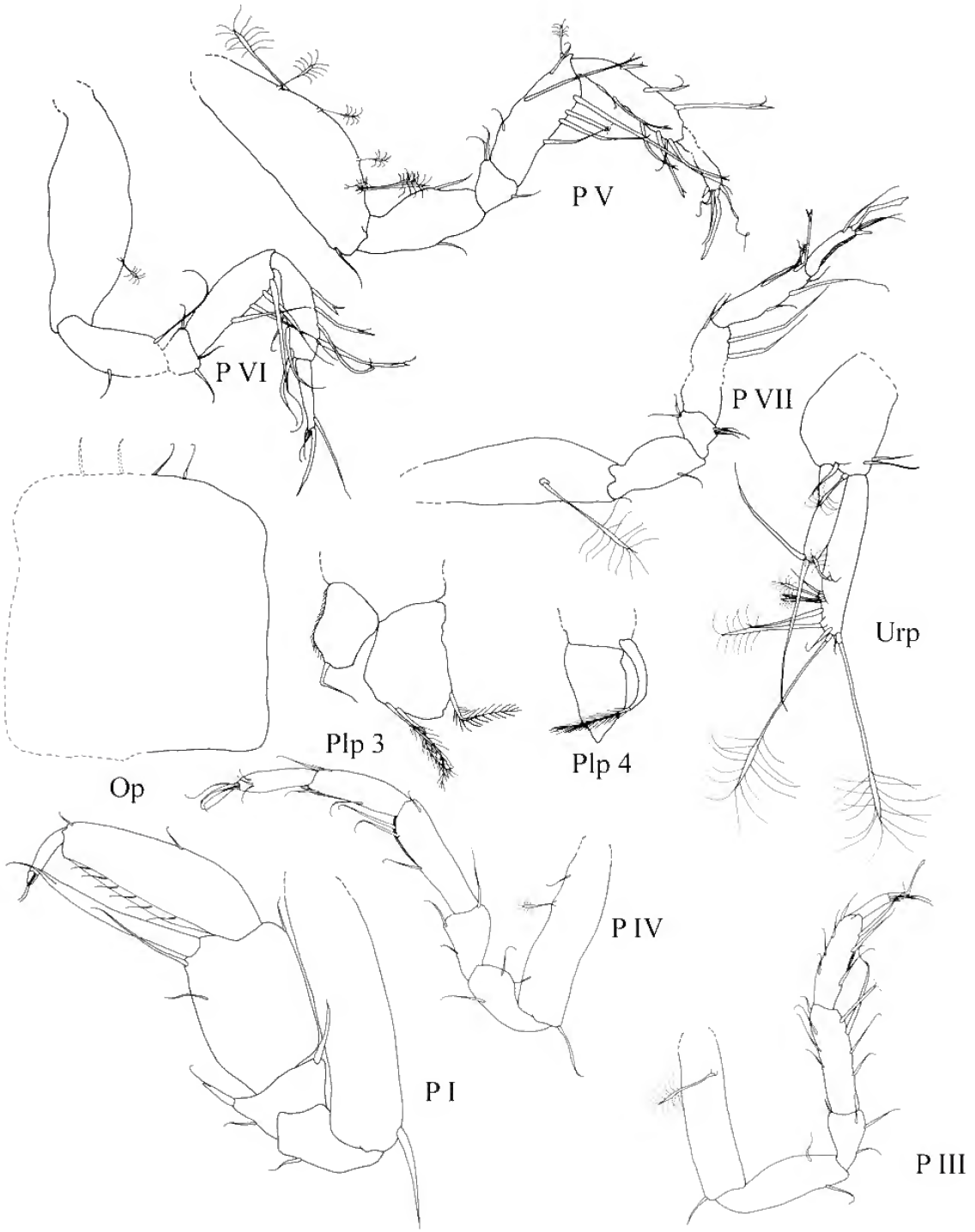

Figure 3. *Chelantermedia composita* sp. nov. Paratype female. NMV J186121. Pereopods I–VII and pleopods (Op, Plp 3, 4, Urp).

Paradesmosoma australis sp. nov.

Figures 4–7

Material examined. Holotype. Female, preparatory, NMV J18608; Type locality. - Australia, Vic., S of Point Hicks (38°17.70'S, 149°11.30'E), depth 400 m, WHOI epibenthic sled, RV *Franklin*, 24 Jul 1986 (stn. SLOPE 40).

Diagnosis. Body length about 4.4 times longer than width of pereonite 2. Palp of left mandible with 2 articles, article 2 length 2.10 width, tapering to distal end, terminally 1 small seta, margins hirsute. Pereonite 1 length 1.36 pereonite 2 length. Coxae 1–4 faintly produced, without setae. Pleotelson anteriorly widest, about as wide as long, posterolateral spines present, lateral margins slightly convex, posterior margin slightly rounded. Uropods uniramous, endopod length 4.82 protopod length, 10.25 times longer than wide.

Description. *Habitus*: body 2.6 mm long, 4.36 times longer than width of pereonite 2. Pereonite 1 width 1.44 times cephalon width in dorsal view. Pereonite 1 length 1.36 pereonite 2 length, 0.97 pereonite 2 width. Pereonite 5 anterior margin straight, lateral margins slightly concave. Coxae 1–4 faintly produced, without setae. Pleotelson anteriorly widest, about as wide as long, posterolateral spines present, lateral margins slightly convex, posterior margin slightly rounded.

Antennula: About 0.26 mm long, length about 0.10 body length, with 5 articles. Article 1 with 1 small slender seta and 4 small broom setae. Article 2 length 3.70 width, 1.48 article 1 length; marginally with 2 slender setae, distally with 2 long articulated broom setae. Article 3 with 2 slender setae, article 4 distally with 1 broom seta, distal article with 1 aesthetasc, 1 broom seta and 2 long slender setae. *Antenna* (fig. 5): broken off.

Mandible: Palp of 2 articles. Article 1 without setae, article 2 length 2.1 width, tapering to distal end, terminally 1 small seta, margins hirsute. Incisior process with 3 teeth. Lacinia mobilis of left mandible with 3 teeth, right mandible not dissected from specimen. Spine row containing 8 spines. Molar process large, with 12 slender setae. *Maxillula*: Inner lobe not dissected from specimen. Outer lobe broken off from inner lobe, marginally with 6 ventral setae and 6 dorsal setae, terminally with 12 strong spines. *Maxilla*: Medial lobe as long, slightly broader than other lobes, terminally with 3 slender setulate setae, marginally with 14 setae, setae inserting near base longest. Outer lobe terminally with 3 long slender setulate setae, dorsal margin with 5 pairs of fine setae. *Maxilliped*: Epipodite length 3.31 width, length 1.17 endite length, outer margin hirsute. Endite with 2 coupling hooks, with numerous fine setae. Edge of endite and palp articles 1–3 fringed with row of fine setae and 1 seta on distal corner. Palp article 2 with 6 setae on inner margin, article 3 with 12 setae on inner margin, article 4 with 3 setae, article 5 with 4 setae. Article 1 length 0.37 width, article 2 length 1.03 width, article 3 length 0.85 width, article 4 length 1.5 width, article 5 length 1.50 width.

Pereopod I: Basis length 2.57 width, near coxa with 1 distally slender plumose seta, 5 simple slender setae and proximal to ischium 1 slender seta. Ischium length 2.43 width, ventrally with row of 6 simple setae, dorsolaterally with row of 7 simple setae. Merus length 0.72 width, distodorsally 1 simple slender seta, ventrally with a row of 5 simple setae, 2 distally setulate setae and 1 stout unequally bifid seta. Carpus length 1.44 width, with dorsolateral row of 5 simple slender setae, distoventrally with claw-seta and a ventral row of setae of irregular size and type: 3 robust unequally bifid setae and 5 slender setae (1 slender seta inserting proximal to propodus). Propodus broadest at articulation to carpus, tapering towards dactylus, length 3.05 width, ventrally fringed with fine setae and 12 small setae inserted in cuticular membrane. Dactylus length 5 times width, mediodistally with 3 small setae. Unguis (claw) of 1 conate setae, 3 slender setae inserting ventrally. *Pereopod II:* Similar to pereopod III, different from pereopod IV. Basis length 3.04 width, marginally with 7 slender setae and 1 small broom seta, proximal to ischium ventrally with bunch of 5 distally slender plumose setae. Ischium length 3 times width, ventrally with row of 23 distally slender plumose setae, dorsally with 5 setae. Merus length 1.86 width, with dorsolateral row of 9 long simple setae, ventrally with 6 simple slender setae and 2 distally setulate setae. Carpus length 3.05 width, with ventral row of 8 robust unequally bifid setae increasing in length towards propodus, distal seta of row as long as propodus, dorsally with row of 12 simple setae. Propodus length 4.18 width dorsally, ventrally 4 small slender setae, dorsally 7 setae. Dactylus length 5.60 width, mediodistally with 3 small seta. Unguis (claw) of 1 long conate seta, 2 slender setae inserting ventrally. *Pereopod IV*: Basis marginally with 8 distally slender plumose setae. Ischium length 1.77 width, ventrally with row of 24 distally slender plumose setae and dorsally 3 slender setae. Merus length 1.67 width, with 9 simple slender setae and ventral row of 13 distally slender plumose setae. Carpus length 2.41 width, with dorsal row of 16 slender setae and a ventral row of 33 distally slender plumose setae. Propodus length 1.66 width, dorsally with 24 simple slender setae, ventrally with row of 25 distally slender plumose setae, distally 2 small slender setae. Dactylus width 0.13 propodus width, length 1.5 width, 3 small setae mediodistally. Unguis (claw) with 1 conate seta, 2 slender setae ventrally. *Pereopod VI*: Similar to pereopod V and pereopod VII. Basis length 1.93 width, with few small slender setae and 1 long slender seta ventrally proximal to ischium. Ischium length 2.15 width, ventrally with 1 simple seta, distodorsally 2 simple slender setae. Merus length 1.21 width, with 2 ventral setae, distodorsally 1 simple slender seta. Carpus length 3.53 width, ventrally with row of 6 long distally setulate setae and 1 short unequally bifid seta, dorsally with row of 7 simple slender setae. Propodus length 3.91 width, ventrally with row of 11 long distally setulate setae, dorsally with row of 4 simple slender seta, distally 1 small broom seta. Dactylus length 6.75 width, proximal to unguis (claw) 4 simple slender setae. Unguis (claw) of 1 long conate seta.

Pleopod 2 (operculum): Length 0.93 width, lateral margins slightly convex, distal margin deeply concave, with 4 small simple setae. *Pleopod 3*: Endopod length 1.62 width, distally with 3 long plumose setae. Exopod length 0.75 of endopod length, margins hirsute, distally with 1 small seta. *Pleopod 4*: Endopod oval-shaped, length 2.31 width. Exopod length 5 width, distally 1 long plumose seta, outer margin hirsute.

Uropods: Uniramous. Endopod length 4.82 protopod length, 10.25 times longer than wide, marginally with 2 small broom setae, distally with 4 slender setae and 5 broom setae. Protopod length 1.7 width, with 3 simple slender setae.

Etymology. Australis (Latin), means "from the south". The name refers to the fact that this species is the first record of the genus *Paradesmosoma* from the southern hemisphere.

Distribution. South-eastern Australia, off Vic.

Discussion. The new species is assigned to the genus *Paradesmosoma* Kussakin, 1965 based on the characteristic shape of pereopod IV, the kind of setation of this pereopod, carpus and propodus "paddle-like" and surrounded by numerous distally slender plumose setae (occurring in *Paradesmosoma* only) and the characters of pereopod I: carpus less enlarged than propodus, with ventral row of irregular setae of varying types. *P. australis* sp. nov. is most similar to *P. orientale* Kussakin, 1965 in the shape of palp article 2 of the mandible. As in *P. orientale*, palp article 2 is about 2.17 times longer than wide and tapers to the distal end which is tipped by a small simple setae. In contrast to *P. orientale*, the lateral margins of this article are hirsute in *P. australis*. According to Kussakin's (1965) drawings, neither *P. orientale* nor *P. conforme* Kussakin, 1965 possesses posterolateral spines on the pleotelson. *P. australis* has posterolateral spines on the pleotelson. Unlike in the two species from the northern hemisphere, the propodus of pereopod I is posteriorly widest in *P. australis* and tapers toward the dactylus.

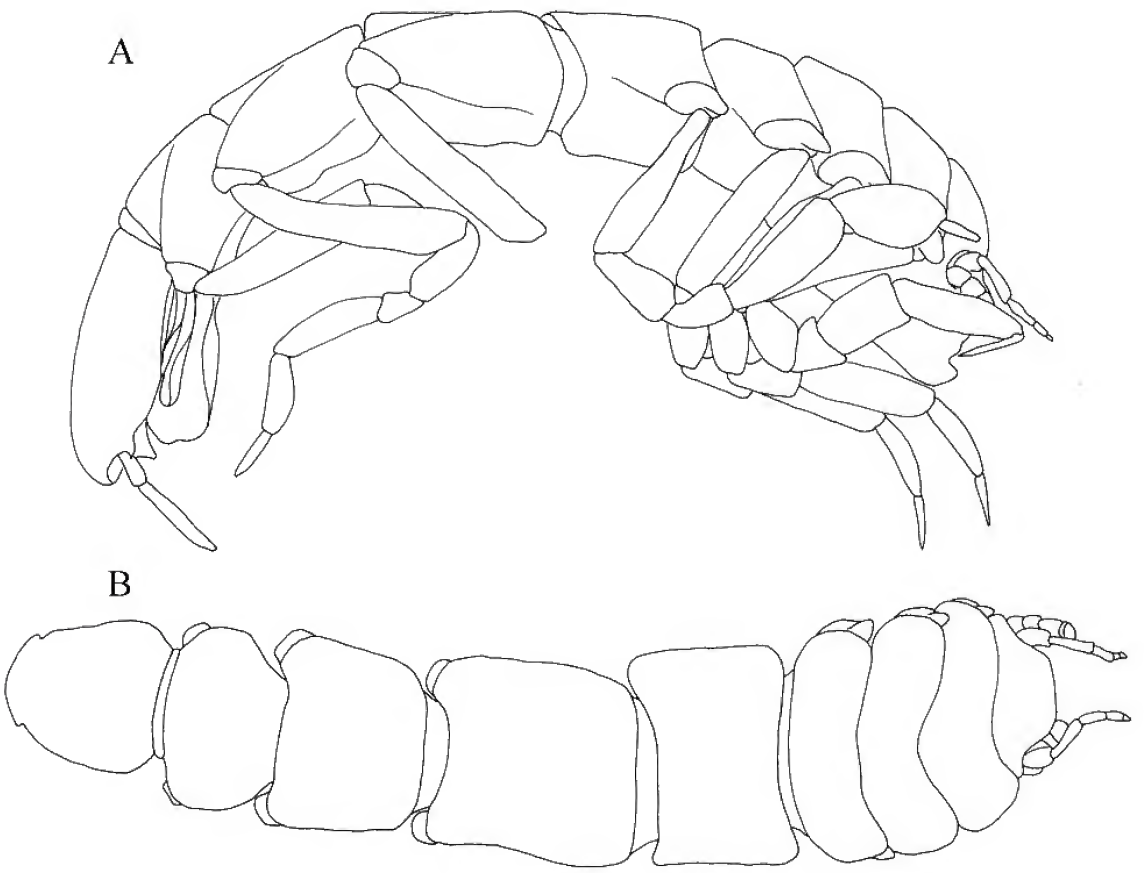

Figure 4. *Paradesmosoma australis* sp. nov. Holotype female. NMV J18608. (A) Lateral and (B) dorsal views.

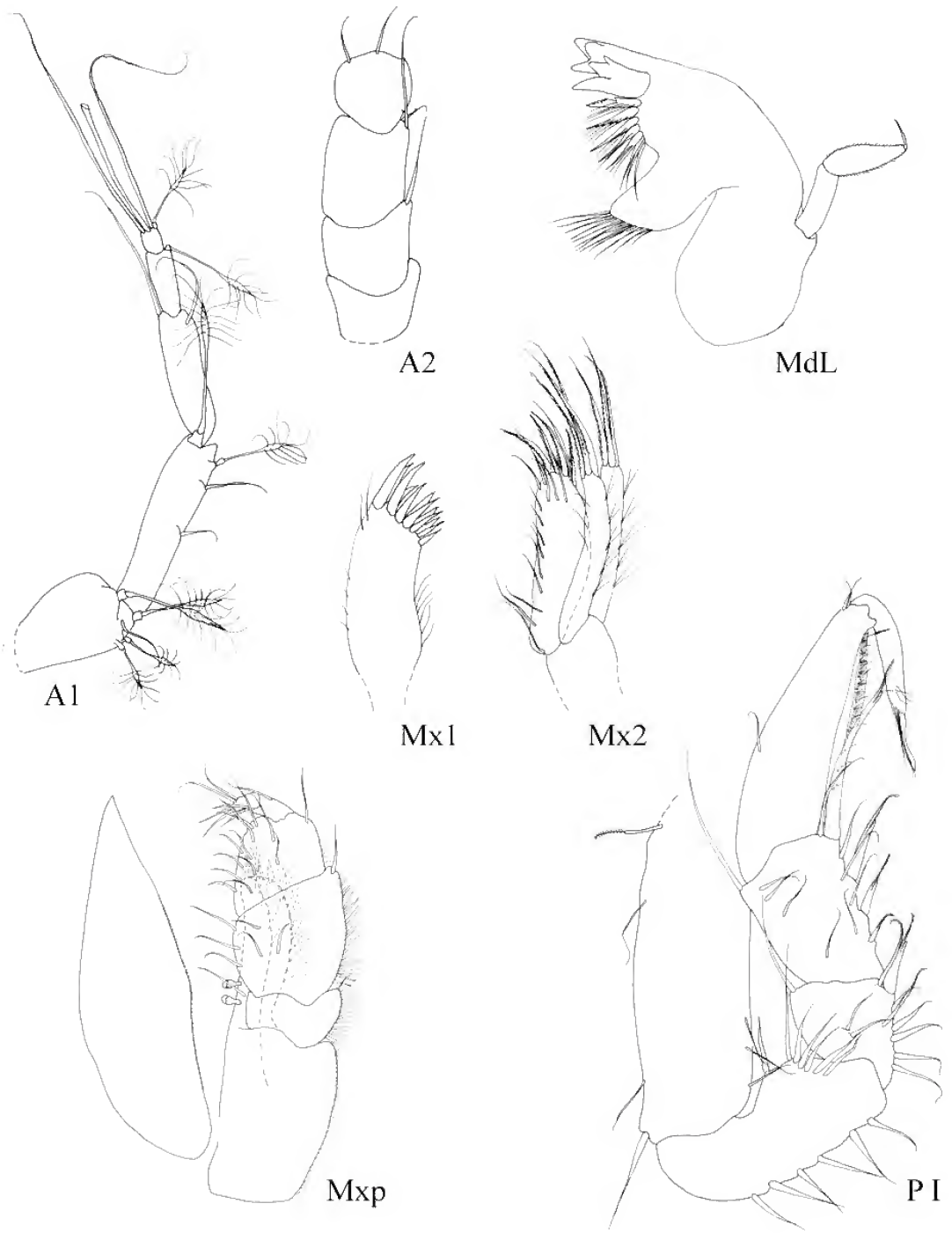

Figure 5. *Paradesmosoma australis* sp. nov. Holotype female. NMV J18608. Antennae, mouthparts and pereopod I.

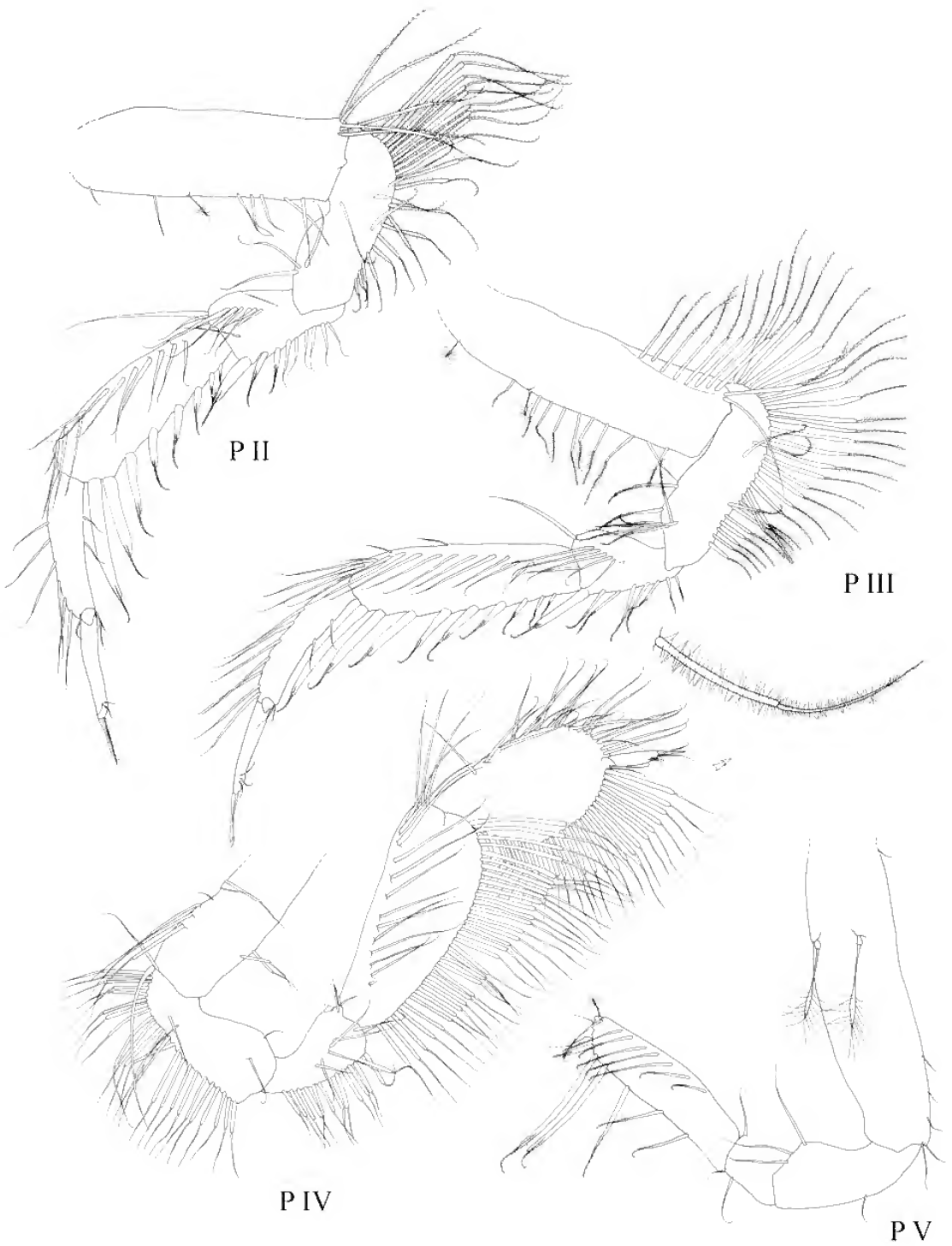

Figure 6. *Paradesmosoma australis* sp. nov. Holotype female. NMV J18608. Pereopods II–V.

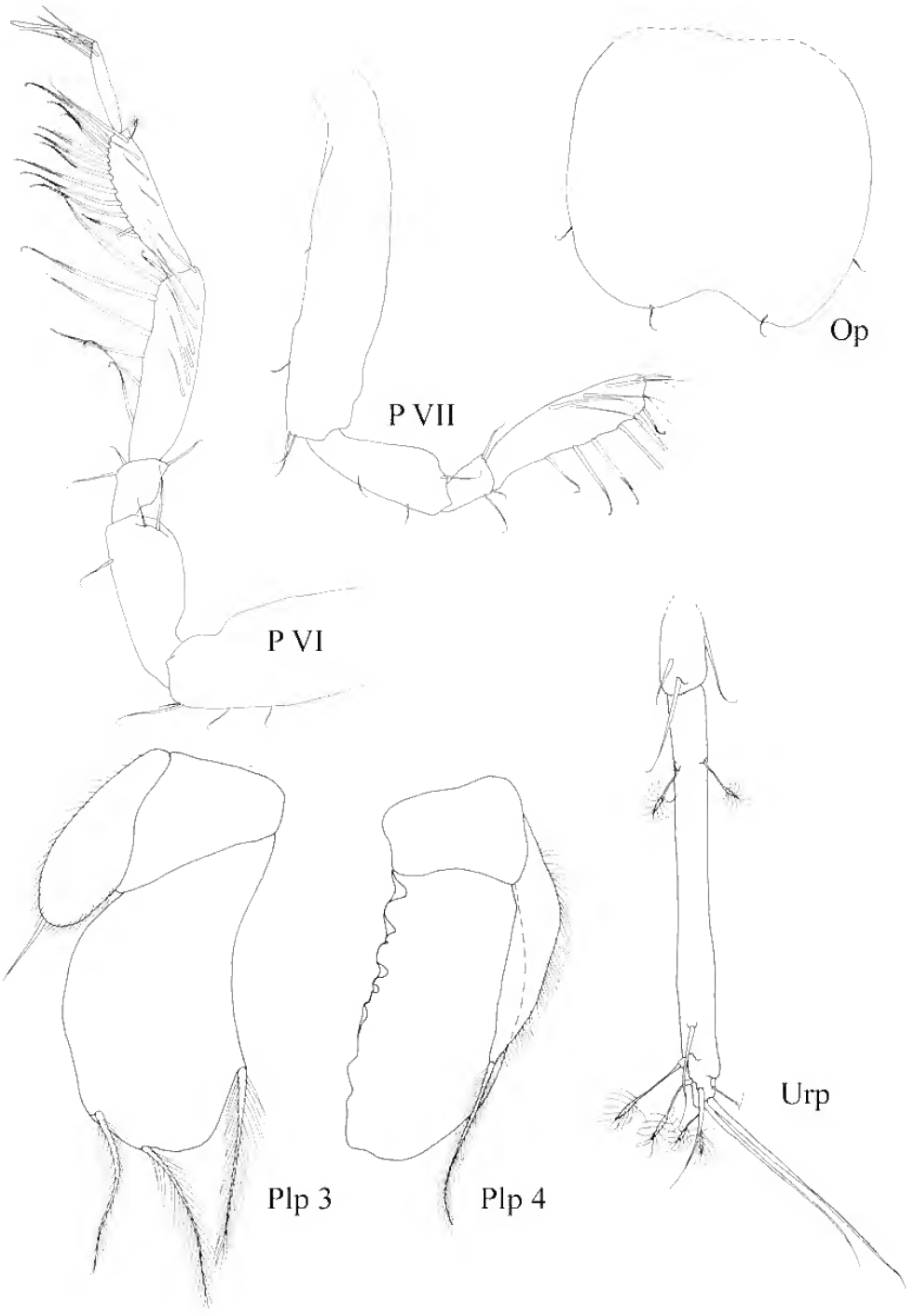

Figure 7. *Paradesmosoma australis* sp. nov. Holotype female. NMV J18608. Pereopods VI and VII, pleopods (Op, Plp 3, Plp 4, Urp).

Oecidiobranchus nowrae sp. nov.

Figures 8–10

Material examined. Holotype. Male, 1.4 mm, NMV J18606. Australia, NSW, 65 km E of Nowra (34°55.52'S, 151°22.20'E), 2055 m depth, G.C.B. Poore et al., RV *Franklin*, 23 Oct 1988 (stn. SLOPE 63).

Diagnosis. Body length 3.83 times longer than width of pereonite 2. Pereonite 1 length 1.10 pereonite 2 length, similar to pereonite 2 width. Pereonite 5 anterior margin slightly convex, lateral margins straight. Lacinia mobilis of left mandible with 5 teeth. Coxae 1–4 produced, tipped with stout setae. PI carpus length 1.41 width, distodorsally with 1 long robust simple seta, ventrally with the large claw-seta and a row of distally setulate setae and setal combs inserted in a cuticular membrane, propodus length 2.61 width, more enlarged than carpus. Pleotelson with posterolateral spines.

Description. Habitus: body 1.4 mm long (measured without appendages), 3.83 times longer than width of pereonite 2. Pereonite 1 width 1.13 times cephalon width in dorsal view. Pereonite 1 length 1.10 pereonite 2 length, similar to pereonite 2 width. Pereonite 5 width 1.36 length, anterior margin slightly convex, lateral margins straight. Coxae 1–4 produced, tipped with stout setae. Pleotelson length 0.71 width, posterolateral spines present. Lateral margins convex, posterior margin rounded.

Antennula: 0.31 mm long, length 0.22 body length, with 5 articles. Article 1 with 3 broom setae. Article 2 length 1.53 width, 2.36 article 1 length; distally with 3 broom setae and 1 small seta. Article 3 with 1 slender seta, article 4 with 2 small broom setae, distal article with 1 aesthetasc, 1 broom seta and 4 long slender setae. *Antenna*: About 1 mm long, length about 0.71 body length, with 22 articles. Articles 3 with 3 small setae, article 4 with 3 small setae. Article 5 with 4 slender setae and distally 1 broom seta. Article 6 with 6 slender setae. Flagellum basally swollen (sexual dimorphism), articles with 1 or 2 slender setae each, distal article with 5 long slender setae.

Mandible: Article 2 of palp ventrodistally with 4 small setae, dorsally with rows of fine setae, apical article with 6 setae, distal one longest. Incisior process with 3 teeth. Lacinia mobilis of left mandible with 5 teeth. Right mandible not dissected from specimen. Spine row containing 5 spines. Molar process with 6 fine slender setae. *Maxillula*: Inner lobe slightly smaller than outer lobe, terminally with 5 setae. Outer lobe dorsally with 4 fine setae, terminally with 11 strong spines (4 spines with setules). *Maxilla*: Not dissected from specimen. *Maxilliped*: Epipodite length 3.13 width, length 1.43 endite length. Endite with 2 coupling hooks, terminally with 1 conate seta and numerous fine setae. Outer edge of endite and palp articles 1–3 fringed with numerous fine setae, distal corners tipped with 1 seta. Palp article 3 with 6 setae on inner margin, article 4 with 2 setae and article 5 with 4 setae. Article 1 length 0.5 width, article 2 length 1.16 width, article 3 length 1.07 width, article 4 length 1.1 width, article 5 length 1.6 width.

Pereopod I: Enlarged, chelate. Basis length 4.53 width, marginally with 1 small broom seta and 5 simple setae, proximal to ischium ventrally 1 long simple seta. Ischium length 1.87 width, distodorsally 1 simple seta, ventrally 2 simple setae. Merus length 1.13 width, ventrally 2 setal combs inserted in a cuticular membrane, distally 1 distally setulate and 1 simple seta, distodorsally 2 setae. Carpus length 1.41 width, distodorsally 1 long robust simple seta, ventrally with the large claw-seta and a row of distally setulate setae and setal combs inserted in a cuticular membrane. Propodus length 2.61 width, more enlarged than carpus, ventral and dorsal margin convex, distodorsally 2 small setae, ventrally fringed with fine setae and 9 small setae inserted in a cuticular membrane. Dactylus length 7.50 width, folding to propodus, mediodistally with 3 small setae. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod III*: Pereopod II missing from specimen, pereopod III similar to pereopod IV. Basis length 5.70 width, marginally with 4 broom setae, 5 small slender setae and proximal to ischium ventrally 1 large simple seta. Ischium length 2.25 width, distodorsally 1 long simple seta and distoventrally 1 long simple seta. Merus length 2.50 width, dorsally with 2, ventrally with 1 simple seta. Carpus length 4.30 width, with ventral row of 4 long slender setae, dorsally with row of 4 setae. Propodus length 3.50 width, ventrally with row of 5 slender setae, dorsally with 4 slender setae and 1 small broom seta. Dactylus length 4 times width, mediodistally with 3 small slender seta. Unguis (claw) of 1 conate seta, 2 slender setae inserting ventrally. *Pereopod V*: Similar to pereopod VI and VII. Basis length 4 times width, marginally with 3 simple slender setae and 3 broom setae. Ischium length 2.64 width, dorsally with 4 slender setae, ventrally with 2 small slender setae. Merus length 1.89 width, 1 small slender seta distodorsally and 1 small slender seta distolaterally. Carpus length 3 times width, ventrally with row of 5 long slender setae, and distodorsally 1 small broom seta. Propodus length 3.4 width, ventrally with a row of 6 long slender setae, dorsally with 7 long slender setae and 2 unequally bifid setae (1 midway, 1 distally). Dactylus length 4 times width, mediodistally with 3 small slender setae, unguis (claw) of 1 long conate seta, 2 slender setae inserting ventrally.

Pleopod 1: Length 2.04 width. Outer margins straight, terminal margin rounded, with 3 small setae on each side. *Pleopod 2*: Sympod oval-shaped, length 2.24 width. Outer margin distally with 1 small seta. Endopod inserting 0.56 of sympod length. *Pleopod 3*: Endopod length 1.4 width, distally with 3 long plumose setae. Exopod length 0.52 of endopod length, terminally tapering, with 1 simple seta, outer margin hirsute. *Pleopod 4*: Endopod oval-shaped, length 1.92 width. Exopod missing.

Uropods: Uniramous. Endopod length 2.33 protopod length, 3.5 times longer than wide, distally with 3 broom setae, 1 small seta and 4 slender setae. Protopod length 1.5 width, with 3 simple slender setae.

Etymology. Nowrae (Lat.) means "from Nowra". The name refers to the sampling area on the southern Australian continental slope 65 km E of Nowra.

Distribution. Off NSW, Australia.

Discussion. Oecidiobranchus nowrae sp. nov. is assigned to the genus *Oecidiobranchus* Hessler, 1970 on the basis of the small and rounded breathing chamber. The male of the new species differs from the other two species of the genus in the characters of pereopod I. Unlike *O. plebejum* Hansen, 1916 and *O. nanseni* Just, 1980, *O. nowrae* possesses a ventral row of distally setulate seta on the carpus. Furthermore, the new species possesses posterolateral spines at the pleotelson. Neither *O. plebejum*, nor *O. nanseni* possess posterolateral spines at the pleotelson.

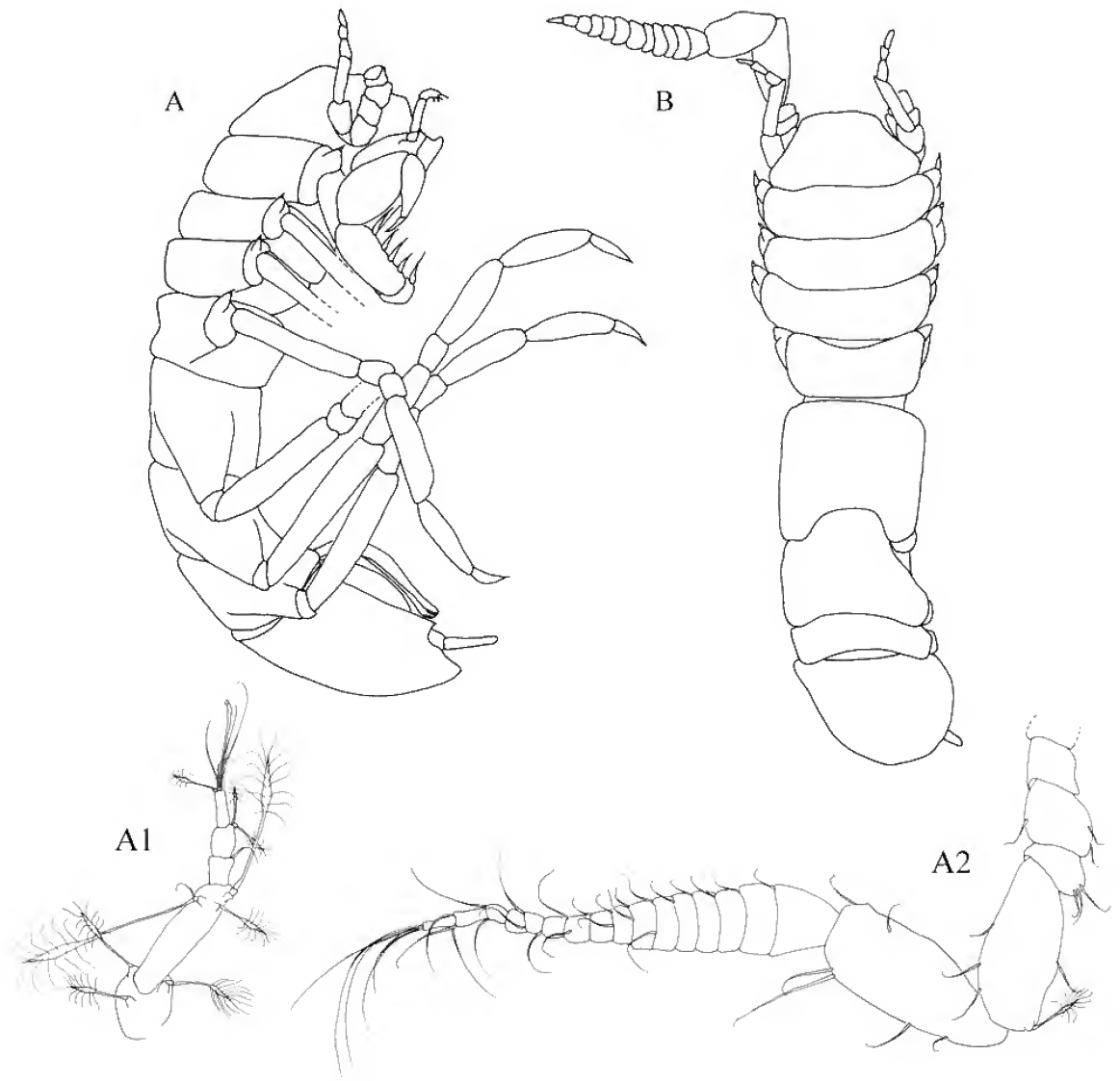

Figure 8. *Oecidiobranchus nowrae* sp. nov. Holotype male. NMV J18606. (A) Lateral and (B) dorsal views, antennae.

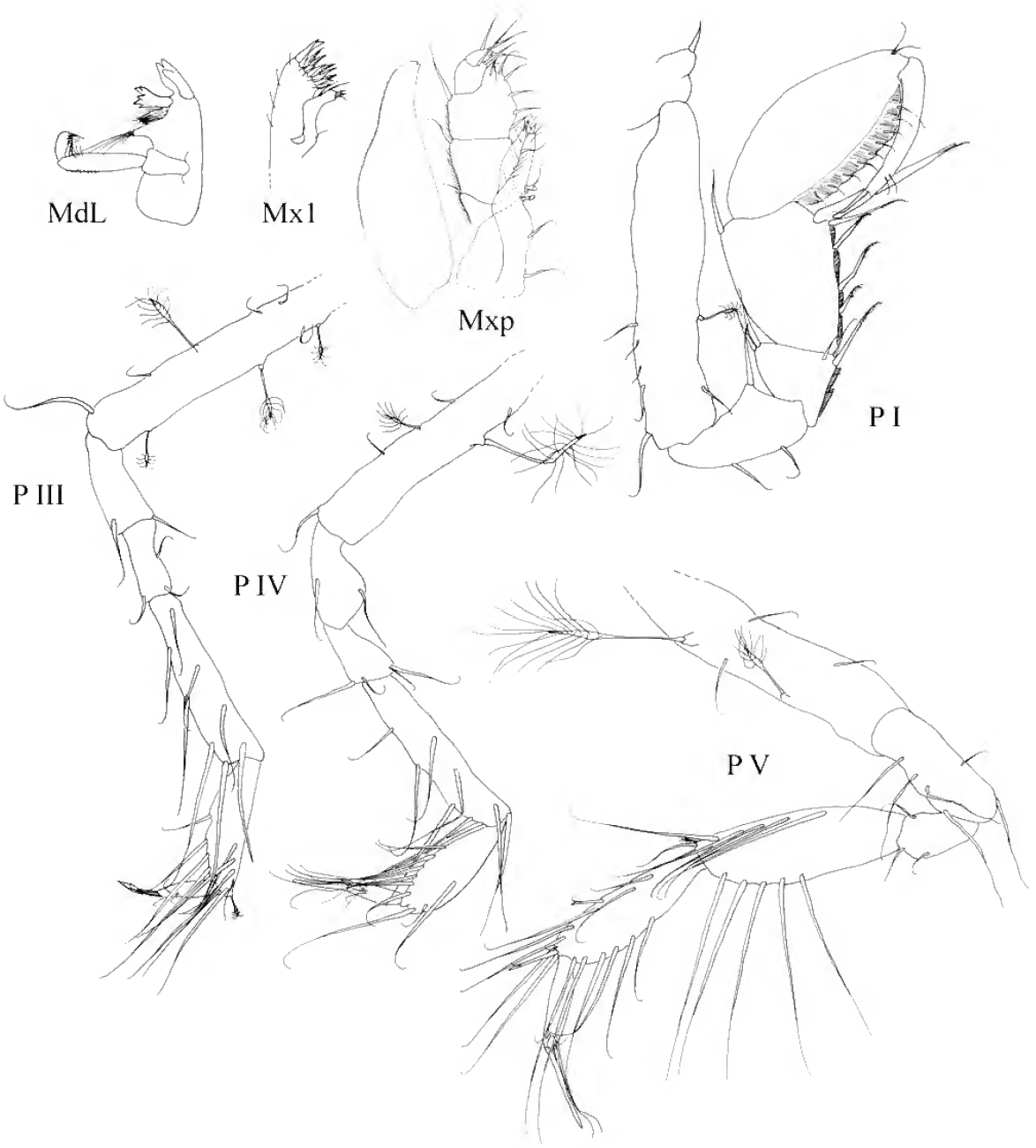

Figure 9. *Oecidiobranchus nowrae* sp. nov. Holotype male. NMV J18606. Mouthparts, pereopods I–V.

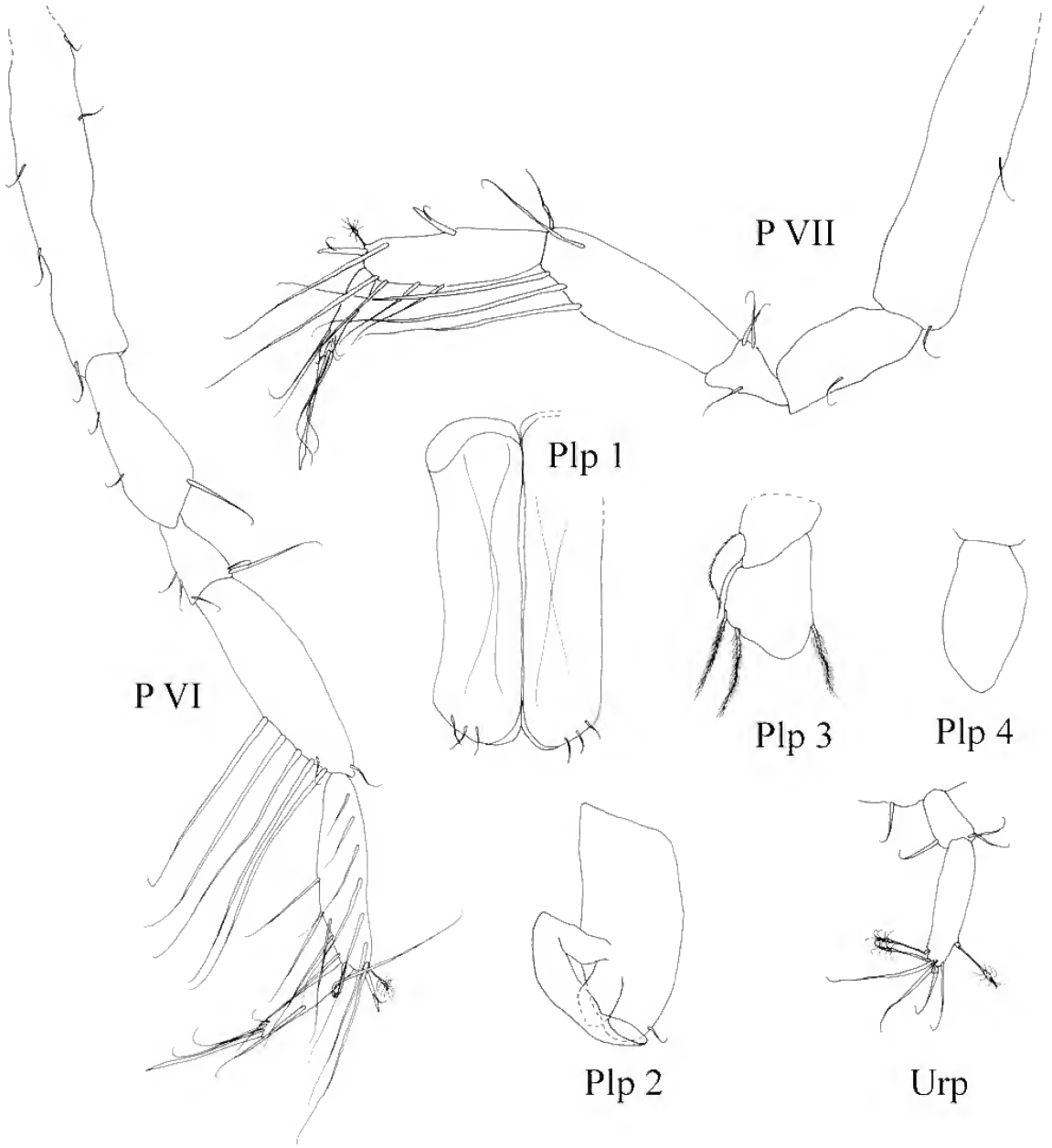

Figure 10. *Oecidiobranchus nowrae* sp. nov. Holotype male. NMV J18606. Pereopods VI and PVII, pleopods (Plp 1, 2, 3, 4, Urp).

Disparella kensleyi sp. nov.

Figures 11–14

Material examined. Holotype. Female, preparatory, 1.9 mm; NMV J18605; Type locality. - Australia, NSW, 74 km E of Nowra (34°56.11'S, 151°28.06'E), 3150 m, box corer, G.C.B. Poore et al, RV *Franklin*, 23 Oct 1988 (stn. SLOPE 64).

Diagnosis. Body length 3.98 times longer than width of pereonite 2. Pereonite 1 length 1.05 pereonite 2 length, 0.93 pereonite 2 width. Pereonite 5 with spine-like ventral elongation. Cephalon with 1 short anteriorly directed spine at insertion of antennae. Palp of mandible of 2 articles, article 1 with 1 small seta, article 2 terminally with 1 small seta. Incisior process with 4 teeth. Lacinia mobilis of left mandible with 4 teeth. Carpus of pereopod I length 5 times width, with ventral row of 5 long unequally bifid setae increasing in length towards the propodus and 3 setal combs inserted in a cuticular membrane, dorsally with 2 long simple setae. Pleotelson with posterolateral spines. Distal margin of operculum slightly concave, with 6 slender setae. Uropods biramous, exopod length 0.43 endopod length.

Description. *Habitus*: body 1.9 mm long (measured without appendages), 3.98 times longer than width of pereonite 2. Pereonite 5 with spine-like ventral elongation. Cephalon with 1 short anteriorly directed spine at insertion of antennae. Pereonite 1 slightly wider than cephalon. Pereonite 1 length 1.05 pereonite 2 length, 0.93 pereonite 2 width. Pereonite 5 anterior margin straight, lateral margins slightly concave. Coxae 1–4 produced, tipped with small stout setae. Pleotelson length 0.71 width, posterolateral spines present, lateral margins convex, posterior margin rounded.

Antennula: 0.3 mm long, length 0.16 body length, with 5 articles. Article 1 with 3 small broom setae. Article 2 length 3.83 width, 1.64 article 1 length; distally with 2 large articulated broom setae. Article 3 with 1 small slender seta, article 4 distally with 2 small broom setae, distal article terminally with 1 aesthetasc, 1 broom seta and 2 long slender setae. *Antenna*: About 1.1 mm long, length 0.58 body length, with about 12 articles (broken off after article 12). Article 3 with 2 small slender setae. Article 4 with 2 slender setae. Article 5 with 3 small slender setae. Article 6 marginally with 2 and distally with 3 slender setae. Flagellar articles 1–3 distally with 2 slender setae, following articles with long slender setae.

Mandible: Palp of 2 articles, article 1 with 1 small seta, article 2 terminally with 1 small seta. Incisior process with 4 teeth. Lacinia mobilis of left mandible with 4 teeth, lacinia mobilis of right mandible triangular and distally serrated (5 small teeth). Spine row containing 3 spines. Molar process with 7 setae. *Maxillula*: Inner lobe smaller than outer lobe (0.71 of outer lobe length), terminally with 5 setae. Outer lobe 5 times longer than wide, marginally with 3 pairs of fine setae, terminally with 9 strong spines and 4 simple setae. *Maxilla:* Not dissected from specimen. *Maxilliped*: Epipodite length 3.13 width, length similar endite length. Endite with 2 coupling hooks, terminally with 2 conate setae and 5 small setae, marginally few fine setae. Outer edge of endite and palp articles 1 and 2 with row of fine setae and 1 small seta on distal corners, inner margin of article 3 with 5 setae, outer margin with 1 seta, article 4 with 3 setae, article 5 with 2 setae. Article 1 length 0.6 width, article 2 length 0.93 width, article 3 length 1.07 width, article 4 length 2.5 width, article 5 length 3 times width.

Pereopod I: Basis length 4.04 width, proximal to ischium ventrally 1 long simple seta. Ischium length 0.63 width, ventrally 1 small slender seta. Merus length 0.71 width, dorsally 2 robust simple setae, ventrally 1 seta (broken off). Carpus length 1.43 width, ventrodistally with large claw-seta and slender proximal seta, ventrally 1 small seta midway. Propodus length 3.47 width, ventrally fringed with fine setae and row of 12 small setae inserted in a cuticular membrane. Dactylus length 7.6 width, mediodistally 1 small seta. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod II*: Similar to pereopod III and pereopod IV. Basis length 6.33 width, marginally with few simple setae and 1 small broom seta, proximal to ischium ventrally with 1 long simple seta. Ischium length 2.62 width, distodorsally with 1 seta, ventrally 1 seta midway. Merus length 1.45 width, distoventrally with 1 stout unequally bifid seta and 2 small slender setae, distodorsally 1 composed seta. Carpus length 5 times width, with ventral row of 5 long unequally bifid setae increasing in length towards the propodus and 3 setal combs inserted in a cuticular membrane, dorsally with 2 long simple setae. Propodus length 5.38 width, ventrally with 1 small slender seta midway, fringed with fine setae, dorsally 2 long simple setae and distally 1 small broom seta. Dactylus length 6.67 width, mediodistally 2 small setae. Unguis (claw) of dactylus with 1 conate seta, 2 slender setae ventrally. *Pereopod V*: Similar to pereopod VI and pereopod VII. Basis length 6.30 width, marginally with 1 small and 2 broom setae. Ischium length 4.10 width. Merus length 1.60 width, with 3 slender setae. Carpus length 4.80 width, with ventral row of 5 long slender setae and dorsally 2 long setae (broken off), distally 1 small slender seta and 1 small broom seta. Propodus length 4.13 width, ventrally with 1 small seta and 3 long slender setae, dorsally with 2 slender setae. Dactylus length 7.60 width, mediodistally 3 small setae, unguis (claw) of 1 long conate seta, 2 slender setae inserting ventrally.

Pleopod 2 (operculum): Length 1.19 width. Lateral margins slightly convex, distal margin slightly concave, distal margin with 6 slender setae. *Pleopod 3*: Endopod length 1.44 width, distally with 3 long plumose setae. Exopod length 0.74 of endopod length, with 1 small terminal seta, outer margin hirsute. *Pleopod 4*: Endopod length 2.66 width. Exopod length 8 times width, distally with 1 long plumose seta.

Uropods: Biramous. Endopod length 3.5 protopod length, 4.66 times longer than wide, distally with 5 broom setae, 2 small slender setae and 2 long slender setae. Exopod length 0.43 endopod length, 4 times width, terminally with 2 slender setae. Protopod length similar width, with 1 slender seta.

Etymology. The name is in remembrance of Dr Brian Kensley.

Distribution. Off NSW, Australia.

Discussion. *Disparella kensleyi* sp. nov. shows affinity to species of *Chelator* and *Prochelator* Hessler, 1970. The chela of the new species is similar to the chela as found in *Chelator* (ventral margin of carpus with small setae only), but *Chelator*

species possess uniramous uropods and a lacinia mobilis with three teeth. A single midventral seta on the carpus together with the claw-seta and the penultimate slender seta is also known for the genus *Prochelator* but in *Prochelator* species the midventral seta is always of composed setal type. Due to the anteriorly directed spine at the antennular folds, which is known for all species of *Disparella*, and the biramous uropods, *D. kensleyi* fits best into *Disparella*. It is distinguished from the other members of the genus by the spine-like ventral elongation at pereonite 5 and the single small midventral seta on the carpus of pereopod I together with the claw-seta and the penultimate slender seta.

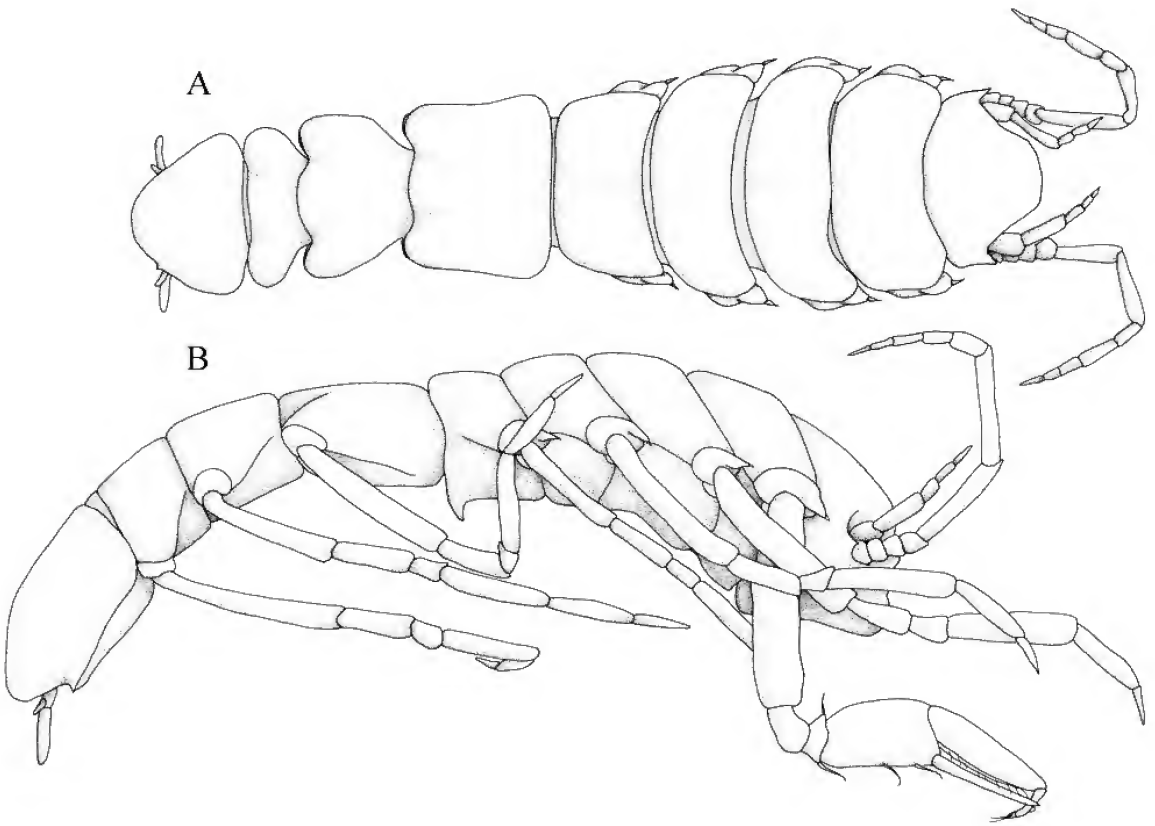

Figure 11. *Disparella kensleyi* sp. nov. Holotype female. NMV J18605. (A) Dorsal and (B) lateral views.

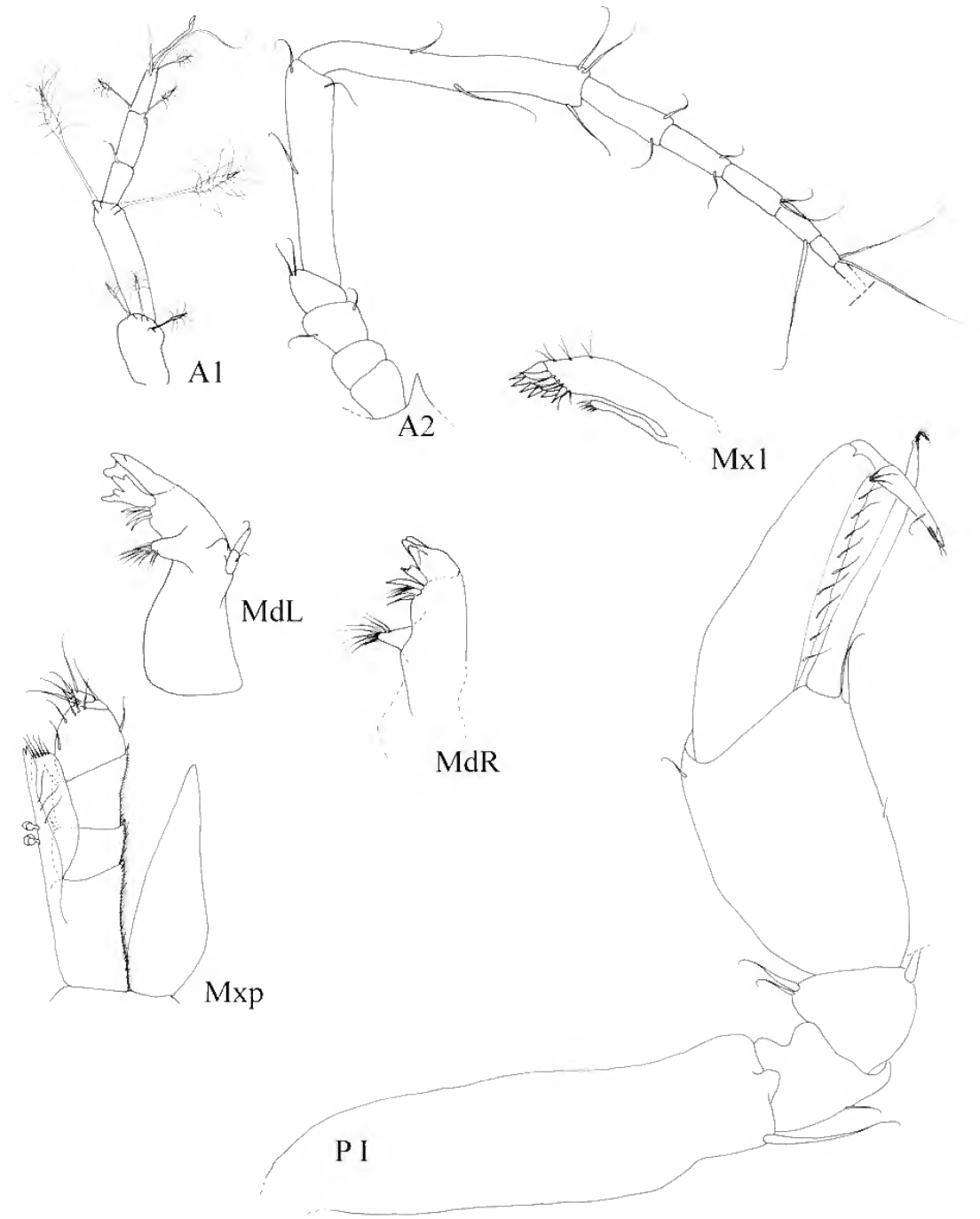

Figure 12. *Disparella kensleyi* sp. nov. Holotype female. NMV J18605. Antennae, mouthparts, pereopod I.

Figure 13. *Disparella kensleyi* sp.nov. Holotype female. NMV J18605. Pereopods II–V.

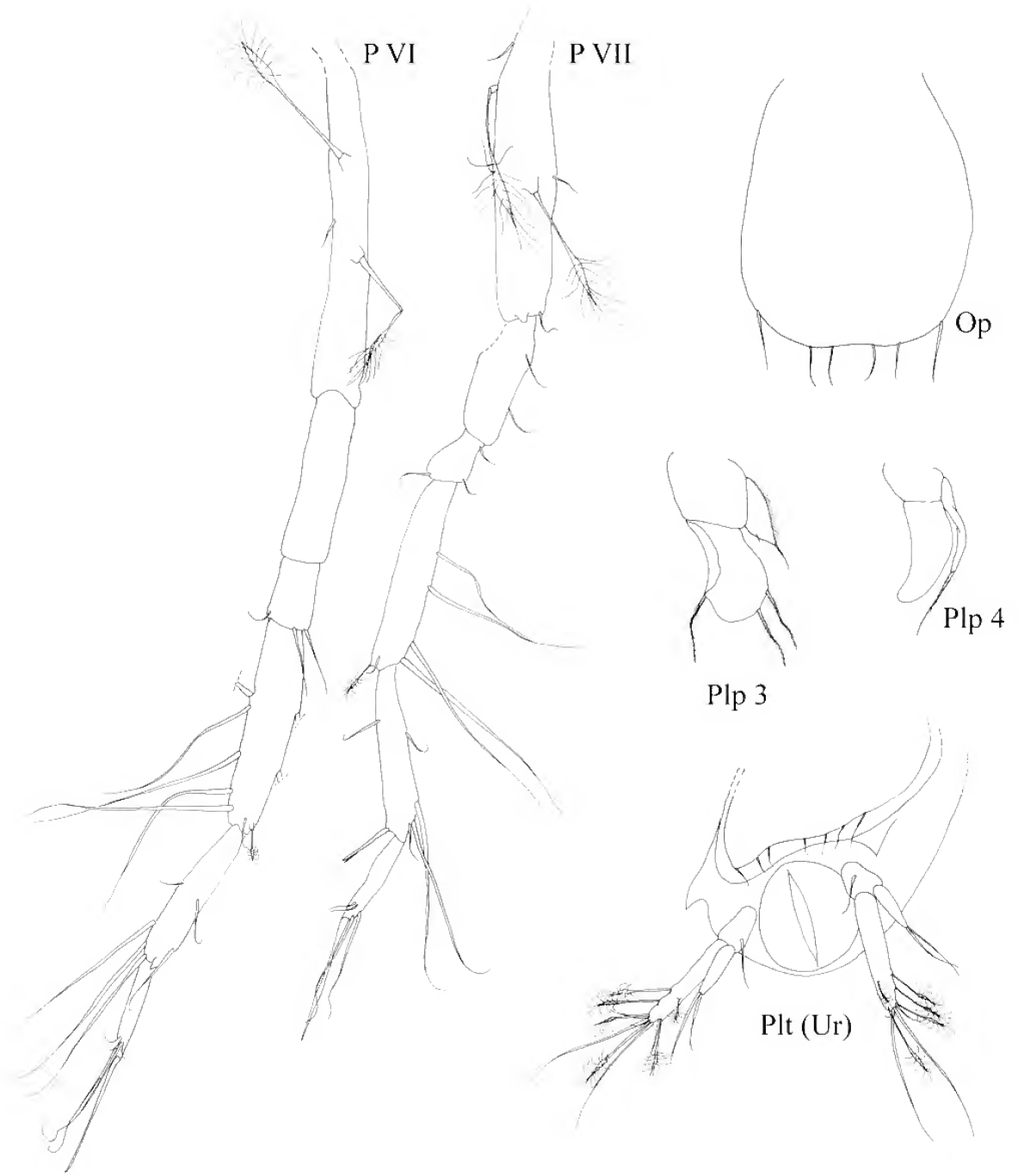

Figure 14. *Disparella kensleyi* sp. nov. Holotype female. NMV J18605. Pereopods VI and VII, pleopods (Op, Plp 3, 4) and pleotelson ventral view.

