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Western Australian Museum
Perth Cultural Centre, James Street, Perth, Western Australia 6000
Mail: Locked Bag 49, Welshpool DC, Western Australia 6986
Tel. (08) 9427 7000
Fax. (08) 9427 2881
E-mail ann.ousey@museum.wa.gov.au

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Cover: Glyphocrangon elephas sp. nov., a deep-water shrimp from southern Australia.

Drawn by Jill Ruse from the original by Tomoyuki Komai.
A distinctive new species of the deep-water shrimp genus *Glyphocrangon* A. Milne-Edwards (Crustacea: Decapoda: Caridea: Glyphocrangonidae) from southern Australia

**Tomoyuki Komai**
Natural History Museum and Institute, Chiba
955-2 Aoba-cho, Chuo-ku, Chiba 260-8682, Japan
E-mail: komai@chiba-muse.or.jp

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**Abstract** – A distinctive new species of glyphocrangonid shrimp, *Glyphocrangon elephas*, is described on the basis of a single ovigerous female specimen from the Great Australian Bight, southern Australia, at a depth of 360 m. The new species somewhat resembles *G. hakuluiae* Takeda and Hanamura from Indonesia and the Northwest Shelf and *G. robusta* Komai from the Philippines, but is characterized by a very strongly sinuous rostrum, very strong and elongate branchiostegal spine on the carapace, unusually thick and highly elevated median carinae on the abdomen and heavily crenulate ventrolateral margins of the telson. *Glyphocrangon elephas* is the first species of Glyphocrangonidae to be recorded from southern Australian waters. The discovery of the new species brings the number of Australian species of *Glyphocrangon* to 11.

**INTRODUCTION**

Shrimps of the genus *Glyphocrangon* A. Milne-Edwards, 1881 exclusively inhabit depths greater than 200 m. They are characterized by the unusually hard body integument strongly sculptured by longitudinal carinae and/or tubercles, teeth or spines, and the peculiar locking mechanism of the posterior abdominal somites and telson. Recently Komai (2004) reviewed species of the genus in the Indo-West Pacific region, recognizing 54 species, including 28 new species. He suggested that intensive collections would eventually reveal existence of more unknown species from the Indo-West Pacific.

Examination of material in the collection of the Western Australian Museum, Perth, revealed a specimen of a distinctive undescribed species of *Glyphocrangon*. This new species, described herein as *G. elephas*, is compared with *G. hakuluiae* Takeda & Hanamura, 1994, known from Indonesia and the Northwest Shelf and *G. robusta* Komai, 2004, from the Philippines. The new species represents the first species of Glyphocrangonidae to be recorded from southern Australia, as well as bringing the number of species of the genus known from Australia to 11.

Descriptive terminology generally follows Komai (2004). Size of the specimen is indicated by postorbital carapace length (CL). The holotype of the new species is deposited in the Western Australian Museum (WAM).

**SYSTEMATICS**

**Family GLYPHOCRANGONIDAE**

**Genus Glyphocrangon** A. Milne Edwards, 1881

*Glyphocrangon elephas* sp. nov.

Figures 1–3

**Material Examined**

**Holotype:** Southern Australia: Great Australian Bight, 33°17'S, 128°32'E, 360 m, 19 March 1978, trawl, coll. M. Walker, ovigerous female CL 13.6 mm (WAM-C14783).

**Description**

Body (Figure 1) robust. Integument of carapace and abdomen naked, glabrous.

Rostrum (Figures 2A, B) moderately narrow in posterior part, strongly deepened at about midlength, 0.7 times of carapace length, directed downward in proximal part, but strongly upturned in distal half; dorsolateral ridges strongly sinuous in lateral view, with 2 pairs of short, rounded teeth; proximal part of dorsolateral ridge between 2 lateral teeth rather low, devoid of longitudinal groove, anterior part distal to anterior pair of lateral teeth highly elevated; middorsal carina low, confined to distal 0.2 of rostrum; dorsal surface lacking transverse septa or rugosity; ventral surface with shallow median groove becoming narrower
Figure 1  *Glyphocrangon elephas* sp. nov. Entire animal in dorsal and lateral views. Holotype ovigerous female (CL 13.6 mm; WAM-C 14785).
posteriorly, flanked by bluntly edged ventrolateral carinae; midventral carina absent.

Carapace (Figures 1, 2A, C) 1.1 times longer than greatest width at about midlength; carinae and tubercles eroded with minute pits. Anterior first (submedian) carina composed of 3 greatly unequal, low, blunt tubercles (first and second tubercules distinctly separated from each other, third tubercule longest); posterior first carina thick, faintly bi-lobed; posterior lobe converging to midline posteriorly, its posterior end not overhanging posterodorsal margin of carapace. Anterior second (intermediate) carina composed of 3 low, blunt tubercles; second, smallest tubercle aligned with other tubercles; posterior second carina composed of 3 low lobes (second lobe longest). Anterior third (antennal) carina very short, blunt, confined to antennal spine; posterior third carina low, broad, faintly 3-lobed (anteriormost lobe shortest), terminating obtusely at anterior end. Anterior fourth (lateral) carina divided in 2 discontinuous lobes, slightly unaligned; anterior lobe weakly compressed vertically, terminating anteriorly in blunt point; posterior lobe low, weakly compressed vertically, slightly divergent posteroventrally against dorsal plane of carapace, terminating anteriorly in blunt point; posterior fourth carina low, broad, parallel to posterior third carina. Anterior fifth (sublateral) carina low, but clearly delineated; posterior fifth carina very low, irregularly shaped, partially fused with posterior part of divided sixth (submarginal) carina. Sixth (submarginal) carina divided in two parts; anterior part low, roughly eroded; posterior part very low, irregularly shaped. Submarginal posteroventral ridge very low, distinct from sixth carina. Postorbital region unarmed, but with low, blunt submarginal ridge extending to antennal spine. Median part of gastric region with 2 rows of 3 or 4 tubercules on anterior part; postmedian region smooth. Lateral part of gastric region with space between first and second carinae nearly flat, with 1 low tubercle; space between second carina and lateral groove narrow, also with 1 small, low tubercle. Posterior dorsolateral region slightly concave, smooth. Hepatic region with upper part only slightly convex, with row of 2 low tubercules, possibly representing trace of anterior third carina; lower part nearly flat, un armed. Each part of branchial region unarmed. Subbranchial region with space between anterior fifth and sixth carinae moderately broad, shallowly depressed below, smooth, in contact with lower part of branchial region. Antennal spines short, nearly straight in dorsal view, weakly ascending in lateral view (angle about 15° against horizontal plane of carapace). Branchiostegal spines very strong, visible in dorsal view, directed forward in both lateral and dorsal views, extending to distal margin of antennal scale; lateral face with 2 inconspicuous ridges, not in contact with anterior fourth carina. Marginal posterolateral corner not delineated. Lateral and cervical grooves shallow. Lateromarginal groove shallow.

First abdominal somite (Figure 1) with dorsal elevation low, but clearly defined by shallow transverse groove, with 1 blunt tubercle on either side of median carina; median carina low, very broad, not reaching posterodorsal margin of somite, terminating anterodorsally in broadly rounded projection. Dorsolateral carina low, thick, with rounded anterior margin. Posterior section of tergum with 5 or 6 low tubercles on either side of midline. Lateral carina low, broad, entire. Pleuron with 1 blunt submarginal tubercle anterolaterally; posterior depression not abruptly delimited; anteroventral corner weakly produced, blunt.

Second to fourth abdominal somites (Figure 1) with only few intercarinal tubercles; surfaces of carinae and tubercles minutely punctate; median carinae unusually thick, posterior ends each weakly to somewhat produced posteriorly; cross sections of median carinae T-shaped; posterior transverse grooves very shallow; dorsolateral carinae showing as low, rounded tubercles; pleura each with some large, low tubercles or protuberances; ventral lobes of pleural elevations lacking prominent tubercle or spine; pleural teeth greatly unequal, blunt, only slightly curved laterally.

Fifth abdominal somite (Figure 1) humpy with rounded tubercles; anterior median carina showing as blunt tubercle; posterior median carina short, thick, its posterior end rounded. Tergum with shallow dorsal groove; anterior submedian carina showing as blunt tubercle; posterior submedian carinae high, thick, reaching nearly to posterodorsal margin of somite, slightly diverging posteriorly in dorsal view; pleuron with 2 short ventral teeth.

Sixth abdominal somite (Figure 1) with high, somewhat compressed median carina, entire, terminating posteriorly in large, blunt projection; dorsal margin smooth, convex in lateral view. Tergum with 1 large, rounded tubercle on either side of median carina; lateral carina composed of 2 large tubercles; posterolateral carina distinct, slightly produced beyond posterolateral margin of somite. Pleuron with 5 large tubercles; lateroventral carina extending onto posterolateral tooth; posterolateral tooth strong, rather subacute, noticeably flared laterally.

Telson (Figures 1, 2E) 0.8 times as long as carapace; anterior projection moderately high, somewhat compressed laterally, directed posteriorly; dorsolateral carina smooth; ventrolateral carina strongly crenulate almost over entire length with short vertical tubercles or rounded tubercles.

Eye (Figures 1, 2A) relatively small for genus, maximal diameter 0.15 of carapace length, without
dark pigmentation in preservative; ocular peduncle with small anteromesial process.

Antennular peduncle (Figure 1, 2A) reaching distal margin of scaphocerite; penultimate segment twice as long as wide. Outer flagellum with moderately long aesthetasc-bearing portion.

Antennal scaphocerite (Figures 1, 2A, D) elongate oval, 0.33 times as long as carapace, 2.20 times longer than wide; dorsal surface naked; lateral margin weakly convex, with distinct lateral tooth arising at proximal 0.44 of scaphocerite length. Carpocerite not reaching distal margin of scaphocerite.

Mouthparts not dissected, but typical of genus. Third maxilliped slightly overreaching distal margin of scaphocerite; marginal spines on distal 2 segments slender.

First pereopod (Figure 3A) with palm devoid of pubescence or short setae on lateral face; ischium with moderately broad, distally acute ventral lamina. Second pereopods (Figure 3B) slightly unequal with right chela smaller; neither reaching distal margin of scaphocerite; left carpus composed of 22 articles. Posterior 3 pairs of pereopods moderately stout. Third pereopod (Figure 3B) overreaching distal margin of scaphocerite by length of dactylus; propodus without distal tuft of setae. Fourth pereopod (Figure 3D) reaching distal margin of scaphocerite by tip of dactylus; dactylus (Figure 3E ) 0.78 times as long as propodus,
subspatulate, terminating in simple, acuminate unguis partially obscured by tufts of setae arising from just lateral to base of unguis; dorsal surface shallowly broadly sulcate medially, without distolateral groove; ventral surface not carinate in midline. Fifth pereopod (Figure 3F) overreaching midlength of scaphocerite by tip of dactylus; dactylus 0.73 times as long as propodus, generally similar to that of fourth pereopod in structure.

Egg size 1.53–1.76 x 1.24–1.47 mm; number not recorded.

Distribution
Known only from the Great Australian Bight, southern Australia, at a depth of 360 m.

Remarks
*Glyphocrangon elephas* sp. nov. somewhat resembles *G. hakuhoeae* from Indonesia and the Australian Northwest Shelf and *G. robusta* from the Philippines, and together differ from all other congeners by the combination of the strongly sinuously curved dorsolateral margins of the rostrum in female and the two unaligned lobes composing the anterior fourth (lateral) carina on the carapace. However, the new species is quite distinctive in having unusually thick and highly elevated median carinae on the second to fourth abdominal somites and the very strongly sinuous rostrum. Other characteristics of the new species include: the branchiostegal spine is very strong, reaching the distal margin of the scaphocerite; and the ventrolateral carina of the telson is strongly crenulate with short vertical ridges or rounded tubercles.

Komai (2004) recorded the following 10 species of *Glyphocrangon* from Australian waters (Table 1): *G. confusa* Komai, 2004 (previously known from Australia as *G. investigatoris* Wood-Mason, in Wood-Mason and Alcock, 1891; see Jones &
Table 1  Summary of the geographical distribution of species of Glyphocrangon known from Australia.

<table>
<thead>
<tr>
<th>Western Australia</th>
<th>Eastern Australia</th>
<th>Southern Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>G. confusa</td>
<td>G. holthuisi</td>
<td>G. elephas sp. nov.</td>
</tr>
<tr>
<td>G. faxoni</td>
<td>G. kapala</td>
<td></td>
</tr>
<tr>
<td>G. hakuroae</td>
<td>G. lowryi</td>
<td></td>
</tr>
<tr>
<td>G. lineata</td>
<td>G. novaceastellum</td>
<td></td>
</tr>
<tr>
<td>G. pugnax</td>
<td>G. tasmanica</td>
<td></td>
</tr>
</tbody>
</table>

Morgan, 1994, 2002; Davie, 2002), G. faxoni De Man, 1918, G. hakuroae, G. holthuisi Kensley, Tranter & Griffin, 1987, G. kapala Komai, 2004 (previously referred to G. assimilis De Man, 1918 by Kensley et al. (1987)), G. lineata Komai, 2004, G. lowryi Kensley, Tranter & Griffin, 1987, G. novaceastellum Kensley, Tranter & Griffin, 1987, G. pugnax De Man, 1918 and G. tasmanica Komai, 2004. It is remarkable that the species composition is quite different between western and eastern Australia, although the numbers of the species occurring in those regions are similar (five species are known from Western and Eastern Australia, respectively). There are no common species between the two regions. The marine fauna of Western Australia contains many Indonesian elements, probably owing to the south flowing Leeuwin Current (e.g., Garrey et al., 1981). In fact, all species of Glyphocrangon recorded from the Northwest Shelf are commonly found in Indonesian waters. In contrast, all known species from eastern Australia appears to be endemic. From southern Australia, so far, only Glyphocrangon elephas is known.

Etymology
From the Latin elephas (elephant), in reference to the elephant nose-like rostrum with strongly sinuous dorsolateral margins. It is used as a noun in apposition.

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I am grateful to Diana Jones of the Western Australian Museum for providing material. I also thank Drs. Peter J. F. Davie and Shane T. Ahyong for reviewing the manuscript and offering helpful comments for improvements.

REFERENCES


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The gastrointestinal nematodes of *Varanus rosenbergi* (Reptilia: Varanidae) and the effects of habitat change in southern Australia, with particular reference to the genus *Abbreviata* (Physalopteroidea)

Hugh I. Jones
School of Biomedical and Chemical Sciences, Microbiology, M 502
The University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009
(email: hjones@cyllene.uwa.edu.au)

Abstract – Nine species of nematode were collected from the stomachs of 56 *Varanus rosenbergi* from southern Australia, viz. *Abbreviata anomala*, *A. antarctica*, *A. confusa*, *A. hastaspicula*, *A. levicauda*, *A. tumidocapitis*, *Pseudorictularia disparilis*, *Maxvachonia chabaudi*, and *Ophidascaris pyrrhus*. *A. antarctica* occurred in 93% of lizards. Sixty-two percent of lizards were infected with this species only, and 30% had concurrent infections with from two to five species of *Abbreviata*, *A. levicauda* and *A. hastaspicula* were present at low prevalence in the drier and hotter parts of this host’s range. Intensity of infection with *Abbreviata* nematodes ranged to more than 400 adults, and more than 600 *Abbreviata* spp. larvae. Highest intensity of infection with *A. antarctica* in Western Australia was east of the agricultural areas, and in or close to reserves where the ecosystem was less disturbed. The high prevalence of nematodes in this genus across a wide range of habitat and climate types suggests a prevalent arthropod intermediate host, or a wide range of species of arthropod, which are susceptible to infection.

**Key words:** *Varanus rosenbergi*, *Abbreviata* nematodes, habitat change, Australia.

INTRODUCTION

*Varanus rosenbergi* Mertens, 1957 was recognised as a subspecies of *Varanus gouldii* by Mertens (1957), and was elevated to species status by Storr (1980). It is a large predatory diurnal monitor lizard which occurs in a wide range of habitats in southern Australia south of latitude 30° S, principally in Western Australia and South Australia, with isolated populations in Victoria and New South Wales (Cogger 1992). Several studies have shown that nematodes in the genus *Abbreviata* predominate in *Varanus* lizards in Australia, frequently reaching high intensity and prevalence in larger species (Jones 1983a, 1983b, 1985, 1988). Apart from *V. varius* in southern Victoria, *V. rosenbergi* occurs further south than any other species of *Varanus*. Its range across a number of ecosystems in this southern distribution may throw light on factors which delimit the distribution of its parasites. The present study was therefore undertaken to determine which nematode species *V. rosenbergi* supported, their prevalence, intensity and geographical range, and to examine the external environmental factors which might influence the worms’ occurrence in this host.

MATERIALS AND METHODS

Nematodes were recovered from 56 *Varanus rosenbergi* preserved in the Western Australian Museum (n: 48), the South Australian Museum (n: 4), CSIRO Sustainable Ecosystems, Canberra (n: 3), and one in a private collection. Forty-eight lizards were from Western Australia, seven from South Australia (five of which were collected on Kangaroo Island), and one from the Australian Capital Territory. This study includes findings from 7 previously reported host specimens (Jones 1983a). All worms were cleaned, cleared in chloroacetophenol for examination, and stored in 70% ethanol with 10% glycerine. Specimens have been deposited in the Western Australian Museum, South Australian Museum and CSIRO Sustainable Ecosystems, Canberra. Landsat images provided by the Western Australian Department of Land Information were used to compare nematode occurrence with surface vegetation cover, and meteorological maps were consulted on the Bureau of Meteorology website (www.bom.gov.au).

RESULTS


**Prevalence and intensity** (Table 1). The
Table 1  Adult nematodes recovered from 56 *V. rosenbergi*

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of lizards infected</th>
<th>Prevalence</th>
<th>Intensity (mean, range and SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Abbreviata anomala</em></td>
<td>1</td>
<td>1.8%</td>
<td>9</td>
</tr>
<tr>
<td><em>Abbreviata antarctica</em></td>
<td>52</td>
<td>92.8%</td>
<td>57 (1-341; 67.1)</td>
</tr>
<tr>
<td><em>Abbreviata confusa</em></td>
<td>2</td>
<td>3.6%</td>
<td>6 (4-8)</td>
</tr>
<tr>
<td><em>Abbreviata hastaspicula</em></td>
<td>9</td>
<td>16.1%</td>
<td>14 (10-19; 5.7)</td>
</tr>
<tr>
<td><em>Abbreviata levicauda</em></td>
<td>8</td>
<td>14.3%</td>
<td>28 (1-68; 24.8)</td>
</tr>
<tr>
<td><em>Abbreviata tumidocapitis</em></td>
<td>14</td>
<td>25.0%</td>
<td>6.5 (1-73; 18.8)</td>
</tr>
<tr>
<td><em>Pseudorictularia disparilis</em></td>
<td>1</td>
<td>1.8%</td>
<td>1</td>
</tr>
<tr>
<td><em>Maxvachonia chabaudi</em></td>
<td>1</td>
<td>1.8%</td>
<td>2</td>
</tr>
</tbody>
</table>

predominant species was *A. antarctica*, which was recovered from 93% of lizards. It occurred in 46/48 hosts from Western Australia, (the remaining two lizards having *Abbreviata* spp. larvae only), in numbers ranging from one to 341 per host; the only two lizards without infection of either adult or larval *Abbreviata* spp. were from mainland South Australia and from Kangaroo Island. Sixty-one percent also had larval or immature *Abbreviata* spp. in the stomach lumen, not referable to species, in numbers from 1–606. No larval cysts were seen in the stomach or peritoneal tissues. *A. tumidocapitis* occurred in 14 hosts, *A. hastaspicula* in nine hosts, and *A. levicauda* in eight hosts; these three species were present at lower mean intensity than *A. antarctica*. *A. confusa* was present in two hosts, and *A. anomala*, *P. disparilis*, *M. chabaudi*, and *O. pyrrhus* were each recovered from one host.

Concurrent infections (Table 2). Sixty-two percent of lizards supported a single gastric nematode species, *A. antarctica*. Apart from one *A. confusa*, all eight other nematode species occurred concurrently with *A. antarctica*. Thirty percent supported two or more species. Twelve out of fourteen *A. tumidocapitis* infections also occurred concurrently with *A. hastaspicula* and/or *A. levicauda*, and they were usually present when other worms were at high intensity. All nine infections with *A. hastaspicula* and all eight infections with *A. levicauda* occurred concurrently with one another, and/or with *A. tumidocapitis*. Although there was no correlation between intensity of *A. antarctica* and intensity of infection with other species (p>0.1), the mean intensity of adult *A. antarctica* was higher when there was concurrent infection with one to four other species of *Abbreviata* (80.5 worms; SD 101.3; N:14) than in single-species infections (37.2 worms; SD 39.4; N:31; p = 0.028). The mean

![Figure 1](image-url)  Number of concurrent species of *Abbreviata* occurring in *Varanus rosenbergi* in Western Australia. (L, larval *Abbreviata* sp. only). The specimen east of the area of the map refers to a lizard at Eucla. The area north of the dotted line has an average annual precipitation of <400mm; the dashed line shows the February mean maximum 24°C isotherm. (P: Perth, A: Albany, E: Esperance).
Tables 2 Number of species of *Abbreviata* nematode per host

<table>
<thead>
<tr>
<th>no. of lizards</th>
<th>no. of nematode species</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>37*</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
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<tr>
<td>1</td>
<td>5</td>
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* includes two lizards with larval *Abbreviata* sp. only

number of all adult *Abbreviata* species in mixed infections was 109.6, (N: 13).