Echinopleura cephalomagna sp. nov.

Figures 15–18

Material examined. Holotype. Female, preparatory, 1.8 mm; NMV J18600 Australia, Vic., S of Point Hicks (38°17.70'S, 149°11.30'E), 400 m depth, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 24 Jul 1986 (stn. SLOPE 40).

Paratypes. 1 female, adult, 2.2 mm; NMV J18601; locality. - Australia, NSW, 54 km ESE of Nowra (34°52.72'S, 151°15.04'E), 996–990 m, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 22 Oct 1988 (stn. SLOPE 53). 1 female, preparatory; 2.1 mm; NMV J53074. Australia, NSW, 54 km ESE of Nowra (34°52.72'S, 151°15.04'E), 996–990 m, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 22 Oct 1988 (stn. SLOPE 53).

Diagnosis. Body length 3.20 times longer than width of pereonite 2. Cephalothorax highest part of body from lateral view. Pereonite 1 slightly smaller than pereonite 2. Lateral margins of pereonite 5, 6 and 7 as well as of pleotelson serrated. Incisior process with 1 rounded tooth. Lacinia mobilis of left mandible represented by 1 small bulge-like tooth.

Description. *Habitus*: body 2.2 mm long (measured without appendages), 3.20 times longer than width of pereonite 2. Cephalothorax highest part of body from lateral view. Pereonite 1 width 1.16 times cephalon width in dorsal view. Pereonite 1 length 0.94 pereonite 2 length, 0.91 pereonite 2 width. Pereonite 5 width 0.67 length, anterior margin straight, lateral margins serrated. Coxae 1–4 produced, tipped with small stout setae. Pleotelson length 1.06 width, lateral margins serrated, lightly convex, posterior margin smooth, rounded.

Antennula: 0.27 mm long, length 0.12 body length, with 6 articles. Article 1 with 1 small slender seta and 3 broom setae. Article 2 length 2.57 width, 0.69 article 1 length; distally with 4 articulated broom setae. Article 3 with 1 small seta, article 4 distally with 2 broom setae, distal article with 1 aesthetasc and 4 slender setae. *Antenna* (fig. 12): broken off.

Mandible: Article 1 of palp distally with 1 slender seta, article 2 distoventrally with 2 small setae, fringed with rows of fine setae, article 3 with 4 small and distally 1 setulate seta. Incisor process with 1 rounded tooth. Lacinia mobilis of left mandible represented by 1 small bulge-like tooth. Lacinia mobilis absent at right mandible. Spine row containing 9 spines. Molar process with 10 setae. *Maxillula*: Inner lobe smaller than outer lobe (0.63 of outer lobe length), distally with 7 simple setae, dorsally with 12 fine setae and ventrally with 5 pairs of fine setae. Outer lobe marginally with 21 pairs of fine setae, terminally with 11 strong spines (7 spines with setules). *Maxilla* (fig. 12): Medial lobe broader than other lobes, terminally with 3 slender setae, ventrolaterally with 12 setae, setae near base longest. Outer lobe dorsally with 8 pairs of fine setae, terminally with 3 long ventrally setulate setae. *Maxilliped* (fig. 12): Epipodite length 3.08 width, length similar endite length. Endite with 2 coupling hooks, terminally with 1 fan seta and numerous fine setae, marginally with pairs of fine setae. Edge of endite fringed with fine setae, palp article 1 with 2 setae on outer margin, article 2 with 3 setae on outer margin and 3 setae on inner margin, article 3 with 7 setae on inner margin, article 4 with 4 setae, article 5 with 3 setae. Article 1 length 0.91 width, article 2 length 0.89 width, article 3 length 1.11 width, article 4 length 1.6 width, article 5 length 2.67 width.

Pereopod I: Basis length 5.94 width, marginally with 14 setae. Ischium length 3.17 width, ventrally with 7 small slender setae, dorsally with 2 simple slender setae. Merus length 1.18 width, ventrally with a row of 4 simple setae, distodorsally with 1 seta (broken off). Carpus length 3.20 width, ventrally with dorsal row of 7 setae, distal and penultimate seta longest, distally setulate, dorsally with 3 small slender setae. Propodus length 8.00 times width, with few setae distally. Dactylus length 4.20 width, mediodistally 3 small setae. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod II*: Similar to pereopod III. Basis length 4.00 times width, marginally with 27 small setae, proximal to ischium ventrally 1 long simple seta. Ischium length 3.13 width, ventrally 16 simple seta, dorsally 4 simple setae. Merus length 1.38 width, ventrally with row of 6 setae, distodorsally 2 simple setae. Carpus length 3.57 width, with ventral row 11 long unequally bifid setae increasing in length towards the propodus, dorsolaterally with row of 11 long simple setae, dorsally with 6 small slender setae. Propodus length 2.70 times width, ventrally with 1 small slender seta, 2 small stout unequally bifid setae and 2 setal combs inserted in a cuticular membrane, dorsally with row of 8 long simple setae. Dactylus length 2.50 width, mediodistally 3 small setae. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod VI*: Similar to pereopod VII, pereopod V missing from specimen. Basis length 4.19 width, with 2 large broom setae, marginally with 13 small setae. Ischium length 3.39 width, laterally with 9 small setae, dorsally with 6 slender setae. Merus length 1.38 width, ventrally with 3 small slender setae. Dorsally with 1 small seta and 1 long simple seta. Carpus length 4.11 width, ventrally with row of 12 long slender setae, dorsally with row of 9 slender setae and 4 small setae. Propodus length 3.79 width, ventrally with row of 5 long slender setae, dorsally with row of 6 setae. Dactylus length 8.50 width, distally with 1 slender seta, unguis (claw) of 1 long conate seta, 2 slender setae inserting ventrally.

Pleopod 2 (operculum): Length 1.37 width. Lateral margins straight, operculum tapering towards distal tip, setose (ventral surface with about 34 setae), marginally with 58 setae. *Pleopod 3*: Endopod length 1.8 width, distally with 3 long plumose setae. Exopod length 0.44 of endopod length, margins hirsute, distally with 1 simple seta. *Pleopod 4*: Endopod oval-shaped, length 2 times width. Exopod length 7.80 width, distally 1 long plumose seta.

Uropods: Uniramous. Endopod length 2.04 protopod length, 8.17 times longer than wide, marginally with 6 slender setae, distally with 5 long slender setae, 2 small setae and 5 broom setae. Protopod length 1.85 width, with 12 setae.

Etymology. The name refers to the extremely large cephalothorax of the new species.

Distribution. South-eastern Australia, off Vic.

Discussion. *Echinopleura cephalomagna* sp. nov. is the second species of the genus *Echinopleura* Sars, 1897. It belongs to this genus because of the slender pereopod I and the features of the

mandible and the serrated body margins from pereonite 5 to the pleotelson. The simplified mandible is unique to *Echinopleura*. The new species is easy to distinguish from the only other species, *E. aculeata* Sars, 1897, by the presence of a well developed mandibular palp. In *E. aculeata* the whole body is serrated, even the cephalon and the coxae. *E. aculeata* possesses a dorsal hook on the ischium of pereopod II, *E. cephalomagna* lacks this hook. While the antennula of *E. aculeata* consists of five articles, the antennula of *E. cephalomagna* consists of six articles.

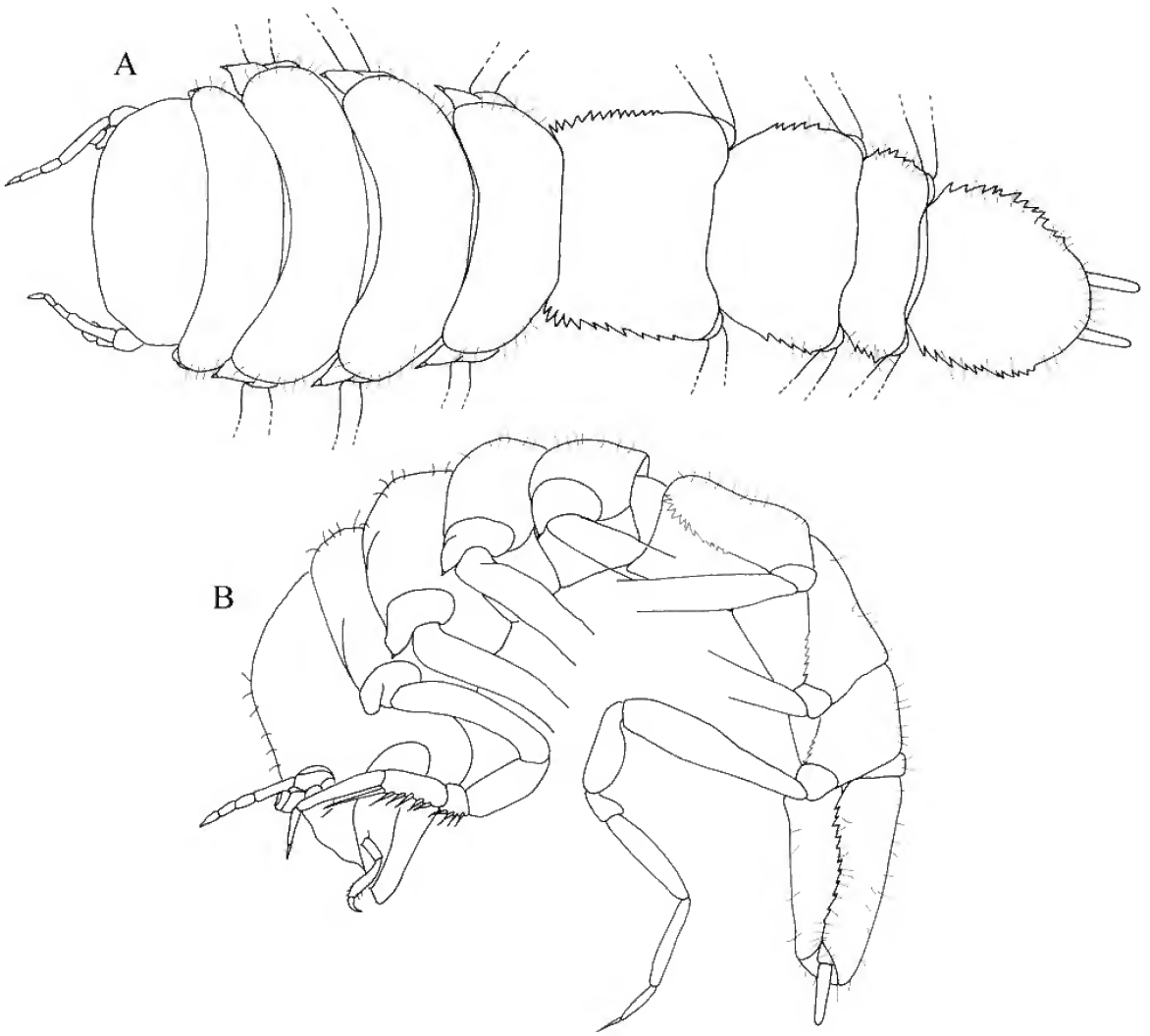

Figure 15. *Echinopleura cephalomagna* sp. nov. Holotype female. NMV J18600. (A) Dorsal and (B) lateral views.

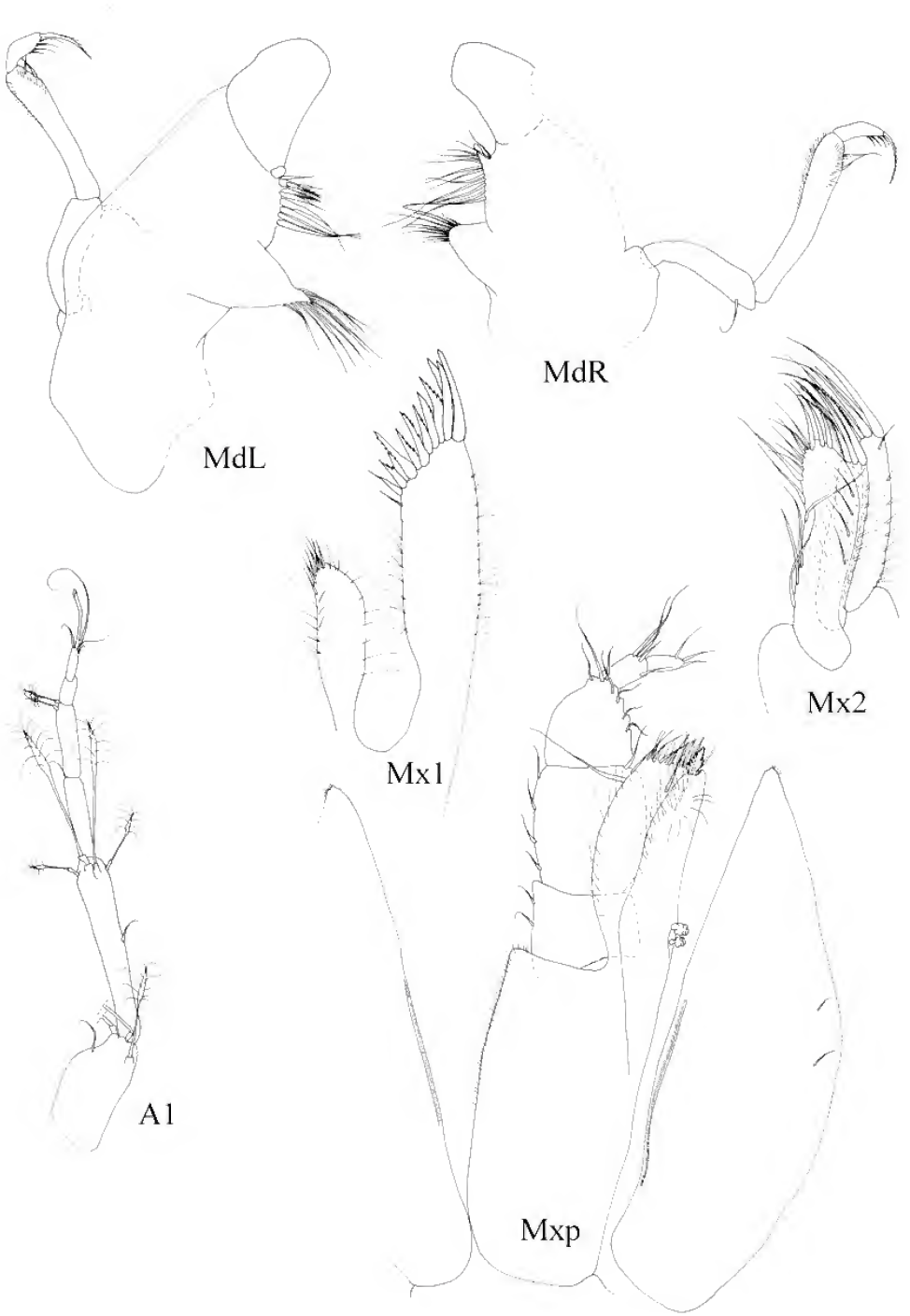

Figure 16. *Echinopleura cephalomagna* sp. nov. Paratype female. NMV J18601. Antennula, mouthparts.

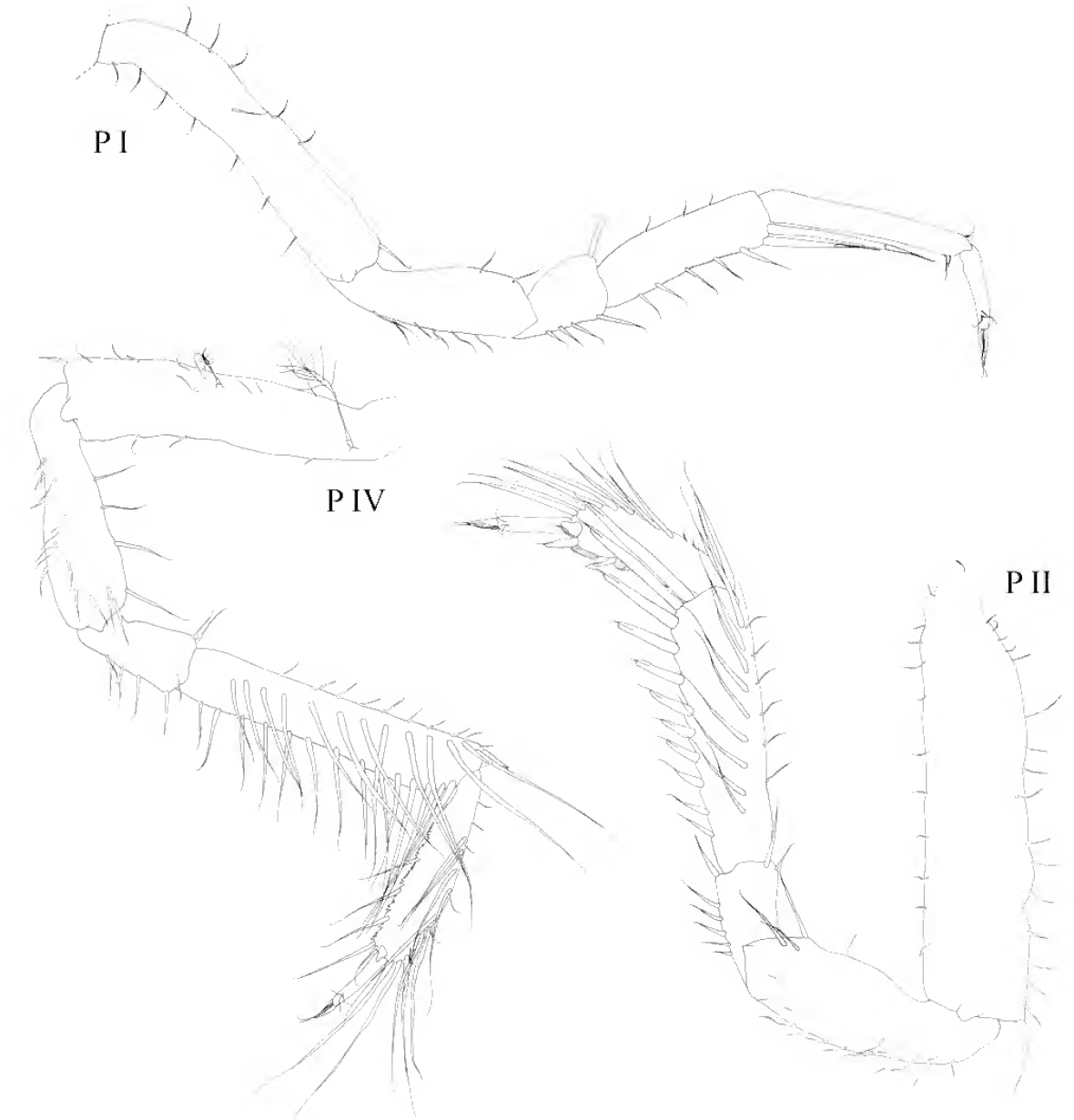

Figure 17. *Echinopleura chephalomagna* sp. nov. Paratype female. NMV J18601. Anterior pereopods.

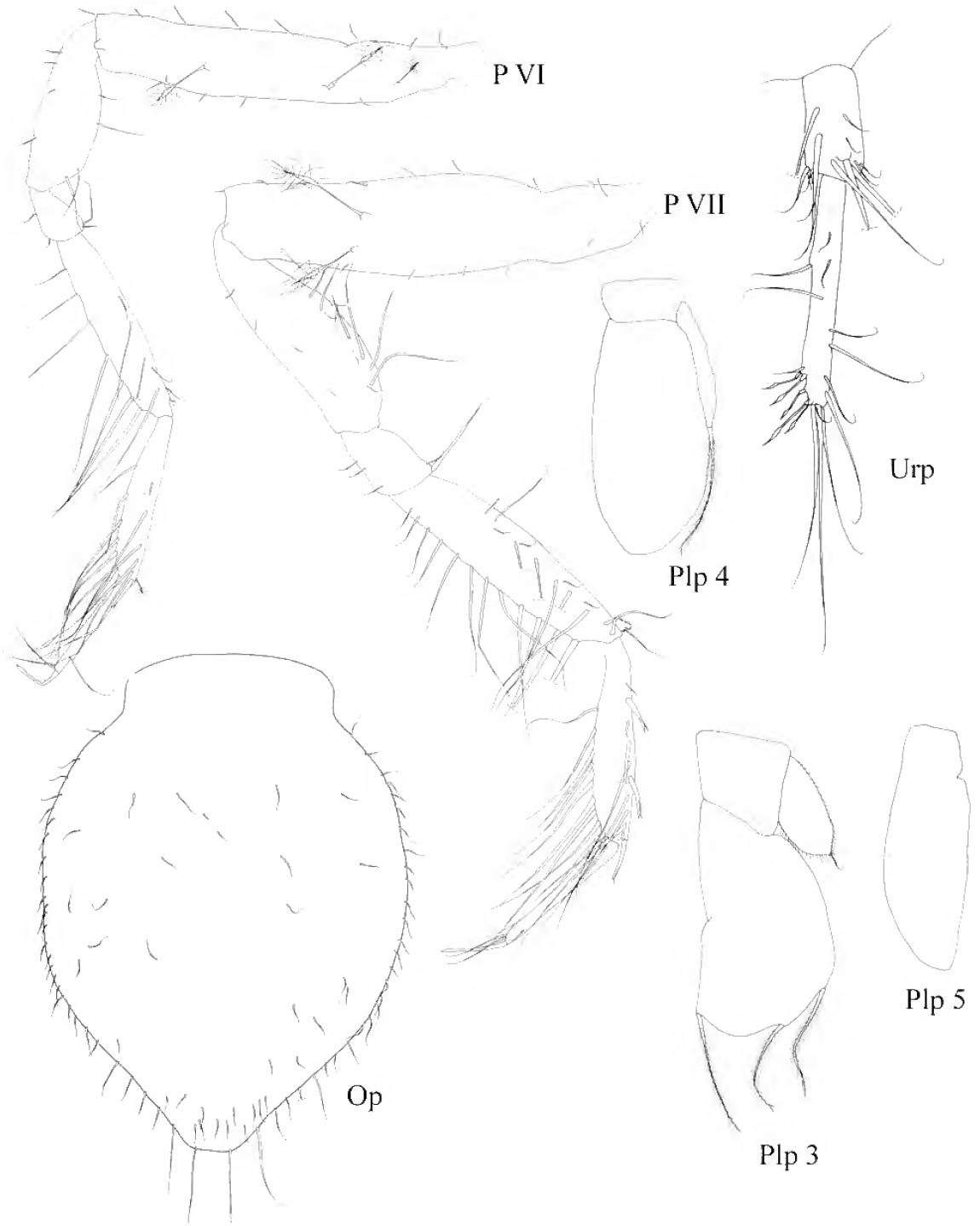

Figure 18. *Echinopleura cephalomagna* sp. nov. Paratype female. NMV J18601. Posterior pereopods, pleopods (Op, Plp 3, Plp 4, Plp 5, Urp).

Whoia victoriensis sp. nov.

Figures 19–23

Material examined. Holotype. Female, preparatory, 1.6 mm NMV J18598; Type locality. – Australia, Vic., 76 km S of Point Hicks (38°29.33'S, 149°19.98'E), 1840–1750 m depth, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 26 Oct 1988 (stn SLOPE 69).

Paratype. Female, preparatory, 1.5 mm NMV J18599. Australia, Vic., 67 km S of Point Hicks (38°23.95'S, 149°17.02'E), 1277–1119 m depth, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 25 Oct 1988 (stn. SLOPE 67).

Diagnosis. Body length 4 times longer than width of pereonite 2. Pereonite 1 slightly smaller than pereonite 2. Pereonite 5 anterior margin straight, lateral margins straight. Antennula with 6 articles. Incisor process with 2 teeth. Lacinia mobilis of left mandible with 1 tooth. Coxae 1–4 angular, coxa 1 with small stout seta, 2–4 without setae. Ischium, merus and carpus of anterior pereopods laterally with numerous folds in which rows of fine setae are inserted. Pereopod I and pereopod II similar in setation, carpus with ventral row of 5 large robust unequally bifid distally setulate setae increasing in length towards propodus, distal seta of row reaching full length of propodus, dorsally with a row of 5 slender distally setulate setae, propodus ventrally with 2 small stout unequally bifid setae and a row of 14 small setae inserted between them, dorsally with a row of 5 slender distally setulate setae and distally 1 small seta. Lateral margins of pleotelson hirsute, form tapering to posterior margin. Urbiramous, setose, exopod well developed (length 0.64 endopod length).

Description. *Habitus*: body 1.6 mm long (measured without appendages), 4.02 times longer than width of pereonite 2. Pereonite 1 width 1.13 times cephalon width in dorsal view. Pereonite 1 length 0.60 pereonite 2 length, 0.91 pereonite 2 width. Pereonite 5 anterior margin straight, lateral margins straight. Coxae 1–4 angular, coxa 1 with small stout seta, 2–4 without setae. Pleotelson tapering to posterior margin, length 1.19 width, without posterolateral spines, lateral margins hirsute, convex, posterior margin triangularly convex.

Antennula: Length 0.23 body length, with 6 articles. Article 1 with 1 small seta and 4 broom setae. Article 2 length 4.25 width, 1.90 article 1 length; distally with 4 articulated broom setae and 1 small seta. Article 3 with 1 small seta, article 4 with 2 slender setae and 1 small seta, article 5 with 1 slender seta, distal article terminally with 1 aesthetasc, 1 broom seta and 2 long slender setae. *Antenna*: broken off.

Mandible: 1st article of palp with 1 small seta, 2nd article ventrodistally with 2 small setulate setae, dorsally with rows of fine setae, apical article dorsally with 1 small seta and rows of fine setae, ventrally with 5 setae, distal 1 longest. Incisor process with 2 teeth. Lacinia mobilis of left mandible with 1 tooth, lacinia mobilis of right mandible of the same shape as lacinia mobilis of left mandible. Spine row containing 9 spines. Molar process with 5 finely setulate setae. *Maxillula*: Inner lobe slightly smaller than outer lobe, terminally with 7 setae, ventrally with 4 slender setae, dorsally with 5 pairs of fine setae. Outer lobe marginally with 10 pairs of fine setae, terminally with 9 strong spines (3 spines with setules). *Maxilla*: Medial lobe broader than other lobes, distally with 7 simple setae, marginally with pairs of fine setae, basally with 7 slender setae. Outer lobe terminally with 3 setae, ventrally with 3 simple setae, dorsally with fine setae. *Maxilliped*: Epipodite length 2.67 width, length 0.90 endite length. Endite with 2 coupling hooks, terminally with 1 fan seta and numerous small setae. Edge of endite and palp articles 1.3 hirsute, distal corners with 1 small seta. Article 2 inner margin with 3 setae, article 3 inner margin with 7 setae, article 4 with 4 setae, article 5 with 5 setae. Article 1 length 0.69 width, article 2 length similar to width, article 3 length 0.79 width, article 4 length 1.8 width, article 5 length 4 times width.

Pereopod I: Basis length 2.28 width, with few small setae and proximal to ischium ventrally with 1 long simple seta. Ischium length 2.14 width, ventrally with 3 slender distally setulate setae and 2 robust unequally bifid distally setulate setae, dorsally with 3 slender distally setulate setae. Ischium, merus and carpus laterally with numerous folds in which rows of fine setae are inserted. Merus length 0.42 width, ventrally with 3 robust stout unequally bifid distally setulate setae, distodorsally 1 simple slender seta and 1 robust unequally bifid distally setulate seta. Carpus length 1.96 width, with ventral row of 5 large robust unequally bifid distally setulate setae increasing in length toward propodus, distal seta of row reaching full length of propodus, dorsally with a row of 5 slender distally setulate setae. Propodus length 2.69 width, ventrally with 2 small stout unequally bifid setae and a row of 14 small setae inserted between them, dorsally with a row of 5 slender distally setulate setae and distally 1 small seta. Dactylus length 4.13 width, mediodistally with 3 small setae, unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod II*: In setation similar to pereopod I. Difference in length-to-width ratios: basis length 1.90 width, ischium length 2.10 width, merus length 0.35 width, carpus length 1.93 width, propodus length 2.94 width, dactylus length 3.43 width. Unguis (claw) of dactylus with 1 cuspidate and 1 conate seta, 2 slender setae medially. *Pereopod VII*: Similar to pereopod V and pereopod VI. Basis length 3.06 width, with few setae. Ischium length 2.19 width, ventrally with 3 small slender setae. Merus length 0.73 width, distodorsally 1 simple slender seta, ventrally 1 small and 1 simple slender seta. Carpus length 2.58 width, ventrally with row of 9 long slender distally setulate setae, dorsally with a row of 11 long slender distally setulate setae. Propodus length 3.79 width, ventrally with row of 4 long slender distally setulate setae, dorsally with row of 10 long slender distally setulate setae and 2 small unequally bifid setae, 1 midway, 1 distally. Dactylus length 4.2 width, unguis (claw) of 1 conate seta, 1 slender seta inserted ventrally.

Pleopod 2 (operculum): Length 1.16 width. Surrounded by 64 setae, lateral margins slightly convex, distal margin straight. *Pleopod 3*: Endopod length 1.62 width, inner margin hirsute, distally with 3 long plumose setae. Exopod length 0.41 of endopod length, outer margin hirsute, distally 1 slender seta. *Pleopod 4*: Endopod oval-shaped, length 1.91 width. Exopod length 7.5 width, outer margin basally hirsute, distally with 1 long plumose seta. *Pleopod 5*: Endopod only, length 4.18 width.

Uropods: Biramous. Endopod length 2.64 protopod length, 5.50 times longer than wide, marginally with 6 small broom setae and 2 simple slender setae, distally with 2 broom setae, 1

small slender seta and 5 long slender setae. Exopod length 0.64 endopod length, 7 times width with marginally 2 simple slender setae, distally with 5 long slender setae. Protopod length 1.39 width, with 2 small slender setae and 4 long simple slender setae.

Etymology. The name refers to the state Victoria in Australia.

Distribution. South-eastern Australia, off Vic.

Discussion. The new species is assigned to the genus *Whoia* Hessler, 1970 because of its robust pereopod I with nearly quadrangular articles and the similar size and shape of pereopods I and II. *Whoia victoriensis* sp. nov. is in regard to the body shape most similar to *W. angusta* Sars, 1899. Characters distinguishing the new species from the other three species of the genus are: lacinia mobilis only one tooth, pereopod I with rows of extremely robust ventral setae on carpus and propodus, propodus dorsally with row of setae, uropods biramous, exopod well developed, reaching more than half of endopod length. The new species shares an antennula consisting of six articles with *W. dumbshafensis* Svavarsson, 1988, in *W. variabilis* Hessler, 1970 and *W. angusta* the antennula has five articles. In *W. angusta* the lacinia mobilis has four teeth and the lateral margins of pereonite 5 are straight. In *W. variabilis* the uropodal exopod is much smaller than in *W. victoriensis* sp. nov and the uropods are less setose, pereopod I does not bear large robust setae, the lacinia mobilis has four teeth. The lacinia mobilis of *W. dumbshafensis* has only two teeth.

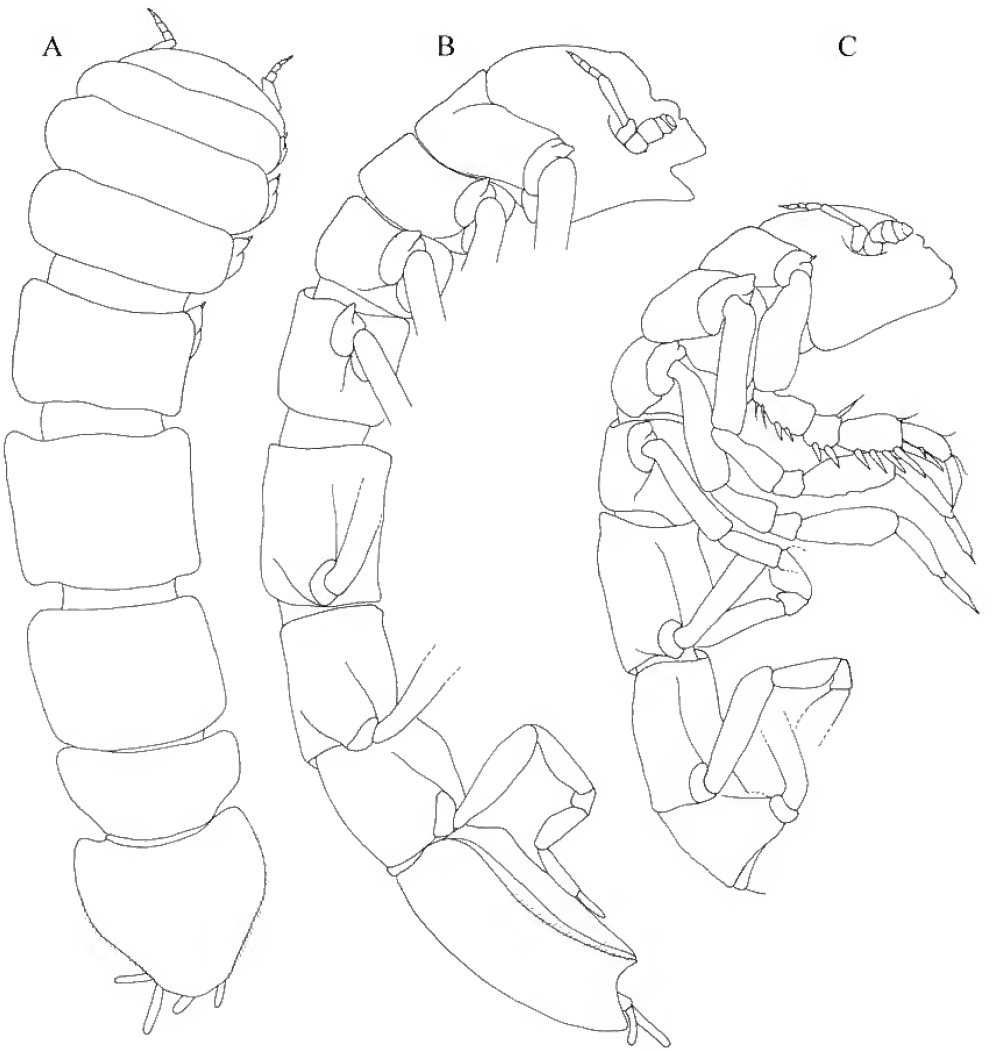

Figure 19. *Whoia victoriensis* sp. nov. Holoype female. NMV J18598. Dorsal and lateral views (A, B), paratype female, lateral view (C).

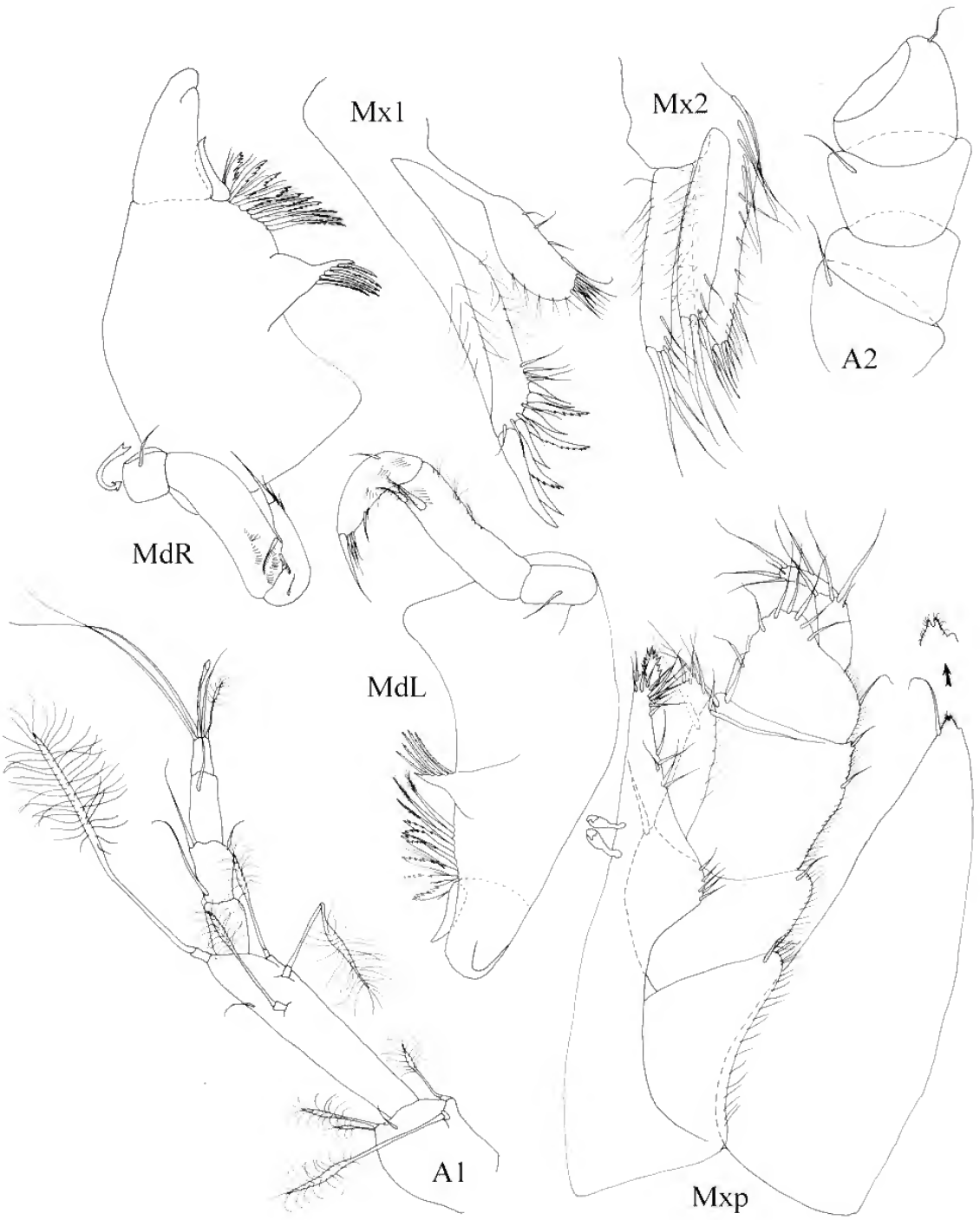

Figure 20. *Whoia victoriensis* sp. nov. Paratype female. NMV J18599. Antennae (A2 only articles 1–4), mouthparts.

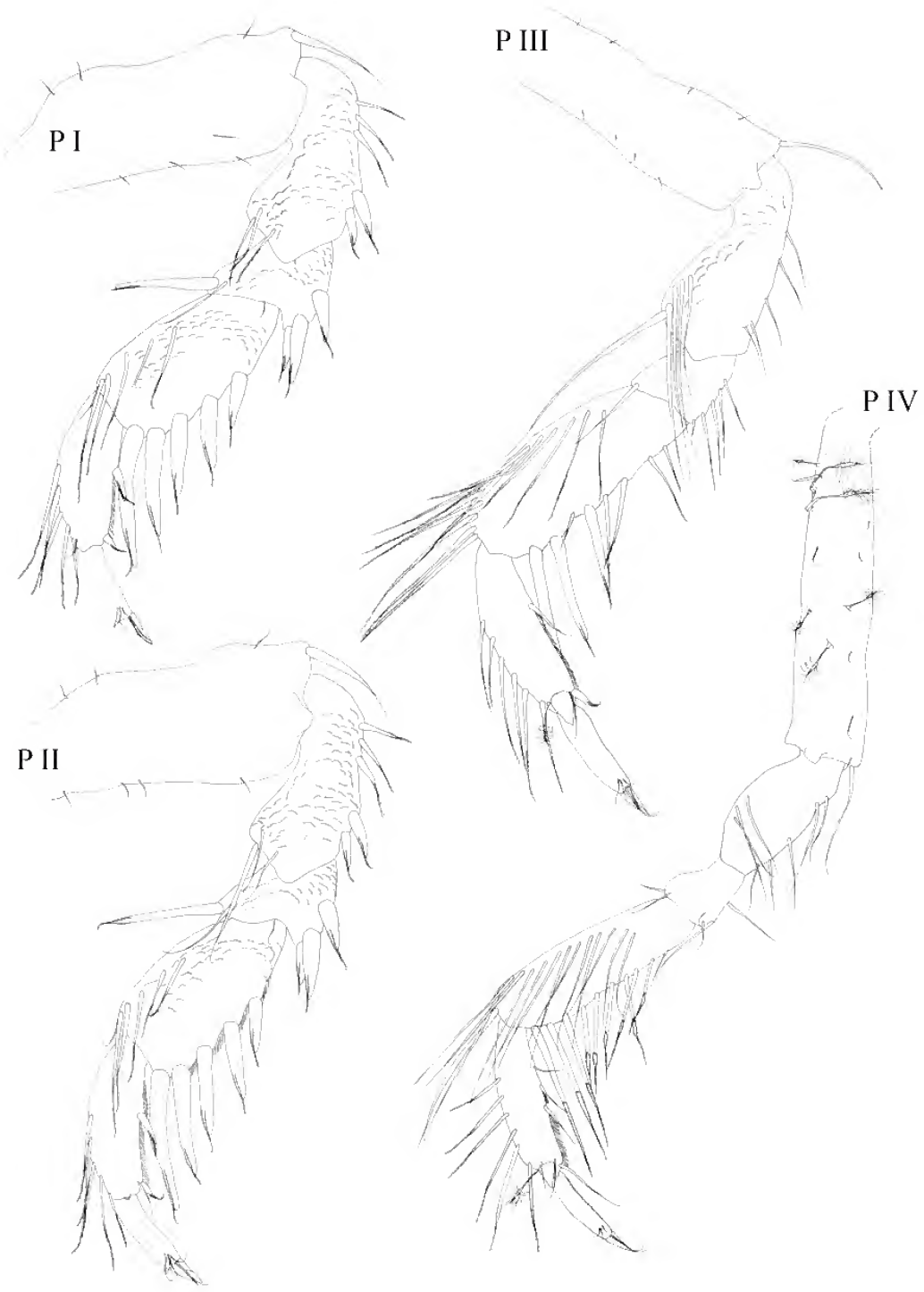

Figure 21. *Whoia victoriensis* sp. nov. Paratype female. NMV J18599. Anterior pereopods.

Figure 22. *Whoia victoriensis* sp. nov. Paratype female. NMV J18599. Posterior pereopods.

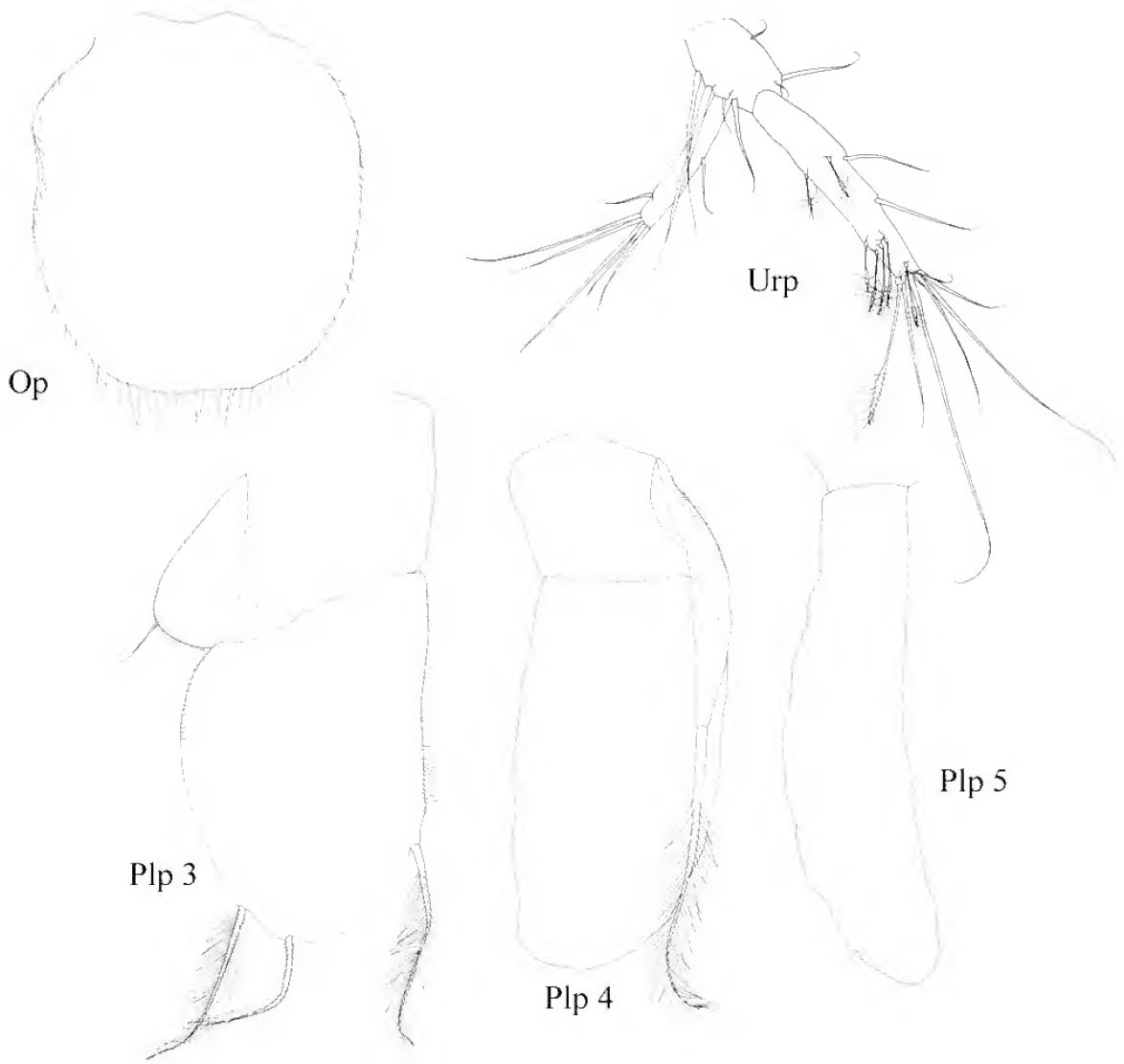

Figure 23. *Whoia victoriensis* sp. nov. Paratype female. NMV J18599. Pleopods (Op, Plp 3, Plp 4, Urp).

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A new species of *Leongathus* from the Tasman Sea collected during the 2003 NORFANZ Expedition (Crustacea: Amphipoda: Phoxocephalidae)

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Abstract Taylor, J. 2006. A new species of *Leongathus* from the Tasman Sea collected during the 2003 NORFANZ Expedition (Crustacea: Amphipoda: Phoxocephalidae). *Memoirs of Museum Victoria* 63(2): 207–213.

Leongathus Barnard & Drummond, 1978 is rediagnosed and a new species *Leongathus alannah* sp. nov. described from the Tasman Sea, collected by the 2003 NORFANZ Expedition. A discussion of the problematic placement of the new species is included in light of the new species exhibiting a combination of characters from Leongathinae and Harpiniinae.

Keywords Amphipoda, Phoxocephalidae, Harpiniinae, Leongathinae, *Harpinia, Proharpinia, Leongathus,* NORFANZ, Tasman Sea.

Introduction

A new species of phoxocephalid amphipod was discovered from 700–800 m depth in the Tasman Sea by the 2003 NORFANZ Expedition. The subfamily and generic placement of this species is unclear. It agrees with the diagnosis of the Harpiniinae Barnard and Drummond, 1978, in possessing article 2 of pereopod 5 of narrow form (3 times as long as broad), a state unique to that subfamily. On the other hand, it bears a partly trituritive molar as uniquely seen in the monotypic Leongathinae, *Leongathus nootoo* Barnard and Drummond, 1978. Using Barnard and Karaman's (1991) key to Harpiniinae, the new species keys closest to the genus *Proharpinia* Schellenberg, 1931 based on the presence of eyes, non-ensiform antenna 2, thin article 4 of pereopod 6, ovate propodus of gnathopods and presence of spines on rami of uropod 2. However, the new species differs from species belonging to *Proharpinia* by the presence of setae on the inner plate of maxilla 1, the unreduced flagellum of antenna 2, the presence of setae on epimeron 1–3, the presence of apical nails on rami of uropods and partly trituritive molar. The new species differs from the subfamily diagnosis of Leongathinae only in the presence of the narrow article 2 of pereopod 5, the harpiniin synapomorphy. It shares many characters with the monotypic *Leongathus* including the proximal confinement of the ventral setae of antenna 1 article 2, dissimilar gnathopods (gnathopod 2 enlarged) and the cryptic carpus of gnathopod 2.

This species is an example of an increasing number of new species of Phoxocephalidae that do not comply with described genera (Taylor and Poore, 2001). The problem has been overcome in the past by the publication of new genera that bear little in the way of new or advanced characters but rather a recombination of known traits. As a result, approximately half of all phoxocephalid genera are monotypic. For example, *Linca* Alonso de Pina, 1993 was erected based on a single specimen from the Argentine continental shelf and although showing some convergence with the Brolginae, its similarity to *Birubius* Barnard and Drummond, 1978 best placed it in the Birubiinae. A preliminary cladistic analysis of the Phoxocephalidae does not support the monophyly of existing subfamilies and highlights the incongruity between the phylogeny and the current generic level classification (Taylor, 2003). Many species have been given generic or subfamily status because of the few unusual traits they exhibit resulting in numerous paraphyletic taxa remaining.

Results of the preliminary cladistic analysis by Taylor, (2003) identified only one strict synapomorphy (pereopod 5 basis of narrow form) defining a clade that includes all genera of the Harpiniinae. Although further phylogenetic work that includes all species of this subfamily may indicate otherwise, results indicate that there is no cladistic support for any of the nine genera of Harpiniinae and only one, *Harpinia* can be diagnosed.

The options for the new species, described here, are: to erect a new genus of uncertain subfamily affinities on the basis of a new combination of characters (ignoring potential synapomorphies with existing genera); place it in Harpiniinae (*Proharpinia* or *Harpinia* Boeck, 1876) on the basis of shared pereopod 5; or, place it in the same genus as *Leongathus nootoo* on the basis of shared partly trituritive molar and the other characters given above. In the absence of convincing evidence one way or the other, the last strategy is followed and *Leongathus* is rediagnosed.

Abbreviations are: A, antenna; H, head; MD, mandible; MX, maxilla; MP, maxilliped; GN, gnathopod; P, pereopod; EP, epimera; C, coxa; U, uropod; T, telson; r, right; tl., total length; NMV, Museum Victoria, Melbourne; AM, Australian Museum, Sydney, where material is lodged. All dissections and illustrations follow the methods of Barnard and Drummond, 1978 whereby the left side of the animal is illustrated unless otherwise stated. Descriptions of the new species closely follow that of other species described in Barnard and Drummond (1978). Original illustrations were scanned and inked using Adobe Illustrator following the methods of Coleman, 2003.

Leongathus Barnard and Drummond

Leongathus Barnard and Drummond, 1978: 532. – Barnard and Karaman, 1991: 617.

Type species. Leongathus nootoo Barnard and Drummond, 1978 (by original designation).

Diagnosis. Rostrum unconstricted. Eyes present, weak or absent. Antenna 1 peduncular article 2 of medium length, ventral setae confined proximally. Antenna 2 peduncular article 1 not or scarcely ensiform, article 3 with 2 facial setules, facial robust setae on article 4 in 1 main row, all robust setae thick, article 5 ordinary. Right mandibular incisor with 3 teeth, right lacinia mobilis bifid, flabellate, denticulate, molar partly triturative, with 7+ large teeth; palpar hump medium, apex of palp article 3 oblique. Maxilla 1 inner plate with 4–5 setae, palp 2-articulate. Maxillipeds ordinary, apex of palp article 3 not strongly protuberant, dactyl elongate, apical nail not distinct.

Gnathopods dissimilar, gnathopod 2 strongly enlarged, carpus of gnathopod 1 of ordinary length, free, of gnathopod 2 short, cryptic (posterior margin concealed by the abutment of propodus and merus), palms oblique, gnathopods 1–2 propodus respectively thin and broadened, poorly setiferous anteriorly. Pereopods 3–4 carpus without posteroproximal robust setae, propodus with mostly thin armaments. Pereopod 5 basis of narrow form or broad form (basis equal to or greater than twice width of ischium), but tapering distally, pereopods 5–6 merus-carpus medium to narrow; pereopod 7 unreduced, article 3 not enlarged, dactyl well developed.

Epimera 1–2 with or without long facial brushes of setae, with or without posterior setae, epimeron 3 bearing long setae. Urosomite 3 without dorsal hook. Uropod 1 peduncle without inter-ramal robust setae, without major displaced robust seta (seta that is shifted onto the apical margin disjunctly from the true inner margin), uropods 1–2 rami not continuously setose to apex, without subapical robust setae or nails, uropod 1 inner ramus with 1 row of marginal robust setae. Uropod 2 inner ramus ordinary. Uropod 3 ordinary, outer ramus longer than peduncle, bearing a 2nd article on outer ramus (minute in *L. alannah*), with 2 long apical setae. Telson ordinary.

Remarks. To accommodate the new species the diagnosis of Barnard and Karaman (1991) has been expanded to include the traits eyes present; antenna 2 peduncular article 1 not ensiform; right lacinia mobilis flabellate, denticulate; maxilla 1 inner plate with 4–5 setae; pereopod 5 basis of narrow form or broad form; pereopods 5–6 merus-carpus medium to narrow; epimera 1–2 with or without long facial brushes of setae, with or without posterior setae.

Leongathus alannah sp. nov

Figures 1–4

Material examined. Holotype: Australia, Tasman Sea, West Norfolk Ridge, Wanganella Bank (32°36.29'S, 167°43.59'E), 707 m, beam trawl, P.B. Berents, 29 May 2003 (stn TAN0308/107), AM P68013 (female, tl. 20 mm).

Paratypes: Type locality, AM P73354 (1 female, tl. 16 mm). Australia, Tasman Sea, North Norfolk Ridge, (28°51.13'S, 167°42.32'E), 812 m, beam trawl, D.J. Bray, 15 May 2003 (stn TAN0308/029) NMV J53346 (2 females, tl. 13–14 mm). Tasman Sea, North Norfolk Ridge, (32°36.18'S, 167°47.26'E), 1029 m, beam trawl, P.B. Berents, 29 May 2003 (stn TAN0308/111), AM P66426 (female, tl. 18 mm).

Description. Female. Eyes present. Rostrum unconstricted, exceeding apex of peduncular article 1 on antenna 1. Antenna 1 peduncular article 1 about 1.5 times as long as wide, about 2.1 times as wide as peduncular article 2, ventral margin with 4 setae, dorsal apex with 3 setae; peduncular article 2 about 0.5 times as long as peduncular article 1, with 13 ventral and 3 apical setae; primary flagellum with 16 articles, about 0.8 times as long as peduncle; accessory flagellum with 12 articles. Antenna 2 not ensiform, peduncular article 4 with 11 robust setae in 1 apical row, dorsal margin with 2 notches each bearing 1 robust seta and simple setae, ventral margin with 19 long setae, 3 long ventrodistal robust seta; peduncular article 5 about 0.8 times as long as peduncular article 4, with 7 facial robust seta, dorsal margin with 4 setae, ventral margin with 15 long setae; flagellum 1.1 times as long as peduncular articles 4–5 combined, with 16 articles. Mandible, molar partly trituritive, bearing 13 large teeth; right incisor with 3 teeth; left incisor with 3 humps in 2 branches; right lacinia mobilis bifid, distal branch shorter than proximal, flabellate, denticulate, proximal branch simple; left lacinia mobilis with 5 teeth; right raker 10; left rakers 11; molars composed of elongate lamina in form of cone bearing 14 cusps and 2 short plusetae weakly disjunct, molars covered with fine setae; palp article 1 short, article 2 with 10 medium inner apical setae, 6 outer setae and 4 facial setae, article 3 about 1.1 times as long as article 2, apex oblique with 19 robust-slender setae, with 6 basofacial setae. Maxilla 1 inner plate bearing 2 long apical pluseta, 3 apicolateral much shorter seta; palp article 2 with 18 marginal robust setae. Maxilla 2 plates extending equally, outer slightly broader than inner, setation of inner and outer plate as illustrated. Maxilliped inner plates with 2 large thick apical robust setae, 6 apicofacial setae; outer plate large with 12 medial and apical robust setae, 13 apical and lateral setae; palp article 1 lacking apicolateral setae, article 2 with 3 apicolateral setae, medial margin of article 2 strongly setose, article 3 protuberant, with 12 facial setae, 5 lateral setae, nail of article 4 obsolescent, with 2 accessory setules. Coxa 1 slightly expanded distally; main ventral setae of coxae 1–4=21–25–18–43, posteriormost seta of coxae 1–3 shortened; anterior and posterior margins of coxa 4 divergent, posterodorsal corner rounded, posterodorsal margin short,

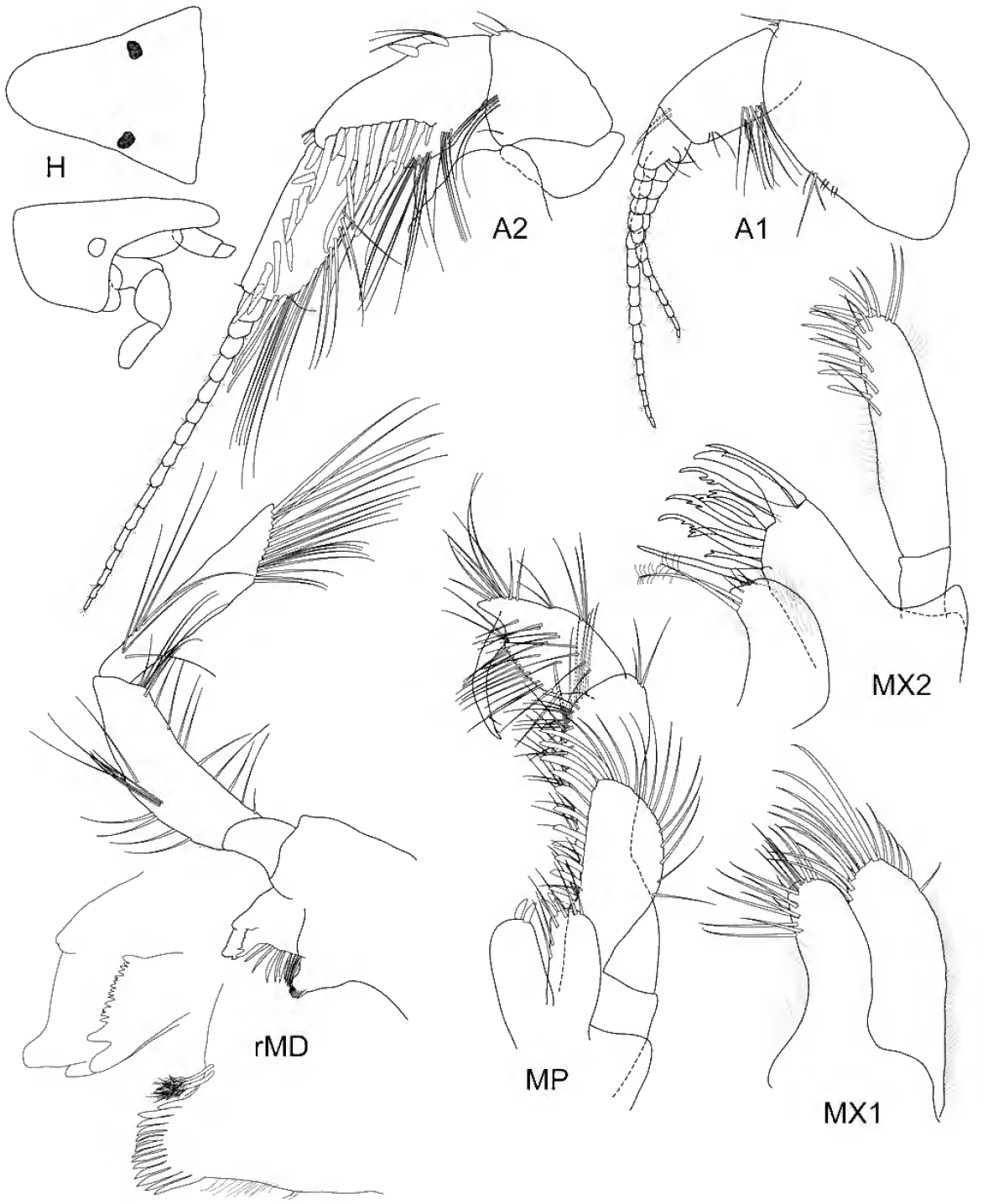

Figure 1. *Leongathus alannah* sp. nov., female, holotype, tl. 20.0 mm.