**Geographical distribution.** Three species of *Abbreviata*, *A. hastaspicula*, *A. levicauda* and *A. tumidocapitis*, were with one exception absent from the relatively cooler and more humid south-west of Western Australia, occurring principally in the northern parts of the range of *V. rosenbergi*. *A. levicauda* and *A. hastaspicula* occurred inland, in areas with an average annual rainfall of less than 400mm and a mean maximum February temperature in excess of 24°C, Figure 1. *A. tumidocapitis* had a similar distribution, although there were three records near the south coast. The two *A. confusa* records were from Kangaroo Island, South Australia, and near Queanbean in the Australian Capital Territory.

*A. antarctica* occurred throughout the range of *V. rosenbergi*. Intensity was significantly higher in lizards collected in eastern Western Australia, east of latitude 119°E, where in general the vegetation was less disturbed, Figure 2. Lizards from reserves in or west of the Wheatbelt (Cape Naturaliste NP, Stirling Range NP, Lake Magenta NR, Pallarup and Dunn Rocks NR and Dragon Rocks NR) contained 45–341 worms per host (N: 6, mean 138). Lizards collected from around the cities of Perth and Albany and from the intensively cleared areas of the Wheatbelt supported lighter infections, with from one to 24 worms per host (N: 18, mean 9.4).

**DISCUSSION**

*Varanus rosenbergi* supports a considerable gastric nematode fauna throughout its geographical range. Four species of nematode were recovered from one host only, and these were probably accidental infections resulting from ingestion with prey; *Maxvachonia* spp. (*Oxyurata*) occur in the rectum of several species of skinks, geckos and agamid lizards (Mawson 1972), *A. anomala* is found in agamid lizards in the genus *Pogona* (Jones 1986a), and *O. pyrrhus* in snakes (Jones 1980). *P. disparilis* is probably a parasite of amphibians (Owens and Moorhouse 1980). All other nematodes were in the genus *Abbreviata*. *A. antarctica* has been recorded from many species of larger reptile in eastern, southern and northern Australia, but appears to be absent from the hotter drier inland areas of the continent. Prevalence and intensity are greater in this lizard than in any other reptile host so far recorded. In the hotter and drier inland parts of

![Figure 2](image-url)
Western Australia this species is replaced by A. hastaspicula and A. levicauda; the former attain highest numbers in V. gouldii and V. panoptes north of the distribution of V. rosenbergi (Jones, 1983a), whereas A. levicauda, although common in these two host species, occurs predominantly in V. tristis (Jones 1986b). These two nematodes were therefore only recovered from the northern areas of the range of V. rosenbergi, in low numbers. A. tumidocapitis is usually found concurrently with infections of these two species (Jones 1983a). The two records of A. confusa were respectively from Kangaroo Island and from the isolated population of V. rosenbergi in NSW, near Queanbean. This worm has not been reported from southern Western Australia, though it is found in several species of Varanus in the tropical north of this State (Jones 1988).

The intensity of A. antarctica infections within the range of V. rosenbergi was not directly related either to mean precipitation or to temperature. Numbers were highest east of approximately 119°E, where the vegetation is less disturbed. The only records of high intensity (43 to 329 adult worms) in the Southwest were from, or close to, National Parks or Reserves, suggesting that intensity is reduced by European-induced habitat changes. Nature reserves occupy only 2.4% of the wheatbelt (in 1978), and a study of 23 of these reserves found V. gouldii (in which V. rosenbergi was included) in only five of these, of which the smallest with V. gouldii had an area of 272 hectares (Kitchener et al., 1980). Relatively high numbers were recorded from near the towns of Hopetoun and Esperance, around which there has been extensive land clearance, but both satellite images and direct observation (M. Tonts, pers. comm.) show that this eastern agricultural area contains extensive pockets and strips of residual uncleared land, which could act as refugia for both the lizards and their nematodes' intermediate hosts. The observation that A. antarctica numbers were higher in concurrent infections with congeneric species which were near the southern edge of their range than in single-species infections, indicates the complex interplay of climatic and environmental parameters affecting nematode survival and transmission. It is likely that climate has an effect, perhaps indirectly, on survival of nematode eggs, as well as its effect on intermediate hosts. Several biological variables are unknown, including the specificity of the arthropod intermediate hosts required by A. antarctica, the prevalence of smaller lizard paratenic hosts, and the density and home ranges of V. rosenbergi in different habitats, which can be highly variable (King and Green 1999). V. rosenbergi has a varied diet; on Kangaroo Island, arthropods comprise about 35% of the diet by volume, and the majority of vertebrate food is probably obtained from road kills (King and Green 1999). The extent of land clearance in the agricultural areas, clearly shown on satellite images, the habitat perturbation around cities, and the higher vehicle numbers on the roads all have an impact on the ecology of reptile hosts, and therefore on the dynamics of their acquiring infection. Studies on Abbreviata spp. in elapid snakes in Western Australia and on O. pyrrhus and the trematode Dolichopercoids macalpini in Notechis ater near Hobart in Tasmania indicate that lower prevalence or absence may be due to altered environments in these urban areas (Jones 1978, 2003). However, records are too sparse from some areas, and collection sites reported are in some cases not sufficiently precise to link habitat to nematode intensity with more confidence.

The significantly higher mean intensity of A. antarctica in the presence of concurrent infections with one to four congeneric species reflects the low numbers of A. antarctica in the more disturbed ecosystems in the Southwest, from which other species are absent (apart from one anomalous record from Two Peoples Bay east of Albany). A. antarctica itself is absent from the drier and hotter areas further north, beyond the range of V. rosenbergi. The factors affecting the population dynamics and interspecific relations of these species are not yet understood, but the observations reported here suggest that intensity of A. antarctica infection is not adversely affected by competition from other species in this environment. The absence of A. hastaspicula, A. levicauda and A. tumidocapitis in the cooler and more humid areas may be a consequence of the scarcity or absence of suitable intermediate hosts, or by the viability of eggs in the external environment.

**CONCLUSIONS**

V. rosenbergi is heavily infected with species of Abbreviata throughout its range in southern Australia. All but two of the lizards examined were infected, and 26.8% were concurrently infected with three or more species. These results add to previous work in confirming the dominant position of nematodes in the genus Abbreviata in the gastric fauna of varanid lizards in arid Australia. The high prevalence across a range of habitat types suggests either that the arthropod intermediate hosts are equally widespread, or that they have a low host-specificity and that many species are involved. However, the lower intensity of A. antarctica in those areas where there has been extensive clearing of natural vegetation suggests diminished transmission, and indicates that the nematode parasites are affected by these profound changes to the ecosystem. The patterns of infection in this lizard would be clarified by knowledge of the arthropod intermediate hosts.
ACKNOWLEDGEMENTS

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REFERENCES


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The wolf spider genus *Artoria* Thorell in Australia: new synonymies and generic transfers (Araneae, Lycosidae)

Volker W. Framenau

Department of Terrestrial Invertebrates, Western Australian Museum, Locked Bag 49, Welshpool D.C., Western Australia 6986, Australia

Abstract – The Australian wolf spider species *Artoria albopilata* (Urquhart, 1893), comb. nov., *Artoria gloriosa* (Rainbow, 1920), comb. nov., and *Artoria impedita* (Simon, 1909), comb. nov. are redescribed and the male of *Artoria cingulipes* Simon, 1909 and the female of *Artoria parvula* (Thorell, 1877) are illustrated for the first time. *Artoria versicolor* (L. Koch, 1877), *Lycosa ambrymiana* Berland, 1938 and *Lycosa naeviella* (Roewer, 1951) are considered junior synonyms of *Artoria berenice* (L. Koch, 1877), comb. nov. Based on the original species description, *Artoria pruinosa* (L. Koch, 1877), comb. nov. is transferred from *Dinogosa Roewer, 1955.*

*Artoria parvula* is recorded from Australia for the first time and updated distribution maps with considerable range extensions are provided for most other Australian species of *Artoria* (A. albopilatipes Framenau, 2002; *A. alta* Framenau, 2004; A. *avona* Framenau, 2002; *A. flavimana* Simon, 1909; *A. hewquaenensis* Framenau, 2002; *A. linearata* (L. Koch, 1877); A. *nickayi* Framenau, 2002; A. *quadra* Framenau, 2002; *A. triangularis* Framenau, 2002; *A. urichi*, Framenau, 2002.

INTRODUCTION

The wolf spider genus *Artoria* Thorell, 1877 currently includes 13 Australian species (Framenau, 2002; 2004). The genus appears to be widespread in south-east Asia and the Australasian region with probably more than 80 undescribed species in Australia alone (Framenau 2002). Vink (2002) recently recorded three new species from New Zealand. The palpal morphology of *Artoria* is unique within the Lycosidae, and a preliminary molecular analysis suggests that this genus forms a monophyletic clade with *Anoteropsis* Koch, 1877 and *Notocosa* Vink, 2002 (Vink et al., 2002). This is consistent with morphological evidence, in particular the presence of a unique basoembolic apophysis on the male pedipalp, a putative synapomorphy for this group. *Artoria*, as well as *Anoteropsis* and *Notocosa*, do not fit in any of the current wolf spider subfamilies defined by Dondale (1986), Alderweireldt and Jocqué (1993) or Zyuzin (1985, 1993).

Ludwig Koch (1876, 1877, 1878) described 13 Australian species of wolf spiders based or partly based on material from what is known as the Bradley Collection. Three of these species conform to the definition of the genus *Artoria* and are included here: *A. pruinosa* (L. Koch, 1877), comb. nov., *A. berenice* (L. Koch, 1877), comb. nov., and *A. versicolor* (L. Koch, 1877) (revised in Framenau 2002) and here considered a junior synonym of *A. berenice*. There has been some speculation about the whereabouts of Bradley’s Collection. None of its material could be located at the Natural History Museum, London, the Museum für Naturkunde, Zentralinstitut der Humboldt-Universität, Berlin, or the Zoologisches Institut und Zoologisches Museum, Universität Hamburg, where most of L. Koch’s material is housed. A previous assumption that some spiders lodged in the Macleay Museum, University of Sydney, was part of the original Bradley Collection, could not be confirmed after a visit to this museum (personal observation). Some of L. Koch’s material, presumably including at least part of the Bradley Collection, had been transferred to the Museum of Breslau (today Wroclaw, Poland) before the Second World War (e.g., Baehr and Baehr 1987, p. 384). However, a recent list of L. Koch’s spider material that survived the total destruction of Wroclaw during WWII does not include any of the species that were described from the Bradley Collection (W. Wesolowska, personal communication). With no evidence of the whereabouts of this collection, I consider all wolf spider types from this collection lost.

As part of a revision of the wolf spiders of Australia, the main purposes of this study are to rectify the generic placement of all currently misplaced known Australian species of *Artoria*, to describe unknown sexes of species considered in Framenau (2002), and to expand the distribution maps of currently known species based on my database of more than 15,000 records (over 40,000 specimens examined) of wolf spiders lodged in Australian and overseas institutions. This
complements a previous review of the genus *Artoria* that focused on species represented in a wolf spider study of floodplains in the Victorian Alps (Framenau, 2002; Framenau et al., 2002).

*Artoria* now includes 22 species as follows:

A. *albopilotalis* Framenau, 2002  
A. *albopilata* (Urquhart, 1893), comb. nov.  
A. *alta* Framenau, 2004  

(only male known)  
A. *avonsa* Framenau, 2002  
A. *berenice* (L. Koch, 1877)  

Australia  
A. *cingulipes* Simon, 1909  
A. *flavimana* Simon, 1909  
A. *gloriosa* (Rainbow, 1920), comb. nov.  
A. *hospita* Vink, 2002  
A. *huangquaensis* Framenau, 2002  
A. *impepida* (Simon, 1909), comb. nov.  
A. *lineata* (L. Koch, 1877)  
A. *mckayi* Framenau, 2002  
A. *palustris* (Dahl, 1908)  

New Zealand  
A. *paraula* Thorell, 1877  
A. *praemorsa* (L. Koch, 1877), comb. nov.  
A. *quadritarsis* Framenau, 2002  
A. *segrega* Vink, 2002  
A. *separata* Vink, 2002  
A. *taeniifera* Simon, 1909  

(only female known)  
A. *triangularis* Framenau, 2002  
A. *uichii* Framenau, 2002  

Platnick (2004) listed a further three species (A. *amoenia* (Roewer, 1960), A. *maculatipes* (Roewer, 1960) and A. *lycosimorpha* Strand, 1909, from Africa), however, these generic placements are incorrect or doubtful based on Roewer’s (1960) original descriptions and illustrations (Framenau, 2002).

**MATERIAL AND METHODS**

Descriptions are based on specimens preserved in 70% EtOH. Internal female genitalia were prepared for examination by submersion in lactic acid at room temperature for 2hrs. For clarity, the setae have been omitted from the illustrations of epigyna and male pedipalps. The morphological nomenclature follows Framenau (2002). All type material was examined unless otherwise stated. All measurements are in millimeters (mm).

**Abbreviations**

Measurements (adult spiders, if not otherwise stated): total length (TL), carapace length (CL) and width (CW), abdomen length (AL) and width (AW).

Eyes: anterior (AE), anterior median (AME), anterior lateral (ALE), posterior (PE), posterior median (PME), posterior lateral (PLE).

**Australian States and Territories**: Australian Capital Territory (ACT), New South Wales (NSW), Northern Territory (NT), Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic), Western Australia (WA).

**Collections**: Australian Museum, Sydney (AM); Australian National Insect Collection, Canberra (ANIC); Natural History Museum, London (BMNH); International Rice Research Institute, Entomology Division, Manila (IRRI); Macleay Museum, University of Sydney (MMUS); Muséum National d’Histoire Naturelle, Paris (MNHN); Muséum National d’Histoire Naturelle, Telyes (France) (MNHT); Museo Civico di Storia Naturale ‘Giacomo Doria’, Genova (Italy) (MSNG); Museum Victoria, Melbourne (MV); Museum and Art Gallery of the Northern Territory, Darwin (NTMAG); Queensland Museum, Brisbane (QM); Queen Victoria Museum and Art Gallery, Launceston (QVMAG); South Australian Museum, Adelaide (SAM); Tasmanian Museum and Art Gallery, Hobart (TMAG); Western Australian Museum, Perth (WAM); Museum für Naturkunde, Zentralinstitut der Humboldt-Universität, Berlin (ZMB); Zoologisches Institut und Zoologisches Museum, Universität Hamburg (ZMH).

**SYSTEMATICS**

Family *Lycosidae* Sundevall, 1833

*Artoria* Thorell, 1877

*Artoria albopilata* (Urquhart, 1893), comb. nov.  
(Figures 1A–E, 2)


**Types**

**Syntypes** of *Lycosa albo-pilata* Urquhart, 1893: Male and female, Tasmania (no exact location). Types considered lost. Not examined.

**Syntype** female of *Lycosa expolita* L. Koch, 1877, Queensland, Brisbane, 27°28’S, 153°01’E, MHNT AR0825 (misidentification). Examined.

**Other Material Examined**

Australian Capital Territory: 4 males, Blundells Creek, 3km E of Picadilly Circus, 35°22’S, 148°50’E, December 1984, T. Weir, J. Lawrence, M.-L. Johnson, 850m (ANIC); 4 males, 1 female, same location, January 1985, T. Weir, J. Lawrence, Dressler, 850m (ANIC); 7 males, Tidbinbilla Nature Reserve, 35°28’S, 148°52’E, 9 March 1978, pitfall trap, P. Ormay, PO ref site 11, 2408m (AM KS13830); 7 males, same data, PO ref site 12, 2409m (AM KS13873). New South Wales: 1 female, Badja
State Forest, Badja Fire Trail, 36°07'30"S, 149°31'37"E, 13 March 1999, pitfall trap, J. Tarnawski, S. Lassau, CBCR003-028, SE Forests Survey, site 2 (AM KS64405); 1 male, Badja State Forest, Peters Road, 36°08'52"S, 149°32'09"E, 13 March 1999, pitfall trap, J. Tarnawski, S. Lassau, CBCR003-029, SE Forests Survey (AM KS64401); 1 male, Badja State Forest, Polly's Gully Road, 36°06'39"S, 149°28'26"E, 14 March 1999, pitfall trap, L. Wilkie, R. Harris, H. Smith, CBCR003-095, SE Forests Survey (AM KS64394); 4 females, Badja State Forest, Rocky Range Fire Trail, 36°03'21"S, 149°28'29"E, 14 March 1999, pitfall trap, J. Tarnawski, S. Lassau, CBCR003-031, SE Forests Survey (AM KS64407); 1 male, Badja State Forest, Tuross River Road, 36°12'31"S, 149°30'07"E, 13 March 1999, pitfall trap, L. Wilkie, R. Harris, H. Smith, CBCR003-091, SE Forests Survey, site 2 (AM KS64402); 1 male, Badja State Forest, Wiola Creek Fire Trail, 36°05'24"S, 149°34'51"E, 13 March 1999, pitfall trap, J. Tarnawski, S. Lassau, CBCR003-026, SE Forests Survey, site 3 (AM KS86409); 4 females, 2 juv., Beauty State Forest, SW end of Rock Waterhole Road, 28°33'S, 152°19'E, 4 February – 9 April 1993, M. Gray, G. Cassis, 01CG, 530m (AM KS36135); 1 male, Beauty State Forest, Tooloom Scrub, 28°35'S, 152°22'E, 12 December 1988, pitfall trap, Smith, Hines, Pugh, Webber, Focal Peak Survey U.N.E., T6, road in dry rainforest, sheltered slope, 600–900m (AM KS50956); 1 male, same data, T 8, Hoop Pine plantation, sheltered slope, 600–900m (AM KS51276); 4 males, 1 juv., Bondi State Forest, 37°08'S, 149°09'E, 25 October – 28 November 1980, Woodlot (Woodlot material) (AM KS45437); 1 female, same data 4 July 1980, 28 November 1980, 7 January 1981, Woodlot (Woodlot material) (AM KS45438); 38 males, 8 females, 1 female with eggsac, 5 juv., Bondi State Forest, S of Bombala, 37°08'S, 149°09'E, 26 January 1981, G. Gowing et al., WL 1, Div 1–7, 10, litter, open eucalypt forest (AM KS12046, KS12061, KS12066, KS12084, KS12095, KS12110, KS12114, KS12123, KS12128, KS12140); 2 males, 3 females, 2 juv., same data, 6 May 1980, WL 1, Div 5–7, 10, litter, open eucalypt forest (AM KS12153, KS12158, KS12198, KS12215); 3 males, 5 females, 4 juv., Bondi State Forest, S of Bombala, Woodlot 1, 37°08'S, 149°09'E, 1 July 1981, G. Gowing et al., WL 1, Div 5, 7, 10, litter, open forest (AM AM KS11440, KS11478-9, KS11489, KS11588, KS11592); 206 males, 22 females, 19 juv., same data, 14 November 1980, WL 1, Div 2–10 eucalypt litter (AM KS11526, KS11531, KS11549, KS11559, KS11576, KS11587, KS11597, KS11610, KS11622, KS11636, KS11661, KS11709, KS11720, KS11742, KS11752, KS11761, KS11772, KS11784, KS11799, KS11802, KS11807, KS11814, KS11824, KS11833, KS11842, KS11856, KS11864, KS11878, KS11892, KS11903, KS11914, KS11999, KS12007, KS12025); 4 males, same data, 15 October 1980, WL 1, Div 8, litter, open forest (AM KS11334); 1 male, same data, 25 October 1980, WL 1 reference collection, WL 1, Div 8, litter, open forest (AM KS18064); 6 males, same data, 25 October 1980, WL 1, Div 7, 10 (AM KS15201-2); 1 female, Bondi State Forest, S of Bombala, Woodlot 1, 37°08'S, 149°09'E, 31 December 1979, pitfall trap, G. Gowing et al., WL 1 reference collection, WL 1, Div 8, litter, open forest (AM KS18065); 4 females, same data, 31 March 1981, G. Gowing et al., WL 1, Div 2, 4, litter, open eucalypt forest (AM KS11406; KS11424); 3 males, Bondi State Forest, Woodlot 2, 37°07'S, 149°08'E, 28 November 1980, G. Gowing et al., WL2-PAUC 6, 7, 9 (AM KS69145, KS69154, KS69169); 1 male, same data, 28 October 1980, PAUC 9 (AM KS70268); 16 males, 2 females, same data, 31 December 1979, PAUC 5 (AM KS70203); 1 female, Boonoo State Forest, Boonoo Forest Drive, 1.8km from Mt Lindesay Hwy, 28°56'S, 152°06'E, 8 February – 9 April 1993, M. Gray, G. Cassis, 09CG, 163A, 1060m (AM KS70001); 1 male, Cherry Tree North State Forest, 28°58'S, 152°15'E, 17 December 1988, pitfall trap, Smith, Hines, Pugh, Webber, Focal Peak Survey U.N.E., CT 4, dry rainforest, exposed slope, 300m (AM KS68191); 6 males, same data, CT 9, >300m (AM KS63740); 40 males, 1 female, Coolangubra State Forest, near Waratach Creek, 37°01'S, 149°23'E, January 1984, pitfall trap, G. A. Webb, Plot 1314, 2/8/1 (RTU 12) (AM KS79632); 45 males, 3 females, same data, Plot 1314, 1/4/2 (RTU 12) (AM KS79631); 2 females, Kangaroo Creek State Forest, 1.5km along Burns Road from junction with Kangaroo Creek Road, 30°04'S, 152°52'E, 4 February – 9 April 1993, M. Gray, G. Cassis, 64CR, 430m (AM KS39730); 1 female, Kosciusko National Park, Bogong Creek and Alpine Way, 36°12'S, 148°19'E, 28 November 1994, pans, D. Bicke, wet sclerophyll, 500m (AM KS45823); 1 female, Mt Keira Fauna Reserve, Cave Camp, 34°24'S, 150°51'E, 23 November – 20 December 1978, pitfall trap, C. Horsemann, new series trap 3, 1220m (AM KS2213); 1 male, Shooters Hill, 33°54'S, 149°52'E, 5 July 1975, M. R. Gray (AM KS45150); 1 female, Spirabo State Forest, 0.5km N 3-way intersection, near Five Bull Creek, 29°18'S, 152°06'E, 6 February – 9 April 1993, M. Gray, G. Cassis, 45CG, 1070m (AM KS69681); 3 females, Styx River State Forest, bottom end of Cliffs trail, ca. 1.3km from Oxley Road, 30°33'54"S, 152°20'50"E, 4 February – 9 April 1993, M. Gray, G. Cassis, NE NSW NPWS Survey, 33BR, 1080m (AM KS35651); 1 female, Tallaganda State Forest, Rocky Pic Road, 35°36'46"S, 149°29'52"E, 15 March 1999, pitfall trap, J. Tarnawski, S. Lassau, CBCR003-035, SE Forests Survey, site 2 (AM KS64404); 1 female, same data, CBCR003-036, site 3 (AM KS64406). Queensland: 1 female, Blackbutt Range summit, 5km E Benarkin, 26°52'S, 152°11'E, 24 October – 24 November 1995, pitfall trap, G. Monteith, rainforest (QM S43821); 4 males, 2 females, 1 juv., Boat