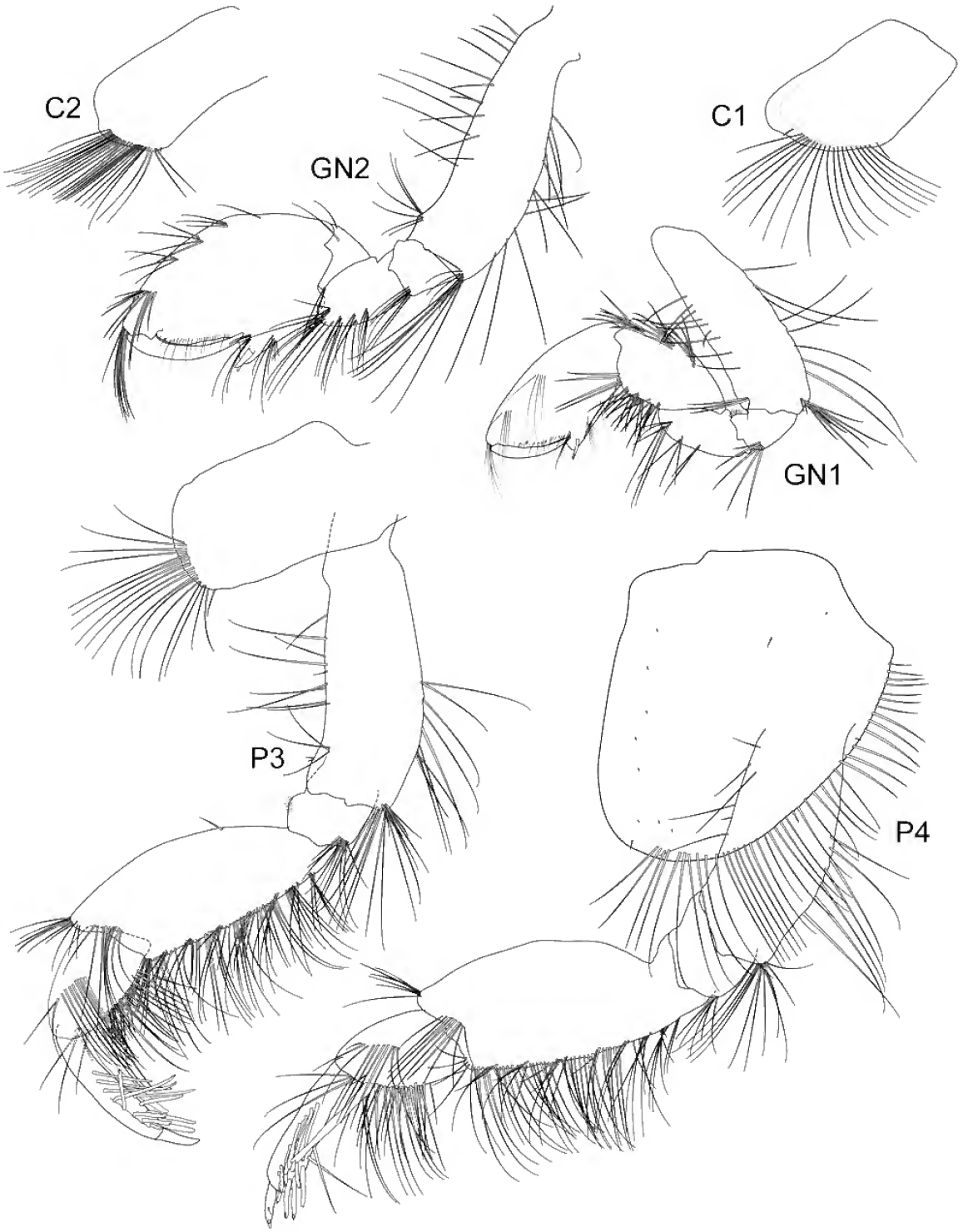

Figure 2. *Leongathus alannah* sp. nov., female, holotype, tl. 20.0 mm.

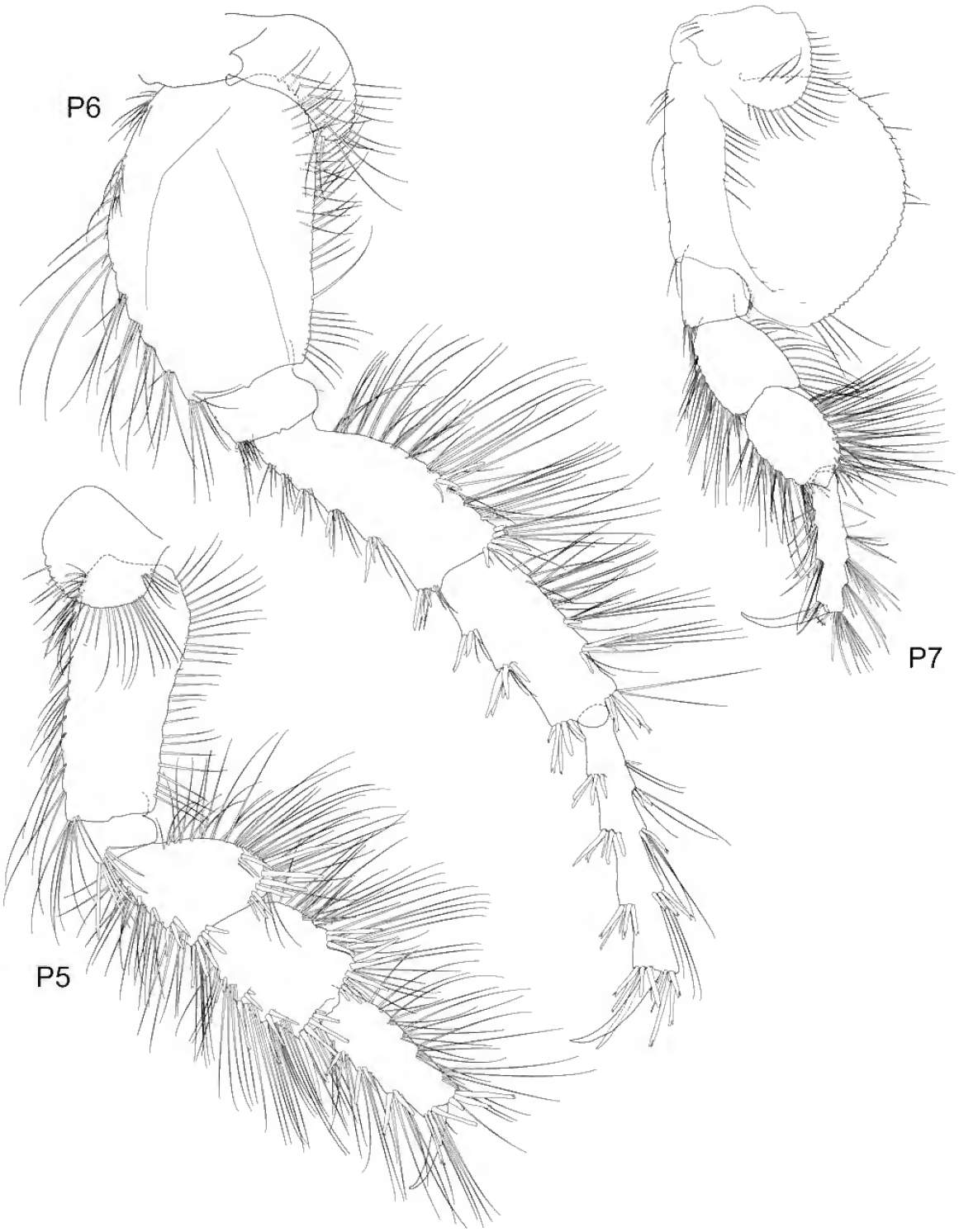

Figure 3. *Leongathus alannah* sp. nov., female, holotype, tl. 20.0 mm.

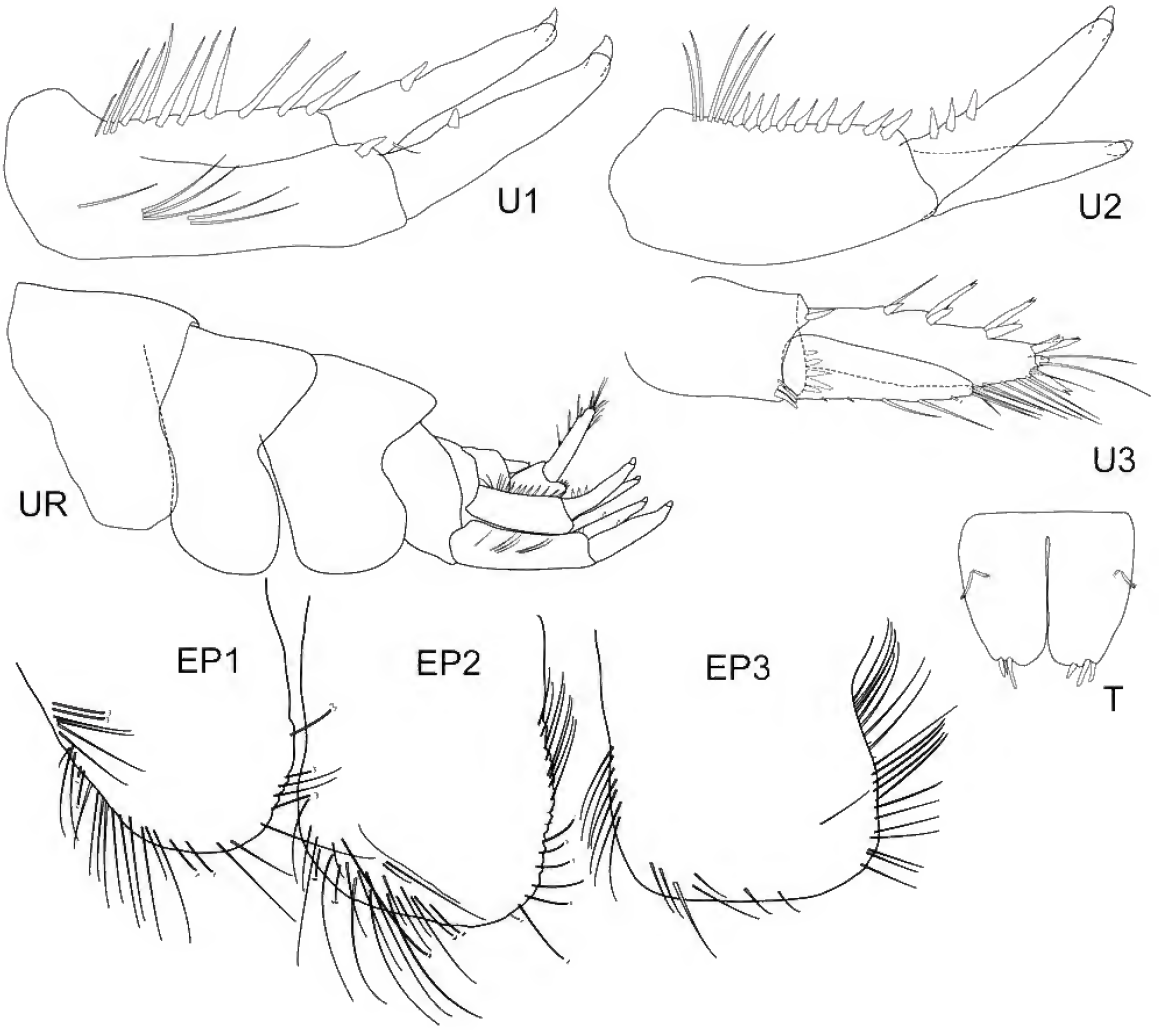

Figure 4. *Leongathus alannah* sp. nov., female, holotype, tl. 20.0 mm.

width-length ratio of coxa 4 almost = 5:6. Long posterior setae on basis of gnathopods 1–2 and pereopods 3–4 =17–19–21–16, short posteriors = 2–0–3–2, long anteriors = 12–20–12–6, short anteriors = 1–0–2–0.

Gnathopod 1 carpus free, gnathopod 2 enlarged, carpus cryptic. Width ratios of carpus-propodus on gnathopods 1–2 = 9:11 and 8:19, length ratios = 17:23 and 1:5; palmar humps ordinary, palms oblique. Pereopods 3–4 similar, facial setae on merus = 9 and 9, on carpus = 10 and 10; main spine of carpus extending to M. 77 and M. 95, carpus lacking proximoposterior robust setae; robust setae formula of propodus = 8+4 and 9+9; acclivity on inner margin of dactyls of pereopods 3–4 weak, obsolescent, emergent setule short, midfacial pluseta ordinary. Coxae 5–7 posteroventral setae formula = 23–13–21; merus-carpus of pereopod 5 medium of pereopod 6 narrow, facial robust setae rows sparse, facial ridge formula on basis of pereopods 5–7 = 0–1–1, anterior ridge of pereopod 7 long; width ratios of basis, merus, carpus, propodus of pereopod 5 = 2:2:2:1, of pereopod 6 = 19:10:8:4, of pereopod 7 = 35:12:11:5, length ratios of pereopod 5 = 15:6:6:8, of pereopod 6 = 18:22:19:22, of pereopod 7 = 37:14:14:5; basis of pereopod 7 barely exceeding apex of merus, with row of 9 facial setae along facial ridge, with ventral setae. Pleopods 1–3 with 2 coupling hooks; articles on outer rami = 24–22–24; articles on inner rami = 16–17–17.

Epimeron 1 posteroventral corner rounded, anteroventral margin with 26 medium setae, posterior margin with 12 setae; epimeron 2 posteroventral corner rounded, with 3 rows of 5–7 anteroventral setae, posterior margin with 12 setae; epimeron 3 posteroventral corner rounded, ventral margin with 6 setae, posterior margin with 18 setae. Urosomite 1 naked; urosomite 3 without dorsal hook. Uropods 1–2 rami with distinct apical nails, uropod 1 outer ramus with 3 dorsal robust setae, inner without robust setae, uropod 2 outer and inner rami with 1 dorsomedial robust seta; uropod 1 peduncle with 11 apicolateral robust setae, with 3 sets of 1–3 basofacial slender setae, without apical enlarged robust seta; uropod 2 peduncle with 9 dorsal robust setae and 5 slender setae; apicolateral corners of peduncles on uropods 1–2 without comb. Uropod 3 unreduced, outer ramus longer than peduncle. Uropod 3 peduncle with 5 ventral robust setae, dorsally with 1 lateral robust seta; rami feminine, inner extending to M. 80 on article 1 of outer ramus, apex with 1 setae, medial margin with 4 slender setae, lateral margin naked, article 2 of outer ramus very short, 0.05, bearing 2 long setae, apicomedial margin of article 1 with 4 slender setae, lateral margin with 4 acclivities, robust setal formula = 1–2–2–2, slender setae formula = 1–0–0–0. Telson length-width ratio = 17:19, almost fully cleft, each apex wide, rounded, lateral acclivity broad, shallow, bearing 3 robust setae, midlateral setules diverse.

Adult male. Unknown.

Distribution. Australia, Tasman Sea, Norfolk Ridge; 707–812 m depth.

Etymology. Named for my daughter Alannah Taylor with whom I was pregnant whilst preparing illustrations.

Remarks. The following variations from the holotype were observed in the paratypes. The main ventral setae of coxae 1–4 = (20–21)–(21–25)–(18–22)–(42–46). Uropod 1 outer ramus with 3–5 dorsal robust setae, inner ramus 0–3 dorsal robust setae. Uropod 2 outer ramus with 1–6 dorsal robust setae, inner ramus with 1 or without dorsal robust setae.

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Early Silurian phacopide trilobites from central Victoria, Australia

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Abstract

Sandford, A.C. and Holloway, D.J. 2006. Early Silurian phacopide trilobites from central Victoria, Australia. *Memoirs of Museum Victoria* 63(2): 215–255.

A diverse component of trilobite faunas in lower Silurian marine strata of central Victoria are members of the suborder Phacopina, here assigned to 19 species within the Phacopidae, Dalmanitidae and Acastidae. New genera are represented by the blind acastid *Berylacaste berylae* gen. et sp. nov. and the phacopid *Ivops wallanensis* gen. et sp. nov. Other new species are the phacopids *Acernaspis georgei* and *Ananaspis kenleyi*, and the dalmanitids *Preodontochile springfieldensis* and *Struveria*? *plinthourgos*. Two previously described species, *Ananaspis typhlagogus* Öpik, 1953 and *Dalmanites athamas* Öpik, 1953 [= '*Dalmanitina* (*Eudolatites*)' *aborigenum* Öpik, 1953], are revised. Other species are assigned to *Bessazoon*, *Phacopidella*? and indeterminate phacopid and dalmanitid genera. These trilobites are a significant representation of early Silurian Phacopina on the world scale.

Keywords

Trilobita, Silurian, Phacopidae, Dalmanitidae, Acastidae, Victoria, Australia, systematics, new taxa

Introduction

Trilobite assemblages occur in lower Silurian (Llandovery and Wenlock) sedimentary sequences at various localities in central Victoria, between Costerfield in the north and Camberwell in metropolitan Melbourne in the south (fig. 1). Despite the occurrence in these sequences of at least 45 trilobite taxa, 19 of which are members of the Phacopina, only nine species have been described previously (Table 1). These include '*Phacops*' *typhlagogus* Öpik, 1953, *Dalmanites athamas* Öpik, 1953, *D. wandongensis* Gill, 1948 and '*Dalmanitina* (*Eudolatites*)' *aborigenum* Öpik, 1953. Fossil collections in Museum Victoria permit the revision of Öpik's poorly known species and the description of the 16 other species of Phacopina recorded.

Strata and ages

Stratigraphic terminology employed here follows Rickards and Sandford (1998), and differs significantly from that of VandenBerg et al. (2000) and VandenBerg (2003, figs 5.2, 5.7).

Trilobites of the suborder Phacopina occur at many horizons in the Llandovery and Wenlock strata of central Victoria. The stratigraphically lowest, and one of the earliest recorded trilobites from Victoria (as *Asaphus*, see Selwyn, 1863), is *Phacopidella*? sp. from a siltstone underlying the Lintons Creek Conglomerate Member of the Springfield Formation at Keilor, at a similar horizon to beds yielding graptolites of the late Llandovery (Telychian) *Spirograptus turriculatus–Monograptus crispus* biozones (Rickards and Sandford, 1998). Further north, on Deep Creek at Springfield, the uppermost part of the Springfield Formation, which is correlated with beds containing graptolites of the *Monoclimacis crenulata* Biozone, has yielded a low diversity deep water fauna of Phacopina dominated by *Preodontochile springfieldensis* sp. nov. The overlying sandstones of the Chintin Formation contain several more diverse trilobite faunas including three representatives of the Phacopina, *Acernaspis georgei* sp. nov., *Ananaspis typhlagogus*? (Öpik, 1953) and *Bessazoon* sp., suggesting an age range for the unit of latest Llandovery–early Wenlock.

Known from a single specimen from Camberwell, *Struveria*? *plinthourgos* sp. nov. is part of a poorly sampled trilobite fauna occurring high in the Anderson Creek Formation in the eastern suburbs of Melbourne, at similar horizons to those yielding graptolites of the late Wenlock (early Homerian) *Cyrtograptus lundgreni–Testograptus testis* Biozone (Rickards and Sandford, 1998). The only other trilobites known from the formation are three specimens of the blind illaenid *Thomastus jutsoni* (Chapman, 1912) and one of an undescribed homalonotid.

Öpik (1953) documented a trilobite fauna from concretion-bearing mudstones of the so-called '*Illaenus* band' in the Costerfield area. Following Thomas (1937) this unit was traditionally regarded as defining the base of the Wapentake Formation, but Edwards et al. (1998) placed the '*Illaenus* band' at the top of the underlying Costerfield Siltstone. Although

Table 1. List of trilobite taxa in the Llandovery and Wenlock beds of central Victoria. Taxa from the Yan Yean Formation marked with † occur only in the upper horizons of the unit, which are earliest Ludlow in age.

Yan Yean Formation (late Wenlock-earliest Ludlow)
Proetidae indet.
Decoroproetus sp.†
Maurotarion euryceps (McCoy, 1876)
Encrinuridae indet.
Sthenarocalymene sp. †
Trimerus (*Trimerus*) *vomer* (Chapman, 1912) †
Ananaspis kenleyi sp. nov. †
Phacopidae gen. indet 1. †
Dalmanites wandongensis Gill, 1948
Kettneraspis hollowayi Sandford, 2000 †

Anderson Creek Formation (Wenlock)
Thomastus jutsoni (Chapman, 1912)
Trimerus? sp.
Struveria? plinthourgos sp. nov.

Bylands Siltstone (Wenlock)
Thomastus aops Sandford and Holloway, 1998
Proetidae indet.
Homalonotid indet.
Ananaspis sp. 1
Ivops wallanensis gen. et sp. nov.
Ananaspis typhlagogus? (Öpik, 1953)
Struveria sp. 2
Berylacaste berylae gen. et sp. nov.
Dicranurus sp.
Selenopeltinae sp.
Odontopleuridae indet.

Wapentake Formation (Wenlock)
Thomastus thomastus Öpik, 1953
Maurotarion sp.
Trimerus (*Ramiotis*) *tomczykowae* Sandford, 2005
Ananaspis typhlagogus (Öpik, 1953)
Acernaspis? sp..

Wapentake Formation (cont.)
Dalmanites athamas Öpik, 1953
Struveria sp. 2
Odontopleuridae indet.

Chintin Formation (latest Llandovery–early Wenlock)
Proetidae sp.
Decoroproetus sp.
Radnoria sp.
Encrinuridae indet.
Calymene sp.
Calymenella sp. 1
Trimerus (*Ramiotis*) *rickardsi* Sandford, 2005
Acernaspis georgei sp. nov.
Ananaspis typhlagogus (Öpik, 1953)
Bessazoon sp.
Odontopleuridae indet.

Springfield Formation (mid-late Llandovery)
Encrinuridae indet.
Hadromeros? sp.
Calymenella sp. 2
Phacopidella? sp.
Phacopidae gen. indet. 2
Phacopidae gen. indet. 3
Preodontochile springfieldensis sp. nov.

Costerfield Siltstone (late Llandovery?)
Dalmanitidae indet.

Deep Creek Siltstone (early-mid Llandovery)
Calymenidae indet.

Uncertain stratigraphic assignment
Ananaspis sp. 2
Struveria sp. 1

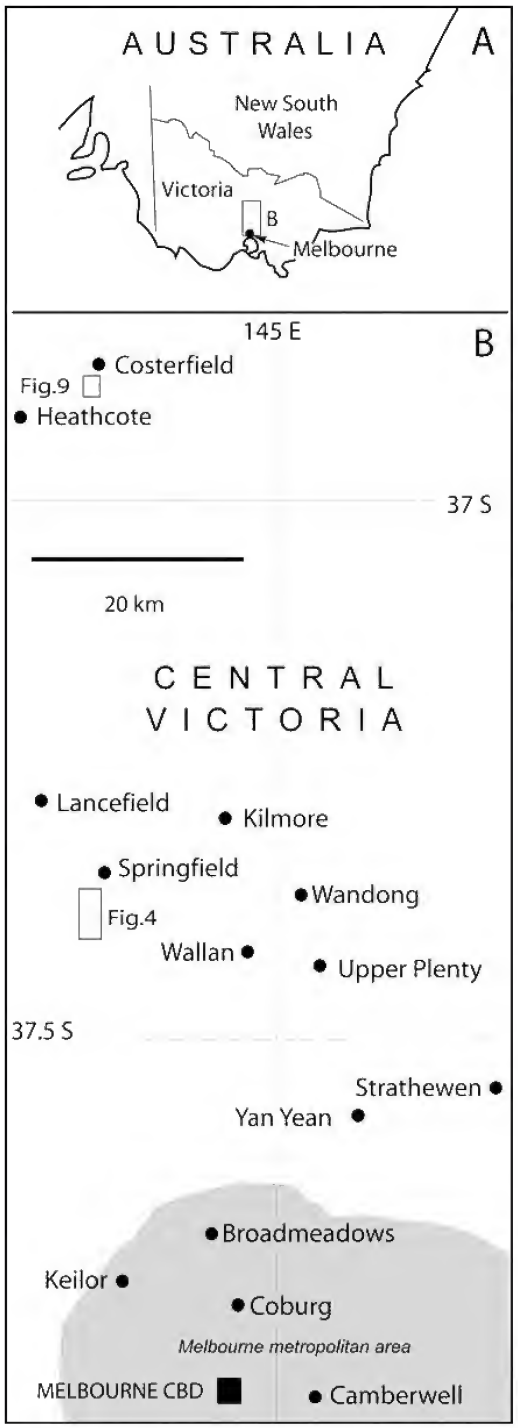

Figure 1. A, map of south-eastern Australia; approximate area of fig. 1B is indicated by a rectangle. B, map of central Victoria showing localities cited in the text; the areas covered by maps in figs. 4 and 9 are indicated.

Thomas (1940, 1941, 1956) mapped the '*Illaenus* band' as a distinct horizon extending around most of the Costerfield Dome, Edwards et al. (1998: 50) stated that it is not an extensive mappable unit. As noted by Rickards and Sandford (1998), fossils are not confined to a narrow horizon in this part of the sequence; indeed at localities on the western side of the Heathcote–Nagambie road both *Thomastus* (attributed to *Illaenus* by Thomas, 1937) and concretions occur 200 m stratigraphically below and 100 m above the band as mapped by Thomas (see fig. 9). Hence several concretion-rich beds seem to be present over a fairly wide stratigraphical interval, and as there is otherwise no distinct lithological change in this part of the sequence it seems an inappropriate level to define a lithostratigraphical boundary. Rickards and Sandford (1998) defined the base of the Wapentake Formation at the top of sandstones lower in the sequence (the Costerfield Sandstone of Reeder, 1990), and that is the boundary accepted here. We do not recognise the '*Illaenus* band' as a distinct unit of the Wapentake Formation, and we use the former term only when referring to poorly localised material from old collections.

The fauna of the Wapentake Formation is dominated by the illaenid *Thomastus thomastus* (see Sandford and Holloway, 1998) but Öpik also described three species of Phacopina, namely '*Phacops*' *typhlagogus*, *Dalmanites athamas* and '*Dalmanitina* (*Eudolatites*)' *aborigenum*. Öpik considered that shelly elements of the fauna indicated a late Llandovery age but noted the post-Llandovery aspect of certain elements including *D. athamas*. From a sandy concretion within the beds Thomas in Öpik (1953: 12) identified the graptolites *Monograptus* cf. *jaculum* and *Climacograptus hughesi*; however, these identifications cannot be confirmed as the specimens are lost, so the postulated late Llandovery age cannot be verified. Rickards and Sandford (1998) considered that the presence of *Ananaspis* indicated a Wenlock age for the fauna, and noted the similarity of the trilobite assemblage to that of the Wenlock Anderson Creek Formation, with both faunas having *Thomastus* as the dominant element and also containing dalmanitid and homalonotid species.

At Wallan Rickards and Sandford (1998) distinguished a massive siltstone from the underlying Chintin Formation and named it the Bylands Siltstone. The unit contains several species of Phacopina including the blind acastid *Berylacaste berylae* gen. et sp. nov., the phacopids *Ivops wallanensis* gen. et sp. nov. and *Ananaspis typhlagogus*?, the dalmanitid *Struveria* sp. and, at a slightly higher horizon, *Ananaspis* sp. 1. As in the case of the Wapentake Formation assemblage, the presence of *Ananaspis* and the similarity of the Wallan fauna to that of the Anderson Creek Formation indicates a Wenlock age for the unit.

Dalmanites wandongensis dominates a low diversity trilobite fauna from the middle horizons of the Yan Yean Formation at Wandong and Kilmore. Graptolites from these horizons belong to the latest Wenlock *Colonograptus ludensis* Biozone. *D. wandongensis* ranges into the upper horizons of the Yan Yean Formation, of earliest Ludlow age (*Neodiversograptus nilssoni* Biozone), where it dominates a more diverse fauna including the phacopid *Ananaspis kenleyi* sp. nov. Farther south at Strathewen the upper beds of the Yan Yean Formation have yielded a single specimen of a phacopid

(Phacopidae gen. indet. 1 herein) with small eyes, a condition that may be associated with life in a deep-water environment (Fortey and Owens, 1997: 267; Whittington, 1997: 163).

Faunal comparisons

Trilobites are poorly represented in the Victorian Llandovery (Table 1). None are known from Rhuddanian strata, and only *Hadromeros, Phacopidella*?, an indeterminate flexicalymenine and an indeterminate encrinurid from the Aeronian–lower Telychian, making comparison difficult with faunas from this interval elsewhere. Trilobites are more abundant in upper Telychian strata. *Calymenella* occurs in the Calton Hill Sandstone Member of the Springfield Formation. The low diversity *Preodontochile* fauna from the uppermost beds of the Springfield Formation on Deep Creek compares only to the monospecific *Preodontochile* fauna from the Llandovery of Spain. These *Preodontochile* faunas are interpreted as atheloptic assemblages representing a deep water biofacies whose relationship to other Llandovery deep water assemblages is unclear. Edgecombe and Sherwin (2001) interpreted the *Aulacopleura–Raphiophorus* Biofacies as inhabiting cold, deep-water, offshore environments, and Chatterton and Ludvigsen (2004) regarded the *Maurotarion*–dalmanitid Biofacies as a deep water fauna representing depths not as great as the *Aulacopleura–Raphiophorus* Biofacies. The latter is represented in Australia by a low-diversity fauna from the early Telychian Cotton Formation in central New South Wales (Edgecombe and Sherwin, 2001), containing *Aulacopleura*, *Raphiophorus* and *Odontopleura* (*Sinespinaspis*), and bears no similarity to the Llandovery faunas of central Victoria. The late Telychian to Sheinwoodian Chintin Formation yields the oldest diverse trilobite faunas in the Silurian of central Victoria. Eleven taxa are present including *Acernaspis georgei* sp. nov., *Ananaspis typhlagogus*? (Öpik, 1953), *Bessazoon* sp., *Trimerus* (*Ramiotis*) *rickardsi* Sandford, 2005, *Radnoria* sp., *Calymene* sp., *Decoroproetus* sp. and *Calymenella* sp. In composition the Chintin fauna is closely comparable to that of the late Telychian Richea Siltstone in south-west Tasmania (Holloway and Sandford, 1993), which also contains species of *Acernaspis, Bessazoon, Trimerus* (*Ramiotis*) and *Decoroproetus*. Taxa represented in the Richea fauna but not known from the Chintin fauna include *Maurotarion, Dicranurus, Gravicalymene, Anacaenaspis* and *Latiproetus*?

The only other Llandovery trilobite faunas known from Australia occur in the Broken River region of north Queensland. The early Telychian fauna of the Poley Cow Formation contains *Gaotania, Gravicalymene*?, *Prostrix, Batocara, Coronocephalus, Kosovopeltis, Proetus, Warburgella*?, *Otarion, Maurotarion, Scharyia, Youngia, Sphaerexochus, Sphaerocoryphe* and *Ceratocephala* (Holloway, 1994). From the laterally equivalent Quinton Formation, Lane and Thomas (1978) described *Rhaxeros, Sphaerexochus, Encrinurus*?, a possible warburgelline and an indeterminate calymenid, and Öpik (in White, 1965: 43) listed *Encrinurus*, *Proetus*?, *Onycopyge* or *Sphaerexochus*, and undetermined scutelluids. These faunas thus show little similarity in generic composition to the Llandovery faunas of Victoria and Tasmania, and they further differ in lacking phacopids, homalonotids and dalmanitids, and in the presence of scutelluids and illaenids. These differences may reflect biogeographical provincialism or environmental preferences. Rickards, Wright and Sherwin (*in* Pickett et al., 2000: 131) noted an analogous contrast between the Llandovery graptolite faunas of north Queensland and those of central Victoria, the latter having much stronger European affinities (98% of species) than the Queensland faunas (75% of species). Rickards et al. considered that the composition of the Victorian graptolite faunas indicate stronger interaction with the Americas rather than with the Uralian-Cordilleran Province.

Trilobites represented in the lower and middle Wenlock of central Victoria include species of *Thomastus, Maurotarion, Decoroproetus, Trimerus* (*Ramiotis*), *Ivops* gen. nov., *Ananaspis*, *Dalmanites, Struveria*, *Berylacaste* gen. nov., *Dicranurus*, and indeterminate Encrinuridae and Odontopleuridae. Faunas of similar age are present in the Rosyth Limestone and the laterally equivalent Boree Creek Formation in the Orange district, central western New South Wales, but of the 29 genera from those formations listed by Holloway (*in* Pickett et al., 2000: 163) only *Ananaspis*, *Decoroproetus* and *Dicranurus* also occur in central Victoria, and dalmanitids, homalonotids and acastids are conspicuously absent from the New South Wales faunas.

Differences in faunal composition between central Victoria and more northerly regions continued into the late Wenlock and earliest Ludlow. The only trilobite genus in common between the Yan Yean Formation and the Walker Volcanics of the Canberra area (see Holloway *in* Pickett et al., 2000: 164) is *Sthenarocalymene* (= *Gravicalymene*? of Holloway's list), and the latter fauna lacks phacopids and dalmanitids but includes scutelluids, illaenids, harpetids, cheirurids and staurocephalids that are absent from the Yan Yean. Diverse trilobite faunas of mid-Wenlock to early Ludlow or possibly even late Ludlow age occur in the Orange–Molong district in limestone bodies within the Mirrabooka Formation, and in the laterally equivalent Borenore and Molong limestones. Illaenids and scutelluids dominate the fauna, which otherwise resembles that from the underlying Boree Creek Formation except that phacopids are absent (Holloway and Lane, 1998).

The general absence of phacopid and dalmanitid trilobites in the Wenlock faunas of the Canberra and Orange districts (apart from the occurrence of *Ananaspis* in the Boree Creek Formation and Rosyth Limestone) is at least partly due to environmental preferences. The Silurian sequences of those districts were deposited on a series of offshore highs and troughs whereas those of central Victoria were deposited on the continental margin. The fauna of the Borenore Limestone and its stratigraphical equivalents is similar to those occurring in lithologically similar pure limestones of Silurian age elsewhere in the world (see Lane, 1972; Thomas and Lane, 1998). Mikulic (1981) reported that in middle and late Silurian reef limestones of North America the reef core is dominated by illaenids, scutelluids, lichids and cheirurids, and the reef fringes are characterised by assemblages of cheirurids, calymenids and encrinurids. He interpreted rare phacopid and dalmanitid trilobites in the reef fringes as temporary migrants from non-reef areas.

After the Wenlock members of the Phacopina were a significant component of trilobite faunas in New South Wales as in Victoria. The fauna of the late Ludlow Rosebank Shale in the Yass district includes both phacopids and dalmanitids [*Ananaspis crossleii* (Etheridge and Mitchell, 1896), *Dalmanites meridianus* (Etheridge and Mitchell, 1896)]. In the Early Devonian, *Echidnops*, *Paciphacops, Lochkovella, Odontochile*, several genera not belonging to the Phacopina, and at least one species (*Sthenarocalymene* sp. A, see Chatterton, Johnson and Campbell, 1979; Holloway and Neil, 1982) were present in both central Victoria and New South Wales; however, continuing limitations on faunal exchange is evident in the absence of homalonotids and acastids in New South Wales, and in the absence of harpetids in central Victoria.

Systematic palaeontology

With the exception of the partly mineralized exoskeletons preserved in concretions of the Wapentake Formation, all trilobite specimens figured here are preserved in mudstones and sandstones as internal and external moulds. For photography, internal moulds were coated with colloidal graphite, latex peels were made from external moulds, and all were whitened with ammonium chloride. Specimens housed in Museum Victoria are registered with the prefix NMV P, and those housed in the collections of Geoscience Australia, Canberra, are registered with the prefix CPC. Two missing specimens of *Ananaspis typhlagogus* are documented with registration numbers of the old Geological Survey of Victoria collection, prefixed GSV. Trilobite localities with the prefix PL are documented in the Museum Victoria invertebrate palaeontology locality register.

Order **Phacopida** Salter, 1864
Suborder **Phacopina** Richter, Richter and Struve, 1959
Superfamily **Phacopoidea** Hawle and Corda, 1847
Family **Phacopidae** Hawle and Corda, 1847

Remarks. In his seminal review of the Phacopidae in which he established the genera *Acernaspis* and *Ananaspis*, Campbell (1967) proposed a classification of the family that he considered to be 'horizontal' in the sense of Simpson (1961). His approach was criticised by some workers (e.g. Eldredge, 1973: 292) as creating paraphyletic and polyphyletic taxa, an outcome that was acknowledged by Campbell (1977: 26). Nevertheless, *Acernaspis* and *Ananaspis* have been universally recognised, and the former has come to be accepted as monophyletic (Ramsköld and Werdelin, 1991: 61).

Ananaspis continues to present more problems than *Acernaspis* because it embraces greater variability in characters such as the width of the cheeks in relation to that of the glabella, the relative lengths (exsag.) of L2 and L3, the size of the eye and the position of its lower margin in respect to the lateral border furrow, the depth of the vincular furrow medially and the strength of its notching laterally, the glabellar sculpture (but in relation to this character see remarks on *Acernaspis* below), and the width and degree of taper of the pygidial axis. These characters, many of which were regarded by Campbell (1967) and later workers as diagnostic of *Ananaspis*, are expressed to differing degrees and in a variety of combinations in the species assigned. Ramsköld and Werdelin (1991) restricted *Ananaspis* to a small number of species of Ludlow and Lochkovian ages [*A. orientalis* (Maksimova, 1968), to which Ramsköld and Werdelin ascribed a possible Ludlow age, is from the Kokbaital Horizon of Central Kazakhastan, now known to be early Lochkovian; Talent et al., 2001: 61]. Several other species previously assigned to *Ananaspis*, and of late Llandovery–late Wenlock age, were referred to by Ramsköld and Werdelin as '*Ananaspis*' or *incertae sedis*, and said to represent '...a number of monospecific (or nearly so) genera ... between *Acernaspis* and *Ananaspis*' (Ramsköld and Werdelin, 1991: 56). We are not in complete agreement between ourselves on the relationships of these species which include '*Phacops*' *typhlagogus* Öpik, 1953, redescribed below. However, it is difficult to identify any consistently developed characters that could be used to distinguish such species from others assigned to *Ananaspis* s.s. by Ramsköld and Werdelin, or to be sure that the latter species are more closely related to each other than to some of the species excluded from *Ananaspis* by those authors. Consequently *Ananaspis* is more broadly conceived herein than by Ramsköld and Werdelin.

Acernaspis Campbell, 1967

=*Eskaspis* Clarkson et al., 1977; =*Murphycops* Lespérance, 1968

Type species. *Phacops orestes* Billings, 1860 from the Jupiter Formation (Llandovery), Anticosti I., Quebec, by original designation.

Remarks. Chatterton and Ludvigsen (2004: 39) discussed the possible synonymy of *Acernaspis* with *Portlockia* McCoy, 1846 (type species *P. sublaevis*) from the Wenlock of western Ireland and gave notice of their intention to apply to the International Commission of Zoological Nomenclature to suppress the latter generic name as a *nomen oblitum*. We would support such an application as being in the best interests of nomenclatural stability.

Chatterton and Ludvigsen (2004) considered *Acernaspis mimica* Lespérance and Letendre, 1982 to be a synonym of *A. orestes*, and also noted that *A. superciliexcelsis* Howells, 1982 differs only in very minor respects from *orestes* and might be considered synonymous. These conclusions are in accord with the cladistic analysis of *Acernaspis* presented by Ramsköld and Werdelin (1991, fig. 5), in which these three taxa are grouped together. Curtis and Lane (1998) considered a number of other species to be synonyms of *orestes* including *A. quadrilineata* (Angelin, 1851), *A. konoverensis* Männil, 1970, *A. elliptifrons* (Esmark, 1833) and *A. sororia* Ramsköld, 1985; however, Ramsköld and Werdelin's cladistic analysis shows these species and *orestes* grouped quite separately. Chatterton and Ludvigsen arrived at a similar conclusion, rejecting Curtis and Lane's synonymy and listing a number of characters distinguishing *orestes* and *quadrilineata*, emphasising minor differences in the lens formula and the proportions of the glabella.

Acernaspis rubicundula Ramsköld, 1985, from the lower Wenlock of Sweden, was interpreted by Ramsköld as intermediate between *Acernaspis* and *Ananaspis* with respect to morphological trends that he recognised between his late Llandovery species *Acernaspis sororia* and *Ananaspis stokesii* (Milne Edwards, 1840) from the British Wenlock. He emphasised the glabellar width, the short (exsag.) L2 and the glabellar tuberculation as characters of *rubicundula* typical of *Ananaspis*, and remarked that *stokesii* differs from *rubicundula* in few features of which only the strongly forwardly expanding glabella and deep lateral border furrow (on the fixigena) were mentioned. Neotenic changes significant in the evolution of *Ananaspis* from *Acernaspis*, including a decrease in the length (exsag.) of L2 and the development of glabellar tuberculation, were outlined by Ramsköld (1988). In this context he interpreted *rubicundula* as a sister-taxon to all other *Acernaspis* species, exhibiting the first of these neotenic changes. In their cladistic analysis of *Acernaspis*, Ramsköld and Werdelin (1991) discovered that their consensus tree was essentially unresolved with the inclusion of *rubicundula* but on its removal an almost fully resolved consensus tree was obtained. Nevertheless they retained *rubicundula* in *Acernaspis*, and we agree that the majority of its characters clearly ally the species with that genus. However, in view of its unusual features, we assign *rubicundula* to *Acernaspis* with question, together with a somewhat similar species described below as *A.*? sp.

Acernaspis georgei sp. nov.

Figures 2, 3A–B, D–E, H–I

Acernaspis.—Rickards and Sandford, 1998: 750.

Type material. Holotype NMV P515 (cephalon) from PL1964, Geological Survey locality B25, Springfield. Paratypes NMV P138259 (cephalon), NMV P138262 (pygidium), NMV P138278 (pygidium), NMV P147765 (cephalon), NMV P147766 (cephalon), NMV P147796 (pygidium), NMV P312816 (cephalon) from PL256, Wallan. Paratype NMV P138271 (cephalon) from PL598, type section of the Chintin Formation, Springfield.

Other material. NMV P138260–P138261, NMV P147764, NMV P147767–P147768, NMV P147788–P147795, NMV P147797–P147806 from PL256, Wallan. NMV P139447–P139453 from 'Lancefield' (unknown locality in the Parish of Goldie). For localities see Thomas (1960), VandenBerg (1991), Sandford and Rickards (1999) (fig. 1), Sandford (2005) (fig. 11) and (fig. 4).

Derivation of name. After ACS's late father.

Diagnosis. Anterior cephalic border comprising 2.5% sagittal cephalic length in dorsal view. Lateral glabellar furrows moderately impressed, S2 extending close to axial furrow, posterior branch of S3 weakly convex forward, anterior branch placed posteriorly, with midlength opposite anterior margin of palpebral lobe. Palpebral furrow moderately to deeply impressed, distinct palpebral rim furrow, eye length (exsag.) 45% sagittal cephalic length, postocular area with length (exsag.) 5% sagittal cephalic length, visual surface with 15 files of lenses with up to 6 (mostly 5) lenses per file. Genal angle obtusely angular, lacking prominent point or genal spine. Second and third pygidial pleural furrows moderately impressed.

Description. Cephalon semicircular, in frontal view with anterior margin weakly arched. Glabella weakly convex (sag., tr.), not reaching anterior cephalic margin in dorsal view, maximum width across frontal lobe approximately equal to cephalic length, 50% maximum cephalic width and 160% occipital width (tr.). Axial furrow wide and very deep, weakly converging between posterior margin and L1, diverging at 60° between L1 and a point opposite midlength of palpebral lobe, thereafter diverging forward at 20°. Anterior margin gently rounded in front of glabella, forming arc centred on posterior margin. Occipital ring with length (sag.) 15% cephalic length and width (tr.) 33% cephalic width, with exsagittal furrow impressed in anterior margin defining obliquely directed lateral lobes. Occipital furrow deeply impressed. L1 high, lateral node isolated by deep exsagittal furrow. S1 deep laterally, weak across median part of glabella. S2 and S3 moderately impressed on external surface. S2 directed at about 10° to transverse, straight, its inner end situated more or less opposite 40% glabellar length from posterior. Posterior branch of S3 with anteriormost point more or less opposite 55% sagittal glabellar length from posterior. Anterior branch of S3 oriented at 40° to exsagittal line, weakly sigmoidal. L2 and L3 equal in length (exsag.). Anterior border furrow moderately impressed. Anterior border wide. Eye placed with midlength opposite 38% sagittal cephalic length from posterior. Palpebral area high, convex. Palpebral lobe steeply inclined, flat (tr.), raised above palpebral area. Visual surface large, with up to 71 lenses, formula (NMV P138259, fig. 2D, H) 5 5 6 5 5 5 5 5 5 5 5 4 5 5 4 3. Posterior border furrow deep adaxially, terminating abruptly abaxially at a point in line (exsag.) with distal margin of eye. Posterior border narrow adaxially, widening slightly abaxially. Librigenal field concave below eye, not distinctly differentiated from lateral border furrow. Posterior branch of facial suture skirting posterior margin of eye abaxially, crossing genal area directed anterolaterally at about 25° to transverse, reaching a point opposite 33% sagittal cephalic length, deflected backwards at same angle abaxially. Cephalic doublure with vincular furrow deep throughout and strongly notched laterally. Cephalic sculpture finely granulate.

Pygidium lenticular in dorsal outline. Axis comprising 85% sagittal pygidial length and 30% maximum pygidial width anteriorly, with 6 rings that are well defined in anterior part of axis and poorly defined in posterior part, terminal piece merging with postaxial region. Pleurae with 5 pleural furrows, anterior one narrow (exsag.), deep, reaching 75% distance to margin, remaining pleural furrows successively shallower, posteriormost one very weak. Interpleural furrows very shallow. Border and furrow not defined.

Remarks. Acernaspis georgei occurs at several localities in the Chintin Formation, although its relative abundance, faunal associates, preservation and associated lithology vary markedly. In Slab Hut Creek at PL256, Wallan, the species is common (relative abundance 44%) and together with *Calymene* (relative abundance 35%) dominates the fauna preserved almost entirely as fragmentary cephala and pygidia. The trilobites at PL256 occur within bioclastic sandstone coquinas which contain abundant disarticulated crinoid elements, gastropods, bryozoans and clasts of siltstone incorporated into the coquina in the plastic

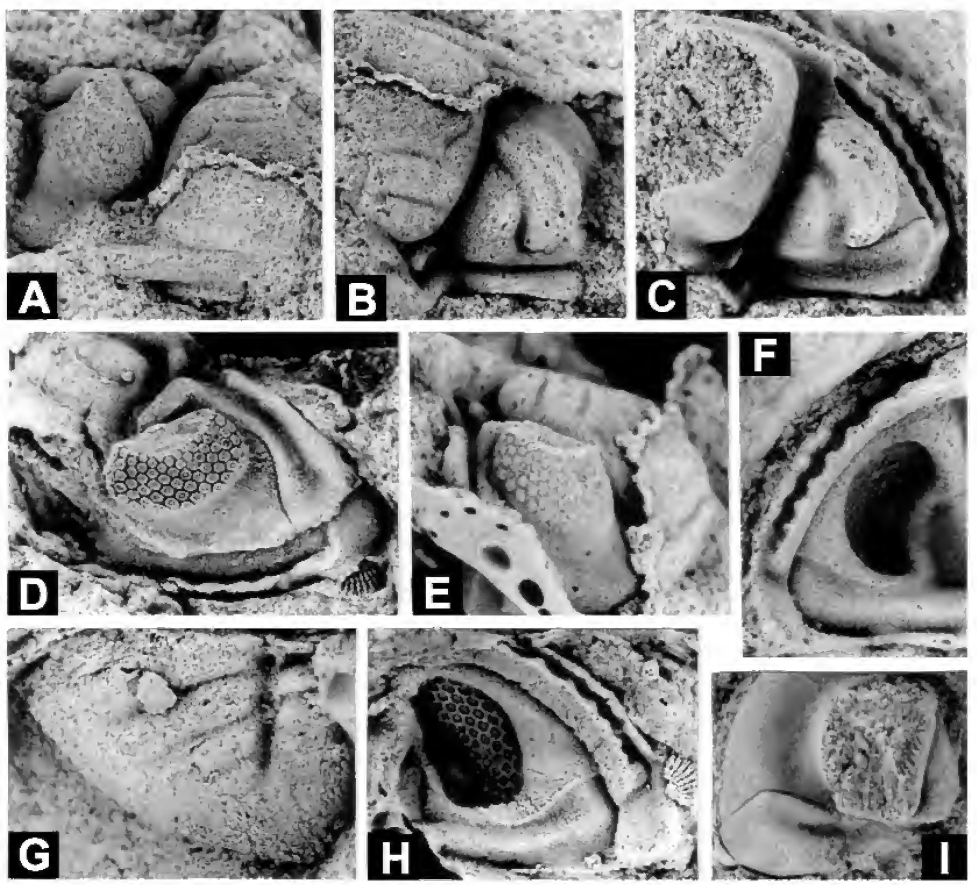

Figure 2. *Acernaspis georgei* sp. nov. A–C, E–F, holotype NMV P515, cephalon (fragment), from PL1964, Springfield; A–C, × 5; E, × 6.5; F, × 6. D, H, paratype NMV P138259, cephalon, from PL256, Wallan; D, × 5; H, × 4. G, paratype NMV P138261, pygidium, × 8, from PL256, Wallan. I, paratype NMV P138271, cephalon (fragment), × 7, from PL598, Springfield. (C, D are internal moulds).

state, presumably as rip-up clasts. The coquinas are bedded but form large irregular bodies within massive siltstones, with which they have sharp contacts. At 'Lancefield' the species occurs (relative abundance 14%) in a fauna dominated by *Bessazoon* sp. and *Calymene* sp., preserved as isolated and generally undamaged exoskeletal elements in medium-grained sandstone.

The species can be confidently assigned to *Acernaspis*. Significant characters in this assignment include the low glabellar profile, non-tuberculate cephalic ornament, long (exsag.) L2 (equal in length to L3), wide anterior border visible in dorsal view, poorly defined lateral cephalic border furrow, short postocular area, strong notching of the vincular furrow laterally and the weak expression of the pygidial interpleural furrows and the fourth and fifth pleural furrows.

A poorly known, unnamed species of *Acernaspis* was described by Holloway and Sandford (1993) from the late Llandovery Richea Siltstone of Tasmania. The present species differs from the Tasmanian one in having a longer postocular area, a deeper palpebral furrow and a longer anterior cephalic border. '*Phacops*' *macdonaldi* Fletcher, 1950, from the upper Llandovery to lower Wenlock of the Orange district, New South Wales, was tentatively assigned to *Acernaspis* by Sherwin (1971), but is now assigned to *Ananaspis* along with its junior subjective synonym '*Acernaspis*?' *oblatus* [*sic*] Sherwin (see discussion of *Ananaspis typhlagogus*).

Acernaspis georgei is most similar to the type species *A. orestes*. The two species share a relatively long (sag.) anterior cephalic border, a long postocular area and a non-spinose genal angle. *A. georgei* has one fewer lens file in the eye but otherwise shares a similar lens formula to small-eyed morphs of *orestes*, which have 16 files of up to six (mostly five) lenses per file. The species differ most notably in the arrangement of the lateral glabellar furrows and in the deeper palpebral furrows of *georgei*.

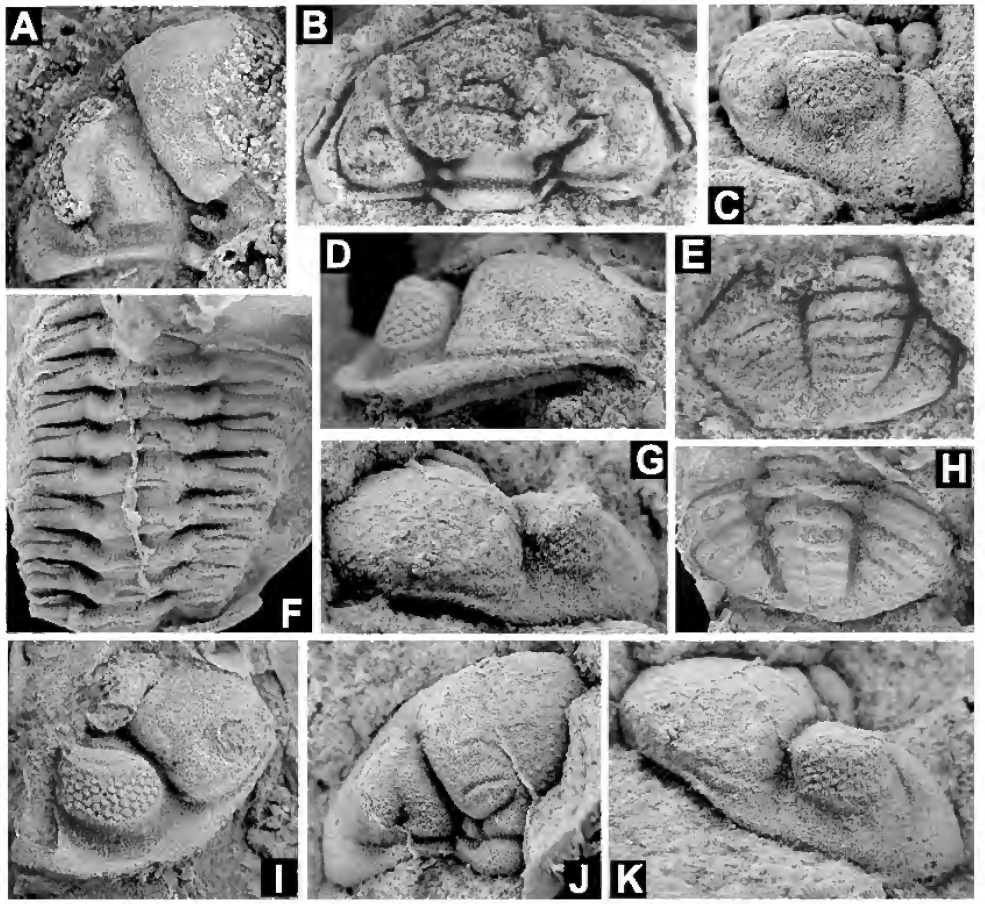

Figure 3. A–B, D–E, H–I, *Acernaspis georgei* sp. nov. A, paratype NMV P147766, incomplete cephalon, × 4, from PL256, Wallan. B, NMV P139448, damaged cephalon with cephalic doublure exposed, × 3.25, from 'Lancefield'. D, I, paratype NMV P312816, incomplete cephalon from PL256; D, × 5; I, × 4.5. E, NMV P139451, pygidium, × 4, from 'Lancefield'. H, paratype NMV P138262, pygidium, × 5, from PL256, Wallan. C, F–G, J–K, *Ananaspis typhlagogus* (Öpik, 1953) from PL6361, Springfield. C, G, J–K, NMV P312813, cephalon; C, J, K × 3.75, G × 4.75. F, NMV P312814, thorax, × 5. (A–B, H are internal moulds).

Species less closely related to *A. georgei* and *A. orestes* include Männil's (1970) Estonian species *A. semicircularis*, *A. estonica*, *A. sulcata*, *A. rectifrons* and *A. incerta*, and the Scottish *A. xynon* Howells, 1982, all of which are easily distinguished in having acutely angular genal angles or short genal spines. In the depth and lateral extension of S2 (to a point close to the axial furrow), *A. georgei* resembles *A. besciensis* Lespérance and Letendre, 1982 from the Rhuddanian of Anticosti Island, Canada (=*A. salmoensis* Lespérance, 1988 *fide* Chatterton and Ludvigsen, 2004), the oldest known species of the genus. *A. besciensis* differs from *A. georgei* in many other features, notably in having fewer lenses per file but more files in the eye (up to four lenses in 16 files), a shorter (tr.) and more forwardly convex S3, a narrow preoccipital ring and a shallower preglabellar furrow.

***Acernaspis*? sp.**

Figures 5A–D

Material. NMV P139804 (incomplete cephalon) from PL385, Costerfield. Wapentake Formation. For locality see fig. 9.

Description. Anterior and anterolateral cephalic margins moderately arched upwards medially in anterior view. Glabella weakly convex (sag., tr.), low anteriorly, sides of composite lobe diverging at about 55° between level of S2 and outer end of preglabellar furrow. S1 curving forward adaxially, connected medially by wide (sag.), shallow depression. S2 moderately impressed, convex forwards, subparallel to posterior branch of S3, its inner end connected to S1 by shallow exsagittal furrow. L2 about 75% length (exsag.) of L3 adaxially. S3 distinctly shallower than S2; posterior branch of S3 not extending as far

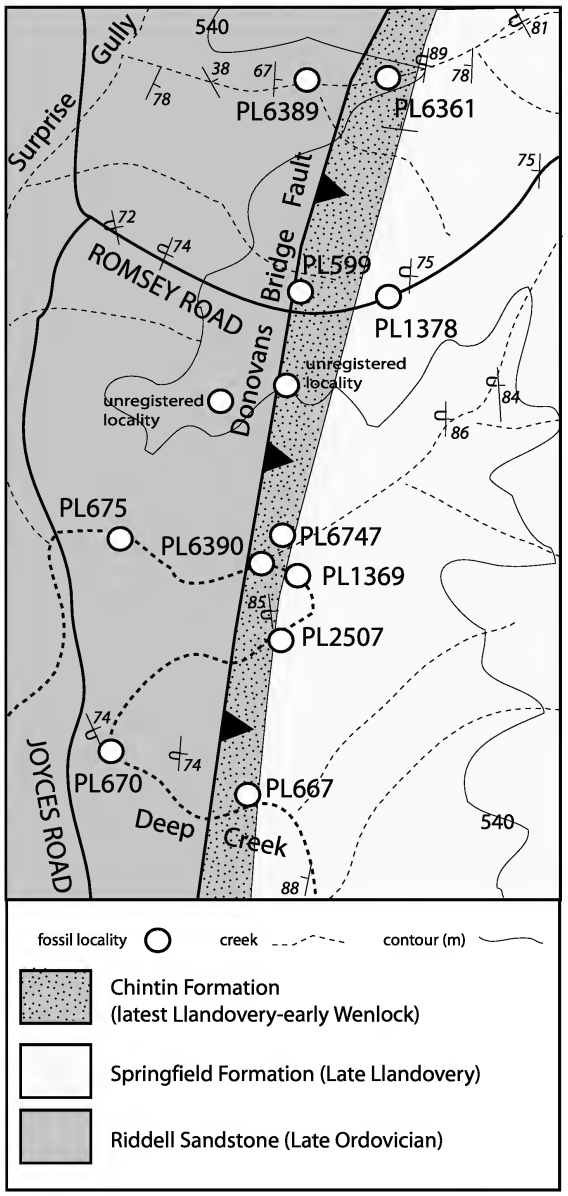

Figure 4. Fossil localities of the Springfield Formation, Chintin Formation and Riddell Sandstone in the Springfield area, 65 km NNE of Melbourne; the area covered by the map is indicated on fig. 1. The geology of this area given by Rickards and Sandford (1998) (fig. 6) is incorrect. The presumed faunal similarities with the Bylands Siltstone are not substantiated on description of the fauna herein. On lithological and apparent faunal similarities Rickards and Sandford erroneously correlated the siltstone at PL1369 with the Bylands Siltstone and showed the Chintin Formation underlying it. Additional field observations show that the Chintin Formation crops out upstream from and hence overlies PL1369, which lies in the uppermost beds of the Springfield Formation, as mapped by VandenBerg (1991).

adaxially and abaxially as S2; anterior branch not quite meeting posterior branch, oriented at about 60° to sagittal line and very weakly curved, meeting axial furrow anteriorly. Preglabellar furrow moderately impressed, continuous medially. Anterior cephalic border of almost uniform length (sag., exsag.) except abaxially. Preserved portion of eye (more than anterior half) with 12 files of lenses, formula (from anterior) 4 5 6 7 6 7 6 6 6 6 7 6 ..., sclera depressed. Palpebral lobe raised high above palpebral area, with shallow but distinct rim furrow; anterior part of palpebral furrow deep and narrow. Librigenal field concave below eye and merging with lateral border furrow. Anterior branch of facial suture cutting across anterolateral corner of glabella (fig. 5B–C). Vincular furrow moderately impressed medially, deep laterally with strong notching. Medial part of cephalic doublure not raised as high above vincular furrow anteriorly as posteriorly, giving doublure a step-like profile or 'bevelled' morphology. Composite glabellar lobe with sculpture of low, perforate tubercles of small to moderate size.

Remarks. The species is represented by a single, incomplete cephalon lacking the posterior portion more or less behind a transverse line through the medial part of S1. The specimen differs from *Ananaspis typhlagogus* from the same formation in that the glabella is much more weakly convex, not as strongly curved in anterior outline and does not overhang the anterior border; the anterior border is wider (sag., exsag.); S2 is deeper, more strongly curved (not transverse adaxially), runs subparallel to the posterior branch of S3, and is connected to S1 adaxially by a shallow exsagittal furrow; the posterior branch of S3 is narrower (tr.) and the anterior branch longer; the preglabellar furrow and preserved portion of the palpebral furrow are deeper; and the visual surface does not overhang the lateral border as strongly in dorsal view and is higher, with more lenses per file (up to seven instead of five as in *typhlagogus*). Although it could be suggested that the low glabellar profile of the specimen is due to tectonic flattening, we consider that this is unlikely because of the other differences from *typhlagogus* listed, especially those in the eyes.

Acernaspis? sp. differs from most species of *Acernaspis* except *A.*? *rubicundula* Ramsköld, 1985, from the lower Wenlock of Sweden, in having tuberculate sculpture on the composite glabellar lobe (see discussion above under genus). *A.*? *rubicundula* differs from *A.*? sp. in that S2 is not as curved, does not extend as close to the sagittal line and is not connected to S1 adaxially by a weak longitudinal furrow; L2 is much shorter (about half length of L3 adaxially); S3 is deeper, with a shorter anterior branch not extending as close to the posterior branch; and S2 and S3 have weakly raised rims. These differences suggest that the Victorian species may not be most closely related to *rubicundula*, despite the similarity in glabellar sculpture.

Ananaspis Campbell, 1967

Type species. Phacops fecundus Barrande, 1846 from the Kopanina Formation (Ludlow), Koledník, Bohemia, by original designation.

Diagnosis. Glabella moderately to strongly convex (sag., tr.), vertical or slightly overhanging anteriorly in dorsal view.

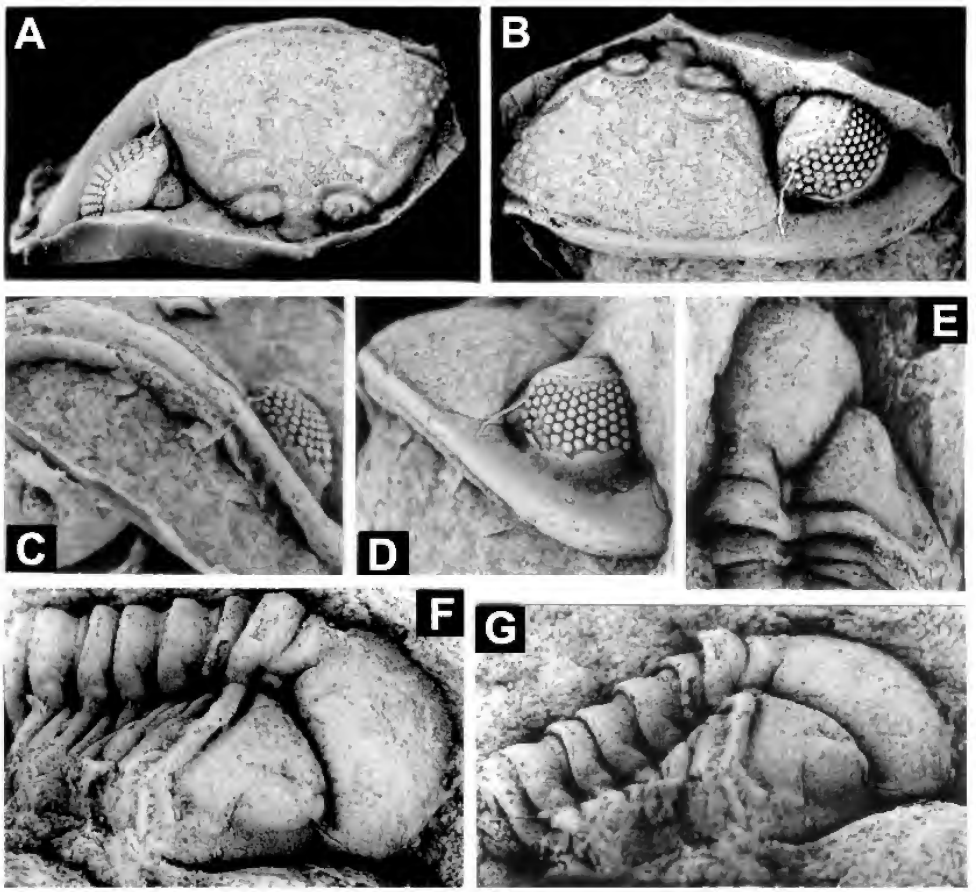

Figure 5. A–D, *Acernaspis*? sp., NMV P139804, cephalon, × 4, from PL385, Costerfield. E–G, Phacopidae gen. indet. 3, NMV P139353, enrolled exoskeleton from PL1369, Springfield; E, × 4.0; F, × 4.5.