South Australia: 13 males, 2 females, Cleland National Park, Wine Shanty Track, 34°57′S, 138°42′E, 28 November – 5 December 1994, pitfall trap, E. G. Matthews, J. A. Forrest (SAM NN13309-23); 3 males, 1 female, Eurolla Conservation Park, 0.7km SE Mt Lofty, 34°58′47″S, 138°42′45″E, 26 November – 1 December 2000, pitfall trap, Sthn Mt Lofty Ranges Survey, ADE021 (SAM NN13332-5); 1 female, Fleurieu Peninsula (no exact location), February – March 2000, pitfall trap, Sthn Mt Lofty Ranges Survey (SAM NN13331); 1 male, Loftia Park, heathfield off Evans Drive, 35°02′S, 138°42′E, 28 November – 5 December 1994, pitfall trap, E. G. Matthews, J. A. Forrest (SAM NN13308); 1 male, Scott Creek Conservation Park, MacKeath Creek, 35°06′S, 138°42′E, 1993, pitfall trap, T. Herbert (SAM NN13307); 3 males, Parawa, 2km WSW, 35°33′01″S, 138°22′08″E, 6 – 10 March 1997, pitfall trap, SEG Fleurieu Survey, TOR001 (SAM NN13327-9); 1 male, Parawa, 5km ENE, 35°32′22″S, 138°24′24″E, 4 – 10 December 1996, pitfall trap, Fleurieu Swamps Survey, TOR00801 (SAM NN13337); 1 male, Penneshaw P.O, 8km SE, Kangaroo Island, 35°47′15″S, 137°58′01″E, 5 – 10 November 1990, pitfall trap, KI Survey (#77) (SAM NN13336); 1 female, Rocky River Headquarter, Flinders Chase National Park, Kangaroo Island, 35°57′00″S, 136°42′30″E, 1 December 1982, B. Guerin et al., in ground litter (SAM NN13286); 5 males, 2 females, same location, 7 – 8 November 1987, pitfall trap, D. Hirst (SAM NN13287-93); 1 female, Spring Mount, 1.5km WSW, Mt Lofty Ranges, 35°26′53″S, 138°31′36″E, 20 – 25 February 2000, Sthn Mt Lofty Ranges Survey, W1L02601 (SAM NN13330); 4 males, 4 females, 2 juv., Waterfall Creek, Western River Conservation Park, Kangaroo Island, 35°42′S, 136°54′E, 3 – 4 November 1987, pitfall trap, D. Hirst (SAM NN13299-306); 3 males, 2 females, 1 juv., same location, 3 November 1987, D. Hirst, in leaf litter (SAM NN13294-8).
males, Lilydale, Merthyr Park, 41°14'S, 147°11'E, 3 November 1998, pitfall trap, T. J. Kingston et al., PF 16 (QVMAG 13:44923); 1 female, Little Donaldson River, 41°23'01''S, 145°13'13''E, 24 January 1987, N. Weston, ANZSES, riparian rainforest, litter, 330m (QM S51044); 1 male, Maggs Mountain, 41°45'S, 146°11'E, 8 October 1979, R. H. Green, comp. 2 turn off (QVMAG 13:44335); 2 males, same location, 11 February 1997, pitfall trap, R. H. Green, Forestry Tasmania donation, site A (QVMAG 13:44434); 1 male, same location, 25 November 1986, pitfall trap, R. H. Green, site A (QVMAG 13:44433); 1 female, same location, 17 February 1981, pitfall trap, R. H. Green, Forestry Tasmania donation, site C (QVMAG 13:44344); 1 female, same location, 26 November 1987, R. H. Green, site E (QVMAG 13:42753); 2 females, same location, 20 February 1989, pitfall trap, R. H. Green, site F (QVMAG 13:44332); 1 male, Maggs Mountain Road, 41°45'S, 146°11'E, 3 March 1979, R. H. Green, wet sclerophyll (QVMAG 13:44326); 1 male, 1 female, Maggs Mountain, 5km up road from Field Station, 41°45'S, 146°09'E, 4 February 1980, R. H. Green (QVMAG 13:44328); 1 male, Maggs Mountain, W of Field Station, 41°45'S, 146°09'E, 4 February 1980, R. H. Green (QVMAG 13:42754); 2 males, 1 female, same location, 6 November 1979, R. H. Green (QVMAG 13:42757); 9 males, 2 females, Maggs Mountain, 500m W of hut, 41°45'S, 146°09'E, 3 March 1979, R. H. Green, dry sclerophyll (QVMAG 13:42752); 2 females, Mount Bertha, 41°22'46''S, 145°13'39''E, 1 January 1997, N. Weston, ANZSES, temperate rainforest, 350m (QM S50813); 14 males, 2 females, Peters Link Road, 20km E of site A, 41°09'S, 148°08'E, 1 November 1993, P. Cranston, J. Trueman, site B (QM S18985); 1 male, Port Sorell, Squeaking Point, 41°11'S, 146°34'E, 29 March 1995, T. Kingston et al., DQ632 398, 10m (QVMAG 13:42784); 1 male, 2 females, Rosebery, Snake Gully, 41°47'S, 145°33'E, 2 December 1997, L. J. Boutin, mixed forest, under rock (QVMAG 13:24073); 1 male, St Mary's, off German Town Road, 41°34'S, 148°11'E, 8 December 1999, L. J. Boutin, under rock (QVMAG 13:44346); 1 female, 1 juv., Strathgordon Caravan Camp, campsite, 42°40'0S, 146°02'E, 24 January 1987, R. Raven, J. Gallon (QM S5748); 1 female, Warra, 43°04'S, 146°43'E, December 1997, D. Bashford, Forestry Tasmania donation, on ground (QVMAG 13:44340); 1 male, Warra, 43°04'S, 146°43'E, December 1997, pitfall trap, D. Bashford, Forestry Tasmania donation, on ground at areas (QVMAG 13:44342); 1 male, Warra Forest, near Geeveston, 43°10'S, 146°54'E, 29 November 2001, beating, L. J. Boutin, control site #C, under bark, by hand at night (QVMAG 13:44339); 2 males, same location and date, 29 November 2001, by hand, on ground, 10am (QVMAG 13:44338); 1 male, Yorktown, Yorktown Road, 41°09'S, 146°46'E, 24 April 1972, R. Upson (QVMAG 13:42311); Victoria: 2 males, 2 females, 2 juv., Cheniston, Macedon, 37°25'S, 144°34'E, no date, H. R. Hogg collection, listed as "Lycosa berenice (?)" by Hogg (1900) (BMNH 1924.3.1.1008-13); 1 female, Forrest, 3km N of, 28°30'S, 143°43'E, 8 March 1986, M. S. Harvey, B. J. Scott (WAM T55319); 1 male, 3 juv., Omeo Hwy, 52km N of Omeo, 37°46'E, 147°42'E, 13 April 1978, M. R. Gray, logs, 1094m (AM KS45362); 1 female, Starling Gap, 37°48'52''S, 145°48'04''E, 2 January 2004, V. W. Framenau, M. L. and J. Thomas (WAM T56088); 15 males, Upper Yarra Region, 11.0km NE McMahon Creek, 37°39'S, 145°56'E, 14 – 24 November 1988, L. Lumsden, DCE Upper Yarra Survey, site 6 (MV K7739); 1 male, Upper Yarra Region, 11.3km ENE McMahon Creek, 37°40’S, 145°57'E, 14 – 24 November 1988, L. Lumsden, DCE Upper Yarra Survey, site 7 (MV K7737); 47 males, 4 females, Upper Yarra Region, 11.4km ENE McMahon Creek, 37°41'S, 145°57'E, 14 – 24 November 1988, L. Lumsden, DCE Upper Yarra Survey, site 8 (MV K7738); 5 males, 1 female, Upper Yarra Region, 9.2km NW Toorongo, 37°44'S, 146°02'E, 14 – 24 November 1988, L. Lumsden, DCE Upper Yarra Survey, site 1 (MV K7736).

**Diagnosis**

*Artoria albopilata* is very similar to *A. gloriosa* from Lord Howe Island. Males differ in the shape of the median apophysis, which ends in three lobes in *A. albopilata* but only two tips in *A. gloriosa*. In addition, the tip of the embolus is sharp and sickle-shaped in *A. albopilata*, but broad and blunt in *A. gloriosa*. Females differ in the shape of the epigyne, in particular the anterior border, which is semicircular in *A. albopilata*, but undulating in *A. gloriosa*. In addition, the median septum fills the atrium in *A. albopilata*, but is truncated anteriorly in *A. gloriosa*.