Composite lobe expanding strongly forward, maximum width twice width at L1 or a little more. L2 commonly significantly shorter (exsag.) than L3. Eye of moderate to large size, lower edge situated in or slightly above lateral border furrow anteriorly and distant from lateral border furrow posteriorly, visual surface lacking strongly raised sclera (may be slightly thickened dorsally). Palpebral area as high as or higher than palpebral lobe. Fixigenal portion of lateral border furrow deep and continuous with posterior border furrow. Vincular furrow shallow to moderately impressed medially, commonly rather weakly notched laterally. Glabellar sculpture of bimodal tubercles lacking perforations and with superimposed and interspersed granules, doublure finely and densely granulate. Hypostome with short (sag.) posterior border having 3 angular points on margin. Pygidial pleural furrows deep and wide (exsag.), interpleural furrows distinct.

Remarks. This diagnosis distinguishes *Ananaspis* from a number of closely related genera recognised since the work of Campbell (1967). *Echidnops* Sandford, 2002 is the closest to *Ananaspis* but differs not only in having characteristic occipital and thoracic axial spines but also a much more deeply incised vincular furrow medially. *Paciphacops* Maksimova, 1972 is distinguished especially by the strongly raised sclera on the visual surface and the perforate glabellar tubercles, but in addition L1 is more depressed medially, the glabella is more raised and subquadrate in anterior profile, and the vincular furrow is deep medially. *Lochkovella* Chlupáč, 1972 (see also Sandford, 2004) differs from *Ananaspis* in that the cephalic tuberculation is finer and of more uniform size, the eye is situated very low on the cheek with its lower edge indenting the lateral cephalic border, the hypostome has a long (sag.) posterior border with five marginal denticles, the pygidial interpleural furrows are not as deep, and the pygidial granulation is coarser. Similar distinctions can be made with *Nephranomma* Erben, 1952 (see Sandford, 2003) which further differs from *Ananaspis* in lacking a vincular furrow medially and in having a distinctive scaly sculpture on the cephalic doublure. See the remarks on *Ivops* gen. nov. for comparison of that genus with *Ananaspis*.

Ananaspis kenleyi sp. nov.

Figures 6A–H, I?, J–K

Ananaspis.—Rickards and Sandford, 1998: 753.
'*Ananaspis*' sp. nov.—Sandford, 2000: 199.

Type material. Holotype NMV P136821 (cephalon) from PL375, Kilmore East. Paratype NMV P136815 (cephalon) from PL377, Kilmore East. Paratypes NMV P136819 (cephalon), NMV P136820 (pygidium), NMV P140154 (enrolled thoracopygon), NMV P140155 (cephalon), NMV P140156 (cephalon) from PL375, Kilmore East. Yan Yean Formation.

Other material. NMV P137165 from PL286, Williams locality F22, Wandong. NMV P136801, NMV P137142 from "Wandong" (exact locality unknown). NMV P136816 from PL377, Kilmore East. NMV P136802, NMV P138648 from PL380, Geological Survey locality Bb18, Wandong. NMV P137146 from PL1692, Wandong. NMV P140403 from PL1691, Kilmore East. NMV P139409 from PL1342, Kilmore East. NMV P140598 from PL1699, Upper Plenty. Yan Yean Formation. For localities see Taylor (1864), Williams (1964) (fig. 2) and Sandford (2006) (figs 2–3).

Derivation of name. After Peter Kenley, formerly of the Geological Survey of Victoria, who made valuable fossil collections from the Silurian of central Victoria.

Diagnosis. Eye large, length (exsag.) 44% sagittal cephalic length, placed with midlength opposite 45% sagittal cephalic length from posterior, visual surface with about 20–21 files of up to 7 lenses, postocular fixigenal field short, 7% sagittal cephalic length. Posterior border furrow narrowing and shallowing abaxially behind eye, terminating almost in line (exsag.) with lateral extremity of visual surface. Lateral border furrow indistinct, especially on librigena. Vincular furrow wide and shallow medially. Glabella with low tubercles of moderate size and density. Pygidium with 6–7 axial rings, 2nd to 5th ones with successively diminishing pseudo-articulating half rings. Five distinct pygidial pleural furrows, first 3 much deeper than remainder, last one very shallow, interpleural furrows very weak.

Description. Glabella narrow, maximum width approximately 80% sagittal length and 175% occipital width, placed level with 70% sagittal length from posterior. Axial furrow weakly converging forward adjacent to occipital ring and L1, wide and deep in front of occipital ring, diverging forward at about 65° adjacent to composite lobe. Occipital ring comprising 12% cephalic length sagittally, with small notch in anterior margin defining obliquely oriented lateral lobe. Occipital furrow deep, transverse medially. Medial part of L1 as high as composite lobe, lateral node small, depressed, isolated by deep exsagittal furrow. Glabellar width at L1 85% occipital width. S1 shallowing rapidly adaxial to inner edge of L1 node, expanding forwards to become a wide (sag.), triangular depressed area. S2 and S3 variably impressed. S2 weakly arcuate, reaching axial furrow, oriented at about 15° to transverse, anteriormost point opposite 38% sagittal cephalic length from posterior. Posterior branch of S3 strongly arcuate, anteriormost point opposite 55% sagittal glabellar length. Anterior branch of S3 sinusoidal, reaching axial furrow anteriorly. Length of L2 (exsag.) 70% length of L3 and 11% sagittal cephalic length. Front of glabella very high, strongly convex (tr.) in anterior view, in dorsal view forming strongly rounded arc centred at glabellar midlength (sag.) and overhanging anterior border. Preglabellar furrow shallow and wide. Palpebral area high, of low convexity, palpebral furrow moderately impressed, continuous with wide, moderately impressed sutural furrow behind eye. Palpebral lobe arcuate, of uniform width, raised above palpebral area. Lens formula from anterior (NMV P140136) 3 5 6 7 6 7 7 6 7 6 6 7 6 ? ? ? ? ? ? ? , about 120 lenses, visual surface without raised sclera. Librigenal field below eye concave, not distinctly separated from border. Medial part of cephalic doublure 30% sagittal cephalic length, anterior half very weakly convex (sag.) and posterior half weakly concave, vincular furrow running adjacent to anterior margin and separated from it by narrow (sag.) rim. Hypostomal suture transverse medially.

Thoracic axis narrowing weakly backwards, comprising about 30% segmental width (tr.). Axial rings with strong lateral nodes defined by posteriorly divergent furrows that notch front of segments. Pleurae horizontal and transverse adaxial of fulcrum, steeply inclined lateral to fulcrum and widening to well-rounded tips. Deep pleural furrow situated at midlength (exsag.) of segment at fulcrum, on anterior segments terminating distally at edge of articulating facet but extending onto facet on posterior segments.

Pygidium lenticular in dorsal view. Axis comprising 80% sagittal pygidial length and 25% maximum pygidial width anteriorly, tapering uniformly backwards. Axial rings strongly raised anteriorly, decreasing in height, length and definition posteriorly. First 5 rings comprise 72% axial length. Posterior end of axis broadly rounded and well defined. Pleural field weakly convex with weakly defined border. Anteriormost pleural furrow deep and wide, posterior furrows successively narrower (exsag.) and shallower.

Remarks. Ananaspis kenleyi occurs in the uppermost beds of the Yan Yean Formation at a number of localities between Upper Plenty and Kilmore but is nowhere common. It occurs together with the abundant *Dalmanites wandongensis*, and the rare *Trimerus* (*Trimerus*) *vomer* Chapman, 1912 and *Sthenarocalymene* sp.

Sandford (2000) considered *Ananaspis kenleyi* (as '*Ananaspis*' sp. nov.) to be most closely related and possibly ancestral to the distinctive *A. woiwurrungi* from the overlying Melbourne Formation. Sandford listed differences between the two species, *kenleyi* having stronger glabellar tuberculation that extends further posteriorly, shorter eyes, a deeper medial section of the vincular furrow and deeper pygidial pleural furrows (in *woiwurrungi* only the first to third pleural furrows are distinct on the external surface). Other differences in *kenleyi* are the narrower glabella (cf. maximum glabellar width 90% maximum cephalic width and 200% occipital width in *woiwurrungi*), shorter L2 (length 80% length of L3 and 15% sagittal cephalic length in *woiwurrungi*), fewer lenses in the eye (cf. 22 files with up to 8 lenses per file in *woiwurrungi*), slightly longer postocular fixigenal field (cf. length 5% sagittal cephalic length in *woiwurrungi*), indistinct lateral border furrow (shallow in *woiwurrungi*), shorter pygidial axis and less distinct interpleural furrows.

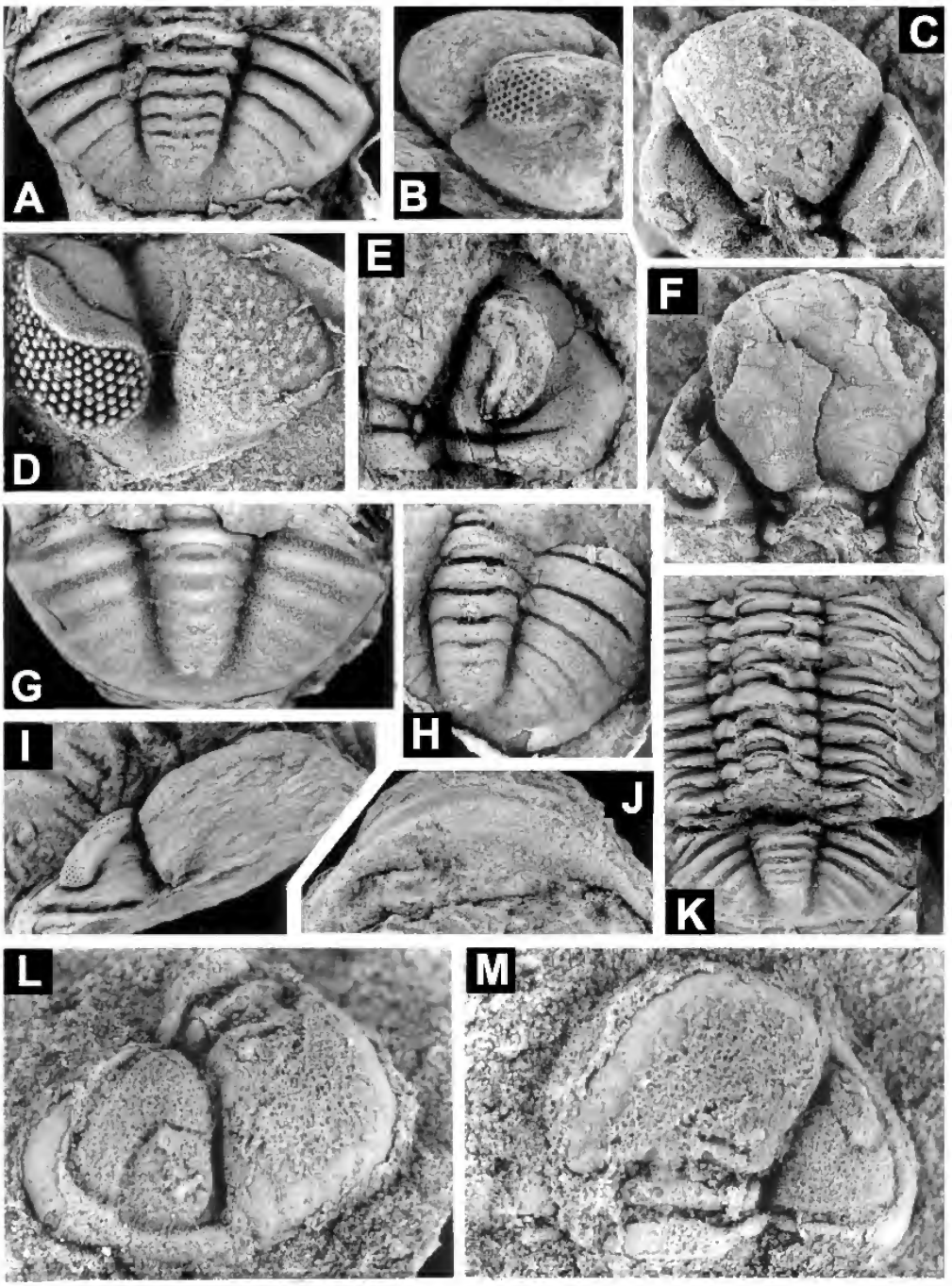

Figure 6. A–H, I?, J–K, *Ananaspis kenleyi* sp. nov. A, holotype NMV P136802, pygidium, × 6, from 'Broadhursts Creek', Wandong. B–C, paratype NMV P136821, cephalon × 4, from PL375, Kilmore East. D, paratype NMV P140156, cephalon, × 4.5, from PL375, Kilmore East. E, paratype NMV P140403, cephalon (fragment), × 2.5, from PL1691, Kilmore East. F, paratype NMV P137165, cephalon, × 3.5, from PL286, Wandong. G, paratype NMV P140154, thoracopygon with pygidium displaced and inverted, view of pygidium, × 4.5. H, paratype NMV P136820, pygidium with circular textural markings, × 4, from PL375, Kilmore East. I, paratype NMV P136815 cephalon, × 3, PL377, Kilmore East. J, paratype NMV P136819, exoskeleton with displaced cephalon, view of doublure, × 4, PL375, Kilmore East. K, paratype NMV P138648, thoracopygon, × 2.5, from 'Broadhursts Creek', Wandong. L–M, Phacopidae gen. indet. 1, NMV P136136 cephalon, × 5, from PL1368, Strathewen. (B–C, F–G, I–K are internal moulds).

Many of the differences between *kenleyi* and *woiwurrungi* can be interpreted in the context of ontogenetic and heterochronic processes. Chlupáč (1977) and Ramsköld (1988) discussed a number of features in the ontogeny of phacopids. Chlupáč noted that juvenile phacopids exhibit wider, more inflated glabellae with deeper S2 and S3, continuous S1, fewer lenses in the eye, deeper vincular furrows, stronger tuberculation and deeper pygidial pleural and interpleural furrows. Ramsköld's more detailed study showed that many of the characters of *Ananaspis* could be recognised in the ontogeny of *Acernaspis*. He noted that, compared with adults, juvenile *Acernaspis* exhibit a narrower, longer occipital ring with a median node, a longer (sag., exsag.) and less depressed L1, shorter L2, deeper and straighter S2 and S3 with S2 extending closer to the axial furrow, a smaller and more anteriorly placed palpebral lobe with deeper palpebral furrows, stronger tuberculation on the glabella and cheeks, deeper lateral border furrows, and the presence of genal spines.

Arguing that most of the juvenile characters are primitive for phacopids (where this could be determined), Ramsköld (1988) concluded that *Ananaspis* was a paedomorphic genus descended neotenically from *Acernaspis*. The opposite can be said for the *kenleyi–woiwurrungi* lineage. *Ananaspis kenleyi* exhibits a more paedomorphic or *Ananaspis*-like appearance compared to the more *Acernaspis*-like *woiwurrungi*, the significant differences being the stronger glabellar tuberculation, deeper vincular furrow, smaller eye, shorter L2 and deeper pygidial pleural furrows of *kenleyi*. The *kenleyi–woiwurrungi* lineage represents a reversal from the *Acernaspis–Ananaspis* morphocline and indicates that the radiation of phacopines in the Silurian was more complex than supposed by Campbell (1967) or Ramsköld (1988).

The relationships of the *kenleyi–woiwurrungi* lineage to other *Ananaspis* species remains uncertain although, as noted by Sandford (2000), there are similarities with the Wenlock species *Ananaspis stokesii* from Britain, *A. nuda* (Salter, 1864) (= '*Ananaspis* sp. aff. *A. stokesii*' of Siveter, 1989, pl. 19, figs 1–27, pl. 20, figs 8–10) from Ireland, and *A. amelangi* from Sweden (note that although the name *amelangi* was originally incorrectly derived, under the Code it cannot be corrected and its proposed change to *amelangorum* by Ramsköld and Werdelin, 1991: 70 is an unjustified emendation; ICZN Articles 32.2, 32.3, 32.5.1). Of these species *A. kenleyi* is most like *nuda*, exhibiting similar glabellar tuberculation and pygidial pleural furrows. However, the indistinct lateral border furrow on the fixigena and the shallower pygidial interpleural furrows distinguish the *kenleyi–woiwurrungi* lineage from these northern hemisphere species and others assigned to *Ananaspis*.

Ananaspis typhlagogus (Öpik, 1953)

Figures 3C, F–G, J–K, 7–8, ?10E–G, ?10J

Phacops typhlagogus.—Öpik, 1953: 26, pl. 10, figs 81–84.—Talent, 1964: 50.—Sherwin, 1971: 94.

Ananaspis typhlagogus.—Campbell, 1967: 32.—Ramsköld, 1988: 312, 313.—Rickards and Sandford, 1998: 751.—Sandford and Holloway, 1998: 915.

'*Phacops*' *typhlagonus* [*sic*].—Chlupáč, 1977: 77.

'*Ananaspis*' *typhlagoga* [*sic*].—Ramsköld and Werdelin, 1991: 72, 74.

Type material. Holotype CPC 686 (incomplete and partially enrolled exoskeleton), figured Öpik (1953: pl. 10, figs 81–84), figs 7C–E, from the '*Illaenus* band' (exact locality unknown), Costerfield. Wapentake Formation.

Other material. NMV P138228, NMV P138234–P138238, GSV36558 (missing), GSV46658 (missing), unregistered Geoscience Australia collection specimen from the '*Illaenus* band' (exact locality unknown), Costerfield. NMV P138229 from PL385, Costerfield. NMV P138279–P138289, NMV P140039, NMV P147835–P147837 from PL1460 (Thomas locality F43A), Costerfield. NMV P140152 from PL390, Costerfield. NMV P147049 from PL2263, Costerfield. Wapentake Formation. NMV P312813–P312815 from PL6361, Springfield. Chintin Formation. A single crushed cephalon NMV P147055 (figs. 10E–G, J) from PL206, Wallan, in the Bylands Siltstone, is tentatively assigned to the species.

Diagnosis. Glabella comprising a little more than 33% maximum cephalic width posteriorly and about 58% across frontal lobe. L2 not markedly shorter (exsag.) than L3 adaxially, S2 transverse adaxially and curving backwards abaxially. Composite lobe with densely and evenly distributed tubercles, larger ones of moderate size. Eye large, posterior edge very close to posterior border furrow, lower edge separated from lateral border furrow anteriorly by narrow band of librigenal field, visual surface with 16–18 rows of up to 5 lenses each. Fixigenal lateral border furrow shallow and wide. Pygidium with 6 axial rings and 4–5 pleural furrows.

Description. Exoskeleton of estimated maximum length 40 mm. Cephalon semi-elliptical in outline, length (sag.) approximately 58% maximum width, in frontal view anterior margin broadly arched upward adaxially with very weak downward sag medially. Glabella of moderate to strong convexity (sag., tr.), slightly overhanging anterior cephalic border in dorsal view, anterior margin forming arc centred approximately level with inner ends of S2. Width of glabella across frontal lobe almost twice width across L1 and approximately equal to sagittal cephalic length. Axial furrow shallow opposite occipital ring, very deep in front of occipital furrow and diverging forward at 55°–70° in front of S1. Occipital ring of uniform length (sag. exsag.) except distally where it is contracted, deflected slightly obliquely forward and bears weak lateral lobes. Occipital furrow very deep behind lateral node on L1, transverse and moderately impressed medially. L1 about 60% as long as occipital ring medially, with small, subquadrate, depressed lateral nodes. S1 deflected slightly forward adaxial to lateral node on L1, expanding and shallowing medially but continuous across glabella. L2 with maximum length (exsag.) 70%–80% maximum length of L3. S2 placed opposite midlength of eye, not reaching axial furrow. Posterior branch of S3 oriented transversely but gently convex forwards, inner end level with glabellar midlength (sag.). Anterior branch of S3 oriented diagonally, weakly convex forward. Preglabellar furrow moderately impressed. In anterior view anterior border narrow medially, wider laterally. Eye 45% sagittal cephalic length, distance of posterior edge from posterior border furrow less than or equal to length (exsag.) of posterior border directly behind. Visual surface on NMV P138236 (figs 7F–H, K) with lens formula 3? 5? 5 4? 5 4? 4 4? 4 5 4 4 4 4 3? 4 3 2; NMV P140152 (fig. 8J) with formula 2? 3? 4? 4 5 4 5 5? 5? 5? 4 5 5 5 4 3? Palpebral area weakly convex (tr., exsag.), palpebral furrow

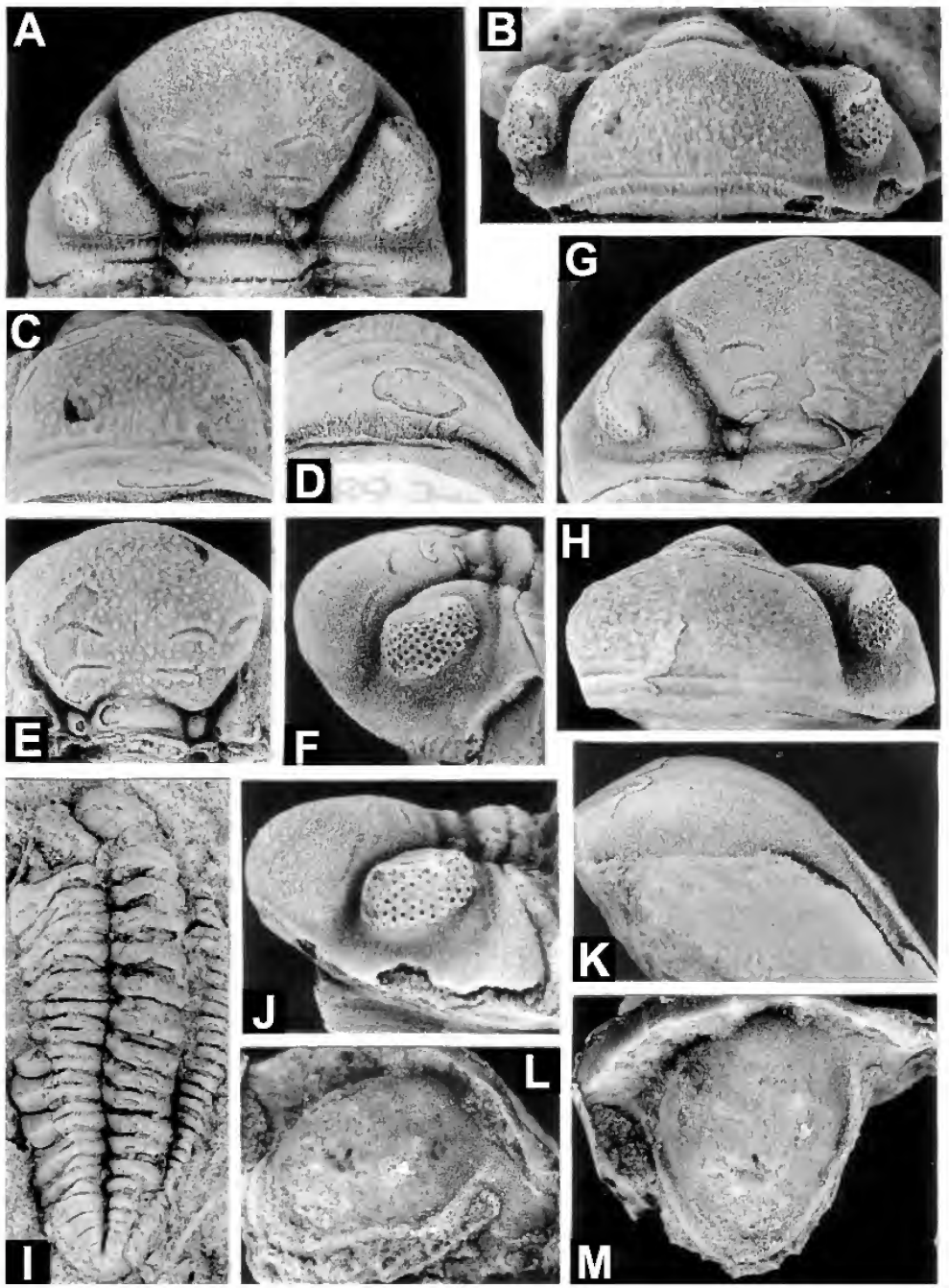

Figure 7. *Ananaspis typhlagogus* (Öpik, 1953). A–B, J, NMV P138229, cephalon × 7, from PL385, Costerfield. C–E, holotype CPC 686, dorsal exoskeleton, views of cephalon, × 3, from the '*Illaenus* band', Costerfield. F–H, K, NMV P138236, cephalon, × 4, from the '*Illaenus* band', Costerfield. I (and fig. 10C), NMV P138237, dorsal exoskeleton, × 4.5, from the '*Illaenus* band', Costerfield. L–M, unregistered specimen in AGSO collection, cephalon, view of hypostome, × 2.5, from the '*Illaenus* band', Costerfield. (I, L–M are latex casts).

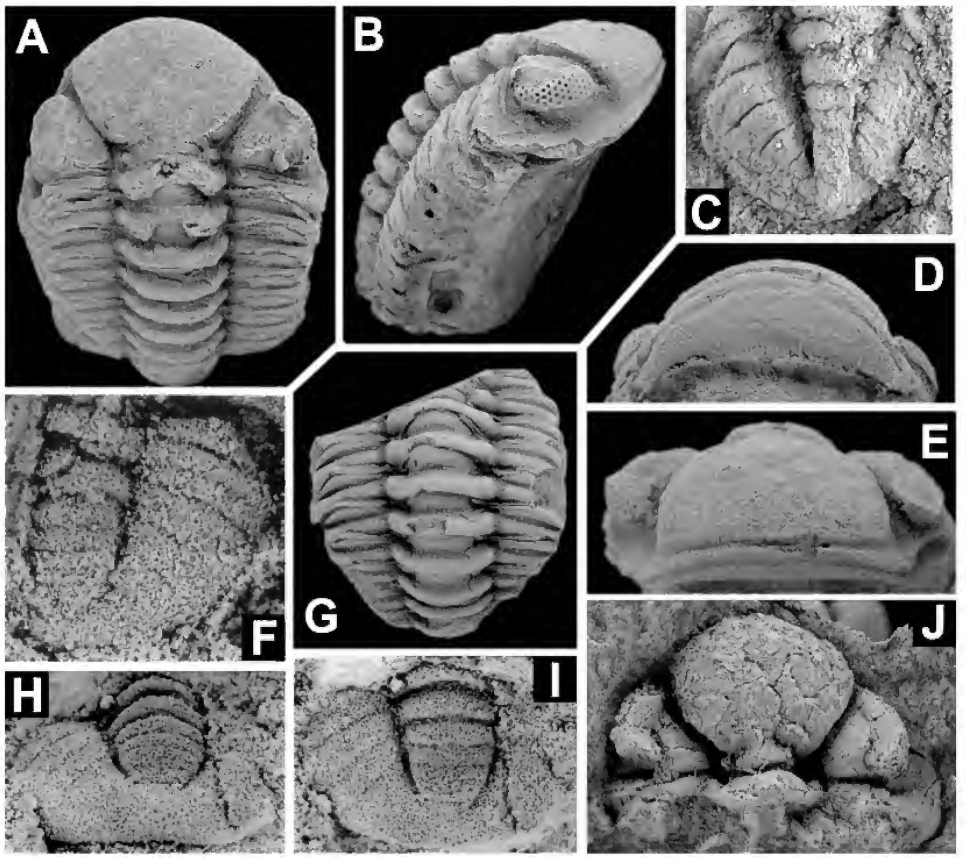

Figure 8. *Ananaspis typhlagogus* (Öpik, 1953). A–B, D–E, NMV P147049, partially enrolled exoskeleton from PL2263, Costerfield; A, × 2.8; B, × 3; D–E, × 3.5. C, NMV P138237, view of pygidium, × 9. F, NMV P138287, pygidium, × 4.3, from PL1460, Costerfield. G, NMV P138233, thorax, × 2.5, from the '*Illaenus* band', Costerfield. H–I, NMV P138285, pygidium, × 4.5, from PL1460, Costerfield. J, NMV P140152, cephalon, × 3.9, from PL390, Costerfield. (C, F, H–J are latex casts).

moderately impressed. Palpebral lobe crescentic in outline, very weakly convex (tr.), slightly elevated above palpebral area, with distinct rim furrow. Posterior border furrow deep, posterior border expanding (exsag.) backward adaxially so that genal angle is produced posteriorly. Librigenal field weakly concave below eye, steeply inclined, indistinctly separated from very weakly convex lateral border. Posterior branch of facial suture directed slightly obliquely forward across genal field and deflected backward across border to meet cephalic margin approximately level with median part of occipital furrow. Medial part of cephalic doublure steeply inclined backwards, weakly concave (sag.) in posterior part and weakly convex anteriorly. Hypostomal suture transverse medially. Vincular furrow moderately impressed, separated from anterior margin by narrow band, lateral notching moderately expressed.

Hypostome about 150% as wide anteriorly as long (sag.), parabolic in outline behind large, equilaterally-triangular anterior wings, with weakly defined shoulder opposite midlength (sag.). Middle body ovate in outline, moderately and evenly convex (sag., tr.), middle furrow and maculae indistinct. Lateral border narrow, in lateral view sloping gently dorsally from anterior wing to shoulder where it is gently deflected ventrally. Posterior border expanding slightly medially, posterior border furrow shallower than lateral border furrow.

Thorax of 11 segments. Axis wider (tr.) than pleurae, strongly convex (tr.), rings with lateral lobes weakly defined by slight expansion, by shallow notch in anterior margin, and by slightly oblique orientation of articulating furrow. Pleurae steeply inclined beyond fulcrum, well rounded distally, with deep pleural furrow terminating distally at edge of articulating facet, approximately 25% distance from fulcrum to tip.

Pygidia all incomplete or poorly preserved, with large, strongly oblique articulating facet and broadly rounded posterior margin. Axis gently tapering backwards and decreasing in height, bluntly rounded posteriorly, 1st ring standing higher than remainder and with shallow medial embayment in posterior

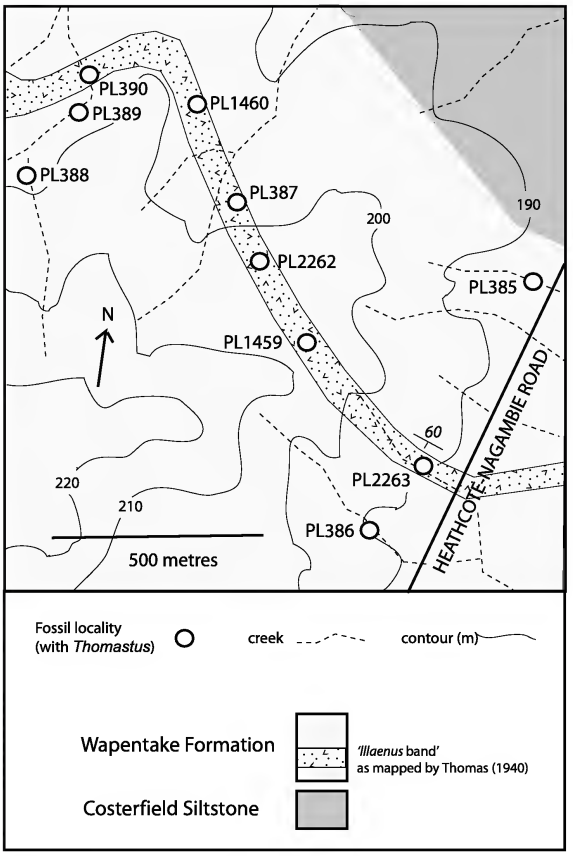

Figure 9. Fossil localities about 1 km south of Costerfield township; the area covered by the map is indicated on fig. 1.

edge to accommodate pseudo-articulating half ring on 2nd segment, 2nd and 3rd inter-ring furrows slightly expanded sagittally but without pseudo-articulating half-rings, 6th and 7th inter-ring furrows very poorly defined close together. Axial furrow deeper alongside axis than behind it. Pleural furrows short (exsag.) and rather sharply incised, 1st interpleural furrow shallow but distinct, remaining interpleural furrows very weak. Border very poorly defined.

Remarks. Ananaspis typhlagogus is not very common in the Wapentake Formation. Öpik (1953) reported that he had numerous fragments of the species but that only the holotype was well enough preserved to be used for description. Specimens such as the holotype that are preserved in the siliceous nodules of the Wapentake Formation are undeformed and the exoskeleton may be partly preserved as a mineralised crust (see Sandford and Holloway, 1998: 921). In contrast, moulds from mudstones of the Wapentake are crushed and fractured (fig. 8J), and those from a sandstone clast are fragmentary (figs 8F, H–I).

Öpik (1953) placed *typhlagogus* with the *Phacops orestes* group (i.e. *Acernaspis*) but noted that the latter species differs in 'many important points' including the lower glabellar profile and stronger vincular notching. Campbell (1967) assigned *typhlagogus* to *Ananaspis* on the basis of its glabellar tuberculation and the bevelled profile of the cephalic anterior margin and doublure.

Ananaspis typhlagogus is very closely related to *A. macdonaldi* Fletcher, 1950 [=*Acernaspis*? *oblatus* [*sic*] Sherwin, 1971; see Holloway, 1980: 64; Ramsköld and Werdelin, 1991:73], from the upper Llandovery to lower Wenlock of central-western New South Wales, and to '*Ananaspis*' sp. of Waisfeld and Sánchez, 1993, from strata of presumed similar age in Argentina. Sherwin (1971) stated that *typhlagogus* has more definite tuberculation and a more strongly inflated glabella than *macdonaldi*. However, the significance of the latter difference is difficult to assess in view of the wide variation in glabellar profile in *typhlagogus*, and we cannot see any clear difference between the species in sculpture. Ramsköld and Werdelin (1991) regarded *macdonaldi* and *typhlagogus* as possible synonyms, but we consider that *typhlagogus* can be distinguished by a higher visual surface of the eye with a greater number of lenses (five in the longest file instead of four in *macdonaldi*), a lower eye socle, a larger L1, and a more strongly curved posteromedial outline of the hypostome. '*Ananaspis*' sp. from Argentina, known only from an internal mould of a single cephalon (Waisfeld and Sánchez, 1993, pl. 1, figs 7–10), is difficult to distinguish from *typhlagogus* but it has an eye with up to six lenses per file and a vincular furrow that appears to be slightly deeper medially and has a distinct flexure anterolaterally.

Also similar morphologically to *A. typhlagogus* is *A. aspera* (Hawle and Corda, 1847) from the Ludlow of the Czech Republic (see Chlupáč, 1977, pl. 5, figs 9–25). The similarities include: relatively narrow (tr.) cheeks; L2 not markedly shorter (exsag.) than L3; adaxial half of S2 transverse; lower edge of eye situated above lateral border furrow anteriorly; visual surface very steeply inclined; and first order glabellar tubercles of moderate size. *A. aspera* differs from *A. typhlagogus* in that the cheeks are approximately as wide as the glabella posteriorly instead of slightly narrower than it; the eyes are much shorter (exsag.); the palpebral furrow is deeper; the lateral border furrow is deeper on the fixigena; and the pygidium has a greater number of more strongly defined segments and a narrower, subparallel-sided axis.

Ananaspis sp. 1

Figures 10A, 10D, 10I

Material. NMV P139354 (partly disarticulated cephalothorax), NMV P139355 (cephalon), NMV P139356 (right cheek) from PL1338, Wallan. Bylands Siltstone. For locality see Sandford and Rickards (1999: fig. 1).

Description. Cephalon subsemicircular, length 50% width. Glabella strongly convex (tr.), with maximum width situated at about 66% sagittal glabellar length and equal to 56% maximum cephalic width, 110% sagittal cephalic length and 170% occipital width. Outline of front of glabella forming arc centred at 33% sagittal cephalic length from posterior. Axial furrow wide and very deep in front of occipital ring, diverging strongly at about 75° between S1 and anterior end of palpebral furrow, thereafter diverging forward at about 45° to widest part of

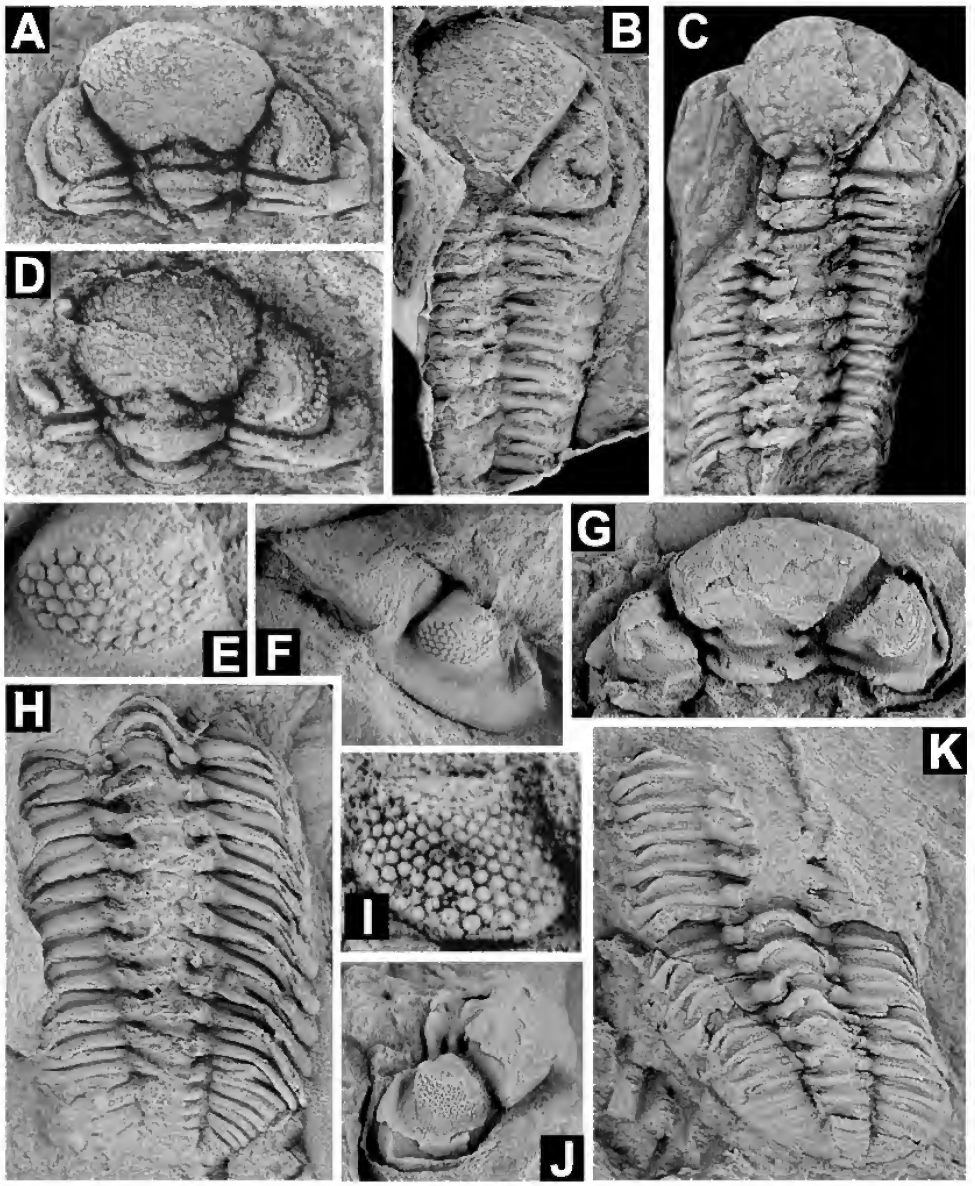

Figure 10. A, D, I, *Ananaspis* sp. 1 from PL1338, Wallan. A, D, NMV P139354, cranidium, × 6.5. I, NMV P139356 cephalon (fragment), enlargement of eye, × 9. B–C, *Ananaspis* sp. 2, NMV P136142, damaged cephalothorax, from PL1371, Coburg; B, × 1.4; C, × 1.2. E–G, J, *Ananaspis typhlagogus*? (Öpik, 1953), NMV P147055, cephalon (crushed) from PL206, Wallan; E–G, × 3; J, × 2.5. H, *Ivops wallanensis* gen. et sp. nov., paratype NMV P139326, thoracopygon, × 3, from PL206, Wallan. K, Phacopidae gen. indet. 3, NMV P312077, partly disarticulated thoracopygon, × 4.5, from PL1369, Springfield. (A, C, E–H, J–K are internal moulds).

frontal lobe. Occipital ring 30% maximum cephalic width, short, 10% glabellar length sagittally and slightly shorter laterally, lacking lateral lobes defined by notches in anterior margin. Occipital furrow deep, transverse. L1 as high as composite lobe medially, lateral node of moderate size and height, isolated by deep exsagittal furrow from preoccipital ring, width of glabella across L1 75% occipital width. S1 deep, directed anteromedially from inner end of lateral node on L1, at about 22° to transverse, connected medially by a shallower, wide (sag.), transverse furrow. L2 65% length (exsag.) of L3

and 11% sagittal cephalic length. S2 and S3 moderately impressed. S2 directed at 45° distally, curving abruptly to transverse direction proximally, anteriormost point opposite 40% sagittal glabellar length from posterior. Posterior branch of S3 weakly convex forward, oriented transversely opposite glabellar midlength (sag.). Anterior branch of S3 straight, not connected to posterior branch, placed anteriorly opposite anterior margin of eye, directed anterolaterally at 60° to exsagittal line. Frontal lobe high. Preglabellar furrow very shallow. Anterior border very short (sag.). Eye large, 50% sagittal cephalic length, placed with midlength of eye opposite 33% sagittal glabellar length, occupying entire length of genal field. Palpebral area low, weakly convex, palpebral furrow moderately impressed. Palpebral lobe steeply inclined, raised above palpebral area, with shallow rim furrow. Visual surface large, higher anteriorly than posteriorly, with more than 18 files of up to 7 lenses each, without raised sclera. Posterior border short (exsag.) adaxially, approximately 300% as long distally. Posterior border furrow deep and wide, continuous with deep and wide fixigenal lateral border furrow. Genal angle obtuse, with small point at angle. Lateral border moderately convex, wide (tr.) posteriorly, narrowing strongly anteriorly. Librigenal lateral border furrow moderately impressed. Posterior branch of facial suture skirting back of eye to lateral border furrow, strongly convex forward across lateral border, anteriormost point opposite 25% cephalic length. Cephalic doublure with extremely shallow vincular furrow anteriorly, very shallow and very weakly notched laterally. Cephalic tubercles variable in size from small to moderate, with superimposed granules, densely distributed on composite lobe of glabella, L1 and palpebral area, remainder of exoskeleton with granulose sculpture.

Remarks. *Ananaspis* sp. 1 is the only trilobite known from PL1338. Stratigraphically, the locality is about 50 m above PL206, which lies 750 m further to the south and yields a more diverse fauna.

Although the above description is based only on one complete cephalon and two fragments, the material is sufficient to distinguish the species from other Victorian Silurian phacopids. The species is most easily distinguished by its fine, dense cephalic tuberculation, by the large size of the eye which extends the entire length of the genal field, and by the very shallow vincular furrow medially. Assignment to *Ananaspis* is indicated by features including short L2 (relative to the length of L3), a narrow glabella, the variably sized glabellar tubercles, a deep lateral border furrow continuous with the posterior border furrow and the obtuse genal angle with a small point. The eye is larger than those of other *Ananaspis*, although eye length is a character that varies significantly between species here assigned to the genus (eye length up to about 47% sagittal cephalic length in *A. amelangi*, 45% in *A. fecunda* and *A. crossleii*, 40% in *A. decora*, 37% in *A. calvescens*, 30% in *A. aspera*). *Ananaspis* sp. 1 most closely resembles *amelangi*, sharing large eye size, similar cephalic ornament and cephalic proportions. The species differ in that *amelangi* has a glabella that does not always extend to the anterior margin of the cephalon, the occipital ring has more strongly defined lateral lobes, the visual surface has only six lenses per file and 15–16 files, the preglabellar and vincular furrows are deeper and the vincular notching is deeper. *Ananaspis* sp. 1 differs from the type species in having finer cephalic tuberculation, a larger eye and fewer lens files in the visual surface (19–21 in *fecunda*). In lens formula *A.* sp. 1 is most similar to *A. guttulus* (16 files of up to seven lenses per file) and *decora* (16–17 files of seven, rarely eight, lenses per file).

Ananaspis sp. 2

Figures 10B–C

Material. NMV P136142 (cephalothorax) from PL1371, about 50 m SW of corner of Murray Road and Elizabeth Street, Coburg. Dargile Group, precise stratigraphic horizon uncertain.

Description. Glabella wide, maximum width 110% sagittal length and 65% maximum cephalic width, overhanging anterior border. Axial furrow very shallow and slightly convergent forwards adjacent to occipital ring, very deep adjacent to composite lobe, straight and diverging forwards at about 65°. Occipital ring 50% maximum glabellar width, medial section raised, separated from short (exsag.) lateral section by deep notch in anterior margin. Occipital furrow transverse medially, deep. L1 short (exsag.) 13% sagittal cephalic length, lateral node low, globular, isolated from remainder of L1. S1 deep laterally, shallower medially where it forms posterior edge of a slightly depressed triangular area between L1 and composite lobe. Length of L2 16% sagittal cephalic length. S2 and posterior branch of S3 of moderate depth, wide, uniformly arcuate, almost reaching axial furrow. S2 directed obliquely inwards-forwards at about 15° to transverse. Posterior branch of S3 oriented transversely opposite glabellar midlength (sag.), anterior branch directed parallel to axial furrow. Posterior border furrow deep and wide (exsag.), widening abaxially, continuous with wide and deep lateral border furrow on fixigena. Postocular area 14% sagittal cephalic length. Glabellar tubercles large to very large, low and flat-topped, distributed irregularly with moderate density. Tuberculation subdued on genal field.

Remarks. The formation to which the strata at PL1371 belong is difficult to determine as the site is no longer exposed. Fossils are uninformative in this respect as the trilobite is the only fossil known and is not known from elsewhere.

The glabellar tuberculation, depth and placement of the lateral glabellar furrows, depth of the posterior and lateral cephalic border furrows and length of the postocular area are comparable to Eastern European and Central Asian species of *Ananaspis*. In the greater width of the glabella the Coburg species is closest to *A. crossleii* from the Yass district of New South Wales (maximum glabellar width 60% maximum cephalic width; see Sherwin, 1971, pl. 2, figs 6–9, pl. 3, figs 1–7). The Coburg specimen differs from *crossleii* in having a wider glabella with larger, flat and less densely distributed tubercles, and a longer (exsag.) postocular area (postocular length 14% sagittal cephalic length versus 10% in *crossleii*).

Ivops gen. nov.

Type species. *Ivops wallanensis* sp. nov. from the Bylands Siltstone (Wenlock), central Victoria.

Derivation of name. After the late Professor Ivo Chlupáč, Charles University, Prague. Gender masculine.

Diagnosis. L1 with lateral node very small and depressed, L2 short (exsag.). S2 containing deep pit adjacent to axial furrow, forming a notch in side of glabella. Anterior branch of S3 long, subparallel to axial furrow. Front of glabella overhanging anterior border. Eye relatively small, length (exsag.) approximately 30% sagittal cephalic length, its lower edge lying just above lateral border furrow anteriorly, visual surface without raised sclera. Lateral border furrow on fixigena continuous with posterior border furrow. Vincular furrow with weak notching laterally. Pygidium with weakly tapering axis constituting about 30% maximum pygidial width anteriorly, and with deep pleural and shallow but distinct interpleural furrows. Dense sculpture of bimodal tubercles on glabella.

Remarks. *Ivops* is known only from the type species. The genus closely resembles *Ananaspis* in glabellar and pygidial proportions, the short L2 (exsagittal length 80% that of L3), the continuity of the posterior border furrow with the lateral border furrow on the fixigena, the weak notching in the lateral part of the vincular furrow, and the depth of the pygidial pleural and interpleural furrows. The relatively small eye with its lower edge placed a short distance above the lateral border furrow and with a small number of lenses in the dorsoventral files are features comparable with species such as *A. aspera* and *A. calvescens*. Despite these shared features *Ivops* is unlike *Ananaspis* and other known Silurian phacopines in that S2 is deep laterally and contains an apodemal pit where it meets the axial furrow. This feature contrasts with the more typical phacopine morphology of a shallow S2 that is isolated from the axial furrow. A laterally deep S2 similar to that of *Ivops* is present in '*Paciphacops*' *microps* Chatterton, Johnson and Campbell, 1979 (type species of *Kainops* Ramsköld and Werdelin, 1991), from the upper Lochkovian to lower Pragian of New South Wales, but in that species S2 does not contain an apodemal pit and does not meet the axial furrow in all specimens. The relatively small eye of *Ivops* (the smallest of known Wenlock phacopids) is interpreted as an adaptation to a deep-water environment; see discussion in remarks on *Berylacaste berylae* gen. et sp. nov.

Ivops wallanensis sp. nov.

Figure 11

Ananaspis.—Rickards and Sandford, 1998: 752.
Ananaspis.—Sandford and Holloway, 1998: 915.

Type material. Holotype NMV P139323 (enrolled cephalothorax). Paratypes NMV P139324 (dorsal exoskeleton, pygidium displaced), NMV P139325 (enrolled cephalothorax), NMV P139326 (thoracopygon), NMV P139328 (partly enrolled dorsal exoskeleton), NMV P138230 (dorsal exoskeleton), NMV P138231 (incomplete cephalothorax). All from PL206, Wallan. Bylands Siltstone.

Other material. NMV P138232, NMV P139327, P147056 from PL206, Wallan. For locality see Sandford and Holloway (1998: text-fig. 1).

Derivation of name. In reference to the type locality.

Diagnosis. As for genus.

Description. Exoskeleton of known maximum length 30 mm. Cephalon about 60% as long (sag.) as wide, anterior outline with greatest curvature medially and in front of anterior extremity of eye. In frontal view anterior margin moderately arched upward medially, glabella strongly convex and evenly rounded. Glabella comprising about 30% maximum cephalic width posteriorly, width across frontal lobe about twice width at occipital ring and equal to sagittal length. Axial furrow diverging forward at about 70° from S1 to anterior end of palpebral furrow, thereafter diverging slightly more weakly to widest part of frontal lobe. Occipital ring high medially and with small, well-developed, obliquely oriented lobe laterally. Occipital furrow deep, transverse medially. L1 slightly narrower (tr.) than occipital ring, as high medially as composite lobe, lateral node smaller than lateral lobe of occipital ring. S1 expanding (exsag.) adaxially or bifid, posterior section transverse and weakly continuous medially, anterior section curving forward and rapidly dying out. L2 almost as short (exsag.) laterally as L1 and about 60% length of L3. S2 meeting axial furrow more or less opposite posterior edge of palpebral lobe, directed anteromedially and shallowing rapidly, weakly arcuate. S3 with anterior and posterior branches confluent opposite about 40% glabellar length (sag.) from posterior, anterior branch extending forward to opposite about 60% glabellar length (sag.) from posterior. Preglabellar furrow distinct across entire width (tr.) of glabella on internal moulds, decreasing in length (exsag.) adaxially in front of lateral part of frontal lobe. Posterior border and border furrow deflected rather strongly backward beyond fulcrum to genal angle. Palpebral lobe narrow (tr.), lenticular in outline, raised above palpebral area, palpebral furrow weakly curved. Visual surface with lenses arranged regularly in files anteriorly but less regularly posteriorly, lens formula (NMV P139328, figs 11H–I, K) from front 456652654?3?. Librigenal field subvertical below eye, lateral border steeply inclined. Posterior branch of facial suture transverse across genal field and deflected backward at about 45° across border. Cephalic doublure flat sagittally, vincular furrow forming distinct bevelled edge anteriorly, deep posterolaterally. Hypostomal suture transverse medially.

Thorax of 11 segments. Axis comprising 30% segmental width (tr.), strongly convex, rings transverse medially, with short exsagittal incisions in anterior margin defining obliquely forwardly directed lateral lobes. Pleurae with well-rounded tips and deep pleural furrows that are situated at midlength (exsag.) of segment at fulcrum and terminate distally at edges of articulating facets.

Pygidium lenticular, length (sag.) about 60% maximum width. Axis with 5 well defined rings and 1 or 2 very short (sag.) and weak ones posteriorly, axial terminus well rounded. Pleurae weakly convex (tr.), with 4 distinct pleural furrows and 2 very weak ones posteriorly. Border not present.

Remarks. The above description is based mainly on the least deformed specimens (e.g. figs 11B–C, E, J). S2 and S3 appear to vary markedly in depth, being very weak on most specimens

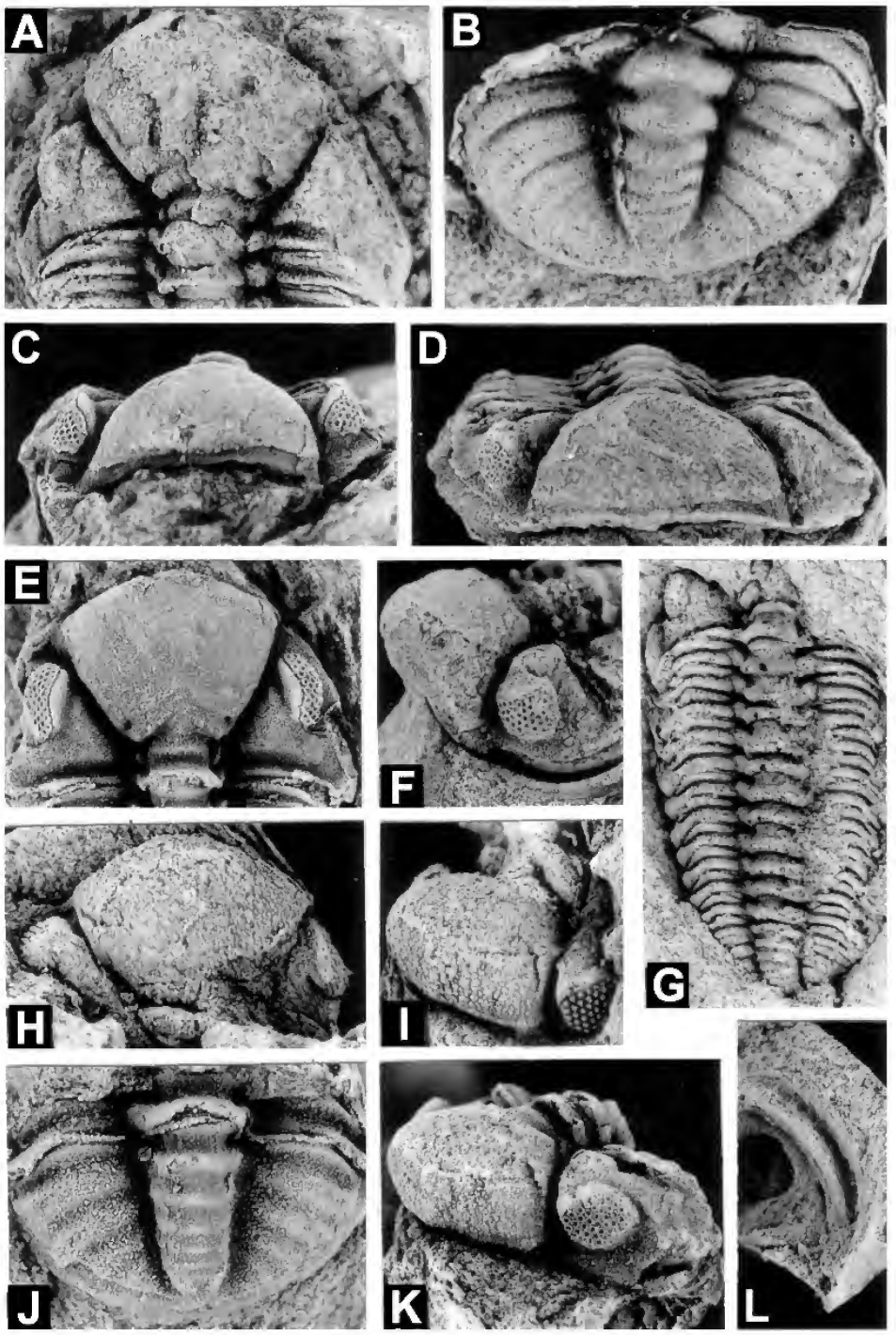

Figure 11. *Ivops wallanensis* gen. et sp. nov., from PL206, Wallan. A, G, paratype NMV P138230, dorsal exoskeleton; A, × 4.3; G, × 3.2. B, F, J, L, paratype NMV P139324, exoskeleton with displaced pygidium; B, view of pygidium, × 6.5; F, view of cephalon, × 3.8; J, view of pygidium, × 5.4; L, view of cephalic doublure, × 3.8. C, E, holotype NMV P139323, enrolled exoskeleton, view of cephalon, × 3.8. D, paratype NMV P139325, cephalon, × 3.8. H–I, K, paratype NMV P139328, partly enrolled exoskeleton, view of cephalon, × 4.3. (A, C–F, J–K are internal moulds).

but moderately impressed on both internal and external moulds of NMV P138230 (figs 11A, G). However, the apodemal pit in the lateral part of S2 is always present.

Phacopidella Reed, 1905

Type species. Phacops glockeri Barrande, 1846 from the upper part of the Motol Formation (upper Wenlock), Czech Republic, by original designation.

Phacopidella? sp.

Figure 12A

Asaphus.—Selwyn, 1863: map note.

Phacops crosslei.—Chapman, 1913: 210, 229.—Chapman, 1915: 169.

Phacopidella?.—Rickards and Sandford, 1998: 749.

Material. NMV P1218 (dorsal exoskeleton with displaced cephalon), probably from PL1393, Geological Survey locality Ba5, Keilor. Springfield Formation, in siltstone underlying the Lintons Creek Conglomerate Member; late Llandovery, Telychian (*Spirograptus turriculatus–Monograptus crispus* biozones). For locality see Selwyn (1863), Rickards and Sandford (1998) (fig. 5).

Description. Exoskeleton, of estimated original length about 35 mm, has been flattened tectonically and slightly sheared. The preserved portion of the cephalon consists of the glabella behind about the middle (sag.) of the frontal lobe together with the posteromedian part of cheeks. The glabella is slightly narrower across L1 than across the occipital ring and expands gently forwards in front of L1, the axial furrow here diverging at about 40°. The occipital ring is almost twice as long sagittally as exsagittally, with lateral lobes defined by very short exsagittal incisions in the anterior edge. The median portion of the occipital furrow is arched forward. L1 has large, quadrate nodes laterally and is slightly shorter (sag., exsag.) than the occipital ring medially. S1 is deep laterally, is deflected forwards adaxial to the short exsagittal furrow defining the lateral node of L1 and shallowing rapidly, becoming indistinct medially. S2 is short (exsag.), very faint and weakly convex forward, directed slightly obliquely backward laterally. L2 is about as long (exsag.) as L1. The posterior branch of S3 is indistinctly preserved on the left side of the glabella, running subparallel to S2. Axial furrow deep. Left palpebral lobe possibly partly preserved, seemingly relatively long (exsag.) and obliquely oriented. Thorax with 11 segments. Axial rings with short, deep exsagittal incisions in anterior margin defining large, quadrate lateral lobes. Pleurae with deep pleural furrow situated at middle (exsag.) of segment at fulcrum; distal parts of pleurae not preserved but overall width of pleural lobe appears not to exceed width of axis. Pygidium large, approximately 160% as wide as long (sag.). Axis about 30% maximum pygidial width anteriorly and about 66% sagittal pygidial length, with 5 well defined rings and weak 6th ring. Pleurae with 5 deep pleural furrows and 2 weak ones posteriorly; interpleural furrows moderately impressed. Dorsal surface of pleurae not intact abaxially on internal mould, so appearance of wide, smooth border is largely an artefact.

Remarks. The lithology of this specimen is identical to that of a specimen of *Hadromeros* from Keilor, one of two trilobites collected by C.D. Aplin in the 1850s that were noted on the geological quarter sheet by Selwyn (1863) as *Cheirurus* and *Asaphus.* NMV P1218 is apparently the second trilobite collected by Aplin, and that recorded by Chapman (1913) as *Phacops crossleii* Etheridge and Mitchell, 1896 from Keilor. However, the museum label with the specimen records the locality as 'Saltwater River, one mile west of Gisborne', as published by Chapman (1915). Chapman (1915) noted the lithology of the trilobite specimen as 'bearing a strong resemblance to the Keilor...mudstones'. Chapman, the museum palaeontologist at the time, appears to have confused Gisborne with Keilor. Only Early to Middle Ordovician graptolitic beds outcrop in the Gisborne area, with a lithology quite unlike that of the trilobite specimen.

The low pygidial convexity (largely a result of tectonic flattening) and well defined pygidial segmentation explain Selwyn's (1863) preliminary assignment of the specimen to *Asaphus.* The glabellar segmentation, especially S1 that is continuous though very weak medially and the shallowness and orientation of S2 and the posterior branch of S3, as well as the overall form of the pygidium, indicate that the specimen belongs to the Phacopidae. The gentle forward expansion of the glabella, the relatively long (sag., exsag.) L1 with large lateral nodes, the well-defined nodes on the occipital ring and thoracic axial rings, and the relatively large and well-segmented pygidium are all consistent with assignment to *Phacopidella.* A characteristic feature of *Phacopidella* (and of *Eophacops*) is the abrupt shallowing and adaxial flexure of the axial furrow at the anterolateral extremity of L3. This part of the glabella is not preserved in the specimen; however, so that the presence of this feature and assignment to *Phacopidella* cannot be confirmed. This uncertainty aside, the specimen differs from the type species of *Phacopidella, P. glockeri,* in having a wider axis on the thorax and pygidium, the pygidial axis extends closer to the posterior margin, and the pygidial pleural and interpleural furrows are deeper.

Phacopidae gen. indet. 1

Figures 6L–M

Lochkovella?.—Rickards and Sandford, 1998: 753.

Material. NMV P136136 (cephalon) from PL1638, Williams locality W25, Strathewen. Yan Yean Formation. The locality occurs in strata mapped just below the boundary of the Anderson Creek Formation and the Dargile Formation (Garratt, 1972). Strata mapped at this horizon in some areas around Melbourne were reassigned by Rickards and Sandford (1998) to the Yan Yean Formation. The presence of a distinctive encrinurid at PL1638 that otherwise occurs in the upper beds of the Yan Yean Formation at Heathcote (at PL2259, Thomas locality F41, Parish of Heathcote) and at Upper Plenty (PL1697, PL1699) supports the assignment of strata at PL1638 to the Yan Yean Formation. For localities see Thomas (1940), Williams (1964) (fig. 2) and Sandford (2006) (figs 2, 4).

Description. Cephalon semi-elliptical in outline, sagittal length about 60% maximum width. Glabella gently to moderately convex (sag., tr.), frontal lobe low, width across frontal lobe approximately twice width across L1 and a little more than sagittal length. Axial furrow wide and very deep, diverging at

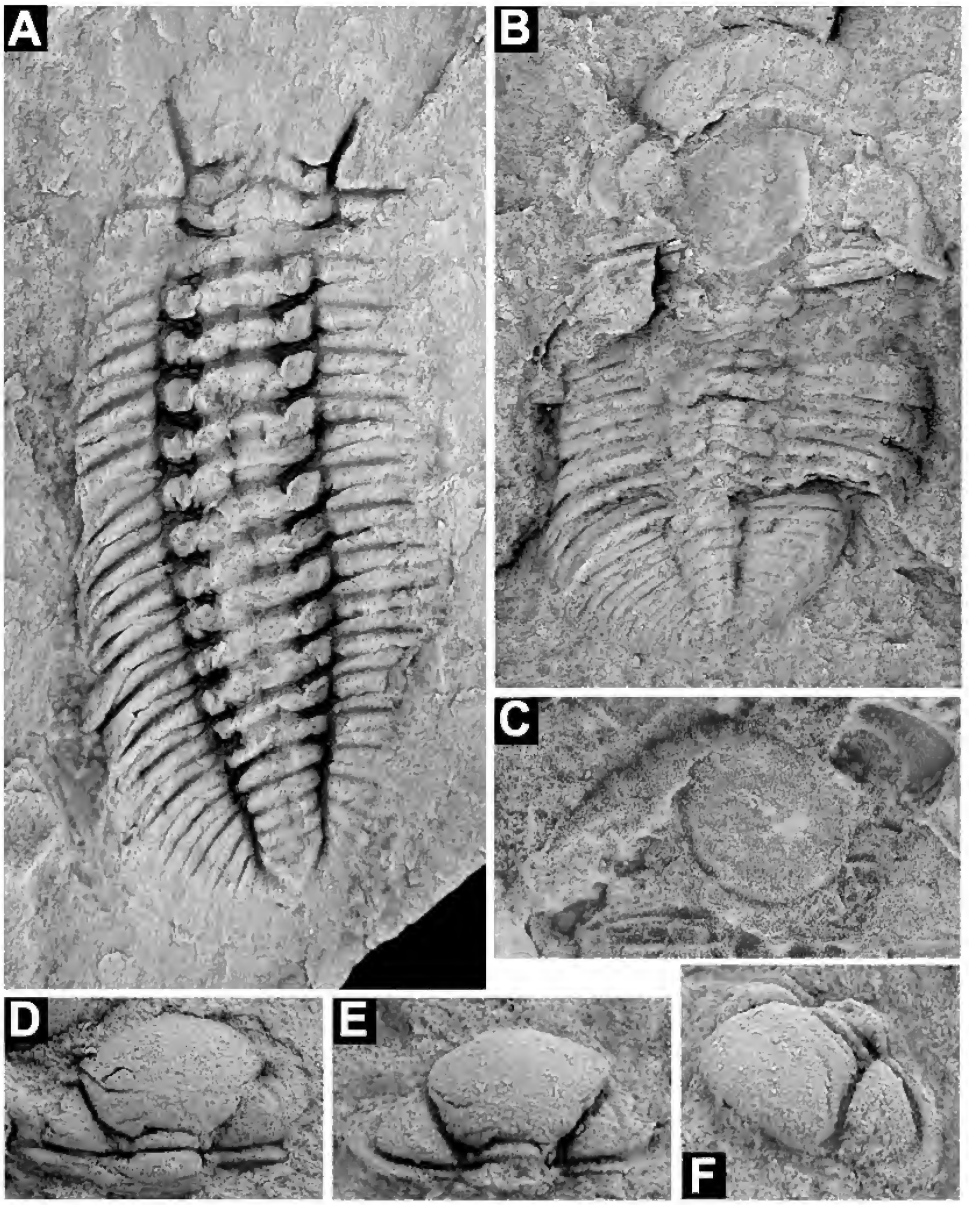

Figure 12. A, *Phacopidella*? sp., NMV P1218, dorsal exoskeleton, × 2.7, from PL1393, Keilor. B–C, *Struveria* sp. 1, NMV P139357, partly disarticulated exoskeleton with hypostome and cephalic doublure exposed, from PL1386, Broadmeadows; B, × 3.4; C, × 4. D–F, Phacopidae gen. indet. 2, NMV P312076, cephalon, × 8, from PL1369, Springfield. (A, E–F are internal moulds).

about 60° in front of S1. Occipital ring comprising 40% maximum cephalic width, raised high medially, shorter (exsag.) and obliquely directed laterally but without well defined lateral lobes. Occipital furrow deep. L1 of almost uniform length (sag., exsag.) across glabella, high medially, inner edge of lateral node obscured. S1 very deep and wide laterally, directed slightly forward of transverse, shallowing abruptly close to sagittal line. S2 deep, weakly convex forward, its outer end opposite posterior edge of eye, running parallel to S1 and very close to it. S3 not clear but posterior branch apparently directed posteromedially at about 30° to transverse and with inner end more or less level with glabellar midlength (sag.) and close to

S2. Eye small and obliquely oriented, situated almost its own length (exsag.) from posterior border furrow and with midlength opposite glabellar midlength (sag.). Palpebral furrow moderately impressed, weakly arcuate, continuous with postocular furrow that is of similar depth and reaches lateral border furrow. Palpebral lobe not raised above palpebral area. Visual surface not well preserved but appears greatly reduced, ovate in outline with lower edge distant from lateral border furrow, and with about 10 lenses. Posterior border furrow deep adaxially, continuous with wide, deep lateral border furrow. Posterior border uniformly short (exsag.) except distally. Genal angle rounded. Lateral border weakly convex, wider behind intersection of postocular furrow than in front. Sculpture obscured by preservational pitting covering most of cephalic surface.

Remarks. Tentative assignment of this specimen to *Lochkovella* by Rickards and Sandford (1998) was based on the small and forwardly placed eye, the deep and continuous posterior and lateral cephalic border furrows, the deep postocular furrow, and the apparent absence of coarse tuberculation on the glabella. These characters as well as the narrow cheeks invite comparison with the Czech Early Devonian (Pragian) species '*Phacops* (*Phacops*?)' *hanusi* Chlupáč, 1977 and '*P.* (*P.*?)' *veles* Chlupáč, 1972, which were assigned to *Lochkovella* by Sandford (2004). However, other characters of the specimen are incompatible with assignment to *Lochkovella*. Such characters include the glabella of low convexity that does not overhang anteriorly, and the very small, elliptical visual surface of the eye with its lower edge distant from the lateral border furrow. It is possible that the specimen belongs to an undescribed genus.

The monotypic *Orygmatos* Sandford, 2000, from a slightly higher stratigraphic horizon low in the Melbourne Formation at Yan Yean, 10 km to the north-east, also has very small eyes with an elliptical visual surface. Compared with the present specimen from Strathewen, *Orygmatos* has an occipital ring that is more expanded (sag., exsag.) and prominent medially, L1 is very short (sag., exsag.) and markedly depressed, the composite glabellar lobe expands more strongly forward and is coarsely tuberculate, the palpebral furrow meets the postocular furrow in an broad curve rather than an abrupt angle, and the posterior border furrow and fixigenal portion of the lateral border furrow are very wide. *Denckmannites* Wedekind, 1914 has even more greatly reduced eyes than the Strathewen specimen, much weaker palpebral and postocular furrows, a more elongated glabella, wider cheeks, and a longer anterior border. The small-eyed *Denckmannites rutherfordi* Sherwin, 1968 from the Ludlow–Přídolí of central western New South Wales was assigned to *Lochkovella* by Chlupáč (1977) but Sandford (2004) noted that the presence of strong notching in the lateral part of the vincular furrow excluded the species from that genus, a conclusion supported by the apparent absence of granular sculpture on the exoskeleton. The very low cephalic profile (sag., tr.), the more pentagonal outline of the glabella, the subparallel alignment of S2 and S3, and the broadly arcuate union of the palpebral and postocular furrows distinguish *rutherfordi* from the Strathewen specimen.

Phacopidae gen. indet. 2

Figures 12D–F

Material. NMV P312076 (cephalon) from PL1369, Deep Creek, Springfield. Springfield Formation. For locality see fig. 4.

Remarks. This very small cephalon (3 mm in length), and two other small specimens documented below as Phacopidae gen. indet. 3, are the only phacopids known from PL1369. The cephalon undoubtedly belongs to a juvenile individual, and its size is in the range of late meraspides and early holaspides of *Acernaspis* (cephalic lengths 1.3 mm to 3.3 mm) documented by Ramsköld (1988). It is characterised by a strongly convex glabella that overhangs anteriorly, a short (exsag.) L2, a very large eye occupying almost the entire length of the genal field, a well defined fixigenal lateral border furrow joining the posterior border furrow, and a granulose sculpture. The glabellar convexity, length of L2 and distinct lateral border furrow suggest assignment to *Ananaspis*, but the last two characters could also be attributed to the small size of the specimen as Ramsköld (1988) observed that in juveniles of *Acernaspis* L2 is shorter and the lateral border furrow deeper than in adults. The glabella lacks the tuberculation characteristic of *Ananaspis*, whereas the sculpture is normally relatively coarser in juveniles than adults.

Phacopidae gen. indet. 3

Figures 5E–G, 10K

Material. NMV P139353 (partially enrolled exoskeleton), NMV P312077 (partly disarticulated thoracopygon) from PL1369, Springfield. Springfield Formation.

Remarks. These two small specimens are considered to belong to the same species because of similarities in the pygidia, which have six axial rings, two pseudo-articulating half rings (although the third ring is damaged in the thoracopygon), four distinct pleural furrows, and well-defined interpleural furrows extending almost to the margin. The partially enrolled exoskeleton has a cephalon with a moderately convex (sag.) glabella that does not overhang the preglabellar furrow and anterior border in dorsal view, very weak S2 and S3, a shallow fixigenal border furrow, an eye of moderate size situated well in front of the posterior border furrow, a weakly curved palpebral lobe, and a finely granulose sculpture. Compared to the cephalon described above as Phacopidae gen. indet. 2, which is from the same locality, the present specimen represents a larger individual (cephalic length 7.5 mm as opposed to 3 mm) and has a more weakly convex glabella and much smaller eye. The difference in the eyes cannot be attributed to ontogenetic changes as eye size increases during ontogeny rather than decreases, as documented by Ramsköld (1988) in *Acernaspis*. We therefore conclude that Phacopidae gen. indet. 2 and Phacopidae gen. indet. 3 belong to different taxa.

Superfamily **Dalmanitoidea** Vodges, 1890
Family **Dalmanitidae** Vodges, 1890

Dalmanites Barrande, 1852

Type species. Trilobus caudatus Brünnich, 1781 from the Coalbrookdale Formation (Wenlock) of England.

Dalmanites athamas Öpik, 1953

Figures 13A–K

Dalmanites sp.—Thomas, 1937: 66.

Dalmanites athamas Öpik, 1953: 28, pl. 10, figs 88–91; text-fig. 9 (IV).—Holloway and Sandford, 1993: 97.—Sandford and Holloway, 1998: 916.—Rickards and Sandford, 1998: 751.

Dalmanitina (*Eudolatites*) *aborigenum* Öpik, 1953: 26 (*partim.*), pl. 10, fig. 85, text-fig. 9 (III) (*non* pl. 10, figs 86–87 = *Struveria*? sp.).

Dalmanites? *athamas*.—Talent, 1964: 50.

'*Dalmanitina*' *aborigenum*.—Talent, 1964: 50.

Type material: Holotype NMV P52484 (pygidium, figured Öpik, 1953: pl. 10, fig. 88) and paratype NMV P52485 (fragment of cephalon, figured Öpik, 1953: pl. 10, fig. 89) from PL2262, Thomas locality F43, Costerfield. Paratype NMV P52486 (fragment of cephalon, figured Öpik, 1953: pl. 10, figs 90–91) from PL2269, Thomas locality F51, Costerfield. Wapentake Formation.

Other material. NMV P138215–P138216 from the '*Illaenus* band' (exact locality unknown), Costerfield. NMV P138217 from PL389, Costerfield. NMV P52482 (holotype of '*Dalmanitina* (*Eudolatites*)' *aborigenum*), P138218–P138219, NMV P138223 from PL2269, Costerfield. NMV P138220 from PL2263, Thomas locality F44, Costerfield. NMV P139805 from PL386, Costerfield. Wapentake Formation. For localities see Thomas (1940) and fig. 9.

Diagnosis. Dalmanites with very short (sag., exsag.) anterior cephalic border lacking median expansion or process. Glabella about 77% as wide across frontal lobe as long (sag.), frontal lobe comprising a little more than half sagittal length of glabella. Pygidium with 14–15 axial rings and 10 pleural furrows. Axis narrow, comprising 23% maximum pygidial width anteriorly, with apodemes on 1st 10–12 segments. Pleural furrows flat-bottomed, as long (exsag.) as or longer than preceding anterior pleural band, posterior bands much shorter except adaxially and dying out distally on more posterior segments, pleural nodes absent.

Description. Glabella with widths across L1, L3 and frontal lobe approximately in ratio 1:1.6:1.8. Occipital ring, L1 and L2 of equal length, together comprising 35% sagittal glabellar length. S1 and S2 transverse, S1 with apodemal pit extending almost to axial furrow, S2 with slightly narrower (tr.) apodemal pit and shallow extension to axial furrow. L3 as long (exsag.) adaxially as L1 and L2, twice as long at axial furrow. S3 deepest proximally, expanding abaxially and subsequently contracting again toward axial furrow. Frontal lobe transversely elliptical, width 150% length, with short longitudinal depression in posterior half and forwardly expanding median field of muscle scars occupying slightly more than anterior half. Anterior border slightly shorter sagittally than laterally, weakly concave. Anterior branch of facial suture running slightly closer to preglabellar furrow than to anterior cephalic margin. Posterior border furrow lanceolate in outline, gently deflected backward distally, not meeting lateral border furrow.

Thoracic axis weakly convex (tr.), gently tapering backward. Axial rings very weakly convex (sag., exsag.), slightly bowed forward medially. Axial furrow deep. Pleural furrows expanding (exsag.) abaxially to fulcrum, deep, anterior slope much steeper than posterior slope. Anterior pleural bands strongly convex (exsag.), posterior bands becoming flattened toward fulcrum and inclined, poorly differentiated from posterior slope of pleural furrow. Pleural bands with sculpture of small, sparse granules.

Pygidium triangular in outline, shape of posterior termination unknown. Axis with length about 70% maximum pygidial width, tapering uniformly backward, 1st ring with subrectangular medial embayment in posterior edge accommodating pseudo-articulating half ring on 2nd segment, inter-ring furrows shallowing medially and expanded (sag.) except towards back of axis where they become increasingly more poorly defined. Axial furrow narrow but distinct on external surface. 1st pleural furrow straight except distally where it is deflected strongly backwards, subsequent furrows successively more evenly curved and more posteriorly directed, 10th furrow directed exsagittally. 7th pleural rib with distinct forward deflection proximally. Interpleural furrows sharply impressed externally. Doublure narrow, moderately convex abaxially and with a low upturned lip adaxially, with densely distributed small granules.

Remarks. The synonymy of '*Dalmanitina* (*Eudolatites*)' *aborigenum* with *Dalmanites athamas* was discussed by Sandford and Holloway (1998: 916). The paratype of *aborigenum*, a pygidial fragment, is not congeneric with the holotype and we assign it to *Struveria* sp. 2.

New material of *athamas* has become available since Öpik's (1953) original description but no cephala that are more complete. Öpik considered the species to be close to and possibly a subspecies of *Dalmanites wandongensis* from the overlying Dargile Formation, but comparison of the available material indicates that the two species are distinct. *D. wandongensis* was revised by Sandford (2006) and differs from *D. athamas* in that L1 is shorter than L2 instead of equal in length; the pygidial pleural furrows are shorter (exsag.) and not as flat-bottomed in cross section but form a continous slope with the succeeding posterior pleural band; and the interpleural furrows are weaker.

Ramsköld (1985) recognised a closely related group of European and North American Wenlock–early Ludlow species of *Dalmanites* including the type species, *D. caudatus* (Brünnich, 1781), as well as *D. corrugatus* (Reed, 1901), *D. limulurus* (Green, 1832), *D. myops* (König, 1825), *D. nexilis* Salter, 1864, *D. obtusus* (Lindström, 1885) and *D. platycaudatus* Weller, 1907. These species share prominent lateral nodes on the first, sixth and seventh thoracic axial rings, and nodes on the pygidial pleural ribs. *D. athamas* lacks the thoracic and pygidial nodes characterising this group, which also differs from *athamas* in having a medially expanded anterior cephalic border, and pygidia with shorter (exsag.) pleural furrows and longer (exag.) posterior pleural bands that are subequal in length to the anterior bands.

Bessazoon Curtis and Lane, 1998

Type species. Dalmanites weaveri var. *tenuimucronata* Whittard, 1938 from the Hughley Shales (upper Llandovery) of Shropshire, England, by original designation.

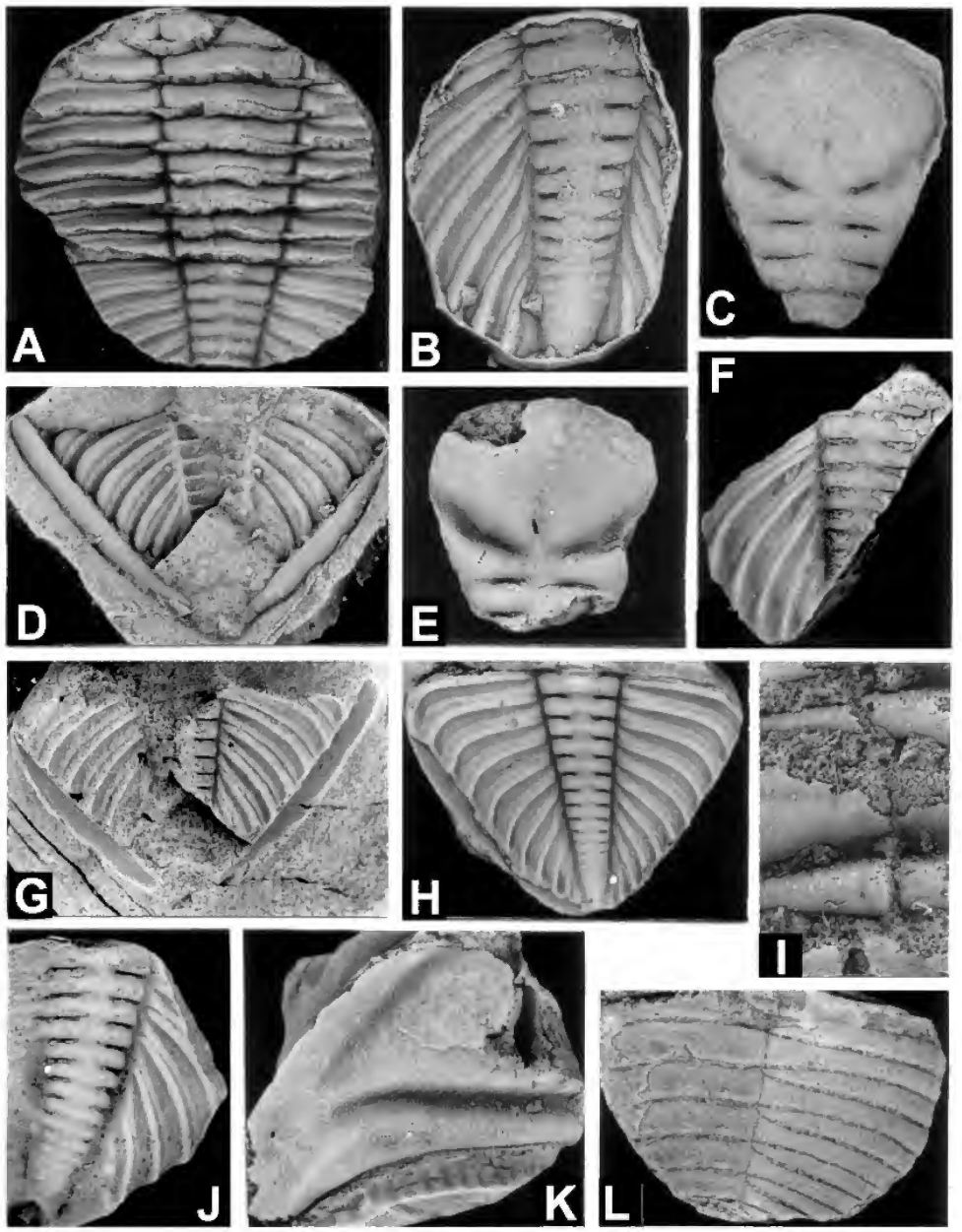

Figure 13. A–K, *Dalmanites athamas* Öpik, 1953. A, NMV P138215, thoracopygon, × 1.5, from the '*Illaenus* band', Costerfield. B, NMV P138219, pygidium, × 3.5, from PL2269, Costerfield. C, paratype NMV P52485, cranidium, × 2, from PL2262, Costerfield. D, G, NMV P138217, pygidium, × 2, from PL389, Costerfield. E, paratype NMV P52486, cranidium, × 2, from PL2269, Costerfield. F, NMV P138218 pygidium, × 2, from PL2269, Costerfield. H, holotype NMV P52484, pygidium, × 1.5, from PL2262, Costerfield. I, NMV P138223, thorax, enlargement showing granulation, from PL2269, Costerfield. J, NMV P139805, teratological pygidium, × 2, from PL386, Costerfield. K, NMV P52482, incomplete fixigena, holotype of '*Dalmanitina* (*Eudolatites*) *aborigenum*' Öpik, 1953, × 2, from PL2269, Costerfield. L, *Struveria* sp. 2, NMV P52483, pygidium, paratype of '*Dalmanitina* (*Eudolatites*) *aborigenum*' Öpik, 1953, × 3, from PL2269, Costerfield. (B, D are latex casts)

Remarks. Of the characters regarded by Curtis and Lane (1998: 62) as diagnostic of *Bessazoon*, Chatterton and Ludvigsen (2004: 47) questioned the taxonomic value of the size of the eyes and the loss of the pygidial mucro in large specimens. In the type species and *B. tigerense* (Holloway and Sandford, 1993) the eyes are very large and occupy almost the entire length of the genal field, but in Curtis and Lane's species *B. buttingtonense* and the cephalon they illustrated as *B.* cf. *B. tenuimucronatum* (their pl. 9, fig. 1) the eyes are smaller and do not extend very close to the border furrows anteriorly and/or posteriorly. In regard to the loss of the mucro, Curtis and Lane illustrated three pygidia assigned to *B. tenuimucronatum* with the posterior termination preserved. Two of these (Curtis and Lane's pl. 8, figs 6, 8) have a mucro, that on the larger specimen being considerably shorter than the one on the smaller specimen. The third pygidium, which is very much larger that the others (Curtis and Lane's 'type 2' pygidium, pl. 8, fig. 2), does not have 'a shorter mucral spine' as stated by Chatterton and Ludvigsen (2004) but an embayment in the margin posteromedially. Because of this difference, as well as the differences in size and the much greater number of axial rings and pleural furrows, it is not possible to be confident that this pygidium is correctly assigned to *B. tenuimucronatum*. However, we note that it has a distinctive pleural structure in which the posterior bands expand distally and the anterior bands are pinched out, and that this structure appears to be shared by the smaller pygidium in pl. 8, fig. 6 (the structure is not clear in the third pygidium as the dorsal surface is broken away distally to reveal the doublure). Although we believe that these pygidia are correctly assigned to the Dalmanitidae, their pleural structure is unusual for Silurian and Devonian representatives of the family, in most of which it is the anterior rather than the posterior pleural band that is dominant distally (Holloway, 1981: 710), as is also the case in *B. buttingtonense* (Curtis and Lane, 1998, pl. 9, figs 2, 4, 7), *B. tigerense* (Holloway and Sandford, 1993, fig. 6) and in the unnamed species from Victoria described below. The only pygidium of *B. buttingtonense* with the posterior termination preserved (Curtis and Lane, pl. 9, fig. 2a, b) is of about the same size as the 'type 2' pygidium of *B. tenuimucronatum* but has neither a mucro nor a posteromedian embayment; instead the margin is rather truncated in dorsal view and arched upwards in posterior view. There is no evidence that the mucro is lost in *B. tigerense* but all known pygidia are smaller than that of *buttingtonense* and the 'type 2' pygidium of *tenuimucronatum*.

Some of the other characters listed by Curtis and Lane as diagnostic of *Bessazoon* cannot in our view be used to distinguish *Bessazoon* either. The size of the palpebral area is determined by the size of the eye, and thus in comparison with other Silurian and Devonian dalmanitids is not particularly large in *B. buttingtonense* and *B.* cf. *B. tenuimucronatum*. We can see no difference from *Dalmanites* and other closely related genera in the form of the palpebral lobe, which rises steeply from the palpebral furrow and becomes flat towards the outer margin. Finally, a posterior cephalic border furrow that fails to meet the lateral border furrow distally, an epiborder furrow on the lateral cephalic borders and genal spine, and a straight-sided pygidial axis are not unusual features for dalmanitids but are present in most Silurian and Devonian representatives. The discrimination and composition of *Bessazoon* are in need of review, but in the meantime we apply the name here to dalmanitids differing from species commonly assigned to *Dalmanites* (e.g. see Ramsköld, 1985) in lacking a well-developed anterior cephalic process (although in *B. tenuimucronatum* the cephalic margin is deflected slightly forwards medially) and tubercles on the glabella, and in having a pygidium with a curved posterolateral outline, a slender, narrow-based mucro merging anteriorly with a strong postaxial ridge, and a very wide doublure extending adaxially beyond the distal ends of the pleural and interpleural furrows.

Bessazoon sp.

Figures 14, 17D–F

Dalmanites.—Rickards and Sandford, 1998: 750.

Material. NMV P139427–P139439, NMV P138276 from PL1452, Goldie. NMV P139470–P139487 from 'Lancefield' (exact locality unknown). NMV P147769–P147770 from PL256, Wallan. NMV P312817 from PL6361, Springfield. Chintin Formation. For locality PL1452 see Thomas (1960), marked as 'shelly fossils, *Dalmanites*'.

Description. Anterior cephalic margin parabolic in outline (fig. 14I). L1 about 75% length of L2. S1 deflected forwards slightly at adaxial end, S2 more or less transverse; S3 shallow, oriented at about 65° to sagittal line, expanding (exsag.) abaxially. Inner ends of S1–S3 in line (exsag.). Palpebral lobe large, length (exsag.) about 40% sagittal glabellar length, almost semicircular in dorsal outline, anterior margin opposite anterior margin of L3 and posterior margin reaching almost as far back as occipital furrow. Palpebral furrow weak (fig. 17E), palpebral area wide (tr.) and weakly concave.

Hypostome approximately as wide across anterior wings as long (sag.), subparallel sided from back of anterior wing to outer end of posterior border furrow, thereafter narrowing backward and parabolic in outline. Anterior wings small, triangular, length (exsag.) about 15% sagittal length of hypostome. Middle body comprising 80% sagittal length of hypostome, weakly convex transversely and flat sagittally. Maculae indistinct swellings behind weak depressions placed opposite 40% hypostomal length from posterior and halfway between sagittal line and lateral border furrow. Lateral border narrow, approximately 6% width of hypostome at midlength (sag.), lateral border furrow weak in anterior half and moderately impressed in posterior half. Posterior border long, 15% hypostomal length sagittally, posterior border furrow semicircular in outline.

Pygidium triangular in outline, relatively undeformed specimens with length (excluding mucro) approximately 75% estimated maximum width. Axis about 25% maximum pygidial width anteriorly, tapering uniformly backward, with 14 axial rings of which last 6 are poorly defined. Inter-ring furrows 1–9 with deep apodemes extending approximately. 33% width, all inter-ring furrows very shallow medially. Axis continuous posteriorly with postaxial ridge and mucro. Axial furrow deep. Mucro slender, at least 75% length (sag.) of remainder of pygidium. 10 pleural furrows that are directed

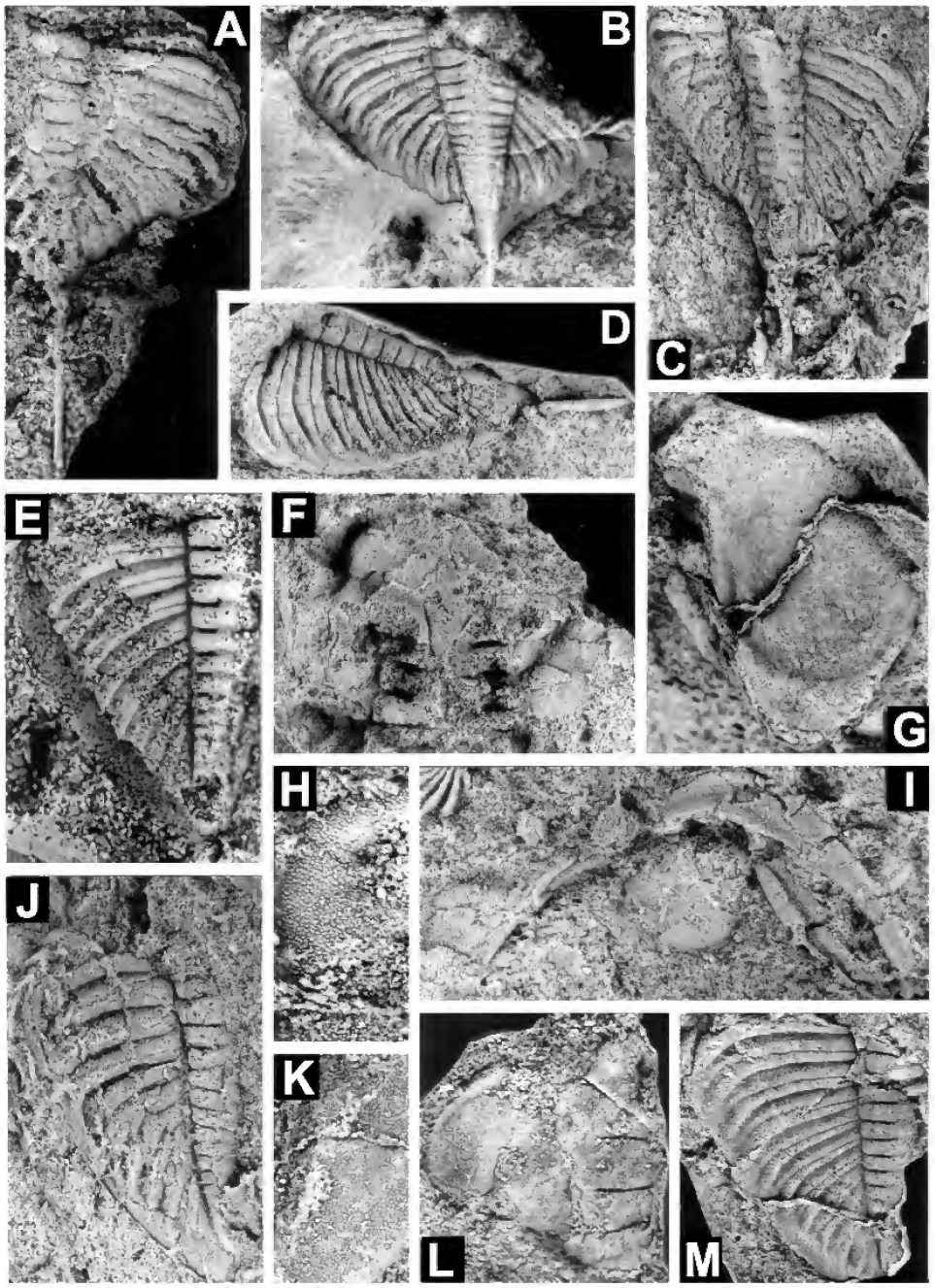

Figure 14. *Bessazoon* sp. A, NMV P139479, pygidium, × 2, from 'Lancefield'. B, NMV P139481, pygidium, × 3.5, from 'Lancefield'. C, NMV P139475, pygidium, from 'Lancefield'. D, NMV P139474, pygidium, × 2.5, from 'Lancefield'. E, NMV P139477, pygidium with doublure exposed, × 6, from 'Lancefield'. F, NMV P139471, crushed cephalon, × 2, from 'Lancefield'. G, NMV P139427, hypostome, × 3, from PL1452, Lancefield. H, J, NMV P139438, pygidium, from PL1452, Lancefield; H, enlargement of anterolateral region showing granular sculpture, × 8; J, × 2. I, NMV P139439, crushed cephalic doublure, × 1.9, from PL1452, Lancefield. K, thoracic segment, enlargement showing granulose ornament on pleural tip, × 8, from 'Lancefield'. L, NMV P139470, fragment of cephalon, × 3, from 'Lancefield'. M, NMV P139473, pygidium, × 2, from 'Lancefield'. (E–F are internal moulds).

successively more strongly backward, last one parallel to sagittal axis. Interpleural furrows moderately incised, widening distally. Anterior pleural bands expand slightly and very gradually abaxially, at fulcrum approximately as long (exsag.) as succeeding pleural furrow, slightly elevated above posterior bands distally. Posterior pleural bands subparallel sided except distally where they taper, at fulcrum comprising about 75% length (exsag.) of anterior bands.

Densely distributed small granules present on preserved parts of external surface including occipital ring, thoracic pleural tips and doublure, dorsal surface of pygidium and pygidial doublure.

Remarks. This species can be distinguished from other Silurian dalmanitids from central Victoria by its pygidial pleural morphology, with relatively narrow, trench-like pleural furrows, and anterior bands that are slightly longer (exsag.) than the posterior bands at the fulcrum and only slightly elevated above the posterior bands distally. *Dalmanites athamas* differs in having longer (exsag.) pleural furrows and anterior pleural bands that are much longer than the posterior bands, whereas *D. wandongensis* has anterior bands that are slightly shorter (exsag.) than the posterior bands at the fulcrum and strongly elevated above the posterior bands distally. *D. wandongensis* also differs from the present species in having a pygidium with a well defined axial terminus and a shorter mucro that is very broad at the base, and a hypostome with deeper middle, lateral border and posterior border furrows, and a posterior margin that is transverse in outline medially instead of parabolic.

The specimens are poorly preserved and mostly fragmentary, especially the cephala. Assignment to *Bessazoon* is based on the finely granulose cephalic ornament, the entire anterior cephalic margin, the curved posterolateral pygidial margin and the long, slender mucro merging with the axial terminus. The type species *B. tenuimucronatum* differs from the present one in having slightly inflated lateral glabellar lobes, a more strongly curved (exsag.) palpebral lobe, a deeper palpebral furrow, and the posterior pleural bands on the pygidium more expanded and prominent distally than the anterior bands rather than the reverse. *B. tigerense* from the upper Llandovery of Tasmania has a more strongly curved palpebral lobe, a deeper palpebral furrow, and less robust postaxial ridge and mucro.

Preodontochile Degardin and Pillet, 1984

Type species. *Dalmanites* (*Preodontochile*) *camprodonensis* Degardin and Pillet, 1984 from the central Pyrenees, Spain, by original designation. The precise age of *D.* (*P.*) *camprodonensis* is uncertain, as Degardin and Pillet stated (p. 87) that the species occurs with graptolites of the early Wenlock *Monograptus riccartonensis* Biozone, but elsewhere (fig. 4) they showed its stratigraphical range as lying in the upper Llandovery.

Remarks. Degardin and Pillet (1984) erected the monotypic *Dalmanites* (*Preodontochile*) for a poorly known species represented by few and poorly preserved specimens including a single crushed cranidium, an isolated thoracic segment and a number of pygidia that are mostly incomplete posteriorly. The material permits only a limited assessment of *Preodontochile*, but as diagnostic of their subgenus Degardin and Pillet listed the small eye, the course of the anterior branch of the facial suture, and the multisegmented pygidium with a short, blunt mucro. They likened the facial suture both to that of *Dalmanites* in being situated in close proximity to the glabella and to that of *Odontochile* in being separated from the glabella by the preglabellar furrow and a narrow band of the anterior cephalic border. However, as noted by Whittington and Campbell (1967), the distinction between *Dalmanites* and *Odontochile* on the basis of the anterior cephalic morphology is not as clear-cut as stated by Richter, Richter and Struve (1959). Several Wenlock–Ludlow species of *Dalmanites*, including the Swedish *D. imbricatulus* (Angelin, 1851) (see Ramsköld, 1985), the North American *D. puticulifrons* Whittington and Campbell, 1967 and *D. rutellum* Campbell, 1967, and the Australian *D. wandongensis*, have a narrow band of the anterior border enclosed by the facial suture on the cranidium. This condition is also present in the Victorian Llandovery dalmanitid described below as *Preodontochile springfieldensis* (see Fig. 16A), which further resembles *P. camprodonensis* in the greatly reduced eye situated far forwards opposite L3, the robust genal spine, the short, bluntly pointed mucro and the finely granulose sculpture. We consider this combination of characters to be of generic significance. With better understanding of *P. camprodonensis* other cephalic features of *P. springfieldensis* may also prove to be diagnostic of the genus, such as the uniformly narrow (sag., exsag.) anterior border that is less than half the width of the lateral border and lacks a median projection. In its pygidium with a large number of segments and narrow axis, *P. camprodonensis* resembles late Silurian–Devonian species assigned to *Odontochile* and closely related genera. Degardin and Pillet (1984) considered a large number of pygidial segments as diagnostic of *Preodontochile*, but in view of the otherwise close similarity of the type species with the more poorly segmented *P. springfieldensis* the number of pygidial segments is here regarded as only of specific significance.

Other dalmanitid genera known from the Llandovery include *Bessazoon* (see above), *Daytonia* Holloway, 1981 and *Prodontochile* Kobayashi and Hamada, 1971, all of which are easily distinguished from *Preodontochile* by their much larger eyes. In addition, *Bessazoon* differs from *Preodontochile* in having the facial suture tightly enclosing the glabella, and a long, slender mucro connected to the pygidial axis by a postaxial ridge; *Daytonia* has the occipital ring markedly reduced in length abaxially, S1 bifurcate adaxially and converging slightly with S2 abaxially, the anterior cephalic border as wide as the lateral border, short and slender genal spines, and a pygidium with parabolic outline and a tiny mucro joined to the axis by a postaxial ridge; and *Prodontochile* has a narrower lateral cephalic border and slender genal spines.

Wenlock–early Ludlow species of *Dalmanites* assigned by Ramsköld (1985) to his group around the type species *D. caudatus* differ from *Preodontochile* in having a large eye extending from opposite L3 to opposite L1, an anterior cephalic border with a well-developed medial process, tuberculate sculpture on the glabella, prominent lateral nodes on some thoracic axial rings, pleural nodes on some pygidial segments, and a long pygidial mucro.

Preodontochile springfieldensis sp. nov.

Figures 15, 16

Type material. Holotype NMV P312070 (cephalon with broken and displaced genal field). Paratypes NMV P312071 (incomplete cephalothorax showing damage to genal field), NMV P139350 (incomplete and partly disarticulated cephalothorax showing cephalic doublure and hypostome), NMV P312074 (incomplete pygidium), NMV P312075 (incomplete and partly disarticulated thoracopygon). All from PL1369, Springfield.

Other material. NMV P139350–P139352, NMV P312072–P312073, from PL1369, Springfield.

Diagnosis. Preodontochile with eye oriented slightly obliquely to exsagittal line and visual surface having approximately 40 lenses arranged in about 15 files of up to 4 lenses each. Posterior cephalic border markedly expanding (exsag.) abaxially, genal spine very broad proximally and tapering strongly distally. Pygidial axis about 25% maximum pygidial width anteriorly, with 10 axial rings, first 5 well defined by inter-ring furrows that contain apodemal pits laterally and are shallow medially, posterior rings poorly defined by shallow inter-ring furrows that are not continuous medially. Pleurae with about 7 shallow pleural furrows and very weakly impressed interpleural furrows. Mucro with length (measured from terminus of axis) comprising about 25% sagittal pygidial length. Pygidial doublure wide.

Description. Cephalon (excluding genal spines) semi-circular in outline, anterior margin with very weak convex-downward medial flexure in anterior profile. Glabella weakly convex, slightly narrower across L1 than across occipital ring, thereafter expanding moderately forward, a little more strongly in front of S3 than behind, width across frontal lobe 170–180% occipital width and about 80% sagittal length of glabella. Occipital ring raised slightly higher than remainder of glabella, width (tr.) about 30% cephalic width across same transverse line, length about 12% cephalic length sagittally, shorter (exsag.) laterally. Median section of occipital furrow gently convex forward and very shallow, lateral section (approximately 30% total width) with arcuate, slit-like apodemal pit not quite reaching axial furrow distally. S1 and S2 defined only by slit-like apodemal pits that are equal in width (tr.) to occipital apodemal pit and placed directly in front of it; S1 gently arcuate, equidistant from occipital furrow and S2; S2 transverse, situated at 33% cephalic length from posterior. L3 as long (exsag.) as L1 and L2 adaxially, 160% as long abaxially. Adaxial portion of S3 oriented at about 20° to transverse, abaxial portion very wide, lenticular in outline, oriented at about 35° to transverse. Frontal lobe comprising half sagittal length of glabella, elliptical in outline, with short, shallow sagittal depression in posterior half. Axial furrow moderately impressed, preglabellar furrow shallow. Anterior cephalic border of uniform length (sag., exsag.), comprising about 8% sagittal cephalic length, subhorizontal, weakly concave. Lateral border furrow defined mainly by change in slope, lateral border very wide (tr.), twice width of anterior border, gently sloping, weakly concave. Posterior border furrow deep, adaxial portion transverse, abaxial portion directed posterolaterally, terminating before reaching lateral border furrow. Genal spine long, with longitudinal furrow dividing horizontal lateral portion from steeply sloping adaxial portion. Eye with length about 20% sagittal cephalic length, anterior edge placed opposite front of L3 and posterior edge just in front of level of S2. Palpebral lobe not greatly raised above palpebral area, crescentic in outline, narrow (tr.). Palpebral furrow weak. Visual surface with lower margin subtending an angle of about 80° in dorsal view. Anterior branch of facial suture diverging gently forward towards widest part of frontal lobe, posterior branch weakly sinusoidal, meeting lateral cephalic margin more or less opposite posterior edge of eye. Librigenal field weakly convex, about 66% width of lateral border.

Cephalic doublure flat anteromedially, approximately 33% sagittal cephalic length, crossed by weak arcuate furrow defining crescentic area adjacent to hypostomal suture. Lateral to hypostomal suture, doublure with upturned inner flange that is continuous posteriorly with adaxial surface of genal spine. Only available hypostome is incomplete posteriorly. Anterior wing small, middle body with parabolic posterior outline, middle furrow indistinct, posterior portion of lateral border furrow and posterior border furrow shallow.

Anterior part of thoracic axis subparallel-sided and comprising about 33% segmental width (tr.) (fig. 15A–B, D, F), posterior part of axis relatively narrower (fig. 16G). Axial rings weakly convex (sag.), with indistinct lateral lobes that lack nodes. Axial furrow moderately impressed. Pleural furrows sigmoidal, short (exsag.) and sharply impressed, at fulcrum dividing segment into anterior and posterior bands of equal length (exsag.) and height. Distal ends of pleurae rounded anteriorly and angular posteriorly.

Pygidium moderately convex transversely, subtriangular in outline with weakly convex sides converging posteriorly at about 60°. Axis tapering uniformly backward, 2nd segment with broad, subrectangular pseudo-articulating half ring, much smaller and weaker pseudo-articulating half rings possibly present on next two segments. Mucro triangular, postaxial ridge absent.

Exoskeleton finely granulate, lacking tubercles.

Remarks. The poor preservation of the only available cranidium of *P. camprodonensis* does not permit detailed comparison with *P. springfieldensis*, but the latter differs in the less obliquely oriented eye and the greater abaxial expansion of the posterior border. Differences in the form of S1 and S2, which in *springfieldensis* are isolated and very narrow (exsag.) but in *camprodonensis* appear wider (exsag.) and deeper, with S1 said to be connected medially (Degardin and Pillet, 1984, p. 87, fig. 5), can be attributed to crushing in the latter. The most striking difference between *P. springfieldensis* and *P. camprodonensis* is in pygidial segmentation. Pygidia of the type species have about 20 axial rings, at least 15 deep and medially continuous inter-ring furrows, at least 11 wide and deep pleural furrows, and very strongly incised interpleural furrows. In contrast, pygidia of *springfieldensis* have only ten axial rings, five continuous inter-ring furrows that are shallow medially, seven narrow (exsag.), shallow to moderately impressed pleural furrows, and very weak interpleural furrows.

The occurrence of *P. springfieldensis* at PL1369 together with another relatively small-eyed form (Phacopidae gen. indet. 3) is significant. Eye reduction in phacopids and other

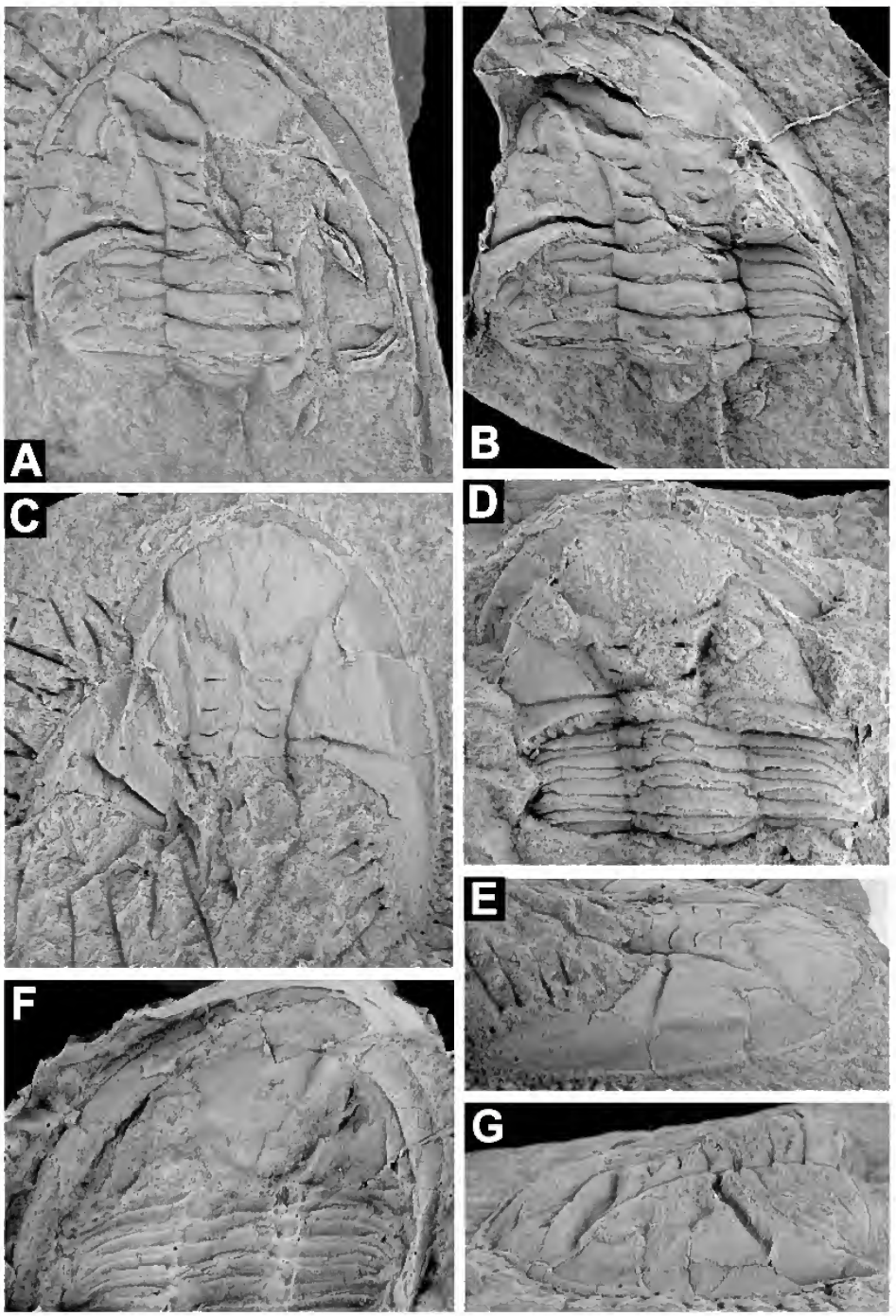

Figure 15. *Preodontochile springfieldensis* sp. nov., from PL1369, Springfield. A–B, G, paratype NMV P312071, incomplete cephalothorax with damaged genal field; A–B, × 2.2; G, × 2.7. C, E (and figs 16A, E–F), holotype NMV P312070, cephalon with left cheek broken and displaced; C, × 2; E, × 1.8. D, F (and fig. 16H), paratype NMV P139350, cephalothorax; D, × 1.8, with glabella showing tool marks from preparation; F, × 2.0, showing cephalic doublure and hypostome. (A, C, E, G are internal moulds).

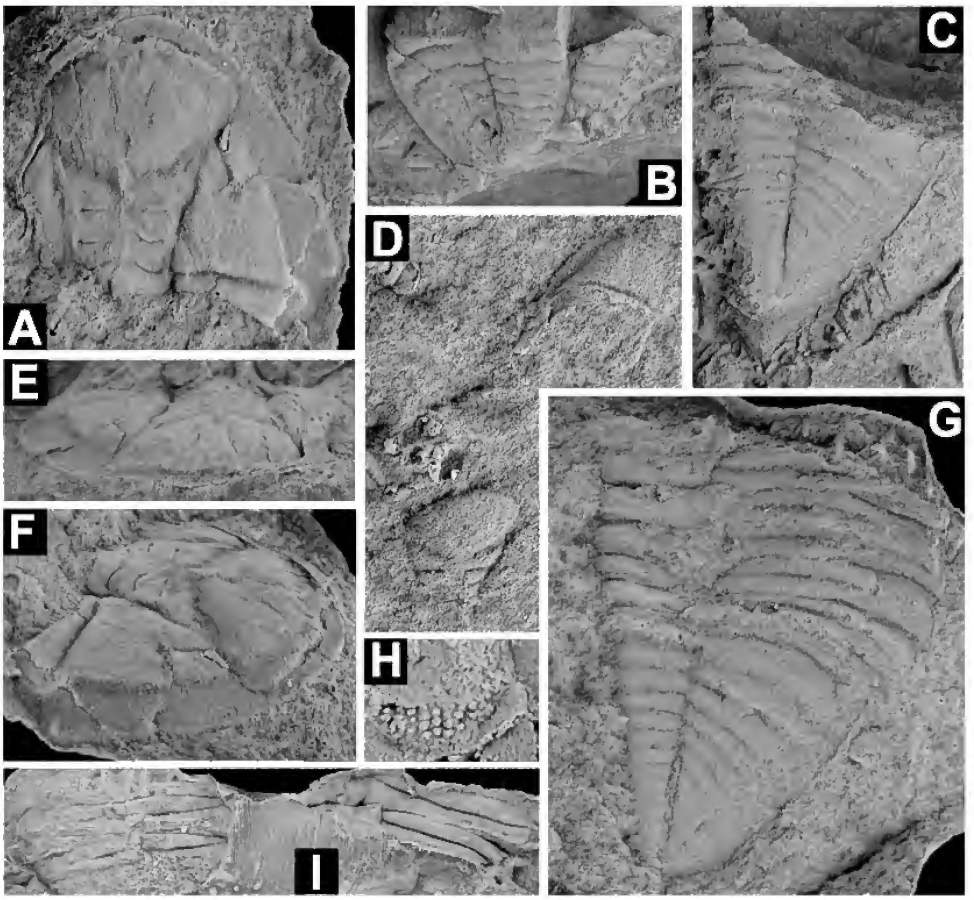

Figure 16. *Preodontochile springfieldensis* sp. nov., from PL1369, Springfield. A, E–F, holotype NMV P312070, × 2. B, paratype NMV P312074, pygidium, × 2. C, G, paratype NMV P312075, thoracopygon; C, × 3; G, × 2.7. D, paratype NMV P312072, cranidium and displaced cheek, × 5. H, paratype NMV P139350, enlargement of eye, × 8. I, NMV P139351, three thoracic segments, × 1.5. (B–C, E are internal moulds).

trilobites has been widely interpreted as an adaptation to deep water, subphotic environments, although Álvaro and Vizcaïno (2003) noted that high turbidity may create subphotic environments in shallower settings. The taphonomy of the Deep Creek trilobite population is indicative of a deep water facies rather than turbid conditions. The degree of articulation is high (isolated tergites 40%), and although there are no fully articulated exoskeletons, specimens have been found with the hypostome only slightly displaced along the hypostomal suture (fig. 15F), and with incomplete thoraces attached to the cephalon or only slightly detached from it or from the pygidium (figs 15A–B, D, G, 16G). This evidence suggests deposition at depths below normal wave base where bottom current activity is negligible, preventing displacement, winnowing and concentration or reworking of the exoskeletal elements. These deep water beds correlate in age with the late Telychian (mid *Monoclimacis crenulata* Biozone) eustatic highstand (event 4) documented from six palaeocontinents by Johnson (1996). The abrupt transition from these beds to the shallower water facies of the overlying Chintin Formation may reflect the influence of an extensive latest Telychian Gondwanan glaciation event documented from Brazil (Grahn and Caputo, 1992). Otherwise, the Chintin Formation appears to correspond closely in age to the subsequent regressive phase that culminated in an earliest Wenlock lowstand.

Struveria Rickards, 1965

Type species. Struveria howgillensis Rickards, 1965 from the upper Wenlock–lower Ludlow of northern England and North Wales, by original designation.

Remarks. Apart from the type species and the Victorian specimens described below, *Struveria* includes *S. orba* (Barrande, 1852) from the upper Wenlock of the Czech Republic, and *S. simrica* (Hede, 1915) from the upper

Llandovery?–Wenlock of southern Sweden (see Laufeld et al., 1975) and the upper Wenlock of Poland (Tomczykowa, 1991). *S. howgillensis* is the most completely known species (Rickards, 1965: pl. 85, figs 1–6) but neither this nor the other representatives have been extensively illustrated, and most are rather poorly preserved. Consequently the genus is not very well known morphologically, but distinctive characters include: a very short (sag., exsag.) anterior cephalic border; almost transverse S1 and S2, both containing apodemal pits; a moderately large eye extending very close to the lateral border furrow anteriorly and laterally; a long, flattened genal spine; a pygidium that is curved in outline posterolaterally and lacks a convex border or mucro; pygidial axial rings bearing oblique muscle impressions laterally, except for the last few; a narrow, rather sharp postaxial ridge; short (sag., exsag.), sharply impressed pygidial pleural and interpleural furrows, the pleural ones terminating distally a short distance from the margin whereas the interpleural ones reach the margin; and posterior pleural bands that are slightly more raised distally than the anterior bands towards the back of the pygidium.

Struveria orba was tentatively assigned to *Delops* by Šnajdr (1982), but the lectotype cranidium and other specimens figured by Šnajdr (1982: pl. 2, figs 5–10) resemble the type species of *Struveria* in the strongly transverse frontal lobe and distinctly concave lateral outline of the glabella behind a transverse line through the inner end of S3, and they lack the tuberculate sculpture and expanded (exsag.) pygidial pleural furrows characteristic of *Delops*. Two pygidia assigned to *orba* by Barrande, one of them a paralectotype (Barrande 1852: pl. 26, fig. 38; Šnajdr 1982: pl. 2, fig. 1), are not conspecific with the lectotype but belong to *Delops dermolac* (see also Budil, 1996). '*Calymene*? *daviesii* Salter, 1865, known only from an internal mould of a pygidium from the upper Wenlock of Wales, was tentatively assigned to *Struveria* by Morris (1988: 223) but we cannot assess this assignment from the woodcut illustration of Salter (1865) (fig. 23).

As pointed out by Rickards (1965: 549) and Bergström (in Laufeld et al., 1975: 219), *Struveria* shows similarities to *Eudolatites*, a genus largely restricted to the Caradoc apart from the late Ashgill subgenus *E.* (*Deloites*) Destombes, 1972, which was regarded as an independent genus by Tomczykowa (1991) and Vaněk and Vokáč (1997). *Eudolatites* differs from *Struveria* in that S1 is more obliquely oriented; S2, though commonly rather deep, seems to lack an apodemal pit (Destombes, 1972: pl. 3, fig. 1a, pl. 4, fig. 1a); the librigenal field is much broader anterior and lateral to the eye; there is either no genal spine present, or it is short, strongly tapered, and rounded in cross section distally rather than flattened (see Rábano *in* Gutierrez Marco and Rábano, 1987: pl. 1, fig. 1c); and the pygidium lacks a sharply defined postaxial ridge.

Struveria sp. 1

Figures 12B–C

Material. NMV P139357 (partly disarticulated dorsal exoskeleton with displaced hypostome, thorax and pygidium) from PL1386, Geological Survey locality B3 (exact locality unknown), Moonee Ponds Creek, Broadmeadows. Precise stratigraphic horizon uncertain.

Remarks. The cephalon of the specimen has the glabella except for the anteriormost part obscured by the displaced hypostome and medial part of the doublure. Much of the left fixigena is preserved, including the large palpebral lobe and the posterior border, the latter curving backwards abaxially to the base of the genal spine. The pygidium is more completely preserved than the cephalon, is almost twice as wide as long (sag.), with six or seven axial rings and pleural furrows, and the axis comprising a little more than 25% maximum pygidial width anteriorly. The specimen can be assigned to *Struveria* with confidence on the basis of the pygidial morphology.

The hypostome of *Struveria* has not previously been illustrated. That of the present specimen is similar to hypostomes of other dalmanitids (e.g. see Ramsköld, 1985, pl. 10, fig. 12).

Struveria sp. 2

Figures 13L, 17A, 17C

Dalmanitina (*Eudolatites*) *aborigenum* Öpik, 1953: 26 (*partim.*), pl. 10, figs 86–87 (*non* pl. 10, fig. 85 = *Dalmanites athamas* Öpik, 1953).

Material. NMV P52483 (fragmentary pygidium), from PL2269, Thomas locality F51, Costerfield. Wapentake Formation. For locality see Thomas (1960). NMV P139337 (cranidium), NMV P138209 (pygidium), from PL206, Wallan. Bylands Siltstone.

Remarks. Compared to the pygidium of *Struveria* sp. 1 from Broadmeadows, the pygidium from Wallan (fig. 17A) is longer (maximum width about 150% sagittal length), with a wider axis (almost 33% maximum pygidial width anteriorly) and a greater number of axial rings (nine or ten) and pleural furrows (ten or 11). It is unlikely that these differences can be explained by the larger size of the Wallan pygidium, and we therefore consider it to belong to a separate species. The cranidium from Wallan (fig. 17C) is small and indifferently preserved but its morphology is consistent with assignment to *Struveria*.

The paratype of '*Dalmanitina* (*Eudolatites*)' *aborigenum* is a fragmentary pygidium from Costerfield, consisting of the anterior part of the axis and the adjacent part of the right pleural lobe (fig. 13L). It differs from pygidia of *Dalmanites athamas*, to which the holotype of *aborigenum* belongs, in that the inter-ring furrows do not shallow markedly medially but are deeply impressed across the entire width of the axis; the pleural furrows are not expanded but are short (exsag.), sharply impressed and similar in appearance to the interpleural furrows; and the anterior and posterior pleural bands are flat-topped. These characters suggest that the specimen belongs to *Struveria*, and it may be conspecific with the Wallan specimens which come from a similar stratigraphical level.

Struveria*? *plinthourgos sp. nov.

Figure 18

Eudolatites sp.—Rickards and Sandford, 1998: 751.

Type material. Holotype NMV P79125 (internal mould of dorsal exoskeleton) from PL1374, old Camberwell brick pit, Rose Street, Camberwell. Anderson Creek Formation.

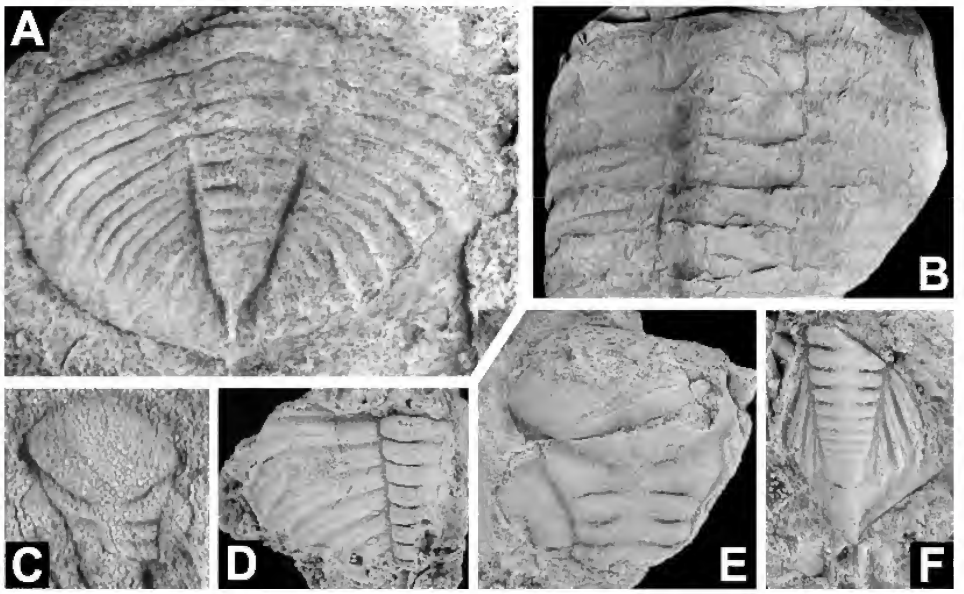

Figure 17. A, C, *Struveria* sp. 2, from PL206, Wallan. A, NMV P138209, pygidium, × 2. C, NMV P139337, cranidium, × 5.5. B, Dalmanitidae indet., NMV P127957, partial view of incomplete thorax, × 0.9, from old Costerfield Antimony Mine, Costerfield. D–F, *Bessazoon* sp. D, NMV P147769, pygidium (fragment), × 1.8, from PL256, Wallan. E, NMV P312817, cranidium (fragment), × 2.2, from PL6361, Springfield. F, NMV P147770, pygidium (fragment), × 2.4, from PL256, Wallan.