**Description**

*Male* (based on QVMAG 13:44346). Carapace: Dark brown, head and posterior flanks distinctly darker; distinct light brown median band, anteriorly as wide as PLE but gradually narrowing towards posterior margin; wide light brown submarginal bands; indistinct dark grey radial pattern; carapace covered with black setae, dense white setae in head region and on median band, less dense white setae in submarginal band; black bristles between and lateral of eyes, one long brown bristle between AME, two long brown bristles below AE. *Sternum*: Dark brown; black bristles increasing in length towards margins; few shorter white setae. *Labium*: Dark brown; front end truncate and white. *Chelicerae*: Dark brown, basally lighter; sparsely covered with black setae and white setae in basal half; three retromarginal teeth, with the basal shortest; three promarginal teeth, with the middle largest. *Pedipalp* (Figures 1A–C): Cymbium tip with approx. twelve macrosetae and some scopuloss
setae dorsally; median apophysis ending in three lobes, of which the lateral ones are folded ventrally, median apophysis with a longitudinal ridge in basal half that has two shark tooth-like tips; embolus ending in a sharp, sickle-shaped tip (Figure 1C). Abdomen: Dark olive grey and covered with whitish and longer black setae; light heart mark in anterior half very distinct through a dense layer of white setae; heart mark constricted and narrow in posterior half; black patches laterally at base of heart mark, at its constriction and its posterior end; yellow patches lateral of heart mark near its base behind black patches; venter brown, lateral borders a light brown dotted line, two indistinct longitudinal yellow stripes in anterior half; covered with whitish and brown setae; spinnerets yellow with brown pigmentation. Legs: Leg formula IV > I > II > III; dark brown, with indistinct darker annulations; spination of leg I: Femur: 3 dorsal, 1 (small) retrolateral, 1 apicoprolateral, 1 apicoventral, 1 apicoventral. Patella: 1 dorsal in basal half; Tibia: 3 ventral pairs, 2 prolateral, 2 retrolateral; Metatarsus: 3 ventral pairs, 2 prolateral, 1 retrolateral, 1 apicoventral, 1 apicoventral, 1 apicoventral.

Female (based on QVMAG 13:44336). Carapace: As male, generally lighter. Sternum, labium and chelicerae: as male. Epigyne (Figures 1D, E): Ventral view: simple atrium with semicircular anterior border and yellow median septum that fills out the whole atrium (Figure 1D); dorsal view: indistinct spermathecae at the end of thick copulatory ducts that are directed anteriomedially (Figure 1E). Abdomen: As male, but generally lighter and therefore black patches more distinct; four additional black patches in posterior half; venter as
male but lighter (light brown); all spinnerets yellow.

Legs: Leg formula IV > I > II > III; light brown, very distinct dark annulations; spination of leg I: Femur: 3 dorsal, 1 (small) retrolateral, 1 apicoprolateral, 1 apicoretrolateral; patella: 1 dorsal in basal half; tibia: 3 ventral pairs, 1 prolateral; metatarsus: 3 ventral pairs, 2 prolateral, 1 retrolateral, 1 apicoprolateral, 1 apicoretrolateral, 1 apicoventral.

Measurements. Male QVMAG 13:44346 (female QVMAG 13:44336): TL 4.65 (5.55), CL 2.7 (3.0), CW 1.95 (2.1). Eyes: AME 0.07 (0.07), ALE 0.07 (0.09), PME 0.23 (0.26), PLE 0.17 (0.20). Row of eyes: AE 0.52 (0.57), PME 0.67 (0.76), PLE 0.84 (1.02). Sternum (length/width) 1.58/1.05 (1.28/1.05). Labium (length/width) 0.32/0.32 (0.46/0.46). AL 1.95 (2.85), AW 1.35 (2.1). Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 0.92+0.80+ - +0.94 = 2.66, I 1.80+2.26+1.54+0.94 = 6.54, II 1.75+2.17+1.52+0.82 = 6.27, III 1.75+1.97+1.69+0.82 = 6.23, IV 2.26+2.77+2.57+1.12 = 8.72 (Pedipalp 1.00+1.00+ - +0.80 = 2.80, I 1.77+2.20+1.37+0.92 = 6.26, II 1.72+2.00+1.40+0.89 = 6.21, III 1.72+2.03+1.60+0.83 = 6.18, IV 2.17+2.80+2.52+1.14 = 8.63).

Variation. Males (females) (range, mean ± s.d.): TL 4.05 – 6.00, 4.77 ± 0.53; n = 21; CL 2.25 – 2.85, 2.54 ± 0.17; n = 21; CW 1.65 – 2.1, 1.86 ± 0.13; n = 21 (TL 4.35 – 7.65, 6.11 ± 0.83, n = 18; CL 2.55 – 3.60, 3.07 ± 0.24, n = 20; CW 1.88 – 2.55, 2.24 ± 0.19; n = 20).

Remarks

The type material of *A. albopilata*, as others of Urquhart's types, must be considered lost (Forster 1967, Court and Forster 1988, Cor Vink personal communication), however, Urquhart (1893) provided a very accurate description of both the male and the female of this species. The combination of characters described clearly identify this species as an *Artoria*. I have examined both Tasmanian museum collections (TMAG, QVMAG) in which ca. 20 species of *Artoria* are represented. Urquhart's (1893) description of male and female, including a detailed account of the genitalia, clearly identifies the species illustrated here. *Artoria albopilata* conforms to the generic definition of *Artoria* given in Framenau (2002), in particular due to the presence of a strong basoembolic apophysis on the male pedipalp and is consequently transferred from *Lycosa*.

L. Koch (1877) described *Trochosa expolita* (L. Koch, 1877) from three females on loan from the MHNT, and a male on loan from Eugène Simon. Recent investigations of the material deposited in the MHNT provided a vial with a single female of *A. albopilata* (MHNT AR0825), clearly labeled 'Lycosa expolita' from Brisbane. This female, presumably a syntype of *T. expolita*, was therefore misidentified. The revision of a new Australian lycosid genus that includes *T. expolita* (and the
designated as a lectotype series for this species) is subject of a forthcoming paper as part of the current revision of the wolf spiders of Australia.

**Distribution**

South-eastern mainland Australia (NSW, Qld, Vic, SA) and Tasmania (Figure 2).

_Artoria berenice_ (L. Koch, 1877), **comb. nov.**

Figures 3, 4


_Lycosa naevia_ L. Koch, 1878: 79–80, plate 85, Figures 5, 5A (preoccupied by _Lycosa naevia_ L. Koch, 1875; = _Pardosa naevia_ (L. Koch, 1875)).—Rainbow, 1911: 270. **New synonymy.**

_Lycosa berenice_ (?) L. Koch.—Hogg, 1900: 77. (Question mark in brackets in original citation.)

_Lycosa ambrymiana_ Berland, 1938: 184-185, figures 153-156.—Roewer, 1955: 271. **New synonymy.**

_Lycosa ambrymiana_ Berland, 1932.—Bonnet, 1957: 2633 (date misquotation).

_Tarentula naeviella_ Roewer, 1951: 442 (replacement name for _Lycosa naevia_).

_Avicosa berenice_ (L. Koch).—Roewer, 1955: 236.


_Schizocosa berenice_ (L. Koch).—McKay, 1973: 381.


**Types**

_Holotype_ female of _Lycosa berenice_ L. Koch, 1877: no locality given, Bradley Collection, considered lost. Not examined.

_Syntypes_ of _Pardosa versicolor_, unknown number of male and female specimens, Sydney, New South Wales, 33°53'S, 151°13' E, Bradley Collection, considered lost (contra Framenau, 2002). Not examined.


_Holotype_ female of _Lycosa ambrymiana_ Berland, 1938: Mont Marum, Ambrym, Vanuatu, 16°15'S, 168°07'E, 9 January 1936, Aubert de la Ruë, 900m (MNHP). Not examined.

_Altotype_ male of _Lycosa ambrymiana_ Berland, 1938, data as holotype (MNHP). Not examined.

**Remarks**

_Lycosa berenice_ L. Koch, 1877 was described from the Bradley Collection and the female holotype, similar to the holotype of _A. pruinosas_, must be considered lost. However, the original species description and illustrations of _L. berenice_ strongly suggest a synonymy with _A. versicolor_ which was redescribed in detail by Framenau (2002). The body colouration of both species is very similar and uncommon within _Artoria_. The epigyne of _L. berenice_ varies somewhat from that of _A. versicolor_ in that it is comparatively shorter and its lateral borders touch each other anteriorly. However, the examination of a large number of specimens in Australian collections revealed this to be a common variation of this species. Therefore, _L. berenice_ is here transferred from _Schizocosa_ to _Artoria_ and considered a junior synonym of _A. versicolor_.

Likewise, the external and internal (visible through the cuticle of the specimen) genitalia of the holotype of _Lycosa naeviella_ Roewer, 1951 (replacement name for _L. naevia_ L. Koch, 1878) (Figure 3) conform to the genitalia of _A. berenice_, with the exception of a minute incision at its posterior rim. This variation caused L. Koch (1877) to treat _L. naeviella_ as a separate species, however, this incision also represents a common variation in this species. Therefore, _L. naeviella_ must be considered a junior synonym of _A. berenice_.

An assessment of the original description of _Lycosa ambrymiana_ Berland, 1938 from Vanuatu suggested very close affinities of this species with _A. berenice_. Therefore, the holotype female and...
allotype male were requested from the MNHP, however, the material received contained only non-type material (3 females, 1 male and 9 juveniles) from the type series of this species (Berland 1938). Despite the unavailability of the types, there is no doubt that these specimens represent the same species as the types. There are no genitalic or somatic differences between these spiders and *A. berenice* from Australia. Therefore *L. ambrymiana* must be considered a junior synonym of *A. berenice*.

As with *A. berenice*, *A. versicolor* was originally described from material from the Bradley Collection. Framenau (2002) listed syntypes lodged at the MUUS, where parts of the Bradley Collection were believed to be housed. However, a more detailed investigation of the MMUS revealed that the specimens present there do not belong to the Bradley Collection. In particular, none of the specimen vials included any of the typical framed species labels in L. Koch’s handwriting. Therefore, Framenau’s (2002) designation of the type material must be regarded as erroneous and the syntypes of *A. versicolor* considered lost.

**Distribution**

Common in forest litter in south-eastern mainland Australia (NSW, Qld, Vic), and Tasmania (Figure 4); also in New Caledonia and Vanuatu.

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**Artoria cingulipes** Simon, 1909

*Figures 5A–E, 6*


**Type**

*Holotype female of Artoria cingulipes* Simon, 1909: Collie, Western Australia, 33°21’S, 116°09’E, W. Michaelsen, R. Hartmeyer ('Hamburger südwest- australische Expedition'), Station 137 (Michaelsen and Hartmeyer (1907), from German: '26 August 1905, mountain forest, alt. 185m, Darling Ranges'), ZMB 10547. Examined.