Derivation of name. Greek, 'brickmaker', in reference to the type locality.

Diagnosis. Glabella subpentagonal in outline, expanding strongly and rather uniformly forward, width across frontal lobe about twice width across occipital ring and approximately equal to sagittal length. Eye short (exsag.), with posterior edge opposite S3. Pygidium with strongly convex (tr.) axis of 10 or 11 rings, 9 pleural furrows, and relatively broad, concave border on which pleural and interpleural furrows are very weakly expressed.

Description. Cephalon with length (sag.) about 60% maximum width. Glabella comprising a little less than 30% cephalic width posteriorly. Occipital furrow shallowing and deflected forward medially. S1 and S2 transverse, meeting axial furrow distinctly, adaxial portions with slit-like apodemal pits situated in line exsagittally, S2 comprising 33% glabellar width at this level and with apodemal pit occupying half width (tr.) of furrow. L1 approximately 80% length (exsag.) of L2 laterally. S3 diverging forward at about 125°, shallow adaxially and deepening slightly abaxially but not expanding appreciably. L3 a little more than twice as long (exsag.) abaxially as adaxially. Frontal lobe comprising approximately half sagittal length of glabella, rhombic in outline, apparently with short (exsag.) longitudinal depression at about midlength. Eyes and palpebral lobes not preserved, palpebral furrow apparently shallow, weakly curved and oriented slightly oblique to exsagittal line. Posterior branch of facial following gently sigmoidal course, directed slightly forward across most of genal field and deflected backward laterally. Posterior border furrow deeply impressed, apparently deflected forward slightly abaxially and dying out distally before reaching lateral border furrow. Backward deflection of posterior cephalic margin distally indicates that genal spine was present (fig. 18D) but its length is unknown. Fixigenal field densely pitted.

Thorax of 11 segments. Axis strongly convex (tr.), increasing slightly in width from 1st to 4th or 5th segment and thereafter narrowing at similar rate, width on 1st segment equal to that on 8th segment and almost 120% that on last segment. Axial rings gently convex (sag., exsag.), without lateral lobes. Axial furrow deeply impressed. Pleural lobe slightly wider (tr.) than axis in anterior half of thorax and becoming increasingly wider towards back. Pleurae strongly downturned beyond fulcrum, with large articulating facets and pointed tips becoming backwardly deflected towards back of thorax. Pleural furrows very deep, extending weakly onto articulating facets distally where they curve slightly forward.

Posterior termination of pygidium unknown; if it is rounded rather than mucronate or angular, pygidium is about 150% as wide as long (sag.) with parabolic posterior outline; anterolateral corner well-rounded. Axis strongly convex (tr.), width 25% maximum pygidial width anteriorly, possibly not tapering uniformly backward but a little more strongly across first 3 segments than next 2 or 3, thereafter at similar rate as initially. 1st ring with broad, shallow median excavation in posterior margin for pseudo-articulating half ring on 2nd segment, much weaker excavations present on 2nd and 3rd rings. Inter-ring furrows 1–6 with apodemal pits laterally,

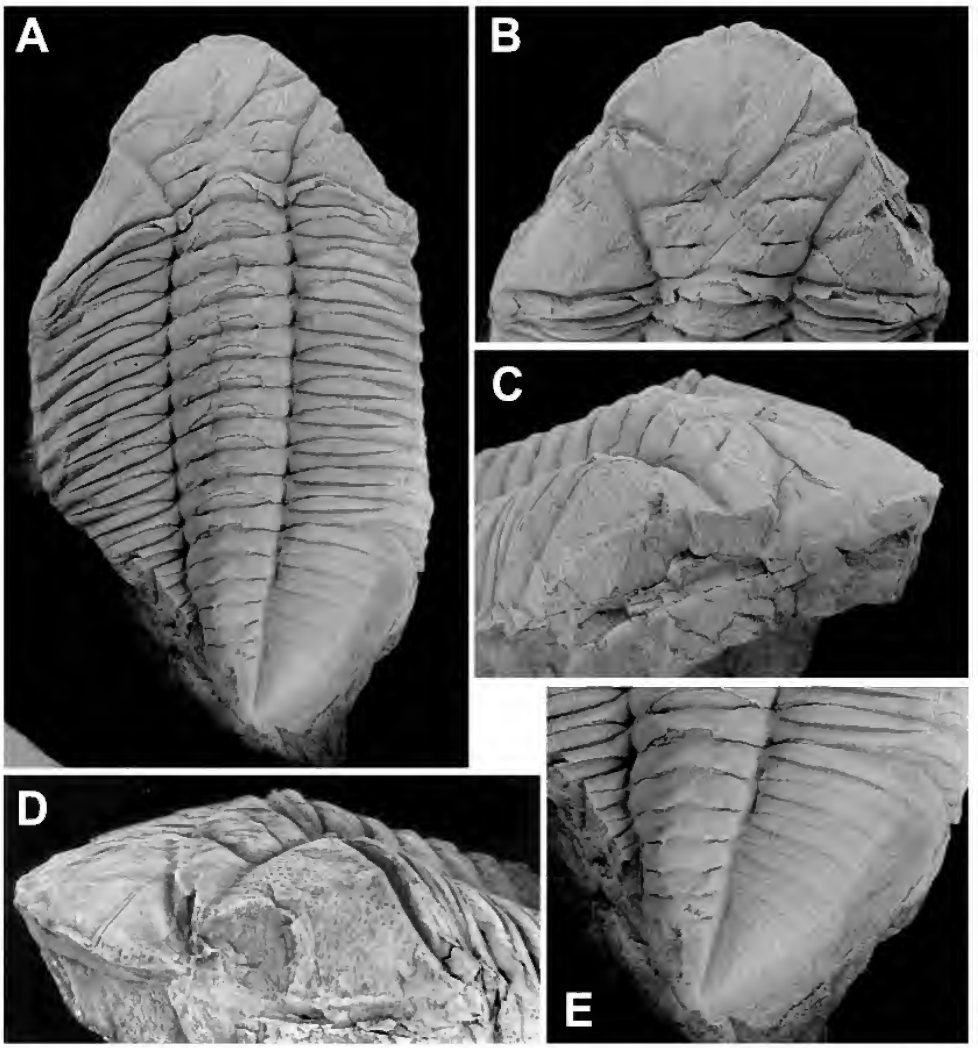

Figure 18. *Struveria? plinthourgos* sp. nov., holotype NMV P79125, internal mould of dorsal exoskeleton, from PL1374, Camberwell; A, × 1; B–E, × 1.25.

remaining inter-ring furrows very weak. Pleural field rather strongly convex (tr.), 1st segment with wide articulating facet extending 66% width of pleura and with deep pleural furrow not extending onto facet distally, subsequent segments with successively shallower pleural furrows more closely approaching interpleural furrows in depth and length (exsag.). Concave border comprising almost 33% pleural width anteriorly, not bounded adaxially by distinct border furrow, outer margin not rolled in transverse section.

Remarks. The only known specimen is an internal mould of a very large and substantially complete dorsal exoskeleton almost 130 mm long (assuming the pygidium lacks a mucro). The cephalon is crushed, especially the frontal lobe of the glabella which bears radiating fractures, so that its flattened profile is not indicative of the original convexity. The anterior outline of the glabella in dorsal view is formed by an arcuate fracture, below which the cephalon slopes steeply downward to a lower margin that is a smoothly curved line (figs 18C–D); it is not clear whether this line is the facial suture or the hypostomal suture, but the former is more likely. The lateral part of the right cheek has been pushed downward and inward along a posterolaterally-directed fracture that has destroyed the palpebral lobe, and of the right librigena only the border and possibly a small portion of the adjacent field are preserved. On the left cheek the palpebral lobe has been broken off along the

palpebral furrow, the flattened appearance of the genal spine base may not be indicative of its original shape in cross-section, and all that remains of the librigena is the lateral outline (fig. 18D). The distal parts of the last few thoracic segments are missing on the left side, together with most of the left pleural lobe and posterior termination of the pygidium.

Generic assignment of the species is problematic, partly because certain important characters cannot be determined, including the form of the cephalic borders and genal spine, and the nature of the pygidial termination. The specimen was assigned to *Eudolatites* by Rickards and Sandford (1998), although that genus is not known to range above the Ordovician, but features such as the transverse orientation of S1 and the presence of an apodemal pit in S2 are incompatible with such an assignment. On the basis of these characters and the form of the pygidial pleural and interpleural furrows we tentatively assign *plinthourgos* to *Struveria*. The species differs from other members of the genus in that the glabella is subpentagonal in outline rather than club-shaped (i.e. it is not concave in lateral outline behind a transverse line through the inner end of S3), the eye is shorter (exsag.) and does not extend as far backward, the palpebral furrow is more weakly curved, the genal spine appears to be smaller at its base, and the pygidium has a concave border; however ,we can not be certain that the last feature is not caused by compression of the dorsal exoskeleton onto the doublure.

Dalmanitidae indet.

Figure 17B

Dalmanitina sp. cf. *Dalmanitina* (*Eudolatites*) *aborigenum*.—Öpik, 1953: 28, pl. 10, fig. 92.

Trilobita *indet*.—Talent, 1964: 51 (pars).

Material. NMV P127957 (incomplete thorax) from old Costerfield Antimony Mine, Costerfield. Costerfield Siltstone. Locality marked Thomas (1941).

Remarks. This poorly preserved thorax with seven or possibly eight segments distinguishable is the only fossil recorded from the Costerfield Siltstone. Based on its large size (about 60 mm wide) and the form of the pleural furrows, Öpik (1953, p. 29) suggested that it probably belongs to *Dalmanitina*, a genus then interpreted more broadly than now, and that it may be related to his species '*Dalmanitina* (*Eudolatites*)' *aborigenum* from beds higher in the sequence. However, Talent (1964), regarded the specimen as too poorly preserved for identification even to family level.

We agree with Öpik that the specimen probably belongs to the Dalmanitidae, and that the short (exsag.), sharply incised pleural furrows preclude assignment to *Dalmanites* or its close allies. However, the holotype of '*Dalmanitina* (*Eudolatites*)' *aborigenum*, the species to which he thought it may be related, belongs to *Dalmanites athamas* (see above), and the fragmentary pygidium also included in *aborigenum* by Öpik is here assigned to *Struveria* sp. 2. In size, the abaxially subquadrate outline of the axial rings and the form of the pleural furrows, the poorly preserved thorax from Costerfield is not unlike *Struveria*? *plithourgos* described above, and it is possible that the two forms are related.

Superfamily **Acastoidea** Delo, 1935
Family **Acastidae** Delo, 1935

Berylacaste gen. nov.

Type species. *Berylacaste berylae* gen. et sp. nov.

Derivation of name. After ACS's mother. Gender feminine.

Diagnosis. Glabella expanding strongly forward, about twice as wide across frontal lobe as across occipital ring, strongly inflated, overhanging anterior cephalic border. L1 almost as long (exsag.) as L2, S2 and S3 very shallow. Visual surface absent, palpebral lobe very small, situated towards front of genal field, merging with eye ridge that reaches axial furrow, palpebral suture straight and obliquely oriented. Genal spine very small, thorn-like. Thoracic pleural tips with small posterolaterally directed spines. Pygidial axis with 3 rings and poorly segmented posterior part, pleurae with 4 pleural furrows and poorly defined border furrow, posteromedian margin rounded, lacking spine or point.

Remarks. *Berylacaste* gen. nov. is known only from the type species. The genus is distinguished from others in the Acastoidea most notably by the strong forward expansion of the glabella, the frontal lobe that overhangs the anterior cephalic border, the vestigial palpebral lobe situated far forward, and the absence of a visual field. Other distinctive characters are the very weak impression of S2 and S3, the presence of genal and thoracic terminal pleural spines, and the very weak pygidial segmentation.

Edgecombe (1993) recognised the monophyletic superfamily Acastoidea *s.s.* comprising the Calmoniidae and the Acastidae, but excluding more primitive genera such as *Phacopidina*, *Baniaspis* and *Kloucekia* which he referred to as Acastoidea *s.l.* without familial assignment. *Berylacaste* gen. nov. can be assigned to his Acastoidea *s.s.* as it exhibits a 'shouldered' anterior cephalic margin (i.e. the median part of the margin in front of the glabella projects in front of the outline of the cheeks) and an abrupt change in depth between the anterior and posterior inter-ring furrows in the pygidial axis. The Acastidae was considered by Edgecombe (1993) to consist of a monophyletic Acastidae *s.s.* together with some other loosely related genera (*Llandovacaste* and *Australoacaste*) that were assigned to Acastidae *s.l.* He gave a brief diagnosis for the Acastidae *s.s.* that included the following synapomorphies: S1 transverse or anteromedially directed, lacking proximal bifurcation; L1 much shorter (exsag.) than L2; S2 transverse. *Berylacaste* conforms to this diagnosis in the orientation of S1 and S2, but S1 appears to be slightly expanded or incipiently bifurcate at its proximal end in some specimens (e.g. figs 19F–G), and L1 is not markedly shorter than L2. We note, however, that there is some variation in the length of L1 within the Acastidae *s.s.*, and that it may be almost as long as L2 (e.g. see Richter and Richter, 1954, pl. 3, fig. 37; Tomczykowa, 1991, pl. 7, fig. 23, pl. 9, figs 7–12, 14, 16–17).

Ramsköld and Edgecombe (1993: 265) identified a 'Wenlock group' of acastid genera including *Acaste, Acastoides* and *Acastocephala*, some species of which persist into the late Silurian. *Berylacaste* is contemporaneous with most members

of that group but shares few of their stated characteristics, such as a distinctly convex forward S2, a deep sagittal impression at the back of the glabellar frontal lobe, a deep preglabellar furrow, and a genal angle that is rounded or bears a tiny node. The wide glabella considered characteristic of the 'Wenlock group' is not as strongly expanded as that of *Berylacaste*. In the form of the genal spine and the apparent lack of a sagittal impression on the frontal glabellar lobe *Berylacaste* is more similar to Ludlow–Přídolí species of *Acastella*, but in the other cephalic characters listed above *Berylacaste* is easily distinguished from those species, which also differ in having a strongly segmented pygidium with a spine or blunt point posteriorly. *Scotiella* (see Shergold, 1967, pl. 2, figs 1–8, pl. 3, figs 1–8) and *Ewacaste* Ramsköld and Edgecombe, 1993 (see Schrank, 1972, pl. 21, figs 6–9; Tomczykowa, 1991, pl. 7, figs 21–24) are like *Berylacaste* in the very weak S2 and S3 but have less inflated glabellae that expand only weakly forward and large eyes, and *Scotiella* also has a mucronate pygidium. *Berylacaste* cannot be considered primitive; rather, it is a highly derived form evolved independently of and along different lines to other Acastidae.

Reduction of the visual surface and palpebral lobe also occurs in the Devonian calmoniid genera *Typhloniscus* (see Cooper, 1982), *Punillaspis* Baldis and Longobucco, 1977 and *Tormesiscus* Waisfeld et al., 1994. The eye of *Berylacaste* most closely resembles that of *Tormesiscus*, in which it is also reduced to a laterally directed palpebral ridge placed anteriorly on the genae. The glabella of *Tormesiscus* is similarly expanded strongly forward and is inflated anteriorly, overhanging the anterior border. The genera differ in thoracic and pygidial features, the depth of the glabellar axial furrows and the course of the facial suture, the latter apparently being submarginal in *Tormesiscus*.

Berylacaste berylae gen. et sp. nov.

Figures 19–20

Acastidae n. gen.—Rickards and Sandford, 1998: 752.

Type material. Holotype NMV P138224 (dorsal exoskeleton) and paratypes NMV P138225 (dorsal exoskeleton), NMV P138226 (cephalon), NMV P139330 (dorsal exoskeleton), NMV P139331 (thoracopygon with displaced pygidium), NMV P139332 (cephalon with displaced librigena), NMV P139333 (cephalon), NMV P139334. All from PL206, Bylands Siltstone.

Other material. NMV P138227 from PL206, Wallan. Bylands Siltstone.

Derivation of name and diagnosis. As for genus.

Description. Exoskeleton elliptical in outline, estimated maximum length 20 mm. Cephalon strongly convex (sag., tr.), about twice as wide as long (sag.), anterior margin with maximum curvature medially in dorsal view and with outline interrupted anteromedially by slightly protruding glabella. Glabella rounded-pentagonal in dorsal view, about as wide across frontal lobe as long (sag.), maximum width situated at approximately 66% sagittal glabellar length from posterior. Axial furrows deep, diverging forward at about 55°. Occipital ring comprising about 30% maximum glabellar width, approximately twice as long sagittally as distally, with median node situated close to posterior edge. Occipital furrow moderately impressed medially and forming convex forward arc, increasing in depth abaxially and curving slightly forward distally. L1 about as long (exsag.) distally as occipital ring, apparently with weakly defined lateral node. S1 very deeply impressed laterally and directed slightly obliquely inward and backward, shallowing abruptly adaxially and curving forward slightly subparallel to occipital furrow, apparently very weakly impressed medially. S2 and S3 more distinct on internal moulds than on exterior of exoskeleton, S2 transverse, reaching axial furrow, S3 directed obliquely inwards and backwards from axial furrow in concave-forward curve, inner end situated opposite glabellar midlength (sag.). Frontal lobe transversely elliptical or rhombic, lacking sagittal furrow. Anterior border subvertical. Genal field moderately convex (tr.), steeply sloping laterally and in front of palpebral lobe. Palpebral lobe slightly raised, placed opposite anterior half of L3, palpebral furrow shallow, oblique and weakly curved, continuous adaxially with weak furrow behind eye ridge. Anterior branch of facial suture diverging forward in gentle curve subparallel with axial furrow, not cutting across anterolateral corner of glabella, posterior branch directed posterolaterally across genal field and inner part of lateral border, deflected sharply backward across outer part of border to meet cephalic margin opposite L1. Librigena lenticular in outline with long posterior projection. Posterior border narrow proximally, gently widening abaxially to about midpoint (tr.), thereafter uniform in width and gently curving forward. Posterior border furrow deep proximally, moderately impressed distally and continuous with shallower lateral border furrow. Lateral border weakly convex, steep and poorly defined anteriorly. Genal spine diverging slightly from line of lateral margin. Cephalic doublure strongly convex laterally, widening and flattening medially, no vincular furrow.

Hypostome unknown.

Thorax of 11 segments. Axis weakly tapering backward, comprising about 30% segmental width at front of axis and about 25% toward the back. Axial rings strongly convex (sag.), flexed forward distally, lateral lobes not defined. In transverse profile pleurae convex adaxially, concave abaxially. In dorsal view pleurae convex forward adaxially, concave forward abaxially, posterior edge of segment curving slightly forward distally to spinose tip. Pleural furrows short (exsag.) and deep, extending onto articulating facet distally. Anterior pleural band approximately as long (exsag.) as posterior band at fulcrum.

Pygidium lenticular, about twice as wide as long (sag.). Axis as wide as pleura anteriorly, comprising about 75% sagittal pygidial length, weakly tapering backwards and broadly rounded posteriorly. 1st axial ring high, 2nd ring well defined, 3rd ring poorly defined. Pleurae moderately convex (tr., exsag.), comprising at least 5 segments, 1st 4 four with posterior pleural bands slightly more raised than anterior bands on internal moulds and extending onto border distally. Only 2 pleural furrows distinct, 1st sharply incised, not extending onto articulating facet distally, 2nd reaching halfway to margin. 1st 2 interpleural furrows weaker than pleural ones. Pygidial margin smooth on exterior of exoskeleton, weakly scalloped on internal mould. Pygidial doublure narrow, convex.

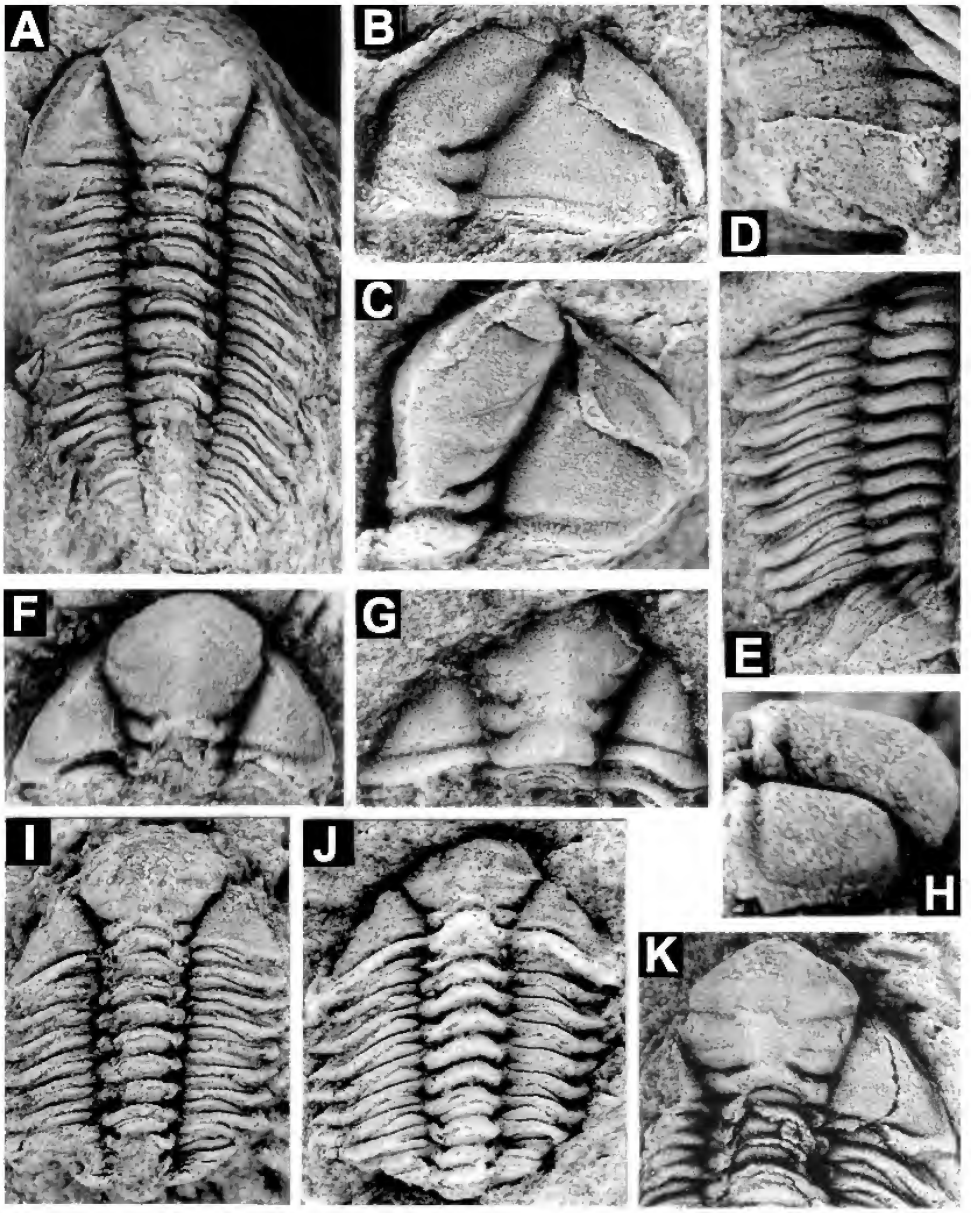

Figure 19. *Berylacaste berylae* gen. et sp. nov., from PL206, Wallan. A, paratype NMV P138224, dorsal exoskeleton, × 4. B–C, paratype NMV P139332, cephalon with displaced librigena, × 5. D–E (and fig. 20D), paratype NMV P139331, thoracopygon; D, × 8; E, × 4. F–H, paratype NMV P139333, cephalon, × 4. I–J (and fig. 20C), paratype NMV P138225, dorsal exoskeleton with down-flexed pygidium, × 5. K, holotype NMV P138224, cephalothorax, × 5. (A, C, F, H, I, K are internal moulds).

Remarks. The specimens are rather poorly preserved and affected by compression, shearing and fracturing. As a result there is apparent variation in the depth of some furrows, such as the medial part of S1 (compare fig. 19A with 19B–C, G) and the lateral cephalic border furrow (compare figs 19B–C with 19H). Some other morphological features are unclear, such as the extent to which lateral nodes are defined on L1 by adaxial expansion and/or bifurcation of S1 (compare figs 19F–G with 19K).

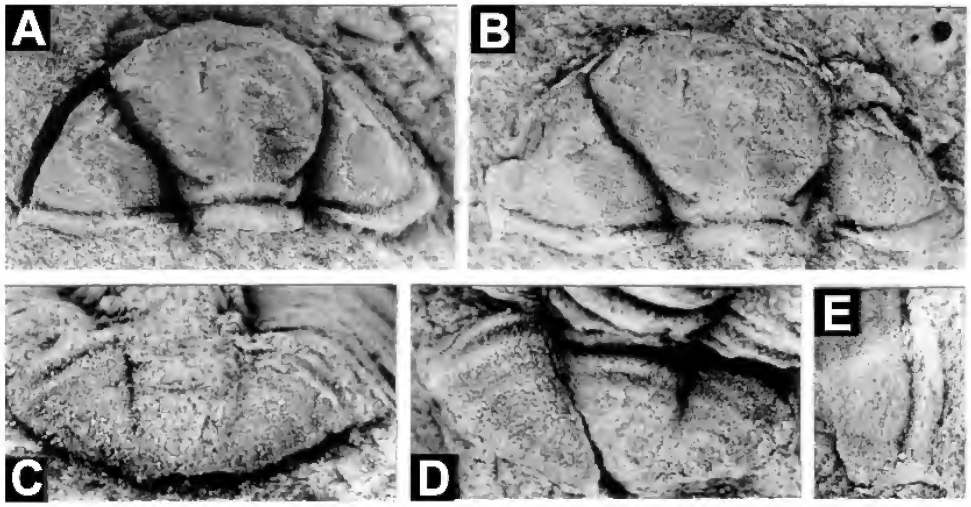

Figure 20. *Berylacaste berylae* gen. et sp. nov., from PL206, Wallan. A–B, E, paratype NMV P138226, cephalon; A–B, × 4; E, enlargement of genal angle showing thorn-like genal spine. C, paratype NMV P138225, enlargement of pygidium, × 10. D, paratype NMV P139331, enlargement of pygidium, × 8.

The blind condition of *Berylacaste* reinforces other evidence for a deep-water, possibly sub-photic environmental setting for the trilobite fauna at PL206, Wallan. *Berylacaste berylae* is well-represented, but the fauna is dominated by the blind, effaced styginid *Thomastus aops* Sandford and Holloway, 1998. Together these blind trilobites represent 63% of the trilobite population and 22% of the faunal diversity. Furthermore *Ivops wallanensis*, representing 19% of the trilobite population, bears an eye markedly smaller than other Wenlock phacopids. The taphonomy of the fauna at PL206 contains a high proportion of partly articulated exoskeletons (60%) and indicates assignment to trilobite taphofacies TIV (see Sandford, 2002), considered to represent depths below maximum storm wave base. Exoskeletons of *T. aops* showing partly displaced librigenae may be moult assemblages characteristic of taphofacies TIV, although as the amount of displacement is small it is more likely due to post-depositional compaction.

Four other acastids are known from central Victoria, all in the Lower Devonian. *Acaste lokii* Edgecombe, 1993 and *Acastella frontosa* Shergold, 1968 are from the Humevale Siltstone at Lilydale, and *Acastella* sp. was recorded by Holloway and Neil (1982) from the Mt Ida Formation at Heathcote. These species are easily distinguished from *Berylacaste berylae* by their large eyes and deeply impressed S2 and S3. A distinctive, as yet undescribed acastid with long occipital and thoracic axial spines occurs in the Humevale Siltstone at Yarra Junction and at Kinglake West.

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A systematic revision of the asterinid genus *Aquilonastra* O'Loughlin, 2004 (Echinodermata: Asteroidea)

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Abstract

O'Loughlin, P. Mark and Rowe, Francis W.E. A systematic revision of the asterinid genus *Aquilonastra* O'Loughlin, 2004 (Echinodermata: Asteroidea). *Memoirs of Museum Victoria* 63(2): 257–287.

The Indo-west Pacific *Aquilonastra* O'Loughlin is reviewed. Eleven species are retained in *Aquilonastra*: *A. anomala* (H.L. Clark); *A. batheri* (Goto); *A. burtonii* (Gray); *A. cepheus* (Müller and Troschel); *A. corallicola* (Marsh); *A. coronata* (Martens); *A. iranica* (Mortensen); *A. limboonkengi* (Smith); *A. minor* (Hayashi); *A. rosea* (H.L. Clark); *A. scobinata* (Livingstone). *Asterina lorioli* Koehler is reassigned to *Aquilonastra*. Thirteen new species are described: *A. byrneae*; *A. colemani*; *A. conandae*; *A. doranae*; *A. halseyae*; *A. marshae*; *A. moosleitneri*; *A. oharai*; *A. richmondi*; *A. rowleyi;* *A. samyni*; *A. watersi*; *A. yairi*. The four subspecies of *Asterina coronata* Martens are junior synonyms: *Asterina coronata cristata* Fisher; *Asterina coronata euerces* Fisher; *Asterina coronata fascicularis* Fisher; *Asterina coronata* forma *japonica* Hayashi. The 13 fissiparous Red Sea specimens described by Perrier as *Asteriscus wega* are the syntypes. *Asteriscus wega* Perrier is a junior synonym of *Asterina burtonii* Gray. The provisional referral to *Aquilonastra* of three species is discussed: *A. rosea*; *A. rowleyi*; *A. scobinata*. No fissiparous species develops into a non-fissiparous pentaradiate form. A key to the species of *Aquilonastra* and map of type localities are provided.

Introduction

A revision of *Aquilonastra* O'Loughlin (in O'Loughlin and Waters, 2004) was anticipated by O'Loughlin and Rowe (2005), and its scope has grown through loans and donations of an abundant array of asterinid specimens and photos from the Indo-Pacific, Red Sea and Mediterranean regions.

This revision and description of 13 new species are based on morphological observations. O'Hara et al. (in preparation) are currently working on a molecular phylogeny analysis of species of *Aquilonastra*, and will examine congruity with the morphological observations. Byrne (2006) reported that for *Aquilonastra* a phylogeny potentially provides evidence of a life history transformation series, from planktonic feeding to planktonic non-feeding to the benthic non-feeding mode of development, all three modes clustered in *Aquilonastra* with *A. minor* a terminal taxon. Three species are referred to *Aquilonastra* provisionally: *A. rosea* (H.L. Clark, 1938), *A. rowleyi* sp. nov. and *A. scobinata* (Livingstone, 1933).

We recognize limitations in this revision. Images for fissiparous specimens on the Seychelles suggest another new species, but no material was available (see figs 3k,3l). Sloan et al. (1979) reported *Asterina burtoni* for Aldabra Atoll as a species with fissiparous and non-fissiparous forms. They described the non-fissiparous form as having five rays and single madreporite. We recognize throughout this work two such forms as distinct species. No material was examined to establish the status of these species. Indeed, we are unable to support the view that pluriradiate, fissiparous asterinids represent juveniles of larger, non-fissiparous pentaradiate adults (see Clark, 1967b for review). James (1975, 1982, 1985, 1989) reported *Asterina burtoni* from Lakshadweep (Laccadives) and Indian and Sri Lankan seas. Again, no material was examined to confirm systematic status. Sastry (1991) also reported *Asterina burtoni* from Lakshadweep, that appears to have represented non-fissiparous and fissiparous forms. No material was examined to confirm systematic status. The evidence in this paper indicates that *Aquilonastra* species have local geographical ranges. Thus some species reported here with extensive distributions (such as Oman to South Africa, and northern Australia to China) may prove with further analysis to be more than one species.

Body form, numbers of spinelets and spines per plate, and size of spinelets and spines are all related to specimen size for the 25 *Aquilonastra* species. And all of these characters show some variation for specimens of the same species at the same size, and on the same specimen. Preservation history is another factor affecting size and form of the various morphological characters. Species diagnostic characters are always given here for nominated specimen sizes, and for dried specimens. All of the *Aquilonastra* species show mottled live colour, and within a species the mottled colour can vary greatly. Colour is sometimes uniform on a specimen. However, some colours predominate in some species. Colour appears to vary with substrate colour. A full generic diagnosis for *Aquilonastra* is given, and these morphological characters are not repeated in each species diagnosis. Terminology follows O'Loughlin and Waters (2004).

Abbreviations for institutions are: AM—The Australian Museum, Sydney; HUJ—The Hebrew University of Jerusalem; MNHN—Muséum National d'Histoire Naturelle, Paris; MRAC—Museum of the Republic of Central Africa, Brussels; NHM—The Natural History Museum, London; NMV—Museum Victoria, Australia; NSMT—National Science Museum, Tokyo; TAU—Tel-Aviv University; TM—Tasmanian Museum, Australia; UF—The University of Florida; WAM—The Western Australian Museum. Specimen registration number prefixes are: AM J; MNHN EcA; NMV F; TM H; WAM Z. MAU is MNHN collection code for Mauritius.

Photography for many figures was performed using a Leica MZ16 stereomicroscope, DC300 Leica digital camera, and "Auto-Montage" software for composition of images.

Table 1. Species of *Aquilonastra* O'Loughlin, 2004, with type localities.

Species	Type localities
A. anomala (H.L. Clark, 1921)	Australia, Torres Strait, Murray I.
A. batheri (Goto, 1914)	Japan
A. burtonii (Gray, 1840)	Red Sea
A. byrneae sp. nov.	Australia, Great Barrier Reef, One Tree I.
A. cepheus (Müller and Troschel, 1842)	Indonesia, Jakarta (as Batavia)
A. colemani sp. nov.	SE Papua New Guinea, China Straits
A. conandae sp. nov.	W Indian Ocean, La Réunion I.
A. corallicola (Marsh, 1977)	W Pacific Ocean, Caroline Is., Palau
A. coronata (Martens, 1866)	Indonesia, Molucca and Flores Is.
A. doranae sp. nov.	S Japan, Ryukyu Is., Okinawa, Henza Island
A. halseyae sp. nov.	N Indian Ocean, Maldive Is.
A. iranica (Mortensen, 1940)	Iranian Gulf
A. limboonkengi (Smith, 1927)	China, Amoy
A. lorioli (Koehler, 1910)	Pakistan, Karachi
A. marshae sp. nov.	Red Sea
A. minor (Hayashi, 1974)	Japan, Honshu, Kushimoto
A. moosleitneri sp. nov.	N Indian Ocean, Maldive Is.
A. oharai sp. nov.	S Japan, Ryukyu Is., Okinawa, Seragaki
A. richmondi sp. nov.	Tanzania, Ras Kimbiji (central coast)
A. rosea (H.L. Clark, 1938)	SW Australia, off Perth, Rottnest I.
A. rowleyi sp. nov.	SE Africa, Sodwana Bay
A. samyni sp. nov.	Arabian Sea, Oman, Masirah I.
A. scobinata (Livingstone, 1933)	Tasmania
A. watersi sp. nov.	Arabian Sea, Oman, Masirah I.
A. yairi sp. nov.	E Mediterranean Sea, Israel, Michmoret

Key to *Aquilonastra* O'Loughlin species

1. Typically 5 equal or subequal rays, sometimes 6; form symmetrical; single conspicuous madreporite, rarely 2, very rarely 3 2
— Typically more than 5 rays, up to 9, in unequal size groups; form asymmetrical; always more than 1 inconspicuous madreporite 18
2. Gonopores actinal 3
— Gonopores abactinal 5
3. Abactinal plates paxilliform; spinelets in dense, frequently crescentiform, clusters; spinelets pencil-like ..... *A. scobinata* (SE Australia)
— Abactinal plates not paxilliform; spinelets not in dense clusters; spinelets not pencil-like 4
4. Abactinal plates with low rounded elevations; spinelets subpaxilliform; maximum R = 9 mm ..... *A. minor* (Japan)
— Abactinal plates lacking rounded elevations; spinelets not subpaxilliform; maximum R = 15 mm ..... *A. byrneae* (NE Australia, Mariana Is.)
5. Abactinal spinelets in dense round paxilliform clusters ..... *A. rosea* (SW Australia)
— Abactinal spinelets not in dense paxilliform clusters 6
6. Projecting abactinal pedicellariae with conspicuous toothed valves, longer than spinelets; oral plate with up to 10 spines ..... *A. rowleyi* (SE Africa)
— If abactinal pedicellariae present, valves not longer than spinelets; oral plate with up to 8 spines 7
7. Abactinal spinelets on rays differentiated on plates into apically thick and marginally thin; some irregularly distributed paxilliform plates 8
— Abactinal spinelets may be of variable form, but not differentiated into two distinct forms; lacking paxilliform abactinal plates 9
8. Abactinal radial plates with central subglobose spinelets, peripheral short conical to subgranuliform spinelets; lacking pedicellariae; actinal central interradial plates each with about 3 spines ..... *A. lorioli* (N Indian Ocean)
— Abactinal radial plates with central digitiform spinelets, peripheral short conical spinelets; pedicellariae present; actinal central interradial plates each with about 5 spines ..... *A. coronata* (Japan to N Australia)
9. Pedicellariae with differentiated valves in abactinal proximal interradii 10
— Lacking pedicellariae 13
10. Abactinal spinelets thick, up to about 12 on each proximal carinal plate (at R = 21 mm) ..... *A. iranica* (Persian Gulf)
— Abactinal spinelets thin or small, up to more than 24 on each proximal carinal plate (at R = 17 mm) 11
11. Abactinal proximal spinelets up to more than 40 per plate; superomarginal plates each with up to about 20 spinelets (at R = 19 mm) ..... *A. batheri* (Japan)
— Abactinal proximal spinelets fewer than 25 per plate; superomarginal plates each with fewer than 10 spinelets (at R = 19 mm) 12
12. Proximal abactinal spinelets small, thick, frequently of two forms, subgranuliform apically on plates; abactinal distal interradial plate spinelets splayed and overlapping adjacent plate spinelets (at R = 20 mm); actinal interradial plates each with up to 5 spines (at R = 20 mm); size up to R = 25 mm ..... *A. richmondi* (E Africa coast, Madagascar, Mauritius)
— Proximal abactinal spinelets thin, similar form; abactinal distal interradial spinelets not overlapping adjacent plate spinelets if splayed; actinal interradial plates each with up to 10 spines (at R = 19 mm); size up to R = 19 mm ..... *A. watersi* (Arabian Sea, Mauritius)
13. Abactinal spinelets sacciform, short, wide globose basally, tapered to sharply pointed apically; up to about 12 spinelets on each proximal abactinal plate (at R = 19 mm); predominantly 2 actinal interradial spines on each plate ..... *A. halseyae* (Maldives)
— Abactinal spinelets not widely globose basally, not tapered to a sharp point apically; more numerous than 14 on each proximal abactinal plate (at R > 12 mm); predominantly > 3 actinal interradial spines on each plate 14
14. Proximal abactinal spinelets short, thick, columnar or conical 15
— Proximal abactinal spinelets long, thin, subsacciform 16
15. Rays long, subdigitiform; spinelets mostly spread over exposed plate surface; predominantly 6 spines per actinal interradial plate (at R = 16 mm); actinal interradial spines short, thick, bluntly conical, sacciform. ..... *A. samyni* (Arabian Sea to SE Africa, Madagascar, La Réunion)
— Rays short, strongly tapered; spinelets mostly concentrated over projecting proximal plate edge; predominantly 3 spines per actinal interradial plate (at R = 16 mm); actinal interradial spines conical to digitiform ..... *A. marshae* (Red Sea, Gulfs of Aqaba and Suez)
16. Rays short, merging with disc; lacking doubly-papulate carinal plates; spinelets not clustered into groups on plates; spinelets frequently splay-pointed ..... *A. oharai* (Okinawa)
— Rays long, discrete; some doubly-papulate carinal plates present; spinelets frequently clustered into groups on plates; spinelets not splay-pointed 17
17. Rays tapered; abactinal plates angled over papulae; spinelets long, thin, sub-sacciform to sacciform, tapering to fine point, rugose, subacicular; spinelets frequently projecting proximally over papulae ..... *A. cepheus* (Indonesia to N Australia)
— Rays digitiform; abactinal plates not angled over papulae; spinelets long, thick, conical to subsacciform, with numerous (5–6) points on distal sides and end of spinelets; spinelets not projecting proximally over papulae ..... *A. limboonkengi* (China)
18. Actinal interradial spines predominantly 1 per plate ..... *A. conandae* (Mascarene Is.)
— Actinal interradial spines predominantly > 1 per plate 19
19. Spinelets of 2 distinct forms, long thick digitiform apically on upper ray and marginal plates ..... *A. corallicola* (NE Indian to central W Pacific Oceans)
— Spinelets of one form 20
20. Spinelets elongate, not subgranuliform (at R = 5 mm) 21
— Spinelets truncate, subgranuliform (at R = 5 mm) 23

21. Spinelets long, frequently distinctly splay-pointed; pedicellariae present; size up to R = 12.5 mm ..... *A. anomala* (central W Pacific)
— Spinelets not long, not distinctly splay-pointed; lacking pedicellariae; size up to R = 5 mm 22
22. Rays narrow at base, long, elevated; spinelets thick columnar or conical; actinal interradial spines up to 2 per plate ..... *A. colemani* (Papua New Guinea, Indonesia)
— Rays wide at base, short, not elevated; spinelets thin digitiform or conical with distally long spines; actinal interradial spines up to 5 per plate ..... *A. doranae* (Okinawa)
23. Size up to R = 18 mm; some central abactinal plates atypically large and irregular ..... *A. burtonii* (Red and Arabian Seas)
— Size up to R = 9 mm; central abactinal plates not unusually large and irregular 24
24. Abactinal spinelets up to 16 per plate; spinelets splay-pointed; suboral spines up to 4 per plate ..... *A. yairi* (Red and Mediterranean Seas)
— Abactinal spinelets up to 10 per plate; spinelets not splay-pointed; suboral spines up to 2 per plate ..... *A. moosleitneri* (Maldive Is.)

Asterinidae Gray, 1840

Remarks. For recent revision of Asterinidae see O'Loughlin and Waters (2004). For addition of new genus *Ailsastra* see O'Loughlin and Rowe (2005).

Aquilonastra O'Loughlin, 2004

Aquilonastra O'Loughlin, in O'Loughlin and Waters, 2004: 5 (key), 13–15, tables 1 and 2.—O'Loughlin and Rowe, 2005: 181.—Saba and Fujita, 2006: 270.—Byrne, 2006: 244, 245, 248, 250, 251.

Diagnosis (emended from O'Loughlin and Waters, 2004). Rays discrete, broad or narrow at base, tapering, rounded distally, interradial margin deeply incurved; fissiparous or non-fissiparous; fissiparous species with more than 1 inconspicuous madreporite, up to 9 rays, rays frequently unequal in length, form frequently asymmetrical; non-fissiparous species with 1 conspicuous madreporite, rarely 2, predominantly 5 rays, sometimes 6, form symmetrical, typically stellate; body flat actinally, high convex abactinally; disc variably distinct in non-fissiparous species, sometimes delineated by 5 transversely elongate radial and 5 short interradial plates; abactinal plates predominantly irregular on upper rays, in longitudinal series on sides of rays, series not perpendicular to margin; papulate areas extensive, plates predominantly with single notch for papula in papulate areas, papulae predominantly single per space, large, in longitudinal series along sides of rays; abactinal plates with glassy convexities; abactinal spinelets small, glassy, subgranuliform to digitiform, columnar or conical or sacciform or splay-pointed sacciform, in bands or tufts, numerous (10–40 per proximal abactinal plate); superomarginal and inferomarginal plates in regular series; actinal plates in longitudinal, not oblique, series; suboral spines present; adradial actinal spines in complete series; superambulacral plates present; superactinal plates present.

Type species. Asteriscus cepheus Müller and Troschel, 1842 (by original designation in O'Loughlin and Waters, 2004).

Other species. For all 25 species see Table 1 and Fig 1.

Remarks. O'Loughlin and Waters (2004) referred 12 species to the new genus *Aquilonastra*. They noted that *A. heteractis* had some characters that were exceptional to those shared by the other species of *Aquilonastra*. More recently O'Loughlin and Rowe (2005) reassigned this species to their new genus in the recombination *Ailsastra heteractis* (H.L. Clark, 1938). The remaining 11 original species are retained here in *Aquilonastra*. *Asterina lorioli* Koehler, 1910 was *incertae sedis* in O'Loughlin and Waters (2004). It is added here in the new combination *Aquilonastra lorioli* (Koehler, 1910). Thirteen new *Aquilonastra* species are described. The emended generic diagnosis refines the description but does not change any diagnostic characters.

Aquilonastra anomala (H.L. Clark, 1921)

Figures 1, 2a, 7a

Asterina anomala H.L. Clark, 1921: 95–96, pl. 7 fig. 8, pl. 23 fig. 5, pl. 26 figs 2, 3.—H.L. Clark, 1938: 143–144.—H.L. Clark, 1946: 133–134.—A.M. Clark and Rowe, 1971: 68, fig. 17g, tbl. 1.—Marsh, 1974: 92.—Marsh, 1977: 270–271, fig. 7, tbl. 2.—Oguro, 1983: 222–224, figs 5, 6, 12, 13.—A.M. Clark, 1993: 207.—Rowe and Gates, 1995: 33–34.—Waters et al., 2004: 874, 876, 877, tbl. 1, figs 1, 2.

Aquilonastra anomala.—O'Loughlin and Waters, 2004: 11, 13–15, fig. 1.

Material examined. N Australia, Torres Strait, Darnley I., 30 Apr 1977, WAM Z6849 (2); Kimberley, 17 Jul 1988, Z6843 (1); Papua New Guinea, Bismark Archipelago, 1–34 m, 29 Jun 2003, UF 2283 (1); 15–22 m, 26 Jun 2003, UF 2217 (1); West New Britain, 3–37 m, 17 Jun 2003, UF 2270 (1); Christmas I., 13 Feb 1987, Z6851 (1); Lord Howe I., AM J6169 (21); 15 Feb 1979, J16574 (2); H.L. Clark, Apr 1932, NMV F95593 (6); 20 May 2003, F97690 (6); 15 Mar 2002, F96699 (1); Solomon Is. 4–6 m, 20 Jun 2004, F94607 (1); 3–5 m, 26 Jun 2004, F94616 (3); Caroline Is. Z6845 (2); Palau, 26 Jul 1999, UF 1740 (3); Samoa, F96698 (2).

Diagnosis. Fissiparous *Aquilonastra* species; up to 8 rays, predominantly 7, broad basally, rounded distally; up to R = 12.5 mm (H.L. Clark, 1938); pedicellariae with differentiated conical valves larger than spinelets sometimes present in proximal interradial angle; up to 4 inconspicuous madreporites seen; abactinal gonopores present.

At R = 8 mm, r = 4 mm, lacking carinal series of plates, upper rays with 2 irregularly arranged longitudinal series of singly papulate plates; plates domed, angled over papulae more than notched; single papula per plate, rarely 2; some secondary plates intergrade with primary plates; spinelets long, thin conical pointed to prominently splay-pointed sacciform, up to about 20 spinelets over projecting surface of each proximal abactinal plate, predominantly in transverse double band, rare clustering of spinelets; distal interradial plates with up to about 6 sacciform splay-pointed spinelets; superomarginal and inferomarginal plates subequal; superomarginal plates each with up to about 8 spinelets, inferomarginal plates each with up to about 16 slightly larger spinelets, marginal spinelets long, splay-pointed sacciform.

Spines per actinal plate up to: oral 7, suboral 5, furrow 6, subambulacral 5, actinal interradial 7 (variable, predominantly 3–4); interradial spines glassy, thin, conical, pointed, spinous, in transverse series or tufts on plates.

Colour (live). "Green, prettily variegated with white and rusky, with traces of red and yellow along the margins" (H.L. Clark, 1921); "green is common as a tinge, if not as a ground colour, and orange and brown are very generally evident; white blotches or markings may occur" (H.L. Clark, 1946); brown with reddish tinge apically, green tinge radially, white interradially, some orange marginally (photo by G. Paulay).

Distribution. N and NE Australia; Papua New Guinea; Lord Howe I.; Solomon Is.; Caroline Is., Palau; Marshall Is.; Fiji; Tonga; Samoa; Cook Is.; 0–37 m (Marsh, 1974; A.M. Clark, 1993; this work).

Remarks. A distinguishing character for the fissiparous *A. anomala* is the relatively long, frequently splay-pointed, abactinal spinelets. Green is commonly present in the mottled live colours.

Aquilonastra batheri (Goto, 1914)

Figures 1, 2b, 7b

Asterina penicillaris (part).—Sladen, 1889: 393 (two *Challenger* specimens from Kobé, Japan, non *Asterina penicillaris* (Lamarck, 1816), according to Goto (1914); *Asterina penicillaris* of uncertain identity and validity, according to A.M. Clark (1993)).

Asterina batheri Goto, 1914: 651–656, pl. 19 figs 275–278.—Hayashi, 1940: 119, pl. 13 figs 5, 6.—Hayashi, 1973: 71, pl. 12 fig. 2.—A.M. Clark, 1993: 207.—Fujita and Saba, 2000: 169, pl. 1C, pl. 3D, F.—Waters et al., 2004: 874, 876, 877, tbl. 1, figs 1, 2.

Aquilonastra batheri.— O'Loughlin and Waters, 2004: 11, 13–15, figs 1, 9e.—Saba and Fujita, 2006: 286.—Byrne, 2006: 245, tbl. 2.

Material examined. Japan, Toyama Bay, NMV F97441 (1); AM J11564 (2).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, broad basally, narrowly rounded distally; up to R = 34 mm, r = 14 mm (Goto, 1914); abactinal proximal interradial pedicellariae, pairs of tooth-like differentiated valves; gonopores abactinal; direct development into brachiolaria stage (Hayashi, 1973).

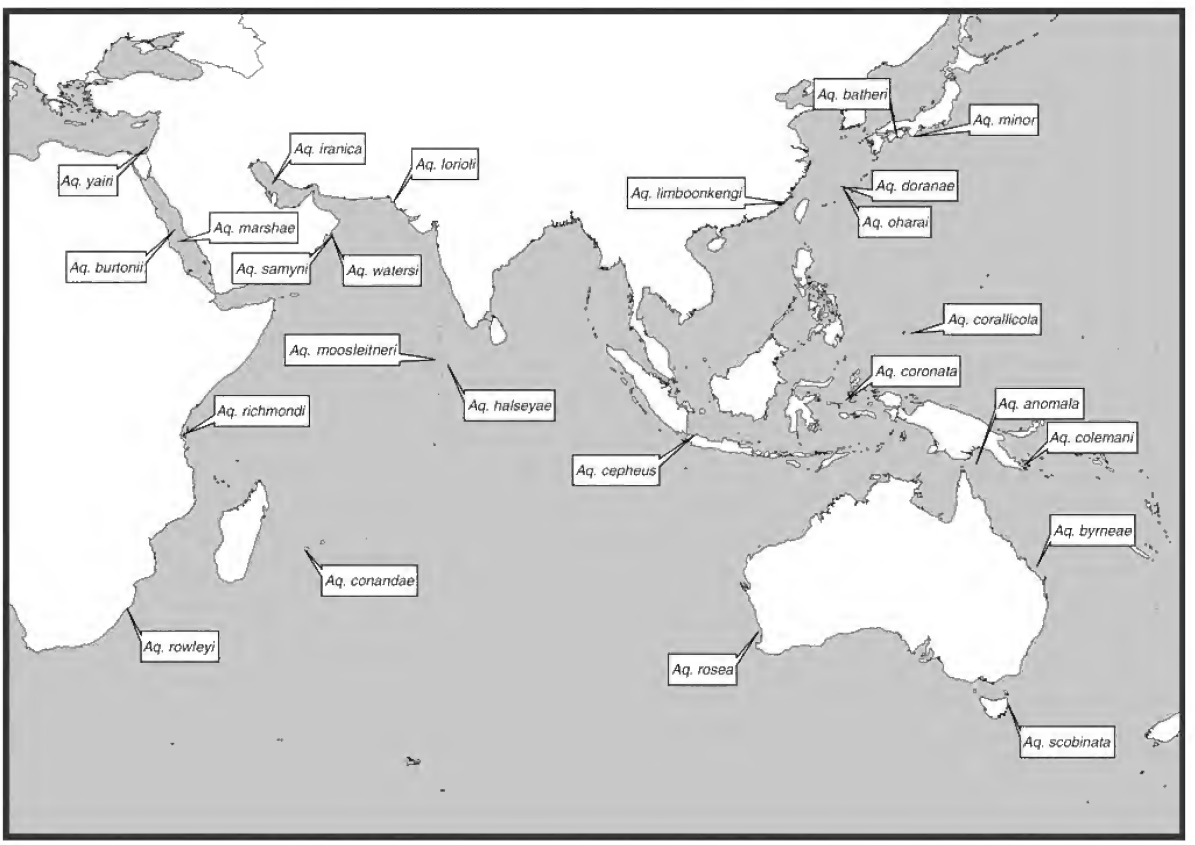

Figure 1. Indo-west Pacific distribution of type localities for the species of *Aquilonastra* O'Loughlin.

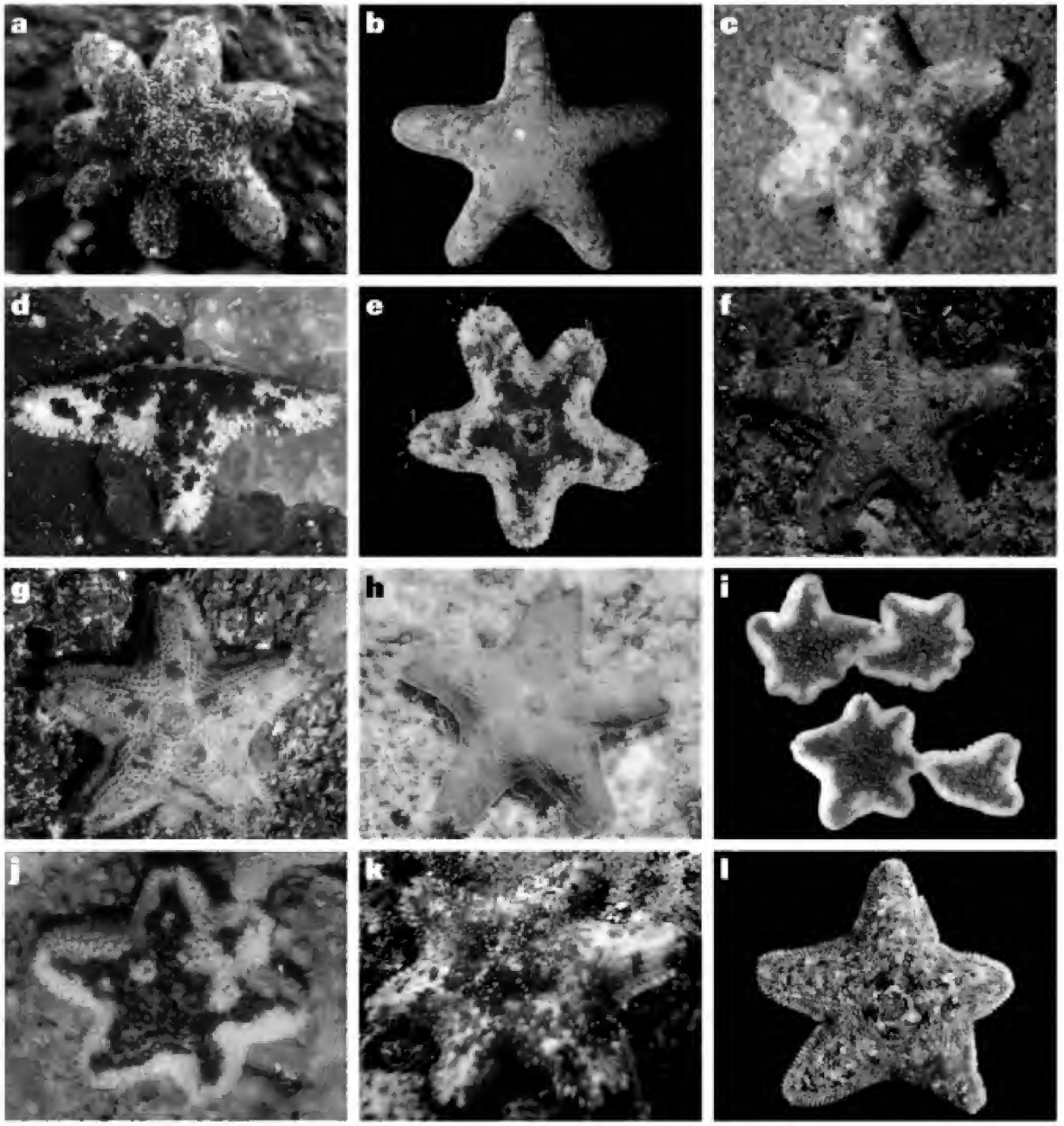

Figure 2. Photos of live colour and form of *Aquilonastra* species. a, *A. anomala* (H.L. Clark), Lord Howe I. (photo N. Coleman); b, *A. batheri* (Goto), Japan, Honshu, Hiroshima, Takehara (NSMT E–4136; photo T. Fujita, see Fujita and Saba, 2000); c, *A. burtonii* (Gray), Red Sea, Egypt (photo J. Hinterkircher); d, *A. burtonii* (Gray), Oman (photo G. Paulay); e, *A. byrneae* sp. nov., Qld, One Tree I. (photo M. Byrne); f, *A. cepheus* (Müller and Troschel), Papua New Guinea, Loloata I. (photo N. Coleman); g, *A. cepheus* (Müller and Troschel), Qld, Lady Elliot I. (photo N. Coleman); h, *A. cepheus* (Müller and Troschel), WA, Exmouth (photo N. Coleman); i, *A. colemani* sp. nov., Indonesia, Mayo I. (NMV F109374; photo S. Uthicke); j, *A. colemani* sp. nov., Papua New Guinea, Milne Bay (photo N. Coleman); k, *A. conandae* sp. nov., Indian Ocean, La Réunion I. (photo A. Barrere); l, *A. coronata* (Martens), Japan, Kyushu, Goto Is., Fukue I. (NSMT E–3683; photo T. Fujita).

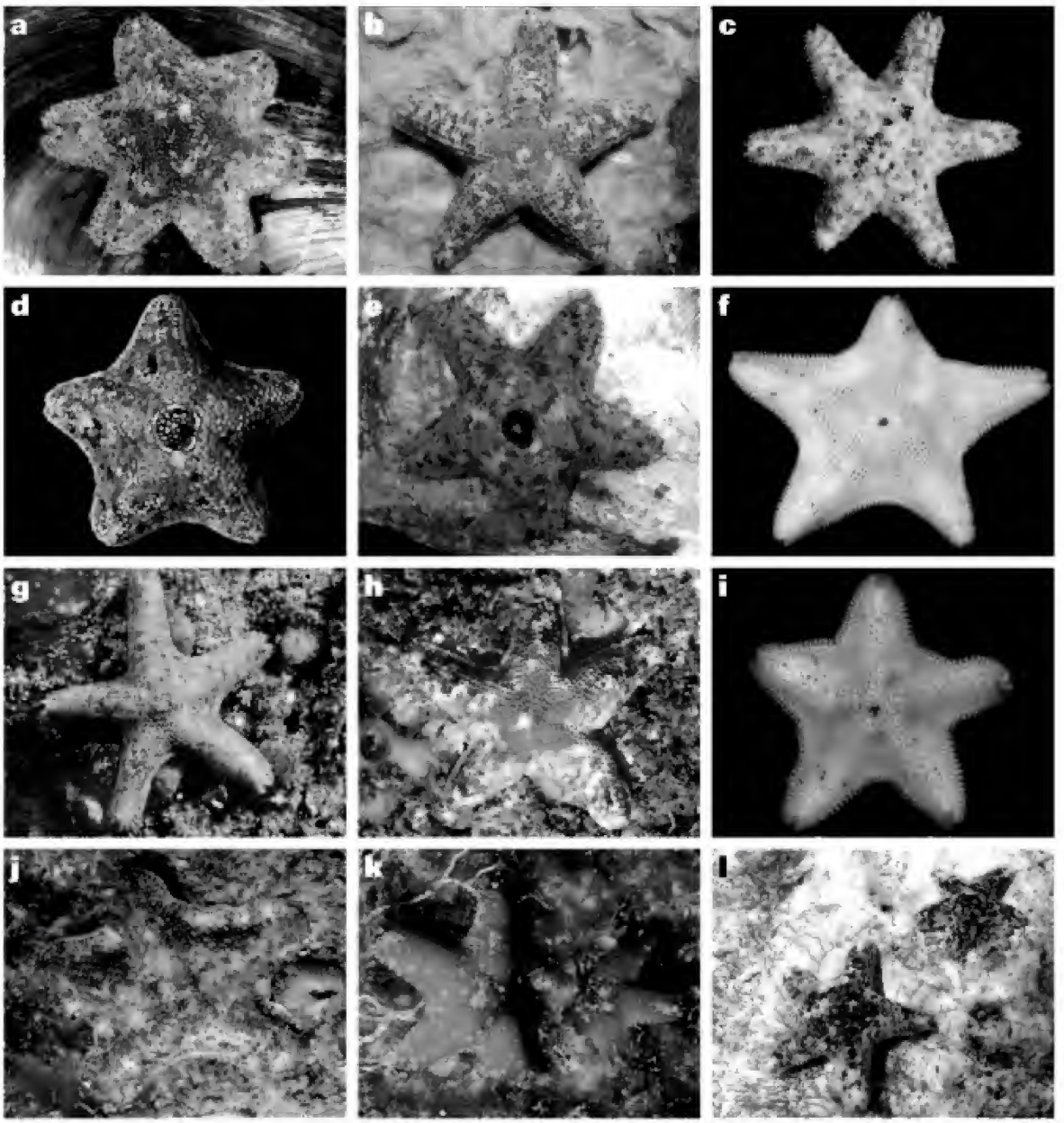

Figure 3. Photos of live colour and form of *Aquilonastra* species. a, *A. doranae* sp. nov., Japan, Okinawa (UF 3913, holotype; photo G. Paulay); b, *A. halseyae* sp. nov., Indian Ocean, Maldive Is. (photo N. Coleman); c, *A. marshae* sp. nov., Red Sea, Egypt (photo J. Hinterkircher); d, *A. minor* (Hayashi), Japan, Honshu, Hiroshima, Takehara (NSMT E–4102; photo T. Fujita, see Fujita and Saba, 2000); e, *A. oharai* sp. nov., Japan, Okinawa (photo G. Paulay); f, *A. rosea* (H.L. Clark), WA, Ludlow (photo N. Coleman); g, *A. samyni* sp. nov., SE Africa, Sodwana Bay (photo Y. Samyn); h, *A. samyni* sp. nov., Oman (photo G. Paulay); i, *A. scobinata* (Livingstone), Victoria (photo L. Altoff); j, *A. watersi* sp. nov., Oman (photo G. Paulay); k, unidentified *Aquilonastra* fissiparous species, Indian Ocean, Seychelles Is. (photo N. Coleman); l, unidentified *Aquilonastra* fissiparous species, Seychelles Is., La Digue I. (photo M. Richmond).

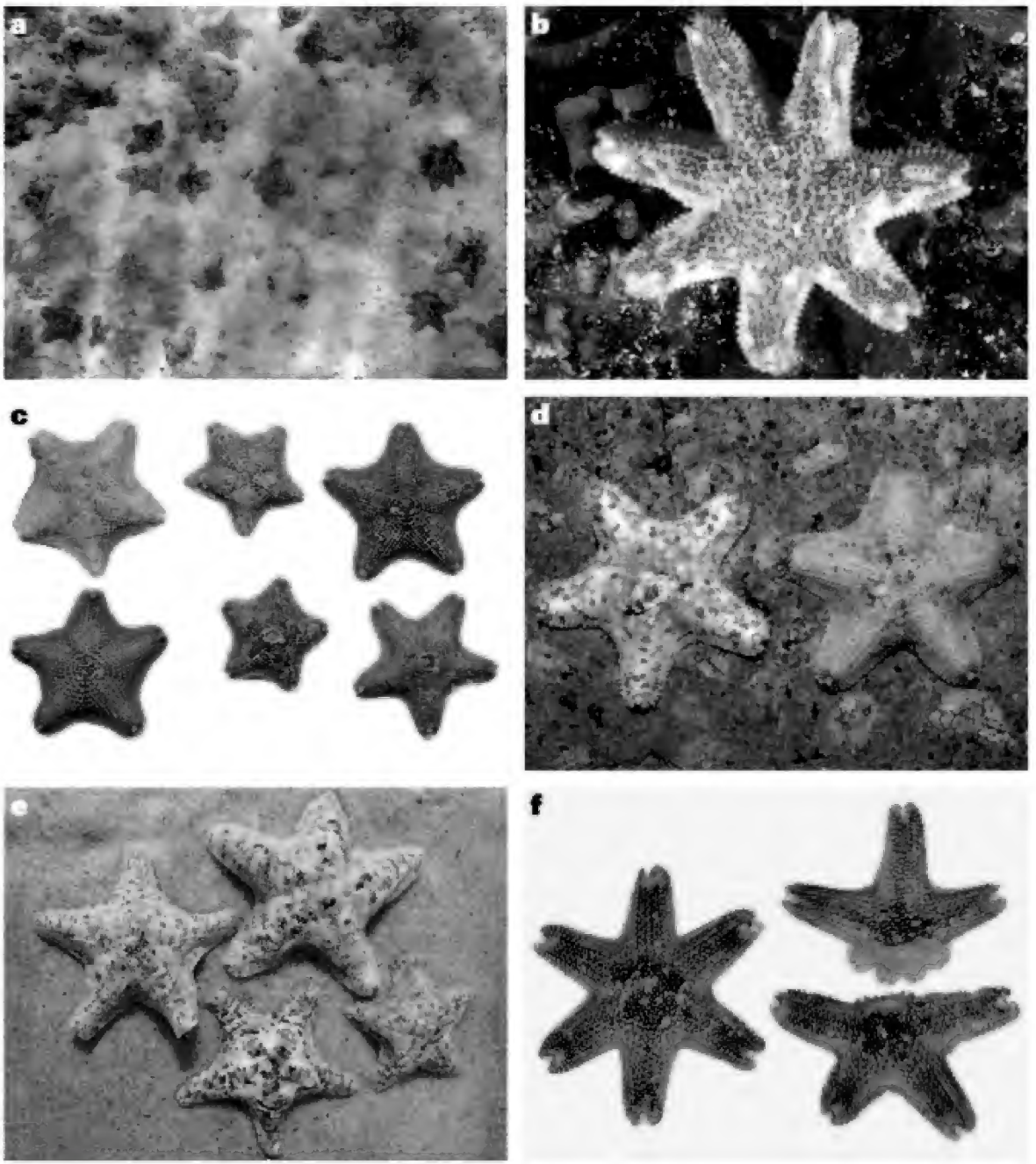

Figure 4. Photos of live colour and form of *Aquilonastra* species. a, *A. conandae* sp. nov., Indian Ocean, La Réunion I., on under-surface of coral slab (photo A. Barrere); b, *A. corallicola* (Marsh), Indian Ocean, Cocos (Keeling) I. (photo N. Coleman); c, *A. lorioli* (Koehler), Pakistan (photo Qaseem Tahera); d, *A. marshae* sp. nov., Red Sea, Egypt (photo J. Hinterkircher); e, *A. richmondi* sp. nov., Tanzania, Mnazi Bay (photo M. Richmond); f, *A. yairi* sp. nov., Israel, Achziv (photo M. Tsurnamal, 5 July 1964).

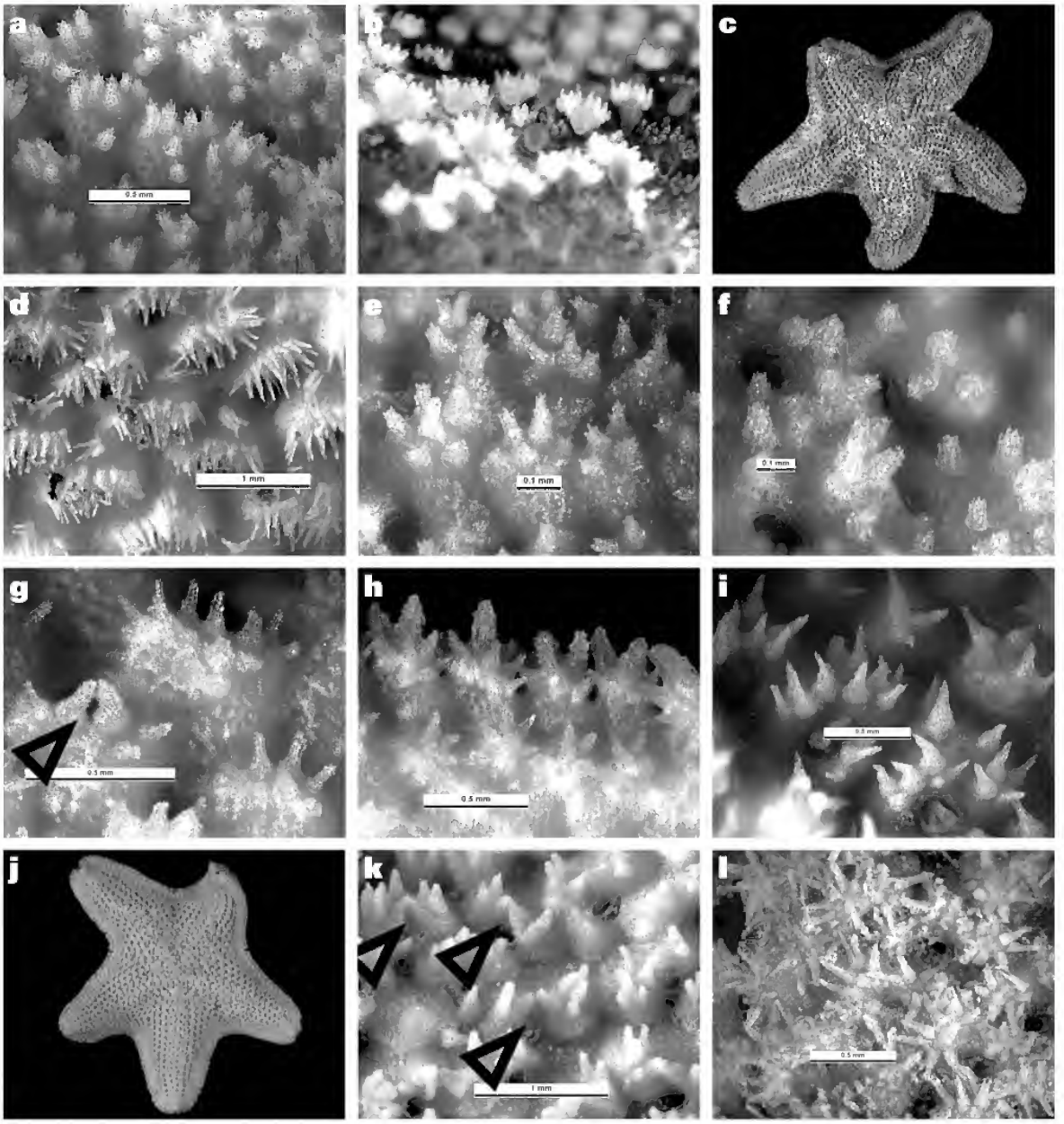

Figure 5. Photos of *Aquilonastra* species. a, *A. burtonii* (Gray), Zanzibar, spinelets (NHM 2004.2831); b, *A. byrneae* sp. nov., Qld, One Tree I., spinelets and papulae (photo M. Byrne); c, *A. cepheus* (Müller and Troschel), Jakarta (R = 20 mm; holotype MNHN EcAs1471); d, *A. cepheus* (Müller and Troschel), Papua New Guinea, spinelets (R = 17 mm; UF 2332); e, *A. colemani* sp. nov., Papua New Guinea, spinelets (UF 3284, holotype); f, *A. conandae* sp. nov., La Réunion I., spinelets (NMV F107414); g, *A. corallicola* (Marsh), Cocos (Keeling) I., pedicellaria (arrow) and spinelets (UF 745); h, *A. corallicola* (Marsh), Cocos (Keeling) I., marginal spinelets (UF 745); i, *A.halseyae* sp. nov., Maldive Is., spinelets (NHM 1965.6.1.84, holotype); j, *A. iranica* (Mortensen), Iranian Gulf (R = 13 mm; WAM Z6868); k, *A. iranica* (Mortensen), Iranian Gulf, spinelets and pedicellariae (arrows) (R = 14 mm; WAM Z6868); l, *A. limboonkengi* (Smith), China, Amoy, spinelets (NHM 1926.12.22.35–36, syntype).

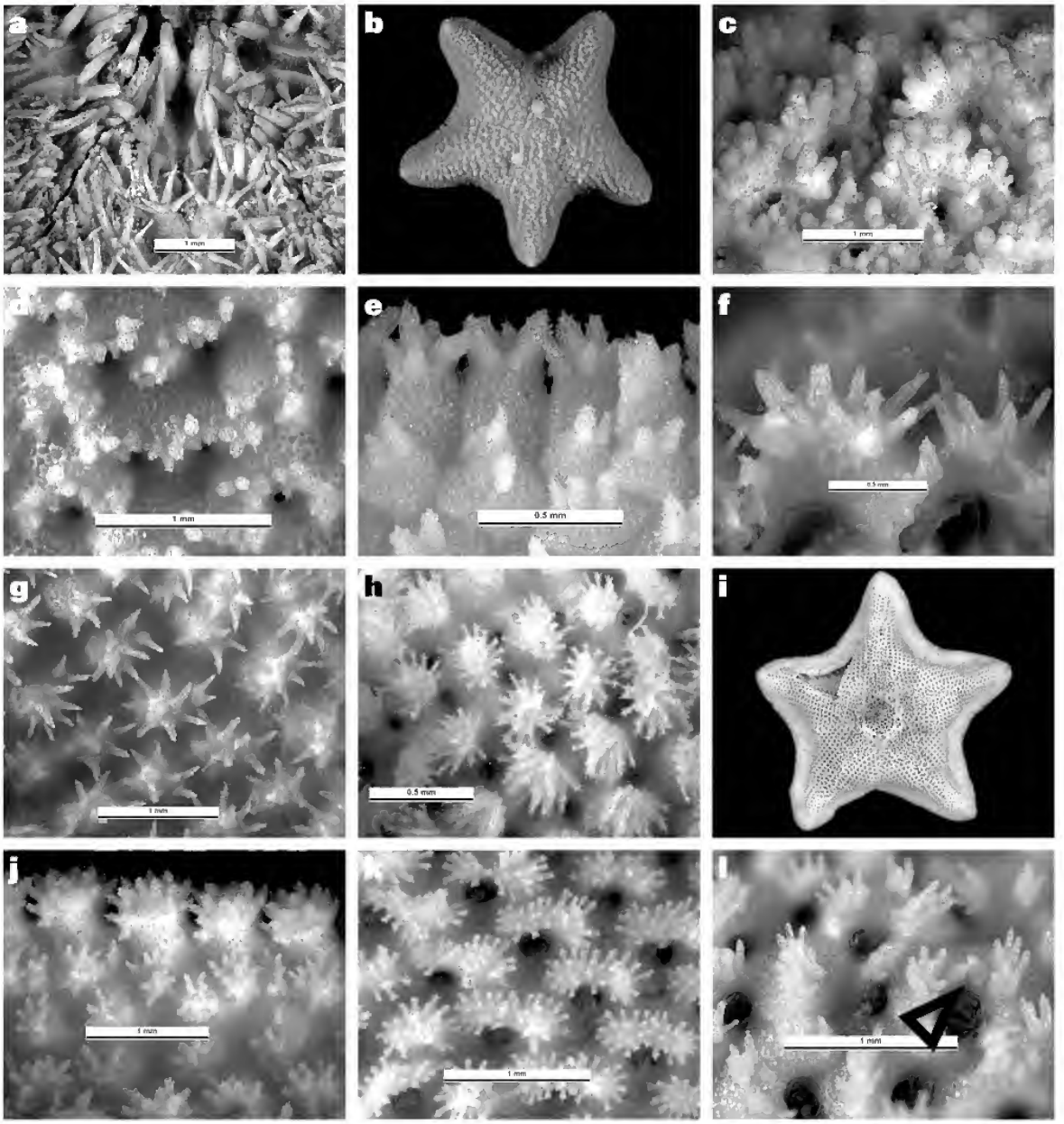

Figure 6. Photos of *Aquilonastra* species. a, *A. limboonkengi* (Smith), China, Amoy, spines (NHM 1926.12.22.35–36, syntype); b, *A. lorioli* (Koehler), Bombay, atypically two conspicuous madreporites, not fissiparous (R = 22 mm; NHM 1960.10.4.11–16); c, *A.lorioli* (Koehler), Pakistan, Karachi, spinelets (MNHN EcAs2662, syntype); d, *A. marshae* sp. nov., Red Sea, Egypt, spinelets (R = 13 mm; NMV F109382); e, *A. marshae* sp. nov., Red Sea, marginal spinelets (TM H1814); f, *A. richmondi* sp. nov., SE Africa, Sodwana Bay, spinelets (MRAC 1737); g, *A. richmondi* sp. nov., SE Africa, Sodwana Bay, distal interradial overlapping spinelets (R = 23 mm; MRAC 1737); h, *A. rosea* (H.L. Clark), WA, Jurien Bay, circular paxilliform spinelet clusters (R = 7 mm; WAM Z31162); i, *A. rowleyi* sp. nov., abactinal view (MRAC 1736, holotype, partly dissected, R = 23 mm); j, *A. samyni* sp. nov., SE Africa, Sodwana Bay, marginal spinelets (MRAC 1741); k, *A. scobinata* (Livingstone), Tasmania, Tamar R. mouth, crescentiform paxilliform spinelet clusters (R = 14 mm; NMV F112176); l, *A. watersi* sp. nov., Arabian Sea, Oman, spinelets and pedicellaria (arrow) (R = 15 mm; partly cleared paratype UF 3283).v

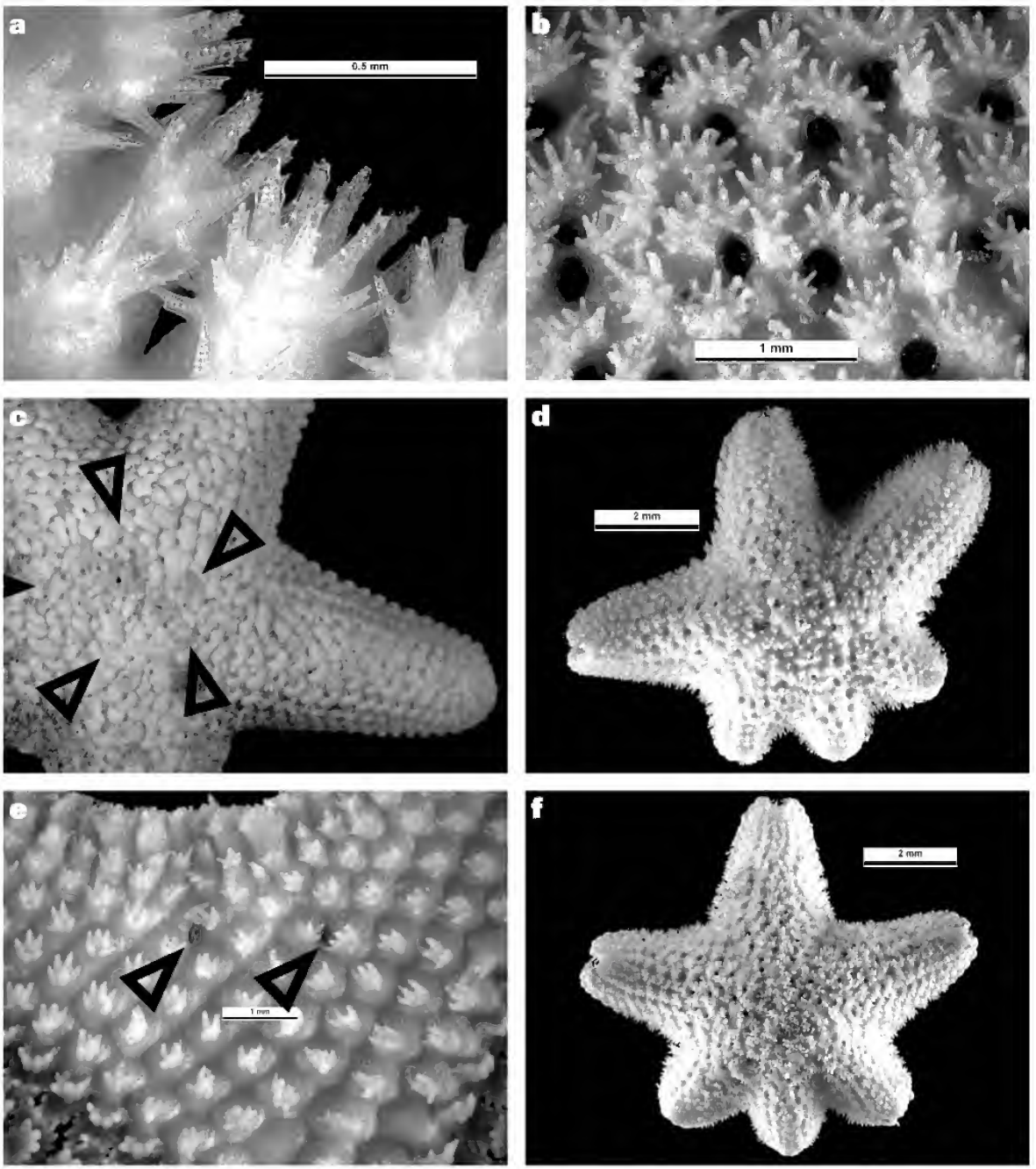

Figure 7. Photos of *Aquilonastra* species. a, *A. anomala* (H.L. Clark), Lord Howe I., marginal spinelets (NMV F97690); b, *A. batheri* (Goto), Japan, doubly papulate carinal plates with groups of spinelets (R = 19 mm; NMV F97441); c, *A. burtonii* (Gray), Red Sea, disc with five inconspicuous madreporites (arrows), five rays, large irregular proximal plates (R = 11 mm; lectotype NHM [18]40.3.23.54); d, *A. burtonii* (Gray), Oman (UF 1126); e, *A. byrneae* sp. nov., Qld, Tryon I., actinal interradius with two distal gonopores (R = 14 mm; NMV F109373); f, *A. colemani* sp. nov., Papua New Guinea (UF 3284, holotype).

At R = 19 mm, r = 10 mm, up to 4 proximal doubly-papulate carinal plates, each with up to 4 tufts each with 6–12 splayed spinelets, up to about 40 spinelets on proximal abactinal plates; plates with low domes for spinelets; few secondary plates; spinelets conical to digitiform, thick, subsacciform, splay-pointed; superomarginal plates smaller than inferomarginals, each series with up to about 20 spinelets per plate, slightly more stout on inferomarginals.

Spines per actinal plate up to: oral 7, suboral 5, furrow 7, subambulacral 9, actinal interradial 12 proximally 6 distally; interradial spines thin conical, to digitiform to subsacciform.

Colour (live). Disc and proximal apical area reddish-orange, madreporite white, proximal rays and interradii mottled with dark and light reddish-orange and white, distally pale reddish-orange (photo from M. Komatsu); disc and upper rays red, with sides of rays mottled mauve and brown, madreporite off-white (photo from T. Fujita).

Distribution. "Common in the middle and southern regions of Japan" (Hayashi, 1973); sublittoral (Hayashi, 1940) to 92 m (Sladen, 1889).

Remarks. O'Loughlin and Waters (2004) determined material from Oman (UF 70) as *A. batheri*. This material is redetermined in this work as *A. watersi* sp. nov. (below). The potentially large size, presence of numerous interradial pedicellariae with differentiated valves, and grouping of spinelets into tufts on proximal abactinal plates are distinguishing characters. Red is commonly present in the mottled live colours.

Aquilonastra burtonii (Gray, 1840)

Figures 1, 2c–d, 5a, 7c–d

Asterina burtonii Gray, 1840: 289.—Gray, 1866: 16.—Gray, 1872: 118.—H.L. Clark, 1923: 283 (status of species; possibly part).—Smith, 1927a: 641–645 (part).—A.M. Clark, 1952: 207 (possibly part; fissiparous; possibly *A. yairi* sp. nov. below).—Tortonese, 1960: 20–21 (probably part).

Asterina burtoni.—Tortonese, 1966: 3, fig. 1.—A.M. Clark, 1967a: 146, tbl. 1 (part; Red Sea material).—James and Pearse, 1969: 84–85 (part).—A.M. Clark and Rowe, 1971: 38 (part), 68, fig. 17a.—Tortonese, 1977: 281–282.—Price, 1983: 47–48, fig. 14 (part).—Archituv and Sher, 1991: 670.—Mladenov and Achituv, 1999: 152 (part).—Karako et al., 2002: 139–144 (part, El Fauz Red Sea population).

Asteriscus wega Perrier, 1869: 102.

Asterina wega.—Perrier, 1875: 318.—Achituv, 1969: 329–341 (part, "pluriradiate" form).—Achituv, 1973a: 333–336 (part, Akhziz lagoon and Haifa populations).

Asterinides burtoni.—Verrill, 1913: 482.

Asterina gibbosa.—Tortonese, 1957: 190 (non *Asterina gibbosa* Pennant, 1777; see Tortonese 1966).

Aquilonastra burtoni.— O'Loughlin and Waters, 2004: 11, 13 (part), 14.

Material examined. Lectotype (judged to be Gray's type by G.A. Smith, 1927a). Red Sea, NHM [18]40.3.23.54 (dry).

Asteriscus wega Val., Red Sea, M. Botta, 1837, MNHN EcAs2713 (1) (labelled "type"; see Remarks; not *A. burtonii*).

Red Sea, coll. Michelin, 1868, EcAs1566 (6); Ras Muhammad, 8 Aug 1968, HUJ SLR1917 (5); Gulf of Suez, Et Tur, 20 Sep 1967, HUJ SLR845 (2); 20 Sep 1967, TAU NS2090 (1, fissiparous form); 24 Dec 1965, TM H1815 (2); Île Abulat, *Calypso*, EcAs11842 (1); La Sicherie, EcAs11841 (1); S Sinai, El Fauz, Nov 2003, NMV F109383 (4); Gulf of Aqaba, near Dahab, 4 Nov 1981, TAU NS24408 (2, fissiparous forms); Sep 1976, TAU NS24501 (1); 18 Dec 1967, HUJ SLR1127 (1); 19 Feb 1968, SLR1341 (2).

Oman, Masirah I., Bar al Hikman peninsula, coral rubble, 3–4 m, 7 Nov 1999, UF 1126 (2); 0–1 m, 7 Nov 1999, UF 3280 (1); 3–4 m, 23 Jan 2005, UF 4240 (1); UF 4239 (2); 1–8 m, 18–24 Jan 2005, UF 4237 (1).

Zanzibar, Prison I., seagrass bed, 6 Aug 1995, NHM 2004.2831 (1).

Diagnosis. Fissiparous *Aquilonastra* species; rays up to 8, frequently 7, form frequently asymmetrical post-fissiparity; form of larger specimens sometimes symmetrical with 5 equal rays; most interradii with inconspicuous madreporite; rays narrow basally, tapering, narrow rounded distally, digitiform; up to R = 18 mm; at R = 12 mm, r = 5 mm; gonopores not seen.

At R = 12 mm, lacking carinal plates; numerous secondary plates, intergrade with primary plates, frequently large irregular proximal abactinal plates; abactinal plates arched over papulae, rarely notched; spinelets small, variable in form, conical to columnar to digitiform, distally spinous, some splay-pointed, spread sparsely over plate surface, rarely up to about 15 spinelets on proximal plates, up to about 7 on mid-interradial plates; superomarginal plates each with up to about 6 spinelets, inferomarginal plates each with up to about 12 larger spinelets.

Spines per actinal plate up to: oral 6, suboral 3 frequently 2, furrow 6, subambulacral 4, actinal interradial 1–4 (predominantly 3); interradial spines conical, sacciform.

Colour (live). "Greenish gray colour on the aboral side; a large and irregular, purplish brown blotch is on the centre, and is surrounded by red spots on the basal parts of the arms; the latter are usually darker (greenish) near their extremity, where a pale median line is to be observed" (Tortonese, 1966; Haifa specimens; the red spots are presumed here to be the madreporites); "variegated yellowish, brown and red" (Tortonese, 1977; Aqaba specimen); majority of 14 colour morphotypes from Elat were "mottled brown and orange" (pers. comm. Y. Achituv); Akhziz specimens were predominantly "mottled brown and orange" (pers. comm. Y. Achituv); "pale grey, mottled red and brown" (label with Zanzibar specimen); mottled browns, off-white (photos by G. Paulay).

Distribution. Eastern Mediterranean, Akhziz lagoon and Haifa populations; Red Sea, Gulf of Suez, Gulf of Aqaba; Arabian Sea, Oman; Arabian Gulf; NW Indian Ocean, Zanzibar; 0–8 m.

Remarks. Smith (1927a) discussed in detail the historical confusion surrounding Gray's *Asterina burtonii*, and gave a full synonymy. Gray's type was reported lost, but Smith asserted that he had found two of Gray's type specimens of *Asterina burtonii*. We follow Smith (1927a), and accept that the larger of these two specimens (NHM [18]40.3.23.54) is the type for *Asterina burtonii*. This lectotype for *Asterina burtonii* has five equal rays, but five small madreporites (R = 11 mm). We judge that the smaller of these two types (NHM [18]40.3.23.55) is conspecific with a second Red Sea fissiparous species *Aquilonastra yairi* sp. nov. (below).

A Paris Museum specimen of *Asteriscus wega* Val. (MNHN EcAs2713) labelled "type" was collected from the Red Sea by M. Botta in 1837. The Valenciennes manuscript name was not published, and this specimen has no type status. The name *Asteriscus wega* was published by Perrier who described (1869, 1875) 13 fissiparous specimens (syntype series) collected from the Red Sea by M. Botta in 1858. These fissiparous specimens, up to R = 15 mm (Perrier reported a diameter of 2–3 centimetres), are not conspecific with the Valenciennes non-fissiparous "type" specimen that has been examined here and has six equal rays and one conspicuous madreporite. It is referred below to *Aquilonastra marshae* sp. nov. Based on Perrier's 1869 and 1875 descriptions, *Asteriscus wega* Perrier, 1869 is judged to be conspecific with *Asterina burtonii* Gray, 1840, of which it becomes a junior synonym. This decision supports the opinion of a synonymy by A.M. Clark (1952, 1967b) and A.M. Clark and Rowe (1971).

Achituv (1973a) studied large numbers of four eastern Mediterranen populations of small fissiparous asterinids from Acre, Akhziz pool, Akhziz lagoon and Haifa. For the first two populations maximum R = 8 mm; for the latter two populations maximum R = 17 mm. These results are closely consistent with data for the two fissiparous species from the Red Sea, *A. yairi* sp. nov. with R up to 7 mm (below) and *A. burtonii* with R up to 18 mm. The invasion of the Mediterranean by both Red Sea fissiparous species is judged to be the best explanation for this data.

Mladenov and Achituv (1999, abstract) reported genetic studies of four populations of *Asterina burtoni*:

1. non-fissiparous Red Sea population from Elat
2. sympatric fissiparous Red Sea population from Elat
3. two allopatric fissiparous Mediterranean populations

They observed a high genetic difference between the fissiparous and non-fissiparous Elat populations, but not as high as between some fissiparous populations. On the assumption that the fissiparous populations were the same species, they concluded that there were not separate species in the four populations. We judge that there are two species represented by the fissiparous populations, and that both species occur in the eastern Mediterranean and one of them at Elat. This would explain the high genetic differences observed by Maldenov and Achituv (1999). To us, the Mladenov and Archituv (1999) evidence supports a conclusion of three species. This conclusion is congruent with morphological differences.

Karako et al. (2002) reported similar genetic studies and results for four fissiparous populations from Akhziv, Shikmona, and Mikhmoret on the coast of Israel, and El Fauz at the mouth of the Gulf of Aqaba, and a non-fissiparous population at Elat at the northern end of the Gulf of Aqaba. "Pentaradiate", rather than having a large conspicuous madreporite, was used to determine non-fissiparous specimens and can be misleading as the larger fissiparous specimens frequently have five equal rays but continue to have more than one inconspicuous madreporite. We judge, as above, that the Karako et al. results support an hypothesis of two fissiparous species and one non-fissiparous species. The three Mediterranean populations appear to us to be *Aquilonastra yairi* sp. nov. (below), and the El Fauz population *A. burtonii*. We refer the non-fissiparous species at Elat to *Aquilonastra marshae* sp. nov. (below). Specimens from all locations in the Karako et al. study, except Shikmona, were examined by us, and provide morphological support for the systematic decision that there are three separate species.

Tortonese (1936, 1966) first recorded *A. burtonii* in the Mediterrnean from Massawa (as *A. wega*) in 1936. Mortensen (1926) reported a fissiparous specimen from the Gulf of Suez as *Asterina burtonii*, but gave insufficient detail to judge here whether the specimen was *A. burtonii* or *A. yairi* sp. nov. In O'Loughlin and Waters (2004), material TM H1815 was referred to *A. burtoni* and that determination is confirmed here. A specimen TM H1814 was also assigned to *A. burtoni*, but is redetermined in this work as *Aquilonastra marshae* sp. nov. (below). There is no evidence in this study of a second smaller fissiparous species (*Aquilonastra yairi* sp. nov. below) in the Gulf of Aqaba.

Soliman (1999) reported studies of two asteroid populations in the Arabian Gulf, understanding them to be both *Asterina burtoni*. There is no indication in the report that either population had fissiparous individuals, and we assume that Soliman studied non-fissiparous populations that were thus not *A. burtonii*. In this review three other asterinid species occur in the region: *A. samyni* sp. nov. (below, Oman) reaches R = 27 mm; *A. watersi* sp. nov. (below, Oman) reaches R = 19 mm; *A. iranica* (Mortensen, 1940, Arabian Gulf) reaches R = 35 mm. One Soliman (1999) population was up to R = 26 mm in size, and we hypothesize that it was *A. samyni*. The other was up to R = 16 mm, and we hypothesize that it was *A. watersi*. Soliman (1995) also reported an asterinid population study in the Arabian Gulf at Qatar. The largest individual was R = 26 mm. Again, we hypothesize that the population was *A. samyni*.

A.M. Clark (1974) and A.M. Clark and Courtman-Stock (1976) reported *Asterina burtoni* for SE Africa, and referred to both single madreporite pentamerous and fissiparous specimens from Mozambique. *A. burtonii* is reported here from Zanzibar, and possibly occurs off Mozambique. H.L. Clark (1923) reported *Asterina burtonii* in the fauna of South Africa, but referred only to a specimen from Mozambique. Non-fissiparous specimens are not *A. burtonii*. Jangoux (1984), and Jangoux and Aziz (1984, 1988) reported *Asterina burtoni* for New Caledonia, La Réunion, Seychelles, Mineures and Maldives. We found no evidence to confirm *A. burtonii* in any of these localities. Following many authors, Walenkamp (1990) listed *A. cepheus* Müller and Troschel, 1842, *A. wega* Perrier, 1869, *A. cephea* var *iranica* Mortensen, 1940 and ? *A. anomala* H.L. Clark, 1921 as junior synonyms of *A. burtonii* Gray, 1840. We consider only *A. wega* to be a junior synonym. Walenkamp's (1990) material is referred to *A. richmondi* sp. nov. (see below).

Perrier (1875), H.L. Clark (1923), Mortensen (1926), Smith (1927), A.M. Clark (1952) and Tortonese (1960) retained the original spelling of Gray (*burtonii*). Recent authors have used *A. burtoni*. Walenkamp (1990) argued for a restoration of the orignial spelling. We agree.

The characters distinguishing *A. burtonii* from *A. yairi* sp. nov. are detailed in the Remarks for *A. yairi* below. The mottled live colours for *A. burtonii* are red, orange, yellow, brown, grey, off-white.

Aquilonastra byrneae sp. nov.

Figures 1, 2e, 5b, 7e

Aquilonastra new. sp.—Byrne, 2006: 245, 248, 251, tbl. 2.

Material examined. Holotype. NE Australia, Great Barrier Reef, near Heron I., One Tree I., rocky shallows, Maria Byrne, Jan 2002, NMV F98748 (alcohol).

Paratypes. Type locality, Dec 2004, F98747 (1, alcohol); interridal, 12 Apr 2006, F111326 (2, alcohol); 27 May 2004, F109358 (1, dry, dissected).

Other material. Tryon I., 15 Sep 1970, F109373 (2, dry); Mariana Is., Guam I., Asan Point, reef flat, under rock, 11 Apr 1996, UF 894 (dry).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, narrow basally, broadly to narrowly rounded distally; up to R = 15 mm, r = 8 mm; gonopores actinal, interradial pairs frequently close, near margin; protandric hermaphrodite (Maria Byrne, pers. comm.).

At R = 15 mm, 0–3 proximal doubly-papulate carinal plates, each with up to 4 tufts with 3–5 spinelets per tuft; numerous proximal secondary plates, 0–3 per space; single large papula per space, rarely 2; disc variably distinctly bordered; spinelets small, short, form variable from conical to digitiform, distally pointed or blunt, some sacciform, not splay-pointed; up to about 16 spinelets across projecting edge of proximal abactinal plates, frequently 1–2 on bare distal mid-plate; up to 12 on proximal surface of distal interradial plates; superomarginal plates smaller than inferomarginals (subequal on Guam specimen), superomarginals with up to about 12 short conical pointed spinelets per plate, inferomarginals with up to about 20 spinelets, more stout and longer on inferomarginals.

Spines per actinal plate up to: oral 7, suboral 6, furrow 7, subambulacral 6, actinal interradial 8, predominantly 5; interradial spines thick, bluntly conical, subsacciform.

Colour (live). Disc sometimes cream centrally surrounded by dark brown ring, abactinally mottled with proximal upper rays predominantly olive-green to greenish-brown, interradii and distal rays predominantly cream; actinal surface cream with green patches (photo and pers. comm. M. Byrne); disc red or brown, thin boundary of white plates, proximal upper rays crimson red, remaining abactinal surface mottled with predominantly dark and pale brown, red and white (Guam photos by G. Paulay as *Asterina cepheus*).

Distribution. NE Australia, Great Barrier Reef, near Heron I., Tryon I. and One Tree I.; (possibly) W Pacific Ocean, Guam; rocky shallows.

Etymology. Named for Maria Byrne, Professor of Developmental and Marine Biology in the University of Sydney, and Director of One Tree Island Research Station on the Great Barrier Reef, in appreciation of her contribution of specimens for this work and her research on life history diversity and evolution in Asterinidae.

Remarks. A significant diagnostic character of *A. byrneae* is the presence of actinal gonopores. The dominant mottled live colours are green, brown and red, with cream or white. At R = 12 mm, the material from the Great Barrier Reef has predominantly 5 actinal interradial spines per plate, the Guam specimen predominantly 3. This variation (on its own) is judged to be an inadequate basis for separating the material into two species, but this and colour differences suggest the possibility of two species. We identify the Guam specimen as *A. byrneae* with some hesitation.

Aquilonastra cepheus (Müller and Troschel, 1842)

Figures 1, 2f–h, 5c–d

Asteriscus cepheus Müller and Troschel, 1842: 41–42.—Dujardin et Hupé, 1862: 375–376.—Perrier, 1869: 99.

Asterina cephea.—Perrier, 1875: 315–317 (part; type).—Möbius, 1880: 50.—Döderlein, 1888: 825.—Sluiter, 1889: 307–308.

Asterina cepheus.—Martens, 1866: 85.—H.L. Clark, 1915: 95.—Fisher, 1919: 411, pl. 115 fig. 4.—Fisher, 1925: 79–80.—Liao and A.M. Clark, 1995: 130, pl. 15, figs 10, 11.—Rowe and Gates, 1995: 34.—A.M. Clark and Mah, 2001: 335.

Asterina burtoni.—H.L. Clark, 1921: 96–97, pl. 6 fig. 2.—Smith, 1927b: 276.—H.L. Clark, 1938: 144–145.—H.L. Clark, 1946: 133.—Marsh, 1974: 91–92 (non *Asterina burtonii* Gray, 1840).

Asterina burtoni cepheus.—A.M. Clark and Rowe, 1971: 68–69, fig. 17h, table 1, pl. 9 figs 4–5. —Liao, 1980: 171, figs 2:1, 2:2, 4, pl.4 figs 6–7.—A.M. Clark, 1993: 208 (non *Asterina burtonii* Gray, 1840)

Aquilonastra cepheus.—O'Loughlin and Waters, 2004: 11, 13–15.

Material examined. Holotype. Indonesia, Jakarta (as Batavia), M. Reynaud, 1829, MNHN EcAs1471 (dry).

Other material. Indonesia, Sulawesi, 2 Jan 2000, UF 2623; New Guinea, Trobriand Group, AM J22934 (1); 1 Jun 1998, UF 2332 (1); 1 Jul 1998, UF 2415(1); Philippines, Bohol I., 25 Mar 2004, NMV F106973 (2); Australia, Queensland, Heron I., 14 Jul 1973, F95594 (2); One Tree I., J23331 (1); Tryon I., 15 Sep 1970, F95789 (4); Northern Territory, Darwin, 11 Oct 1976, F95799 (1); Western Australia, Abrolhos Is., 2 Sep 1972, WAM Z6778 (7); J8321 (5); 11 Mar 1972, F95793 (21); 12 May 1972, F95795 (6); Exmouth Gulf, F95794 (4); F95790 (2); F95792 (1); F95787 (1); F95788 (1); Aug 1972, F95790 (2); Quobba, 20 Jun 1972, F95791 (3).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, rarely 4 or 6, long, broad basally, strongly tapered, narrowly rounded distally, predominantly subequal, form sometimes asymmetrical; up to R = 25 mm; gonopores abactinal, some close pairs under same plate.

At R = 20 mm, r = 10 mm, abactinal plates angled up over papulae, crescentiform appearance; 0–3 proximal doubly papulate carinal plates; some large secondary plates, frequently 1 per space, up to 2; predominantly 1 papula per space, up to 3; disc frequently distinct, bordered by 5 large radial plates 5 small interradials; spinelets glassy, rugose, long, thin, finely pointed distally, not splay-pointed, subacicular, subsacciform to sacciform, up to about 32 spinelets in double series on large radial plates, up to about 24 in double series on proximal abactinal plates (frequently fewer), spinelets on anterior edge of plates, frequently angled over papula, sometimes in tufts; up to about 15 on mid-interradial plates; superomarginal plates with variably up to 8–10 spinelets per plate, inferomarginals with variably up to 16–24 thicker, longer spinelets per plate.

Spines per actinal plate variably up to: oral 6–9, suboral 2–8, furrow 6–8, subambulacral 4–8, actinal interradial 4–8; interradial spines thick, conical, blunt, subsacciform.

Colour (live). Wide range of mostly mottled colours with pink, mauve-red, grey, brown, grey-brown, reddish-brown, dark brown, black flecking, green, cream, white; disc frequently with broken white border (photos from N. Coleman).

Distribution. Indo-Malayan Region, Ceylon, Southern China, Philippines, Indonesia, W Pacific Ocean, northern Australia; 0–70 m (Liao and A.M. Clark, 1995; Marsh, 1974 as *Asterina burtoni*; Rowe and Gates, 1995).

Remarks. As noted in the diagnosis, the numbers of spinelets and spines per plate is more variable than in other *Aquilonastra* species. The distinctive diagnostic character of *A. cepheus* is the thin long finely-pointed subsacciform spinelets projecting over papulae. Smith (1927b), Liao (1980) and Liao and A.M. Clark (1995) all noted this as a distinguishing character. O'Loughlin and Waters (2004) redetermined as *Aquilonastra cepheus* a specimen from Hong Kong (NHM 1981.2.6.25). It is redetermined in this work as *A. limboonkengi* (below). In his comprehensive synonymy for *A. burtonii*, Walenkamp (1990) showed the position of many authors who considered *A. cepheus* to be a junior synonym of *A. burtonii*. Liao and A.M. Clark (1995) restored the species status of *A. cepheus*. *Asterina cepheus* was reported for Thursday I. (N Australia) by Bell (1884, *Alert* collections); for Zanzibar by Bell (1903); and for Saya de Malha and Seychelles Is. by Bell (1909). None of this material was examined. We found no evidence of *A. cepheus* in the western Indian Ocean. The live colour of *A. cepheus* is sometimes uniform, frequently mottled, and varies greatly.

Aquilonastra colemani sp. nov.

Figures 1, 2i–j, 5e, 7f

Material examined. Holotype. SE Papua New Guinea, China Straits, Samarai I., on rubble, 150°48'E, 9°40'S, 10 m, J. Starmer, 6 Jun 1998, UF 3284 (dry).

Paratypes. Type locality and date, UF 2419 (8, dry).

Other material. Indonesia, Flores Sea, West Sumbawa Regency, Mayo I., underside of coral rubble, shallow sublittoral, 14 Nov 2005, NMV F112173 (1); F109374 (4).

Diagnosis. Fissiparous *Aquilonastra* species; up to 7 rays, predominantly 6, narrow base, rounded distally, subdigitiform; up to R = 5 mm, r = 3 mm; high elevation apically, sides of rays steep; up to 2 inconspicuous interradial madreporites seen, up to 3 anal pores; gonopores not evident.

At R = 5 mm, upper ray plates irregular in size and form, longitudinal series of large papulae along sides of rays, single papula per plate; secondary plates present; spinelets thick short conical to columnar, spinous surface, not splay-pointed, up to about 12 spinelets on free surface of proximal abactinal plates; superomarginal and inferomarginal plates subequal; superomarginal plates each with up to about 8 spinelets, inferomarginal plates each with up to about 12 spinelets.

Spines per actinal plate up to: oral 6, suboral 3, furrow 5, subambulacral 3, actinal interradial 2; interradial spines glassy, rugose, bluntly pointed conical to digitiform.

Colour (live). Abactinally very dark brown on disc and upper rays, white margin (photos from N. Coleman, S. Uthicke).

Distribution. SE Papua New Guinea, China Straits; Indonesia, Flores Sea, Mayo I.; 0–10 m.

Etymology. Named for Neville Coleman, with gratitude for his generous assistance in making available to us his many live colour slides of Indo-Pacific asterinids.

Remarks. The distingusihing features of *A. colemani* are the small size (up to R = 5 mm), fissiparous habit, and dark brown with white margin colouration

Aquilonastra conandae sp. nov.

Figures 1, 2k, 4a, 5f, 8a–b

Asterina burtoni.—Kojadinovic et al., 2004: 225–229 (part, fissiparous specimens; non *Asterina burtonii* Gray, 1840).

'Asterina' sp. 2.—Rowe and Richmond, 2004: 3287–3288 (part, not Rivière Banane or Zanzibar specimens), fig. 5 (colour).

Material examined. Holotype (in alcohol). Indian Ocean, Mascarene Is., La Réunion I., Trou d'Eau, rocky shallows, C. Conand, 17 Sep 2004, MNHN EcAh11904.

Paratypes. Type locality and date, AM J24288 (23, in alcohol); EcAh11905 (26, in alcohol); NMV F107411 (1, dry, dissected); F107412 (29, in alcohol); F107413 (4, dry, dissected).

Other material. La Réunion I., type locality, Sep 2003, F107414 (5); 12 Jun 2002, NMV F109368 (2); 22 Mar 2003, F109366 (1); 16 Feb 2006, F109379 (1); Rodrigues I., Île aux Fous, coralline substrate, Shoals of Capricorn Programme, 21 Sep 2001, NHM 2004.2815–2824 (10); Antonio's Finger, 9 m, 21 Sep 2001, J24289 (1); Antonio's Finger Reef, off Grande Baie, NHM 2004.2826–2829 (4); Passe Coco, under rubble, 6 m, NHM 2004.2830 (1); Trou Malabar, coral rubble, 10 m, NHM 2004.2825 (1); Agalega Is., 25 Feb 1979, WAM Z6871 (1); Mauritius (Île Maurice), MAU–74, 27 lots, Peyrot-Clausade, 1974, EcAs11877–11903 (381); EcAs2578 (6); (Île Bourbon), Maillard, 1862, EcAs1563 (1).

Diagnosis. Fissiparous *Aquilonastra* species; rays 5–7, predominantly 6, largest specimens with 5; rays discrete, variably narrow to wide basally, tapering, rounded distally, sometimes digitiform; up to R = 10 mm, r = 5 mm (holotype, in alcohol); contiguous spinelets over papulae possibly act as pedicellariae, spinelets not differentiated as valves; abactinal gonopores.

At R = 8 mm, plates with proximal notch or indentation for papula, rarely doubly notched; secondary plates present; single large papula per papular space; 2 longitudinal series of single papulae along each side of rays; abactinal spinelets glassy, rugose, on upper rays short thick columnar to conical, subgranuliform, up to rarely 12 per plate, readily lost, on sides of rays short conical, in distal interradius thin, some splay-pointed; marginal plates in regular series, subequal; superomarginal spinelets up to about 5 per plate, short conical; inferomarginal spinelets up to about 10 per plate, distal larger, some splay-pointed.

Spines per actinal plate up to: oral 6 (rare), suboral 3 (rare), furrow 4, subambulacral 2, actinal interradial 3 (predominantly 1); interradial spines short, thick, conical to subsacciform, pointed distally.

Colour (live). Variably mottled with red, cream, brown and green (photos from C. Conand).

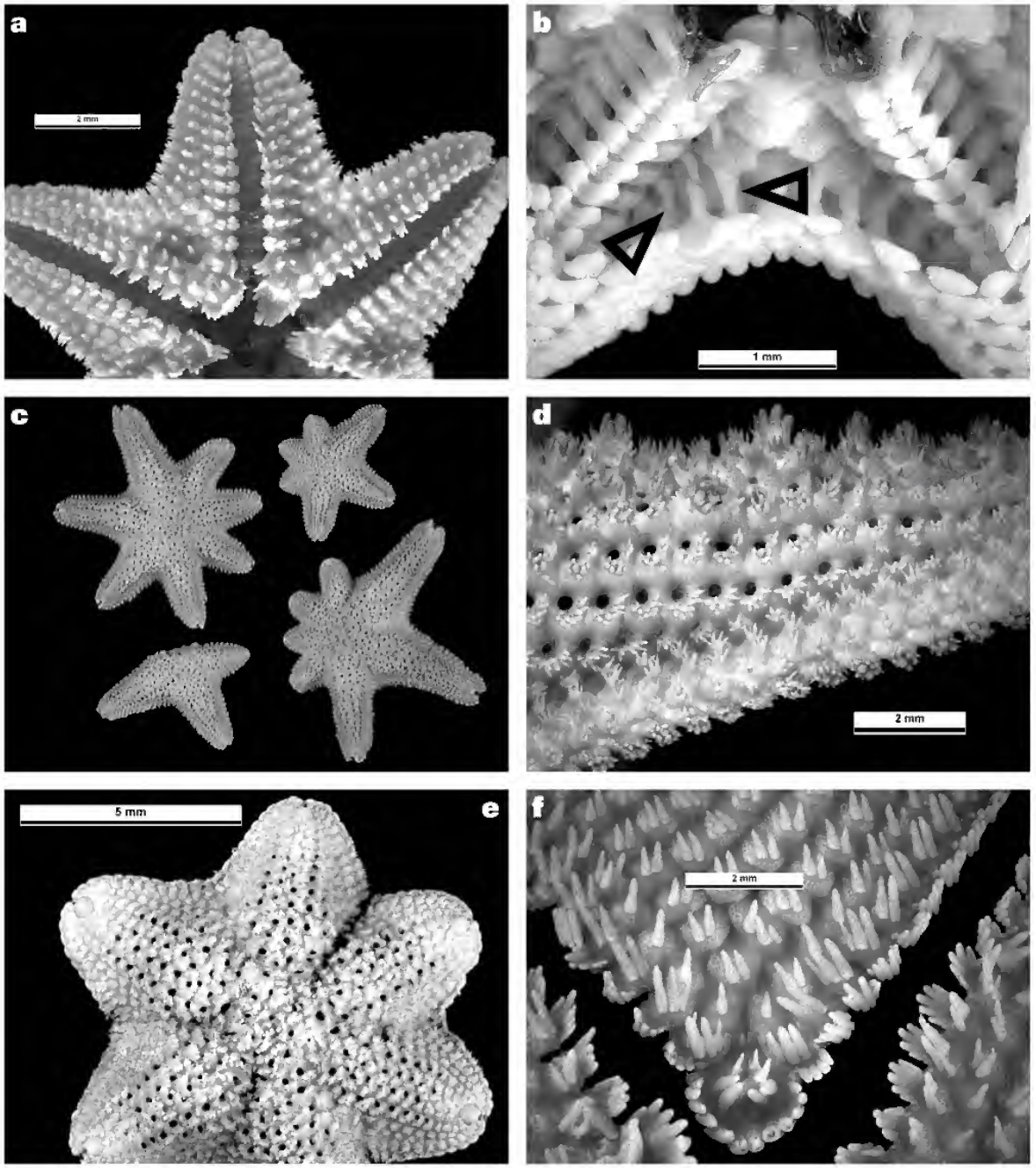

Figure 8. Photos of *Aquilonastra* species. a, *A. conandae* sp. nov., La Réunion, actinal surface (NMV F107414); b, *A. conandae* sp. nov., La Réunion, interior with superambulacral (left arrow) and superactinal (right arrow) plates (NMV F107414); c, *A. corallicola* (Marsh), Cocos (Keeling) I., fissiparous (up to R = 13 mm, UF 745); d, *A. coronata* (Martens), Australia, Darwin, side of ray, some paxilliform plates with differentiated spinelets (R = 22 mm; NMV F95796); e, *A. doranae* sp. nov., Okinawa (R = 5 mm; holotype UF3913); f, *A. halseyae* sp. nov., Maldive Is., actinal spines (NHM 1965.6.1.84, holotype).

Etymology. Named for Chantal Conand, Professor Emeritus, University of La Réunion, in appreciation of her considerable contribution to echinoderm research and this paper.

Distribution. Indian Ocean, Mascarene Is., Agalega Is., Mauritius, Rodrigues Is., La Réunion I., rocky and coralline substrate, 0–10 m.

Remarks. Kojadinovic et al. (2004) determined La Réunion material to be *Asterina burtoni*, and discussed both small asymmetrical fissiparous forms with more than one inconspicuous madreporite and slightly larger symmetrical pentaradiate sexual forms with a single madreporite. Maximum size was R = 9 mm, consistent with *A. conandae* material observed in this study. But none of the many specimens from La Réunion seen here had only a single madreporite. Some of the largest specimens were symmetrical and pentaradiate, but all had more than one inconspicuous madreporite. Only a few pentaradiate symmetrical specimens from La Réunion with a single conspicious madreporite have been seen in this study. Two are referred to *Aquilonastra samyni* sp. nov. (below), and a few to an undescribed species of *Tegulaster.* A specimen from Zanzibar (NHM 2004.2831), referred by Rowe and Richmond (2004: 3288) to '*Asterina*' sp. 2, is determined here as *Aquilonastra burtonii* (above).

The distinguishing diagnostic characters for *A. conandae* amongst western Indo-Pacific fissiparous species of *Aquilonastra* are: predominantly single actinal interradial spine per plate; high proportion of specimens with fewer rays (80% with 5–6 rays); size difference. With R up to 10 mm, *A. conandae* is larger than *A. moosleitneri* sp. nov. below (R up to 9 mm) and *A. yairi* sp. nov. below (R up to 7 mm), and smaller than *A. burtonii* (R up to 18 mm) and *A. corallicola* below (R up to 16 mm).

Aquilonastra corallicola (Marsh, 1977)

Figures 1, 4b, 5g–h, 8c

Asterina corallicola Marsh, 1977: 271–275, figs 8, 9, tbls 1, 2.—Oguro, 1983: 224–225, figs 7–9, 14.—A.M. Clark, 1993: 208.

Asterina anomala.—Fujita et al. 2001: 319, pl. 2G (non *Asterina anomala* H.L. Clark, 1921).

Aquilonastra corallicola.—O'Loughlin and Waters, 2004: 11, 13–15.

Material examined. Paratypes. Caroline Is, Palau, 10 m, M. Yamaguchi, 9 Feb 1971, WAM Z1704 (3); AM J10257 (2).

Other material. Caroline Is, Palau, 6 m, 7 Sep 1995, UF 3209 (1); 0–4 m, 6 Mar 2003, UF 1715 (1); 6 m, 7 Sep 1995, UF 3223 (1); 2 m, 6 Jun 1995, UF 324 (1); 23 m, 8 Jun 1995, UF 2440 (2); Jun 1975, Z6845 (2); Marianas Is, Guam, 2–4 m, 11 Sep 1997, UF 895 (7); 2–3 m, 27 Nov 1998, UF 862 (12); 10–15 m, 14 Jan 2000, UF 678 (1); 18 m, 30 May 1997, UF 1119 (1); 1–2 m, 16 Apr 1999, UF 864 (6); 2 m, 5 Nov 1998, UF 827 (4); 10 m, 20 Jan 2000, UF 675 (1); Saipan I., 3–12 m, 18 Aug 2003, UF 3528 (1); Singapore, 1–3 m, 3 Nov 2000, UF 2714 (1); Indonesia, Sulawesi, 4–32 m, 26 Sep 1999, UF 1827 (1); Indian Ocean, Cocos (Keeling) I., under dead coral rubble, 15 m, 8 Dec 1999, UF 745 (7); 10–20 m, 6 Dec 1999, UF 750 (3); 1–2 m, 8 Dec 1999, UF 768 (2); UF 1648 (1); NE Australia, Great Barrier Reef, One Tree I., NMV F98746 (6); Fiji, 5–8 m, 11 Oct 2001, UF 1007 (1).

Diagnosis. Fissiparous *Aquilonastra* species; up to 8 rays, predominantly 6 or 7, rays elongate, wide basally, tapered, narrowly rounded distally; up to R = 16 mm (Sulawesi), 12 mm (Palau), 13 mm (Cocos); some abactinal pedicellariae, with 2–3 differentiated thick valves; abactinal gonopores.

At R = 12 mm, r = 5 mm; upper ray plates irregular in arrangement, rarely a few doubly papulate carinal plates proximally; 1–3 papulae per papular space, 3 rare; papulae in 2 longitudinal series along each side of ray; 0–2 secondary plates per papular space proximally; upper ray plates paxilliform with 2 forms of spinelets; 1–3 thick, digitiform, blunt apical spinelets on each plate, up to about 12 thin conical pointed spinelets peripherally on each plate, spinelets not splay-pointed; superomarginal plates each with up to about 6 thin pointed spinelets; inferomarginal plates each with 1–4 thick digitiform apical spinelets, up to about 8 smaller thin conical pointed spinelets.

Spines per actinal plate up to: oral 6, suboral 6, furrow 5, subambulacral 5, actinal interradial 5; interradial spines rugose, some digitiform, most thin conical pointed; actinal spines generally of 2 forms, tall digitiform, short thin.

Live colour. Mottled red and yellow (photos from G. Paulay).

Distribution. W Pacific Ocean, Marianas Is., Caroline Is., Fiji, NE Australia; E Indian Ocean, Cocos (Keeling) I.; Sulawesi; Singapore; 0–32 m.

Remarks. The distinugishing characters for this large fissiparous species are the long tapering rays, two forms of spinelets on paxilliform upper ray plates, and golden red mottled colour. Three small specimens from Madagascar (MNHN EcAs11876; R = 4 mm), collected by Cherbonnier on 6 April 1960, are damaged but appear to have the diagnostic characters of *A. corallicola.* The colour and form of the material from Malaysia referred to *Asterina anomala* by Fujita et al. (2001) indicate that it is *A. corallicola.*

Aquilonastra coronata (Martens, 1866)

Figures 1, 2l, 8d

Asterina coronata Martens, 1866: 73–74.—Fisher, 1918: 108–110.—A.M. Clark and Rowe, 1971: 68, pl. 9 fig. 6.—VandenSpiegel et al., 1998: 452–453, fig. 37A–D, pl. 3 fig. 8.—A.M. Clark, 1993: 208.—Rowe and Gates, 1995: 34.—Chao, 1999: 407–408.—Fujita et al., 2001: 319–320, pl. 2H.—Waters et al., 2004: 876–877, tbl. 1, figs 2, 3.

Asterina spinigera Koehler, 1911: 20–21, pl. 4 figs 11, 12 (junior synonym by VandenSpiegel et al., 1998).

Asterina novae-zealandiae.—Goto, 1914: 643, pl. 19 figs 279–281 (non *Asterina novaezelandiae* Perrier, 1875 = *A. coronata* Martens, 1866, according to Fisher, 1919: 413).

Asterina cristata Fisher, 1916: 27–28.

Asterina cristata euerces Fisher, 1917: 91.

Asterina coronata cristata Fisher, 1918: 111, pl. 13.—Fisher, 1919: 411–414, pl. 115 fig. 3, pl. 131 figs 4, 4a.—Fisher, 1925: 80.—A.M. Clark, 1993: 208–209.—O'Loughlin and Waters, 2004: 15 (junior synonym, this work).

Asterina coronata euerces Fisher, 1918: 110.—Fisher, 1919: 414–416, pl. 115 figs 1–2, pl. 116 figs 1–2, pl. 131 figs 5, 5a.—A.M. Clark, 1993: 209.—O'Loughlin and Waters, 2004: 15 (junior synonym, this work).

Asterina coronata fascicularis Fisher, 1918: 110.—Fisher, 1919: 414.—H.L. Clark, 1928: 390.—H.L. Clark, 1938: 145–148, pl. 12 fig. 1.—A.M. Clark, 1993: 209 (junior synonym by Rowe and Gates, 1995).

Asterina coronata coronata.—Fisher, 1918: 110.—Fisher, 1919: 414.—A.M. Clark, 1993: 208.

Asterina coronata forma *japonica* Hayashi, 1940: 119–120, pl. 11 figs 5–7, pl. 13, fig. 7.—Hayashi, 1973: 72, pl. 12 fig. 3 (junior synonym, this work).

Aquilonastra coronata.—O'Loughlin and Waters, 2004: 11, 13–15.—Byrne, 2006: 245, tbls 1, 2, fig. 1.

Material examined. Australia, NT, Darwin, H.L. Clark, Jul 1929, NMV F95797 (2); 11 Jun 1976, F95798 (1); 13 Jun 1976, F95796 (4); AM J6188 (10); J6613 (18); J8206 (2); Caroline Is., J13660 (1); Taiwan, Sanshi, 28 Feb 2003, UF 1425 (2); J19956 (1); Japan, F96700 (1); Kushimoto, J11563 (2).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, broad basally, tapering, narrowly rounded distally; up to R = 32 mm; gonopores abactinal; numerous abactinal pedicellariae frequently present, 2–4 curved pointed differentiated valves.

At R = 30 mm, r = 14 mm; abactinal surface very uneven with irregularly distributed high paxilliform plates; abactinal spinelets of 2 forms on paxilliform plates, up to about 6 thick long digitiform or pointed spinelets on apex of each plate, up to about 10 thin short pointed spinelets around margin of plate; thin spinelets subacicular, not splay-pointed; disc clearly delineated by 5 radial 5 interradial plates; lacking doubly-papulate carinal plates; upper ray with irregular zig zag series of small primary and secondary plates, lacking papulae; 0–4 secondary plates per papular space on upper rays, intergrade with primary plates; 1–4 papulae per papular space; superomarginal plates smaller than inferomarginals, superomarginals with up to about 10 thin, rugose, pointed, not splay-pointed spinelets per plate; inferomarginals with up to about 4 thick long digitiform or pointed spinelets on apex of each plate, up to about 12 thin spinelets around margin of plate.

Spines per actinal plate variably up to: oral 8, suboral 8, furrow 7, subambulacral 7, actinal interradial 7, predominantly 5; interradial spines conical, pointed, frequently two forms on each plate, thick centrally thin peripherally.

Colour (live). "The normal coloration is mottled olive-greens, light and dark, with more or less dark dull red, usually in irregular blotches. One specimen was very largely bright rust-red, over most of the dorsal surface. Some specimens occur with no trace of green dorsally; these are more or less fawn-colour mottled with brown and have a distinct red tinge. Most secimens have red markings but the shade may be very deep; in a few cases it was replaced by black. A common feature is a blotch of carmine at the base of each arm; in one specimen this was nearer vermilion." (H.L. Clark, 1938); mottled grey-brown, with orange and white markings (photo from M. Komatsu); mottled grey-brown, with dark brown, orange and white markings (photo from T. Fujita).

Distribution. Northern Australia to Japan, Singapore to Caroline Is.