**Other material examined**

*South Australia*: 1 female, Arltunga Homestead, 1.4km SSW, 36°20’34”S, 140°57’28”E, 11 – 13 December 1995, pitfall trap, Box Bulloak Survey, BBG01801 (SAM NN13228); 1 female, Bald Hill, NW of Tod River Reservoir, Koppio Hills, 34°29’30”S, 135°46’00”E, 26 March 1987, D. C. Lee, D. Hirst, near creek (SAM NN13225); 1 male, Cape Borda Cemetery, 4.3km SE, Flinders Chase National Park, 17 February 1991, D. Hirst (SAM NN13224).
Park, Kangaroo Island, 35°46'57"S, 136°37'21"E, 22 – 26 October 1990, pitfall trap, KI Survey (#86) (SAM NN13179); 1 male, Cape Gantheaume, 1km N Tinline, Kangaroo Island, 35°59'S, 137°37'E, 10 – 11 November 1987, pitfall trap, D. Hirst (SAM NN13186); 2 males, Dudley Conservation Park, 13.6km SW Penneshaw P.O., Kangaroo Island, 35°49'22"S, 137°51'32"E, 4 – 9 November 1990, pitfall trap, KI Survey DU00701 (SAM NN13177-8); 5 females, Dudley Conservation Park, Kangaroo Island, 35°48'S, 137°51'E, 12 November 1987, D. Hirst (SAM NN13191-5); 1 female, Grassdale, Kelly Hill Conservation Park, Kangaroo Island, 35°59'S, 136°52'E, 9 November 1987, D. Hirst (SAM NN13185); 1 female, Mount Rescue Conservation Park, NE Jimmys Well, 35°51'S, 140°18'E, 20 March 1992, vibration, D. Hirst (SAM NN13197); 5 males, 1 female, Mt Compass, 3km E, 35°29'59"S, 138°29'16"E, 28 – 31 August 1998, pitfall trap, S.E.G Fleurieu Survey, TOR01101 (SAM NN13219-24); 1 male, Mt Rough, 12.2km NNE, Watervalley, 36°15'42"S, 139°54'55"E, 6 – 15 October 2000, pitfall trap, Waterhouse Club, WV003, *Melaleuca*, pink gum (SAM NN13566); 1 male, 1 female, Mt Rough, 8km N, Watervalley, 36°17'48"S, 139°53'50"E, 14 October 2000, pitfall trap, Waterhouse Club, WV001 (SAM NN13201); 1 male, 1 female, Murvio Homestead, 2.7km SE, 36°12'41"S, 140°07'46"E, 30 September – 6 October 1996, pitfall trap, NCS Gum Galloway Survey, GLS041 (SAM NN13199-200); 2 males, 1 female, Nepean Bay, Kangaroo Island, 35°42'S, 137°37'E, 2 – 3 November 1987, pitfall trap, D. Hirst (SAM NN13187-89); 1 female, Old White Hut Well, 10.6km SSE, 36°43'58"S, 139°54'53"E, 1 – 6 March 1987, pitfall trap, SEF Fauna Survey, DUF0902 (SAM NN13198); 2 males, Penneshaw P.O, 4.1km SW, Kangaroo Island, 35°45'20"S, 137°54'20"E, November 1990, pitfall trap, KI Survey, GF00101 (#46) (SAM NN13175-6); 1 male, Penneshaw P.O, 7.6km SE, Kangaroo Island, 35°47'04"S, 137°57'52"E, 5 – 11 November 1990, pitfall trap, KI Survey (#76) (SAM NN13174); 4 males, 1 juv., Rocky River, 4km W, Flinders Chase National Park, Kangaroo Island, 35°57'00"S, 136°42'30"E, 1 – 7 November 1990, pitfall trap, E. G. Matthews, J. A. Forrest (SAM NN13181-4); 1 female, Seal Bay, 6.5km N, Kangaroo Island, 35°55'45"S, 137°19'40"E, 1 – 7 March 1995, pitfall trap, K.I. Dunnart Survey, SD03 (SAM NN13180); 2 males, 1 female, Victor Harbour, 4.75km SW, K.I., 35°35'25"S, 138°34'14"E, 28 – 31 August 1998, pitfall trap, S.E.G Fleurieu Survey, ENC003 (SAM NN13203-5); 11 males, 2 females, Victor Harbour, 4.75km SW, 35°35'25"S, 138°34'14"E, 28 – 31 August 1998, pitfall trap, S.E.G Fleurieu Survey, ENC005 (SAM NN13206-18). Western Australia: 30 males, 18 female, 5 juv., Balgarup River, Muradup, 33°50'30"S, 116°59'19"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site DA 13 (WAM T56148, T56159); 5 males, 1 female, Bella Vista Nature Reserve, 28°32'17"S, 114°40'13"E, 30 March – 18 October 1999, wet pitfall traps, L. King, CALM Salinity Action Plan, site NO 4, traps 1–5 (WAM T56156); 7 males, 13 females, same location, 15 September 1998 – 30 March 1999, wet pitfall traps, L. King, CALM Salinity Action Plan, site NO 4 (WAM T56160); 4 males, 1 female, Binnu, SW of, Chillimoney Road, 28°06'11"S, 114°33'19"E, 15 September 1998 – 31 March 1999, wet pitfall traps, L. King, CALM Salinity Action Plan, site NO 8 (WAM T56144); 1 male, 3 females, Boolaung Nature Reserve, North, 33°21'22"S, 116°03'77"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site DA 01 (WAM T56137); 1 female, Brockman National Park, Pemberton, 34°30'S, 115°66'E, 26 October 1969, R. W. Taylor, ANIC Berlese No. 151, Karri forest, leaf mould (ANIC); 16 males, 5 females, Burdett Road, near junction with Wittenoom Road, 33°27'30"S, 122°08'26"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ES 8 (WAM T56155); 4 males, 4 females, Camel Lake Nature Reserve, East, 34°15'59"S, 117°58'44"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ST 7 (WAM T56141); 1 female, Camel Lake Nature Reserve, South, 34°17'34"S, 117°58'51"E, 15 October 1999 – 30 May and 25 November 2000, wet pitfall traps, B. Durrant, CALM Salinity Action Plan, site ST 4 (WAM T56140); 1 female, Coolinup Nature Reserve, NW Esperance, 33°43'53"S, 122°17'50"E, 15 October 1999 – 2 May and 29 November 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site ES 11, traps 5+5 (WAM T56145); 20 males, 4 females, Coolinup Nature Reserve, SW, Esperance, 34°44'9"S, 122°17'29"E, 15 October 1999 – 2 May and 29 November 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site ES 13, traps 5+5 (WAM T56166); 5 females, Cranbrook Water Supply Reserve, 34°18'30"S, 117°34'09"E, 15 October 1999 – 31 May and 30 October 2000, wet pitfall traps, B. Durrant, CALM Salinity Action Plan, site ST 1 (WAM T56165); 1 female, Crowea, 34°28'2'S, 116°10'E, 29 October 1996, pitfall trap, S. J. Curry (WAM 79/1922); 1 male, same data, 12 November 1976 (WAM T56188); 1 male, same data, 2 December 1977 (WAM T56185); 1 male, Crowea, ridge site, 34°28'2'S, 116°10'E, 24 October 1977, pitfall trap, S. J. Curry (WAM 79/1923); 2 males, same data, 11 November 1977 (WAM T56184); 2 males, same data, 18 November 1977, open (cleared) forest (WAM T55244); 2 males, same data, 25 November 1977, open (cleared) forest (WAM 79/1914-5); 1 male, same data, 2 December 1977, open (cleared) forest (WAM T56183); 1 male, same data, 1
November 1979, closed (uncleared) forest (WAM T56181); 1 male, 2 juv., same data, 8 November 1979, closed (uncleared) forest (WAM T56189); 1 male, same data, 31 October 1980, open forest (WAM T42124); 2 males, 1 juv., same data, 13 November 1980 (WAM 99/38-40); 2 males, same data, 21 November 1980, open (cleared) forest (WAM T56170); 4 males, same data, 28 November 1980, open forest (WAM T42127); 1 male, Crowea, creek site, 34°28’S, 116°10’E, 22 October 1976, pitfall trap, S. J. Curry, creek site, open (cleared) forest (WAM T55243); 1 male, same data, 24 December 1976 (WAM T56187); 1 male, same data, 4 November 1977 (WAM 79/1912); 1 male, same data, 25 November 1977 (WAM T56186); 1 male, same data, 29 November 1979, open (cleared) forest with regrowth (WAM T56182); 1 male, data, 21 November 1980, open forest (WAM T42131); 6 females, 2 juv., spiderlings, Dombalup State Forest, Marri Road, 34°30’S, 116°00’E, 27 January – 5 March 1979, pitfall trap, M. R. Gray, FN1493, litter (AM KS15250); 5 males, 1 female, Dunn Rock, SE face, 33°20’10”S, 119°29’39”E, 15 October 1999 – 2 May and 25 October 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site HK 7, traps x10 (WAM T56164); 7 males, 1 female, ’Glenbourne’ Farm, S of Gracetown, 33°54’28”S, 115°00’49”E, 30 October – 1 November 1999, dry pitfall traps, L. M. Marsh et al. (WAM T55517); 2 males, same data, 33°54’32”S, 115°00’24”E, 13 – 15 September 1997, site 1 (WAM T55530); 1 male, same data, 24 – 26 October 1998, site 1 (WAM T55537); 1 male, same data, 30 October – 1 November 1999, site 1 (WAM T55531); 1 male, same data, 20 – 23 October 2000, site 1 (WAM T56127); 3 males, same data, 33°54’50”S, 115°00’57”E, 27 – 28 October 1996, site 2 (WAM T56190); 1 female, 1 juv., same data, 28 – 30 June 1997, site 2 (WAM T55515); 4 males, same data, 24 – 26 October 1998, site 2 (WAM T55534); 5 males, same data, 30 October – 1 November 1999, site 2 (WAM T55543); 5 males, 2 females, same data, 20 – 23 October 2000, site 2 (WAM T56130); 1 male, same data, 26 – 28 October 2002, site 2 (WAM T58307); 2 males, same data, 25 – 27 October 2003, site 2 (WAM T58309); 4 males, 1 female, same data, 33°54’28”S, 115°00’49”E, 13 – 15 September 1997, site 3 (WAM T55540); 2 males, 2 juv., same data, 24 – 26 October 1998, site 3 (WAM T55528); 15 males, 1 female, same data, 20 – 22 October 2000, site 3 (WAM T56131, T56133); 5 males, same data, 26 – 28 October 2002, site 3 (WAM T58313); 3 males, same data, 25 – 27 October 2003, site 3 (WAM T58312); 1 female, same data, 33°54’35”S, 115°00’15”E, 29 December 1996, site 4 (WAM T55545); 1 female, 2 juv., same data, 28 – 30 June 1997, site 4 (WAM T55519); 4 males, 1 female, 1 juv., same data, 13 – 15 September 1997, site 4 (WAM T55527); 1 female, same data, 24 – 26 October 1998, site 4 (WAM T55536); 2 