Remarks. Fisher (1916, 1917, 1918, 1919, 1925) established and maintained three subspecies of *Asterina coronata*, but stated his own uncertainty. H.L. Clark (1928) recorded his doubt about the subspecies. Hayashi (1940) added a fourth subspecies from Japan. Rowe and Gates (1995) made *A. coronata fascicularis* a junior synonym of *A. coronata*. Material from Taiwan and northern Australian are morphologically conspecific, including the presence of abundant pedicellariae. In his key to four subspecies Fisher (1919) used the presence of pedicellariae to key *A. coronata euerces* from the other three. This is erroneous, since abundant pedicellariae are present in the northern Australian and northern Pacific material. These pedicellariae closely resemble those illustrated by Fisher (1919, pl. 131 fig 5a) for *A. coronata euerces*. Variation in spine number per plate is not an adequate basis for upholding the subspecies. All are judged here to be junior synonyms.

O'Loughlin and Waters (2004) redetermined two specimens from Bombay (NHM 1960.10.4.11–16), previously identified as *Asterina lorioli*, as *Aquilonastra coronata*. That decision is reversed here.

The distinguishing character of *A. coronata* is the irregularly distributed high paxilliform abactinal plates with two forms of spinelets.

Aquilonastra doranae sp. nov.

Figures 1, 3a, 8e

Material examined. Holotype (in alcohol). Japan, Okinawa, Yonashiro Marine Road causeway to Henza I., 26°20'N, 127°56'E, intertidal seagrass, 25 Jul 2004, G. Paulay, UF 3913.

Diagnosis. Fissiparous *Aquilonastra* species; rays 6, subequal, short, broad basally, narrowly rounded distally; R = 5 mm, r = 3.5 mm; 3 inconspicuous interradial madreporites; gonopores not evident.

Abactinal plates strongly imbricate, notched for papula; upper ray plates with 1 papula, 2 irregular longitudinal series; plates on sides of rays with 1 papula, 1 longitudinal series, beginnings of second longitudinal series (0–3 plates); spinelets conical or digitiform, distally spinous, up to about 10 spinelets across raised proximal edge of proximal abactinal plates, plate surfaces bare distally; superomarginal plates each with up to about 6 spinelets, inferomarginal plates each with up to about 12 longer splay-pointed spinelets.

Spines per actinal plate up to: oral 5, suboral 3, furrow 4, subambulacral 3, actinal interradial 5 (predominantly 3); interradial spines conical, long, thin, finely tapered.

Colour (live). Mottled red, green, grey, white abactinally; proximal disc area crimson red; proximal rays and interradii dark grey-green to yellow-green; distal abactinal surface mottled pale green, mauve grey, white (photo by G. Paulay).

Distribution. Japan, Okinawa, Henza I., seagrass shallows.

Etymology. Named for Ruth Doran, with gratitude for her assistance in providing asterinid distribution maps.

Remarks. Although only one specimen is available, the fissiparous habit, geographical isolation, green colouration, short rays, thin digitiform or conical spinelets with long spines distally, and up to five actinal interradial spines per plate together support the erection of a new species.

Aquilonastra halseyae sp. nov.

Figures 1, 3b, 5i, 8f

Asterina burtoni.—A.M. Clark and Davies, 1966: 599, 603.—Jangoux and Aziz, 1984: 861, 872, 873 (part; non *Asterina burtonii* Gray, 1840).

Asterina cepheus.—Moosleitner, 1997: 12–13, fig. 23b (only) (fig. 23a is a photo of a Red Sea *Aquilonastra* sp., pers. comm. H. Moosleitner (= *A. marshae* sp. nov., see below); non *Asteriscus cepheus* Müller and Troschel, 1842).

Asterina burtoni cepheus.—A.M. Clark and Rowe, 1971: 68–69, fig. 17, tbl. 1.—A.M. Clark, 1993: 208 (non *Asteriscus cepheus* Müller and Troschel, 1842).

Material examined. Holotype (in alcohol). Indian Ocean, Maldives, Addu Atoll, Gan I., lagoon reef, 10 m, P. Spencer Davies, 11 Feb 1964, NHM 1965.6.1.84.

Paratypes. Type locality and date, NHM 1965.6.1.85a (1, dry); NHM 1965.6.1.85b (1, part dissection, in alcohol).

Diagnosis. Non–fissiparous *Aquilonastra* species; rays 5, broad basally, narrowly rounded distally; up to R = 19 mm, r = 9 mm; gonopores not seen.

At R = 19 mm, rare proximal doubly papulate carinal plates; rarely 1 secondary plate per papular space; spinelets distinctly sacciform, sharp point distally; up to about 15 spinelets per proximal plate, sometimes in discrete groups; primary superomarginal plates frequently separated by smaller plate; superomarginals with 2–4 thin, sacciform pointed spinelets; inferomarginal plates with up to about 12 spinelets, proximally similar to superomarginal spinelets, more stout and longer distally.

Spines per actinal plate up to: oral 6, suboral 5, furrow 6, subambulacral 4, actinal interradial 4 (predominantly 2); interradial spines stout, short, subsacciform, pointed distally, on raised proximal edge of plates.

Colour (live). "Various shades of brown, sometimes with darker or lighter spots" (Moosleitner, 1997; fig. 23b); disc variably outlined in white; abactinally mottled pink, pale red-brown, white, with dark red-brown flecks; or mottled dark and light red-brown, white, bright red star apically (photos by N. Coleman).

Distribution. Indian Ocean, Maldives, 1–30 m (Moosleitner, 1997).

Etymology. Named for Sheila Halsey of the Natural History Museum in London, who has graciously assisted the authors with literature searches and facilitated the loan of materials for echinoderm research.

Remarks. The distinguishing character of *A. halseyae* is the distinctive sacciform, conical, sharply-pointed form of the abactinal spinelets. A.M. Clark and Rowe (1971) judged that the fissiparous and non-fissiparous asterinds occurring in the Maldives were *Asterina burtoni* Gray, 1840, and referred the fissiparous form to the subspecies *A. burtoni burtoni* and the non-fissiparous form to the subspecies *A. burtoni cepheus*. We refer the non-fissiparous Maldives asterinid to *A. halseyae* sp. nov. (here), and the fissiparous Maldives asterinid to *A. moosleitneri* sp. nov. (below).

Aquilonastra iranica (Mortensen, 1940)

Figures 1, 5j–k

Asterina cephea var. *iranica* Mortensen, 1940: 65–66, pl. 1 figs 1–4.

Asterina burtoni.—A.M. Clark and Rowe, 1971: 68, 69, tbl. 1.—Price, 1983: 47–48, fig. 14 (part, non-fissiparous).

Asterina burtoni burtoni var. *iranica*.—A.M. Clark, 1993: 207, 208.

Aquilonastra iranica.—O'Loughlin and Waters, 2004: 11, 13–15.

Material examined. Syntype, Iranian Gulf, S of Bushire, coral reef, 18 Feb 1937, AM J17891 (1, dry). Other material. Bahrain, Jufair, mudflat, WAM Z6868 (6); W Pakistan, Balochistan coast, Gwader, 25°N62°E, 2 Dec 1977, NMV F112182 (1); F112183 (2).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, long, broad basally, tapering, rounded distally; up to R = 35 mm, r = 15 mm (Mortensen, 1940); abactinal proximal interradial pedicellariae, pairs of tooth-like differentiated valves; abactinal gonopores.

At R = 20 mm, r = 11 mm, from 0 to 5 proximal doubly papulate carinal plates; lacking secondary plates; spinelets on abactinal plates in small groups, up to 4 per group, or in transverse single or double series; up to about 12 spinelets on proximal abactinal plates; spinelets short, thick, conical to subsacciform; distal interradial plates with 4–6 splayed spinelets; superomarginal plates smaller than inferomarginals, up to about 6 spinelets per superomarginal plate, up to about 12 thicker spinelets per inferomarginal plate.

Spines per actinal plate up to: oral 8, suboral 5, furrow 7, subambulacral 9 (sometimes in 2 series), actinal interradial 5 (predominantly 3); interradial spines long, conical.

Colour (live). "Grayish, with reddish or bluish-gray spots; oral side lighter, uniformly coloured" (Mortensen, 1940).

Distribution. Iranian Gulf; Arabian Sea, W Pakistan, soft and hard substrate.

Remarks. O'Loughlin and Waters (2004) raised *A. cephea* var. *iranica* to species status. *A. iranica* is distinguished by: large size (up to R = 35 mm); pedicellariae with differentiated valves; few short thick conical to subsacciform spinelets on proximal abactinal plates.

Aquilonastra limboonkengi (Smith, 1927)

Figures 1, 5l, 6a, 9a

Asterina limboonkengi Smith, 1927b: 273–276, figs 1–3.—Liao, 1980: 171, figs 3:1, 3:2, 5.—A.M. Clark, 1982: 490–491.—A.M. Clark, 1993: 211.—Liao and A.M. Clark, 1995: 66, 130–131, pl. 18 figs 6–7.

Aquilonastra limboonkengi.—O'Loughlin and Waters, 2004: 11, 14, 15.

Material examined. Syntypes. China, Amoy, C. Ping, NHM 1926.12.22.35–36 (2, alcohol; very damaged).

Other material. SE Hong Kong, North Rocks, near Ninepins I., 15 m, NHM 1981.2.6.23–25 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, long, narrow to broad basally, tapering, rounded distally (rays digitiform on syntypes), up to R > 25 mm (Liao and A.M. Clark, 1995); gonopores abactinal.

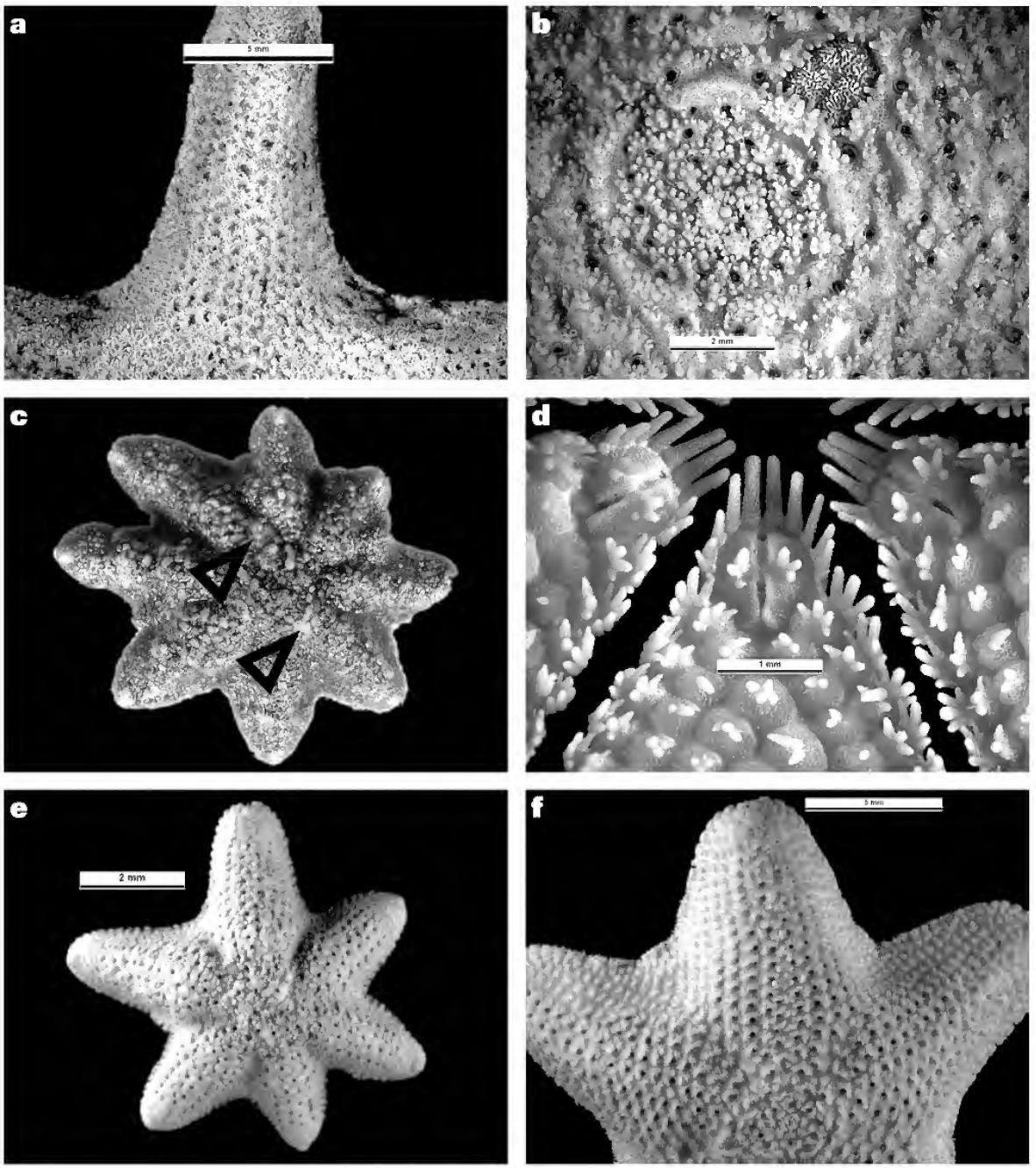

Figure 9. Photos of *Aquilonastra* species. a, *A. limboonkengi* (Smith), China, Amoy, ray (NHM 1926.12.22.35–36, syntype); b, *A.lorioli* (Koehler), Pakistan, Karachi, disc (MNHN EcAs2662, syntype); c, *A. lorioli* (Koehler), Pakistan, New Pachha, atypically eight rays, two conspicuous madreporites (arrows), asymmetrical (non-fissiparous; photo Qaseem Tahera); d, *A. marshae* sp. nov., Red Sea, actinal (TM H1814); e, *A. moosleitneri* sp. nov., Maldive Is. (R = 7 mm; holotype NHM 1902.3.13.27); f, *A. oharai* sp. nov., Okinawa (R = 12 mm; holotype UF 3285).

At R = 18 mm, r = 7 mm (larger syntype), from 0 to 4 proximal doubly-papulate carinal plates; 0–1 secondary plates per papular space; disc bordered with 5 radial 5 smaller interradial plates; spinelets on proximal abactinal plates in up to 4 groups, up to 10 spinelets per group, up to more than 30 spinelets on proximal abactinal plates; spinelets long, thick, conical to subsacciform, with numerous (5–6) points on distal sides and end of spinelets, not splay-pointed; mid-interradial plates with up to about 20 long, thin, pointed spinelets, sometimes larger group over anterior edge of plate, smaller group distally, groups splayed and overlapping spinelets on adjacent plates; superomarginal plates with up to about 12 thin spinelets per plate, up to about 24 thick spinelets per inferomarginal plate.

Spines per actinal plate up to: oral 7, suboral 6, furrow 7, subambulacral 7, actinal interradial 10 (frequently about 6); interradial spines long, conical.

Colour (live). "Dark brown with irregular red, purple or light brown spots" (Liao and A.M. Clark, 1995).

Distribution. SE coastal China, Guangdong and Fujian Provinces (Liao and A.M. Clark, 1995).

Remarks. Liao (1980) and Liao and A.M. Clark (1995) distinguished *Asterina limboonkengi* from *Asterina burtoni cepheus* (= *A. cepheus* here) by: abactinal spinelets squat, opaque with 5–6 terminal points (not slender, transparent with 1–3 terminal points); actinal spines stout, rugose with many points distally (not slender, smooth with few points distally); thin abactinal plates with large papular spaces with numerous secondary plates in large specimens (not thick with small papular spaces lacking secondary plates). We do not agree with all of these distinctions. We considered the actinal spines on the type specimen of *A. cepheus* to be short, thick, conical, blunt, and those on the syntypes of *A. limboonkengi* to be long, conical, finely tapered. We observed secondary plates on the types of both species. We thus have some uncertainty about the status of *A. limboonkengi* in China waters. O'Loughlin and Waters (2004) determined material from Oman (UF 68, UF 246, UF 1645) to be *Aquilonstra limboonkengi*. This material is referred here to the new species *Aquilonastra samyni* (below).

Aquilonastra lorioli (Koehler, 1910) comb. nov.

Figures 1, 4c, 6b–c, 9b–c

Asterina lorioli Koehler, 1910: 129–131, pl. 19 figs 5–8.—H.L Clark, 1915: 95.—A.M. Clark and Rowe, 1971: 38, 67.—A.M. Clark, 1993: 211.—O'Loughlin and Waters, 2004: 11, 37.

Palmipes sarasini de Loriol, 1897: 12.—Koehler, 1910: 129 (part; non *Palmipes sarasini* de Loriol, 1897).

Material examined. Syntypes. Pakistan, Karachi, MNHN EcAs2662 (1, dry, ray broken off); Mergui Archipelago, Cheduba I., WAM Z6848 (1, dry).

Other material. Bombay, BMNH 1960.10.4.11–16 (2); Native Jetty, Karachi, BMNH 1967.11.1.4 (2); Pakistan, Buleji, 24°N, 66°E, 9 Sep 2006, NMV F112184 (9).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, rarely 6 (Koehler, 1910, pl. 19 fig. 7), broad basally, narrowly rounded distally, up to R = 22 mm, r = 13 mm; gonopores abactinal.

At R = 22 mm, variable series of doubly-papulate carinal plates from none to half ray length, each with one cluster or up to 4 tufts of spinelets, up to about 20 spinelets on proximal carinal plates; disc defined by 5 transversely elongate series of subpaxilliform spinelets on radial plates, 5 small interradial plates; some high paxilliform clusters of spinelets on rays; spinelets vary significantly in form from large globose to thick digitiform apically on plates, to small pointed conical on margin of plates and on secondary plates; papular spaces large, predominantly single large papula per space, frequently 2 per space, up to 5 small secondary plates per space; superomarginal and inferomarginal plates subequal, superomarginal plates with up to about 10 short conical spinelets per plate, inferomarginal plates with up to about 20 spinelets.

Spines per actinal plate up to: oral 7, suboral 4, furrow 6, subambulacral 5, actinal interradial 6, predominantly 3; interradial spines thick, digitiform to bluntly conical.

Colour (live). Abactinal colour variably mottled with grey-brown, green-brown, yellow-brown, red-brown, red, brown (photos from Qaseem Tahera).

Distribution. Arabian Sea, Karachi, Bombay, Ceylon.

Remarks. Specimen EcAs2662 (R = 18 mm) is from the type locality (Karachi), and the label is written in Koehler's handwriting (Tim O'Hara pers. comm.). It is judged here to be a syntype. Specimen WAM Z6848 (R = 7 mm) is from the type locality (Cheduba I.), and the label records "Exchange Zoological Survey India". It is judged to be one of the small specimens (7-11 mm) referred to by Koehler (1910), and also a syntype.

O'Loughlin and Waters (2004) listed *Asterina lorioli* as *incertae sedis*, because type material and information about internal skeletal structure were not available. Type material is available for this study, and the species is reassigned as the new combination *Aquilonastra lorioli* (Koehler, 1910). The variety of spinelet form, and paxilliform clusters of spinelets along rays, are similar to the spinelet arrrangement in *Aquilonastra coronata* (Martens, 1886). *A. lorioli* is distinguished by the globose to subgranuliform spinelets. A specimen (photo from Qaseem Tahera, figure 9c) has eight rays and two conspicuous madreporites, but the spinelets are distinctively those of *A. lorioli*.

Aquilonastra marshae sp. nov.

Figures 1, 3c, 6d–e, 9d

Asterina cephea.—Perrier, 1875: 315–317 (part, Red Sea; non *Asteriscus cepheus* Müller and Troschel, 1842).

Asterina burtonii.—Mortensen, 1926: 121 (part).—A.M. Clark, 1952: 207 (part; non-fissiparous).—Tortonese, 1960: 20–21 (part; non *Asterina burtonii* Gray, 1840).

Asterina burtoni.—Achituv, 1969: 329–341 (part, "pentaradiate" form).—James and Pearse, 1969: 84–85 (part).—A.M. Clark and Rowe, 1971: 68, tbl. 1 (part, Red Sea non-fissiparous).—Achituv, 1973b: 547-553.—Tortonese, 1977: 281–282 (part).—Price, 1982: 7 (part, Red Sea non–fissiparous).—Mladenov and Achituv, 1999: 152

(part).—Karako et al., 2002: 139–144 (part, Elat Gulf of Aqaba non-fissiparous population; non *Asterina burtonii* Gray, 1840).

Asterina cepheus.—Moosleitner, 1997: 12–13, fig. 3a (only) (non *Asteriscus cepheus* Müller and Troschel, 1842).

Material examined. Holotype. Red Sea, Jousseaume, 1892, MNHN EcAs11907 (dry).

Paratypes. Type locality and date, EcAs10316 (7, dry).

Other material. Red Sea, M. Botta, 1837, EcAs2713 (1; labelled as "type" of *Asteriscus wega* Val.; discussed under *A. burtonii* above); NMV F112169 (12); S Sinai, El Fauz, Nov 2003, F109382 (5); Ras el Misalla, 22 Sep 1970, HUJ SLR3030 (3); Ras Matarma, 31 Jan 1969, SLR2199 (1); 22 Sep 1981, TAU NS24413 (1); Egypt, under rocks, shallows, 15 Jul 2005, F107430 (1); Feb 2003, F109362 (1); 15 Jul 1966, TM H1814 (1); Gulf of Suez, Mission Dollfus, 1928, EcAs11839 (1); 27 Oct 1971, NS8560 (1); et Tur, 11 Sep 1968, HUJ IEC.57/141–198 (11); Gulf of Aqaba, 8 Oct 1968, TAU NS4130 (5); Jez Tiran, 25 Sep 1981, WAM Z6877 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, sometimes 6, short, broad basally, tapered, narrowly rounded distally; up to R = 16 mm, r = 7 mm; predominantly 1 conspicuous madreporite, sometimes 2; gonopores abactinal; some paired thick spinelets probably act as pedicellariae, not differentiated as valves.

At R = 16 mm, 0–3 doubly-papulate carinal plates; plates angled over papulae, proximally crescentiform, 1 papula per space, frequently 1 secondary plate per papular space; disc bordered or not by 5 radial 5 interradial plates; spinelets thick, short, conical to subdigitiform, rugose, distally with multiple long fine points and frequently splay-pointed; up to about 14 spinelets across raised proximal edge of abactinal plates and angled over papula, frequently 1–2 on central bare distal surface of plate; up to about 8 spinelets per plate in mid-distal interradius; up to about 7 conical pointed spinelets per superomarginal plate, up to about 16 digitiform spinelets per inferomarginal plate, thick distally on plates.

Spines per actinal plate up to: oral 7, suboral 3, furrow 6, subambulacral 5, actinal interradial 5, predominantly 3; actinal interradial spines thick, sacciform, conical to digitiform.

Colour (live). Variably mottled with combinations of dark and pale mauve, dark brown to black, pale brown, red, green, white; sometimes predominantly pink-mauve or white (photos from H. Moosleitner and J. Hinterkircher; Moosleitner (1997)).

Distribution. Red Sea, Gulfs of Suez and Aqaba.

Etymology. Named for Loisette Marsh, Western Australian Museum, with appreciation of her generous assistance with loan material and her significant research into echinoderm systematics in the Indo-Pacific region.

Remarks. Two fissiparous species occur in the Red Sea, and are recognized in this work as *Aquilonastra burtonii* (above) and *Aquilonastra yairi* sp. nov. (below). *Aquilonastra marshae* has frequently been reported in the literature as a larger non-fissiparous pentaradiate growth stage of *Asterina burtonii* (see synonymy). Achituv (1973b) reported on the genital cycle of *Asterina burtoni* from the Gulf of Elat. Fissiparous and non-fissiparous forms were not distinguished. Maximum R was 14 mm. We judge that the material was probably principally *A. marshae*. *Aquilonastra samyni* sp. nov. (below) occurs on the coast of the Arabian Sea and is morphologically similar to *A. marshae*. The diagnostic characters that distinguish *A. marshae* from *A. samyni* are discussed in the Remarks for *A. samyni* below.

Aquilonastra minor (Hayashi, 1974)

Figures 1, 3d

Asterina minor Hayashi, 1974: 41–44, fig. 1.—A.M. Clark, 1993: 211.—Fujita and Saba, 2000: 169–170, pl. 3E.—Waters et al., 2004: 873, 876, 877, tbl. 1, figs 1, 2.

Aquilonastra minor.—O'Loughlin and Waters, 2004: 11, 13–15, fig. 1.—Saba and Fujita, 2006: 270–272, 286, fig. 15.—Byrne, 2006: 245, 251, tbls 1, 2, fig. 1.

Material examined. Japan, NMV F96697 (2).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, short, broad basally, narrowly rounded distally; up to R = 9 mm; gonopores actinal; direct development into brachiolaria stage (Hayashi, 1974).

At R = 7 mm, r = 5 mm, rare proximal doubly papulate carinal plates, rare secondary plates, abactinal plates with low domes, spinelets in tufts or bands, subpaxilliform, described as "paxilliform" by Hayashi (1974); up to about 20 spinelets on proximal abactinal plates; spinelets thin, columnar, distally spinous; superomarginal plates smaller than inferomarginals, up to about 8 spinelets per superomarginal plate, up to about 12 spinelets per inferomarginal plate.

Spines per actinal plate up to: oral 6, suboral 4, furrow 5, subambulacral 3, actinal interradial 3; interradial spines digitiform.

Colour (live). "Pale greenish white, pale green or brownish grey with small greenish white patterns and small dark brown scattering spots, and reddish colour intermixed in the marginal zone; madreporite yellowish orange" (Hayashi, 1974); disc cream, rays and interradii pale mottled pink, brown, cream white (photo from M. Komatsu).

Distribution. Japan, southern Honshu, Kushimoto, littoral (Hayashi, 1974).

Remarks. The largest of the many specimens observed by Hayashi (1974) were up to R = 6 mm. The two specimens donated by Mieko Komatsu to Jon Waters, and subsequently to Museum Victoria, are up to R = 7 mm (preserved). Fujita and Saba (2000) reported R up to 9.4 mm for Takehara (assumed not dried). Saba and Fujita (2006) reported R up to 7.7 mm for Sagami Bay. We wonder whether there is more than one species being referred to *A. minor*. Distinctive characters for *A. minor* are: rounded low domes on some abactinal plates; actinal gonopores.

Aquilonastra moosleitneri sp. nov.

Figures 1, 9e

Asterina burtoni.—A.M. Clark and Davies, 1966: 599.—A.M. Clark, 1967b: 146, fig. 1B.—Jangoux and Aziz, 1984: 861, 872, 873 (part; non *Asterina burtonii* Gray, 1840).

Asterina burtoni burtoni.—A.M. Clark and Rowe, 1971: 68, fig. 17e.—A.M. Clark, 1993: 207–208 (non *Asterina burtonii* Gray, 1840).

Asterina anomala.—Moosleitner, 1997: 12, fig. 22 (non *Asterina anomala* H.L. Clark, 1921).

Material examined. Holotype. Maldive Is., Male, Hulule, J.S Gardiner, 1899–1900, NHM 1902.3.13.27 (alcohol). Paratypes. Type locality and date, NHM 1902.3.13.28–33 (30).

Other material. Maldive Is., Eryadoo I., WAM Z6854 (1; photo in Moosleitner, 1997).

Diagnosis. Fissiparous *Aquilonastra* species; rays up to 7, predominantly 6, form frequently asymmetrical post-fissiparity, form of larger specimens sometimes symmetrical with 5 equal rays, most interradii with inconspicuous madreporite; rays narrow basally, tapering, narrow rounded distally; up to R = 9 mm, r = 4 mm; abactinal gonopores on largest pentaradiate specimens.

At R = 9 mm, lacking carinal plates; some secondary plates; 3 longitudinal series of papulae on sides of mid-ray; spinelets granuliform, short conical to columnar, rugose, blunt; up to about 10 spinelets over each plate, readily detached; superomarginal plates each with up to about 5 spinelets, inferomarginal plates each with up to about 10 larger spinelets.

Spines per actinal plate up to: oral 5, suboral 2, furrow 5, subambulacral 3, actinal interradial 3 (predominantly 3); interradial spines short, conical, pointed.

Colour (live). "Reddish, speckled with darker and lighter spots" (Moosleitner, 1997).

Distribution. Maldive Is.

Etymology. Named for Horst Moosleitner, with gratitude for his assistance in providing photos and specimens for this work, and with appreciation of his work on the asteroids of the Maldives.

Remarks. Moosleitner (1997) noted that in the absence of a connecting growth series this small fissiparous species was probably a separate species from the non-fissiparous asterinid on the Maldives. We agree that there are two species. A.M. Clark (1967b) determined the small fissiparous asterinid from the Maldive Is as *Asterina burtoni.* The 31 specimens (NHM 1902.3.13.27–33) are similar to *Aquilonastra conandae* in size, number of rays, and spinelet and spine form, but are similar to *Aquilonastra burtonii* in frequently having more than one interradial actinal spine per plate. The species size (up to R = 9 mm) is significantly smaller than *A. burtonii* (up to R = 18 mm).

Aquilonastra oharai sp. nov.

Figures 1, 3e, 9f

Material examined. Holotype. Japan, Okinawa, Seragaki, under rock on reef, 1–2 m, G. Paulay, 26 Jul 2004, UF 3285 (alcohol).

Paratypes. Type locality and date, UF 3916 (1, alcohol); Kunigami, reef flat, under rock, G. Paulay, J. Geller, M. Malay, Y. Hiratsuka, 4 Jul 2004, UF 3914 (1, alcohol; BOKI–14, d GP 595, 596).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, wide basally, tapered, rounded distally; up to R = 12 mm, r = 7 mm; gonopores abactinal.

At R = 12 mm, lacking proximal doubly papulate carinal plates; some secondary plates, frequently 1 per proximal papular space; single large papula per space; spinelets conical, thin, fine point to splay-pointed, subsacciform, in double splayed series across proximal edge of plates, rarely in tufts, up to about 14 spinelets on proximal abactinal plates, up to about 8 on distal interradial plates; superomarginal plates smaller than inferomarginals, superomarginals with up to about 7 spinelets per plate, inferomarginals with up to about 14 spinelets, more stout on inferomarginals.

Spines per actinal plate up to: oral 6, suboral 2, furrow 4, subambulacral 4, actinal interradial 6, predominantly 4–6 proximally; interradial spines conical, thick basally, pointed distally.

Colour (live). Variable, disc dark brown, mottled abactinally with mauve-violet, dark and pale brown, greenish brown, off-white; or disc dark brown, mottled abactinally with pale and dark green, and off-white (photos by G. Paulay).

Distribution. Japan, Okinawa, 0–2 m.

Etymology. Named for Tim O'Hara, Senior Curator of Marine Invertebrates, Museum Victoria, in appreciation of his contribution to this work and to echinoderm systematics and biogeography.

Remarks. A. oharai is distinguished from *A. cepheus* and *A. limboonkengi* by the shorter rays, absence of any proximal doubly papulate carinal plates, absence of clustering of the abactinal spinelets on the plates, and the splay-pointed form of some abactinal spinelets. *A. oharai* is described from only three specimens, with R up to 12 mm. The morphological characters used to distinguish the new species may be variable within the species, and size related. In the absence of adequate comparative material we have some uncertainty about the status of *A. oharai* in relation to *A. cepheus* and *A. limboonkengi.*

Aquilonastra richmondi sp. nov.

Figures 1, 4e, 6f,g, 10a

Asterina burtoni.—Jangoux, 1973: 35–38, fig. 13 (probably part, Mozambique material; non *Asterina burtonii* Gray, 1840).

Asterina burtonii.—Walenkamp, 1990: 67–72, figs 30, 31 (part, Mozambique material; non *Asterina burtonii* Gray, 1840).

Asterina coronata.—Jangoux, 1973: 38–39 (part, 3 Mozambique specimens; non *Asterina coronata* Martens, 1866 according to Walenkamp, 1990; non *Asterina burtonii* Gray, 1840).

'Asterina' sp. 1.—Rowe and Richmond, 2004: 3287 (part, Grand Paté specimen), fig. 4 (colour).

Material examined. Holotype. Tanzania, Ras Kimbiji, lower littoral, under boulders, M. Richmond, 4 Sep 2004, NHM 2005.37 (alcohol).

Paratypes. Type locality and date, NHM 2005.35 (1); NHM 2005.36 (1).

Other material. Côtes d'Arabie, St. XLVII, 1901–1904, MNHN EcAs11043 (1); Kenya, Kiunga Marine Reserve, 8 m, Apr 1999, MRAC 1739 (1); Zanzibar, Rousseau, 1841, EcAh3884 (1); Tanzania, Mnazi Bay, Ruvula Peninsula, rocky, lower littoral, 3 Feb 2004, NHM 2004.2832 (1); Mombassa, NHM 1972.8.22.3–17 (2 of 14 seen); Comoros, Mayotte, Mission Cherbonnier 25, littoral reef, 1959, MNHN EcAs11862 (1); Mission Cherbonnier 27, 1959, EcAs11863 (1);

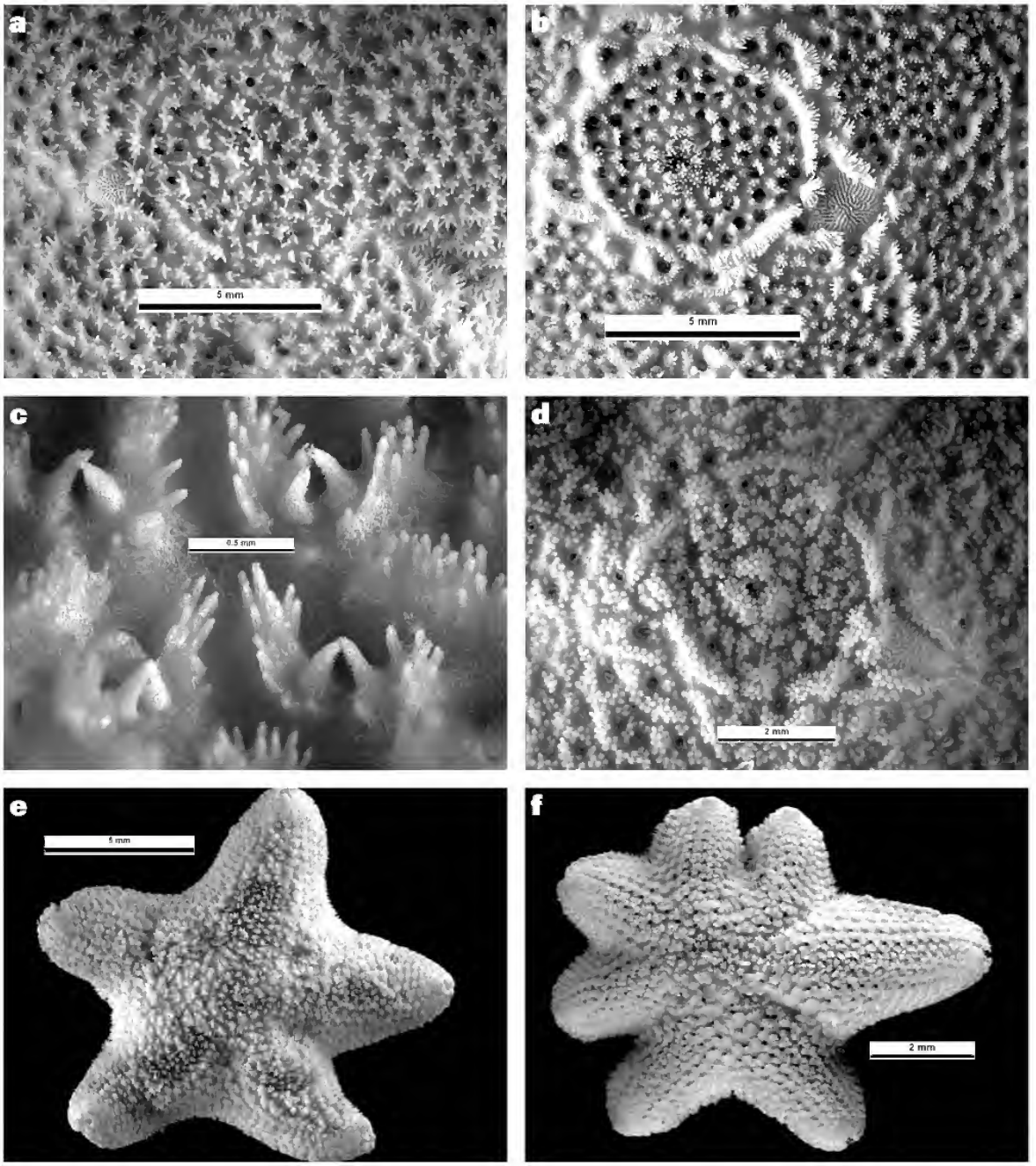

Figure 10. Photos of *Aquilonastra* species. a, *A. richmondi* sp. nov., SE Africa, Sodwana Bay, disc (MRAC 1737); b, *A. rowleyi* sp. nov., SE Africa, Sodwana Bay, disc (MRAC 1736, holotype); c, *A. rowleyi* sp. nov., SE Africa, Sodwana Bay, pedicellariae (MRAC 1736, holotype); d, *A. samyni* sp. nov., SE Africa, Sodwana Bay, disc (MRAC 1741); e, *A. watersi* sp. nov., Rodrigues I. (NHM 2004.2813–2814); f, *A. yairi* sp. nov., Mediterranean Sea, Israel, Michmoret (R = 7 mm; holotype NMV F112174).

NW Madagascar, Nossi-Bi I. (Nosy Bé), Plante Collection, 1965–1970, EcAs11865 (2); littoral reef, 2 Dec 1959, EcAs11858 (5); Cherbonnier, 6 Oct 1959, EcAs11859 (7); SW Madagascar, Mission Cherbonnier 201, Station Platier, 1962, EcAs11861 (2); NE Madagascar, Ile Sainte Marie, Ile aux Nattes, 26 Jun 1960, EcAs11860 (1); SE Madagascar, Fort Dauphin, Mission Decary, 1932, EcAs11864 (1); Madagascar, Gruvel Collection, 1923, EcAs10379 (1); Mauritius, Rodrigues I., Grand Paté, on coral, 20 m, 23 Sep 2001, AM J24287 (1); E South Africa, Sodwana Bay, 11 m, 10 Feb 2001, MRAC 1737 (1); 14 m, Aug 1999, MRAC 1738 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, rarely 6, broad to narrow basally, tapered, narrowly rounded distally; up to R = 25 mm, r = 12 mm; form frequently asymmetrical, one ray shorter than other 4; gonopores abactinal; pedicellariae sometimes evident on upper rays and in interradii, 2–3 short, thick valves not significantly differentiated from adjacent spinelets.

At R = 20, r = 10 mm, abactinal plates closely imbricate, proximal edge projecting, spinelets subpaxilliform; 0–5 proximal doubly-papulate carinal plates; few proximal secondary plates, 0–2 per space; predominantly single large papula per space, sometimes 2; spinelets short, conical, bluntly pointed, subsacciform, not splay-pointed, frequently of two forms, thin on outer margin of plates, thick short on apex of plates (columnar to subgranuliform); up to about 20 spinelets on each proximal abactinal plate, predominantly over surface of plate, some in clusters of 3–4; distal interradial plates with up to about 8 long, thin, pointed spinelets, frequently splayed in distinctive widely radiating cluster per plate, overlapping spinelets of adjacent plates on larger specimens; superomarginal plates smaller than inferomarginals, superomarginal plates with up to about 7 spinelets per plate, inferomarginals with up to about 14 spinelets per plate, thin proximally thick distally.

Spines per actinal plate up to: oral 8, suboral 4, furrow 7, subambulacral 5, actinal interradial 5, predominantly 2; interradial spines thick, rugose, bluntly conical, subsacciform.

Colour (live). Sharply mottled with green, maroon, pale brown, pink, white, black (photos by M. Richmond); variable and changeable, mottled with red, pink, orange, white, grey, blue (Walencamp, 1990; with colour photos).

Distribution. Côtes d'Arabie, E Africa, Kenya, Tanzania, Comoros, Madagascar, Mauritius, E South Africa; under boulders and in crevices in rocks and live coral; 0–20 m.

Etymology. Named for Matt Richmond, with appreciation of his contribution of material from Tanzania and Rodrigues I.

Remarks. Two distinctive features of *A. richmondi* are: frequently two forms of spinelets on the abactinal plates, thicker apically; splayed overlapping spinelet clusters on the distal abactinal plates. The detailed description and colour photos of *A. burtonii* by Walenkamp (1990) indicate that the Mozambique Inhaca material was not *A. burtonii* and is conspecific with *A. richmondi*. Ludwig (1899) reported *Asterina cepheus* for Zanzibar. There is no evidence in this study of *A. cepheus* occurring in the western Indian Ocean, but the morphologically similar *A. richmondi* is reported here for Zanzibar.

Aquilonastra rosea (H.L. Clark, 1938)

Figures 1, 3f, 6h

Paranepanthia rosea H.L. Clark, 1938: 161–162, pl. 22 fig. 8.—H.L. Clark, 1946: 137.—A.M. Clark, 1993: 223.—Marsh and Pawson, 1993: 285.—Rowe and Gates, 1995: 39.

Asterinopsis rosea.—Cotton and Godfrey, 1942: 203.

Aquilonastra rosea.—O'Loughlin and Waters, 2004: 11, 13–15.

Material examined. Paratypes. SW Western Australia, Rottnest I., AM J6171 (3).

Other material. Rottnest I., 18 Aug 2004, WAM Z31171 (1); Perth, 4 Aug 2004, Z31174 (1); Jurien Bay, J7437 (4); 13 m, 27 Apr 2005, Z31162 (1); Abrolhos Is., 110 m, 6 Dec 1970, Z21265 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, long (at R = 17 mm), wide basally, tapering to narrowly rounded distally, up to R = 17 mm, r = 9 mm.

At R = 17 mm, regular doubly papulate carinal plates proximally; abactinal plates not in 2 "fields"; abactinal plates with high raised rounded column or ridge, concave papular notch; longitudinal series of plates and papulae along sides of rays; predominantly single large papula per space; very few secondary plates; disc delineated by 5 wide radial plates, 5 short interradial plates; spinelets sacciform, long, splay-pointed; spinelets in paxilliform dense splayed round tufts of more than 30 per plate; superomarginal and inferomarginal plates with subequal tufts of spinelets.

Spines per actinal plate up to: oral 9; suboral 12; furrow 7; subambulacral 12; actinal interradial 20; spines on subambulacral and actinal plates in tufts; interradial spines sacciform, splay-pointed.

Colour (live). "Rose-red, more or less variegated with cream-colour" (H.L. Clark, 1938).

Distribution. SW Australia, Abrolhos I. to Rottnest I.; 0–110 m.

Remarks. O'Loughlin and Waters (2004) reassigned *Paranepanthia rosea* to *Aquilonastra*. This reassignment is upheld here provisionally on the basis of the arrangement of abactinal plates and papulae, the presence of internal superambulacral plates, and the arrangement of actinal plates. However, the paxilliform tufts of long thin abactinal spinelets and actinal spines, and high numbers of spinelets and spines per plate, are atypical of *Aquilonastra*. *A. scobinata* (below) is morphologically similar to *P. rosea* in having paxilliform tufts of numerous long thin abactinal spinelets, superambulacral plates, and actinal plates in series parallel to the furrow. The paxilliform tufts of spinelets in *A. rosea* are round, those in *A. scobinata* are frequently crescentiform.

Aquilonastra rowleyi sp. nov.

Figures 1, 6i, 10b, c

Material examined. Holotype (dry). South Africa, KwaZulu Natal, Sodwana Bay, 11 m, Y. Samyn and I. Tallon, 10 Feb 2001, MRAC 1736.

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, not discrete or elongate, wide basally, narrowly to broadly rounded distally, R = 23 mm, r = 14 mm; form shallow concave

interradially; pedicellariae present in proximal interradii, 2 valves differentiated with inner teeth, taller than adjacent spinelets; abactinal gonopores.

At R = 23 mm, lacking abactinal carinal series of plates, broad band of upper ray plates irregularly arranged, longitudinal and transverse series along sides of rays creating lattice-like appearance, plates with concave papular notch; single small papula per space; 6 longitudinal series of papulae along each side of mid-ray; secondary plates numerous on irregular upper ray; disc delineated by continuous curved dense band of spinelets on 5 wide radial plates, each with up to about 100 spinelets, 5 small interradial plates; spinelets glassy, elongate, thin, pencil-like; up to about 30 spinelets in short crescentiform band across projecting edge of each plate on proximal ray; irregular lumpiness more than glassy convexities on plates; superomarginal and inferomarginal plates subequal, in regular series; superomarginal plates with up to about 8 pencil-like spinelets; inferomarginal plates with up to about 16 spinelets, proximally subequal with superomarginal spinelets, distally longer and thicker.

Integument evident actinally; non-plated area in one proximal actinal interradius.

Spines per actinal plate up to: oral 10 long, thin; suboral 5 long, 5 short; furrow 7; subambulacral 7; actinal interradial 4, predominantly 3; interradial spines glassy, long, sacciform, in webbed combs.

Colour (live). No record.

Distribution. East African coast, KwaZulu Natal, Sodwana Bay, 11m.

Etymology. Named for Chris Rowley (Marine Biology Section, Museum Victoria), in appreciation of the photography and curatorial assistance that have been graciously provided in support of asterinid systematic research.

Remarks. The new species has many of the diagnostic characters of *Aquilonastra*, but is assigned with reservations because the numerous spinelets are pencil-like and not typical of *Aquilonastra*. They resemble those of *Patiriella oliveri* (Benham, 1911), *Callopatiria granifera* (Gray, 1847), and *Aquilonastra scobinata* (below). The rays are distinct, but the form is closer to subpentagonal than the discrete-rayed form of *Aquilonastra*. In an absence of adequate material we are unwilling to erect another asterinid genus. The tall pedicellariae with distinctive inner-toothed valves are unique amongst asterinids.

Aquilonastra samyni sp. nov.

Figures 1, 3g, h, 6j, 10d

Material examined. Holotype. Oman, Masirah I., 1–7 m, under rocks, G. Paulay, 6 Nov 1999, UF 246 (alcohol).

Paratypes. Type locality, 15–18 m, G. Paulay, 5 Nov 1999, UF 68 (8, alcohol); Bar al Hikman, under rocks, 0–1 m, M. Bouchard, 7 Nov 1999, UF 1645 (2).

Other material. Oman, Bar al Hikman peninsula, 1–3 m, under rocks, 18–20 Jan 2005, UF 4210 (2); 2–3 m, UF 4201 (3); 2–4 m, under rocks, Jan 2005, UF 4143 (3); Muscat, Qurm, intertidal, 26 Jan 2005, UF 4147 (6); UF 4251 (1); UF 4252 (1); Bandar Khayran, under rocks, 0–5 m, 29 Oct 1999, UF 1378 (1); Madagascar, MNHN EcAs11853 (1); NW Madagascar, Nossi Be (Nosi Bé), littoral reef, 24 Sep 1964, EcAs11848 (1); 2 Dec 1959, EcAs11849 (5); 1962, EcAs11850 (1); 6 Oct 1959, EcAs11851 (3); 3 Dec 1959, EcAs11852 (2); SW Madagascar, Tuléar, EcAs11847 (1); Ile Sainte-Marie, 11 Feb 1979, WAM Z6870 (2); La Réunion I., Tobogan, 10 Sep 2001, NMV F109365 (1); South Africa, Sodwana Bay, 10 m, Jul 2000, MRAC 1741 (1); 13 m, Aug 1999, MRAC 1740 (1); MRAC 1743 (1); Bangha Nek, 16 m, Aug 1999, MRAC 1742 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays predominantly 5, rarely 6, narrow basally, slight taper, rounded distally, subdigitiform, up to R = 27 mm, r = 11 mm; single conspicuous madreporite, 2 rare, 3 very rare; gonopores abactinal.

At R = 23 mm, r = 9 mm, 0–3 proximal doubly papulate carinal plates; disc frequently well-delineated by 5 radial 5 interradial plates; up to about 30 spinelets in irregular double transverse series across proximal abactinal plates, some spinelets in poorly defined clusters (spinelets granuliform on small specimens); 0–2 secondary plates per papular space proximally, rarely 2 papulae per space; spinelets small, short, thick, conical to columnar, sometimes splay-pointed, sometimes with long thin distal point; up to about 14 on distal interradial plates, not overlapping adjacent plate spinelets if splayed; superomarginal plates smaller than inferomarginals, superomarginals with up to about 12 spinelets per plate, inferomarginals with up to about 24 larger spinelets per plate.

Spines per actinal plate up to: oral 8, suboral 6, furrow 7, subambulacral 8, actinal interradial 14, predominantly 8–12; interradial spines short, thick, rugose, sacciform, bluntly conical (lower spine numbers per plate on South Africa material).

Colour (live). Variable; disc white, apically around disc bright red, rays mottled mauve, brownish-red, off-white, brown (photos from G. Paulay and Y. Samyn).

Distribution. Oman (Masirah I.); Madagascar; La Réunion I.; E South Africa (Sodwana Bay); 0–18 m.

Etymology. Named for Yves Samyn, of the Royal Belgian Institute of Natural Sciences, for his contribution of specimens used in this work and in appreciation of his research on echinoderm systematics.

Remarks. Pentaradiate, single madreporite, non-fissiparous specimens as small as R = 6 mm have been examined, evidence that this species does not have a small pluriradiate fissiparous growth stage. Large specimens have mostly come from the deeper sublittoral (3–18 m), while the numerous small specimens have mostly come from the intertidal and shallow sublittoral (0–2 m). If this species occurs in deeper sublittoral habitats this might account for the absence of the species in collections from most of the eastern African coast. It might also account for the absence of large specimens from Madagascar, as the collecting appears to have been littoral.

A. samyni is morphologically similar to *A. marshae* (above), but is distinguished from *A. marshae* (characters in brackets) by: rays long, mostly subdigitiform, only slightly tapered (not short, mostly strongly tapered); abactinal surface is predominantly flat (plates not raised proximally and angled over papulae); spinelets are predominantly spread over plate surface (not predominantly concentrated over raised proximal

plate edge); distal plate surfaces with spread spinelets (not bare with 1–2 central spinelets); at R = 16 mm, predominantly 6 spines per actinal plate (not 3); actinal spines short, blunt, sacciform (not conical to digitiform).

For population studies by Soliman (1995, 1999) see Remarks under *A. burtonii* above.

Aquilonastra scobinata (Livingstone, 1933)

Figures 1, 3i, 6k

Asterina scobinata Livingstone, 1933: 1–2, pl. 5 figs 9–12, 15.—H.L. Clark, 1938: 149–150.—Cotton and Godfrey, 1942: 201.—H.L. Clark, 1946: 132.—Dartnall, 1969: 55.—Dartnall, 1970a: 73, 76.—Dartnall, 1970b: 19–20, figs 1, 2.—Dartnall, 1980: 8, 34, 66.—Zeidler and Shepherd, 1982: 412, fig. 10.6e.—O'Loughlin, 1984: 134.—A.M. Clark, 1993: 213.—Rowe and Gates, 1995: 35.—Waters et al., 2004: 873, 876, figs 1, 2.

Aquilonastra scobinata.—O'Loughlin and Waters, 2004: 11, 13–14, fig. 1.—Byrne, 2006: 245, 248, tbls 1, 2, fig. 1.

Material examined. Holotype. Tasmania, AM J1241.

Other material. Tas., Port Arthur, 25 Nov 1968, NMV F112178 (2); Eaglehawk Neck, J9060 (3); Tamar R. mouth, North Head, 28 Oct 1978, F112176 (1); King I., 10 Mar 1980, F112177 (1); Vic., Inverloch, 28 Mar 1981, F72975 (1); Point Leo, 20 Apr 1935, F58683 (1); Phillip I., NMV F72998 (1); Flinders ocean platforms, 7 Sep 1994, F112180 (3); Cape Otway, 3 Apr 1983, F58682 (2); Killarney, F72997 (10); Port Fairy, F72985 (2); SA, Port MacDonnell, 8 Jan 1988 F112179 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, wide basally, tapered, narrowly rounded distally, up to R = 18 mm, r = 8 mm; form frequently asymmetrical with one ray shorter; actinal gonopores, hermaphrodite.

At R = 14 mm, r = 7 mm, proximal ray with zig-zag carinal series of singly papulate plates, bordered laterally by subequal non-papulate plates; singly papulate plates in longitudinal series along sides of rays; papulate plates not notched, slightly crescentiform, non-papulate plates round to oval to irregular; rarely 2 papulae per space; secondary plates rare; disc small, variably delineated by 5 long radial 5 short interradial plates; spinelets elongate, thin, pencil-like, splay-pointed sacciform; up to more than 30 per plate, in splayed tuft or crescentiform or straight band across plate; superomarginal and inferomarginal plates subequal, in regular series; superomarginal plates with up to about 10 pencil-like splay-pointed spinelets; inferomarginal plates with up to about 20 paxilliform similar spinelets.

Spines per actinal plate up to: oral 7; suboral 6; furrow 6; subambulacral 6; actinal interradial 7; interradial spines long, rugose, digitiform, some pointed distally.

Colour (live). Dark brown to greyish-brown to cream, with some dark flecking (O'Loughlin, 1984).

Distribution. Tas., Bass Strait, Cape Conran (eastern Vic., NMV collections) to Port MacDonnell (SA); rocky lower littoral and shallow sublittoral.

Remarks. *A. scobinata* is provisionally maintained in *Aquilonastra* because of the arrangement of abactinal plates and papulae, the presence of internal superambulacral plates, and the arrangement of actinal plates. The paxilliform tufts of long thin pencil-like abactinal spinelets and actinal spines, and high numbers of spinelets and spines per plate, are atypical of *Aquilonastra*. Morphological similarities of *A. scobinata* to *A. rosea* and *A. rowleyi* have been noted above.

Dartnall (1970b) reported actinal gonopores and hermpahrodite reproduction. Mieko Komatsu (pers. comm.) confirmed that a specimen (F112180) was hermaphroditic.

Aquilonastra watersi sp. nov.

Figures 1, 3j, 6l, 10e

'Asterina' sp. 1.—Rowe and Richmond, 2004: 3287 (part, Trou Malabar specimens).

'Asterina' sp. 2. —Rowe and Richmond, 2004: 3287 (part, Rivière Banane specimen).

Asterina cephea.—Loriol, 1885: 69–71, pl. 21 figs 1–5 (non *Asteriscus cepheus* Müller and Troschel, 1842).

Material examined. Holotype. Oman, Masirah I., shore, under rocks, G. Paulay, 5 Nov 1999, UF 3282 (alcohol).

Paratypes. Type locality and date, UF 70 (5, alcohol); UF 3283 (1, dry, dissected); Masirah I., reef slope, under rocks, 1–5 m, G. Paulay, 1 Nov 1999, UF 356 (1, alcohol).

Other material. Oman, Bar al Hikman peninsula, under rocks, 0–6 m, Jan 2005, UF 4142 (10); UF 4148 (1); UF 4144 (1); UF 4192 (2); Red Sea, Egypt, near Qusier, 2002, NMV F106970 (1); Mauritius, MNHN EcAs11866 (1); ex MAU 74–6, EcAs11867 (1); ex MAU 74–20, EcAs11868 (1); ex MAU 74–23, EcAs11869 (1); ex MAU 74–24, EcAs11870 (1); ex MAU 74–33, EcAs11871 (2); ex MAU 74–36, EcAs11872 (1); ex MAU 74–37, EcAs11873 (1); ex MAU 74–38, EcAs11874 (1); ex MAU 74–40, EcAs11875 (1); Mauritius, Robillard, NHM [18]89.3.11.7–9 (3); Cape Malheureux, Coin de Mire I., 24 m, 15 Nov 1999, UF 3281 (1); Rodrigues I., Rivière Banane, in algae, 21 Sep 2001, AM J24290 (1); Trou Malabar, coral rubble, 10 m, 22 Sep 2001, NHM 2004.2813–2814 (2); Madagascar, Nossi-Bi, littoral reef, 2 Dec 1959, EcAs11906 (1).

Diagnosis. Non-fissiparous *Aquilonastra* species; rays 5, broad basally, tapering, rounded distally, up to R = 19 mm, r = 11 mm; gonopores abactinal; few pedicellariae in abactinal interradii, each with 2 thick curved pointed differentiated valves, not evident on small specimens.

At R = 16 mm, r = 9 mm, 0–10 proximal doubly papulate carinal plates, each with up to 4 spinelet clusters each cluster with up to 7 spinelets; up to about 20 spinelets on proximal abactinal plates, in clusters or band across proximal edge of plate; rare small secondary plates; spinelets small, thin, long, digitiform to predominantly bluntly conical, sometimes subsacciform, rarely splay-pointed; up to about 8 in tufts on distal interradial plates, not overlapping adjacent plate spinelets if splayed; superomarginal plates smaller than inferomarginals, superomarginals with up to about 7 spinelets per plate, inferomarginals with up to about 14 larger spinelets per plate.

Spines per actinal plate up to: oral 7, suboral 6, furrow 6, subambulacral 6, actinal interradial 8, predominantly 5–6; interradial spines thick basally, conical, subsacciform.

Colour (live). Mottled pale brown, red-brown, grey-brown, blue-grey, off-white (photo by G. Paulay).

Distribution. Arabian Sea, Oman; Red Sea, Egypt; W Indian Ocean, Mauritius, Rodrigues I.; 0–24 m.

Etymology. Named for Jon Waters, of the University of Otago in New Zealand, in appreciation of his significant contribution to our understanding of the molecular phylogeny of Asterinidae.

Remarks. Two of the larger specimens from Mauritius (UF 3281, MNHN EcAs11868) have the characteristic pedicellariae of the types from Oman. For population studies by Soliman (1999) see *Remarks* under *A. burtonii* above. *A. watersi* is distinguished by differentiated thick pedicellariae, and small, thin, long, subacicular spinelets.

Aquilonastra yairi sp. nov.

Figures 1, 4f, 10f

Asterina wega.—Achituv, 1973a: 333–336 (part, Acre and Akhziz pool populations).

Asterina burtonii.—Smith, 1927a: 641–645 (part).—Tortonese, 1960: 20–21 (probably part).

Asterina burtoni.—Price, 1983: 47–48, fig. 14 (part).—Achituv and Sher, 1991: 670 (part).—Mladenov and Achituv, 1999: 152 (part).—Karako et al., 2002: 139–144 (part, Akhziv, Shikmona, and Mikhmoret Mediterranean populations).—Waters et al., 2004: 874, 876–877, figs 1, 2, tbl. 1 (non *Asterina burtonii* Gray, 1840; see above).

Asterina burtoni burtoni.—A.M. Clark and Rowe, 1971: 68, fig. 17c (Acre), tbl. 1 (part).—A.M. Clark, 1993: 207–208 (part; non *Asterina burtonii* Gray, 1840).

Aquilonastra burtoni.— O'Loughlin and Waters, 2004: 11, 13 (part), 14, fig. 1.—Byrne, 2006: 245, tbls 1, 2, fig. 1 (non *Asterina burtonii* Gray, 1840).

Material examined. Holotype. Mediterranean Sea, Israel, Michmoret, Y. Achituv, 11 Jun 2005, NMV F112174 (alcohol). Paratypes. Type locality and date, F107434 (18, alcohol).

Other material. Israel, Akhziv, 25 Oct 1966, MNHN EcAs11042 (67, dry); Gulf of Suez, A.P. Dollfus, 25 Dec 1928, EcAs11840 (1, dry); AM J17892 (2, dry); Red Sea, NHM [18]40.3.23.55 (1, dry); don. J. Waters, F104975 (22, alcohol); F104974 (2, alcohol).

Diagnosis. Fissiparous *Aquilonastra* species; rays up to 8, predominantly 6, form frequently asymmetrical post-fissiparity; form of larger specimens sometimes symmetrical with 5 equal rays, most interradii with inconspicuous madreporite; rays narrow basally, tapering, narrow rounded distally, digitiform; up to R = 7 mm, r = 4 mm; gonopores not seen.

At R = 7 mm, lacking carinal plates; lacking large irregular proximal abactinal plates; 2 irregular longitudinal series of papulae on each side of rays; spinelets subgranuliform, short thick conical to columnar, splay-pointed, cover plates closely, frequently clustered in groups of up to 8 per group, up to about 16 spinelets on proximal plates, up to about 14 on mid-interradial plates; superomarginal plates each with up to about 7 spinelets, inferomarginal plates each with up to about 14 taller spinelets.

Spines per actinal plate up to: oral 5, suboral 4 (frequently 3), furrow 4, subambulacral 4, actinal interradial 4 (predominantly 3); interradial spines conical, thin, pointed.

Colour (live). Specimens from Shikmona were all "mottled brown and orange" (pers. comm. Y. Achituv).

Distribution. Eastern Mediterranean, Acre, Akhziz pool populations, Michmoret, Shikmona; Red Sea, Gulf of Suez.

Etymology. Named for Yair Achituv (Bar-Ilan University, Israel), with appreciation of his contribution of material for this study and his research on the asterinids of the eastern Mediterranean and Red Sea.

Remarks. At R = 7 mm, *A. yairi* is distinguished from *A. burtonii* by: having more actinal spines per plate (up to four not two suboral; up to four not two interradial); close cover of spinelets on abactinal plates, frequently clustered into groups (not covering plates sparsely); smaller and more regular abactinal plates; more numerous papulae.

Achituv (1969) studied "pentaradiate and pluriradiate" forms of an asterinid from Elat in the Gulf of Aqaba, and referred the pentaradiate form to *Asterina burtoni* and the pluriradiate form to *Asterina wega*. We support his conclusion that there are two discrete species. But we refer the non-fissiparous pentaradiate form to *Aquilonastra marshae* sp. nov. (above). The fissiparous pluriradiate form had R up to 12 mm, and is judged here to be *Aquilonastra burtonii* (Gray, 1840) and not conspecific with the smaller fissiparous species *A. yairi*. We have seen no evidence that *A. yairi* occurs in the Gulf of Aqaba. The use of "pentaradiate" to determine non-fissiparous specimens can be misleading as the larger fissiparous specimens frequently have five equal rays but continue to have more than one inconspicuous interradial madreporite.

For evidence from Achituv (1973) that both *A. burtonii* and *A. yairi* occur in the eastern Mediterranean, see Remarks under *A. burtonii* above.

Specimens (NMV F104974, F104975) were assumed to be *A. burtoni* and reported in the molecular phylogenetic work of Waters et al. (2004), and represented in the phylogenetic tree of O'Loughlin and Waters (2004). Both lots are redetermined in this work as *A. yairi*. In O'Loughlin and Waters (2004), the material AM J17892 (2) was assigned to *A. burtoni*. It is redetermined here as *A. yairi*.

The discovery of two type specimens of *Asterina burtonii* by Smith (1927a) is discussed above under *A. burtonii*. The smaller of these two types is assigned here to *A. yairi*.

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