male, same data, 20 – 22 October 2000, site 4 (WAM T56128, T56132); 1 male, same data, 26 – 28 October 2002, site 4 (WAM T58314); 1 female, same data, 28 – 30 December 2003, site 4 (WAM T56594); 3 males, same data, 33°54’40”S, 115°00’34”E, 27 – 28 October 1996, site 5 (WAM 99/26-28); 1 male, same data, 24 – 26 October 1998, site 5 (WAM T55525); 7 males, same data, 33°55’08”S, 115°00’44”E, 13 – 15 September 1997, site 6 (WAM T55516); 1 female, 2 juv., same data, 27 – 29 December 1997, site 6 (WAM T55518); 2 females, same data, 24 – 26 October 1998, site 6 (WAM T55533); 2 males, same data, 20 – 23 October 2000, site 6 (WAM T56129); 1 female, same data, 26 – 28 October 2002, site 6 (WAM T58317); 1 female, same data, 28 – 30 December 2003, site 6 (WAM T58318); 1 female, 8 juv., Glenegle, 32°15’S, 116°10’E, 1971, J. Springett, Forest Spider Survey 7 (AM KS85112); 1 female, Haddonnet Nature Reserve, 33°36’21”S, 116°37’39”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site DA 10 (WAM T56139); 1 male, Helms Arboretum Reserve, Brockway Road, 33°43’42”S, 121°47’50”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ES 2 (WAM T56168); 3 males, Helms Arboretum Reserve, Shark Lake Road, 33°44’9”S, 121°48’55”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ES 1 (WAM T56157); 9 males, 7 females, Hillman Nature Reserve, 33°17’53”S, 116°46’19”E, 15 October 1999 – 25 May and 2 December 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site DA 11, traps 5+5 (WAM T56154); 1 female, 1 juv., King River, Albany, 34°56’S, 117°54’E, 25 October 1981, D. Hirst (SAM NN13532); 1 male, same data, October 1981 (SAM NN13533); 2 males, 3 females, Kulunilup Nature Reserve, West, 34°20’56”S, 116°46’21”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site UN 7 (WAM T56135); 2 males, Lake King, SE of, N of Edwards Road, 33°22’01”S, 120°59’43”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site GI 2 (WAM T56143); 1 male, Lake Magenta Nature Reserve (S Central), 33°42’11”S, 118°58’59”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site PI 3 (WAM T56161); 1 female, Lake Muir, N of, 34°26’35”S, 116°40’54”E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site UN 11 (WAM T56138); 2 females, 16 juv., Margret River area, Burnside, 2–3km North of Walcliffe Road, 33°56’S, 115°01’E, 26 January – 4 March 1979, pitfall trap, M. R. Gray, FN1489, litter (AM KS15119); 8 males, 5 females,
Metabinup Nature Reserve, North, 34°00'14"S, 116°50'21"E, 15 October 1999 – 1 November 2000, wet pitfall traps, N. A. Guthrie, CALM Salinity Action Plan, site UN 6 (WAM T56124); 1 male, Metabinup Nature Reserve, South, 34°00'24"S, 116°50'21"E, 15 October 1999 – 30 May and 1 November 2000, wet pitfall traps, B. Durrant, CALM Salinity Action Plan, site UN 5 (WAM T56125); 1 male, 3 females, Mininup Nature Reserve, 34°06'19"S, 116°49'35"E, 15 October – 25 May and 1 November 2000, wet pitfall traps, L. King, CALM Salinity Action Plan, site UN 3 (WAM T56134); 1 male, Muir Highway, N of, near Cup Road, 34°23'13"S, 116°30'01"E, 15 October 1999 – 31 October 2000, wet pitfall traps, N. A. Guthrie, CALM Salinity Action Plan, site UN 1 (WAM T56126); 1 female, Muir Highway, N of, near Red Lake Road, 34°25'14"S, 116°40'06"E, 15 October 1999 – 31 October 2000, wet pitfall traps, N. A. Guthrie, CALM Salinity Action Plan, site UN 12 (WAM T56151); 5 females, 1 juv., Normal-up-Walpole National Park, Big Tingle Tree, 34°57'S, 116°16'E, 28 January – 5 March 1979, pitfall trap, M. R. Gray, FN1495, litter (AM KS15419); 9 females, 3 juv., spiderlings, Normal-up-Walpole National Park, Gully Road, 34°58'S, 116°16'E, 28 January – 5 March 1979, pitfall trap, M. R. Gray, FN1495, litter (AM KS15436); 2 females, Ogilvie Road, West, SW Binnu, 27°59'19"S, 114°11'40"E, 15 September 1998 – 30 March 1999, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site NO 11, traps 1-5 (WAM T56123); 1 female, Pemberton, 34°26'S, 116°02'E, 27 July 1969, J. A. Springett (WAM T55300); 1 female, 4 juv., same data, 1971, Forest Spider Survey 30 (AM KS85108); 1 male, 1 female, 6 juv., same data, Forest Spider Survey 29, 27 (AM KS85111); 1 female, 7 juv., same data, Forest Spider Survey 29 (AM KS85109); 1 female, same data, Forest Spider Survey 24 (AM KS85110); 1 male, Perringilup Nature Reserve, 33°56'37"S, 117°38'41"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ST 12 (WAM T56136); 21 females, 23 juv., Pine Creek, 0.5km from Quarty Road, Nannup-Pemberton area, 34°15'S, 115°50'E, 26 January – 4 March 1979, pitfall trap, M. R. Gray, FN1491, litter (AM KS15317); 1 female, Porongurup National Park, 34°40'56"S, 117°51'59"E, 13 June 1996, wet pitfall traps, S. Barrett, 215, 570m (WAM T53806); 1 female with spiderlings, 7 juv., Porongurup National Park, Bolganup Road, 34°41'S, 117°55'E, 2 February – 6 March 1979, pitfall trap, M. R. Gray, FN1506, in Karri forest litter (AM KS15888); 14 females, 6 juv., Porongurup National Park, Bolganup Road, Hayward Park Trail, 34°41'S, 117°55'E, 2 February – 6 March 1979, pitfall trap, M. R. Gray, FN1509, in Karri forest litter (AM KS15912); 1 male, 1 juv., Porongurup Range, 34°12'S, 117°53'E, 6 October 1981, D. Hirst (SAM NN13531); 1 female, Porongurup Range, 34°40'S, 117°50'E, 9 April 1971, J. A. Springett (WAM T51406); 3 females, Quindinup Nature Reserve, North, 34°24'04"S, 116°51'48"E, 15 October 1999 – 31 October 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site UN 9 (WAM T56150); 12 females, Quindinup Nature Reserve, South, 34°25'46"S, 116°52'45"E, 15 October 1999 – 31 May and 31 October 2000, wet pitfall traps, B. Durrant, CALM Salinity Action Plan, site UN 10 (WAM T56153); 1 male, 1 juv., Ravensthorpe, 18km S, 33°45'S, 120°02'E, 27 October 1993, G. Harold, yate woodland (WAM 94/1506-7); 2 males, 1 female, Ravensthorpe, 9.9km E, 33°35'05"S, 120°09'00"E, 21 September 1996, pitfall trap, A. Sanders, RA 13 (WAM T56172); 1 male, Speddingup West Road, N of, Aboriginal Reserve, 33°31'02"S, 121°33'33"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site GP 9 (WAM T56146); 1 male, 1 female, 1 juv., Stirling Range National Park, East, 34°17'57"S, 118°04'19"E, 15 October 1999 – 30 May and 30 October 2000, wet pitfall traps, L. King, CALM Salinity Action Plan, site ST 6 (WAM T56152); 12 males, 5 females, Stirling Range National Park, Talyuberlup Picnic Site, 24°24'56"S, 117°57'16"E, 6 September – 12 December 1996, M. S. Harvey, J. M. Waldock, B. Y. Main (WAM T55245); 1 male, Stirling Range National Park, Toolbrunup, 34°23'12"S, 118°02'48"E, 15 June 1996, wet pitfall traps, S. Barrett, site 227 (WAM T53834); 3 females, 4 juv., Stirling Range National Park, Toolbrunup Peak Track, 34°24'S, 118°04'E, 10 June 1993, J. M. Waldock, A. Sampey, Xanthorhoea litter (WAM 99/167-73); 2 males, 1 female, same location, 10 June – 21 December 1993, wet pitfall traps, J. M. Waldock, A. Sampey, A. Rose (WAM 99/164-6); 1 female, same location, 31 March 1993, M. S. Harvey, J. M. Waldock, under rocks (WAM T56208); 1 female, 1 female with egg sac, Stirling Range National Park, Toolbrunup walking trail, 24°23'32"S, 118°03'32"E, 14 December 2001, M. S. Harvey (WAM T52547-8); 8 males, 2 females, Stirling Range National Park, West, 34°18'01"S, 118°04'03"E, 15 October 1999 – 30 October 2000, wet pitfall traps, N. A. Guthrie, CALM Salinity Action Plan, site ST 5 (WAM T56158); 19 females, 10 juv., Stirling Range National Park, White Gum Flat, 34°22'S, 117°48'E, 3 February – 6 March 1979, pitfall trap, M. R. Gray, FN1512, in White Gum litter (AM KS15939); 1 male, 12 females, Stirling Range National Park, West, 34°18'01"S, 118°04'03"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck et al., CALM Salinity Action Plan, site ST 5 (WAM T56169, T56147); 2 females, Tenterden, Pinjilup
Wolf spiders of the genus *Artoria* in Australia

Road, 34°21'38"S, 117°33'43"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck *et al.*, CALM Salinity Action Plan, site ST 3 (WAM T56142); 15 females, 1 juv., Treen Brook State Forest, 8km W of Pemberton, 34°26'S, 116°04'E, 28 January – 4 March 1979, pitfall trap, M. R. Gray, FN1492, litter (AM KS15336); 6 females, Two People Bay, 34°57'S, 118°04'E, 29 January – 5 March 1979, pitfall trap, M. R. Gray, FN1494, litter (AM KS15395); Walpole National Park, Hilltop Road, 34°57'S, 116°15'E, 28 January – 5 March 1979, pitfall trap. M. R. Gray, FN1498, litter (AM KS15467); 1 female, 2 juv., Two People Bay area, Ledge Point Beach Road, 34°58'S, 118°02'E, 29 January – 5 March 1979, pitfall trap, M. R. Gray, FN1498, litter (AM KS15467); 1 female, Two People Bay Reserve, 34°57'S, 118°11'E, 15 January 1974, M. R. Gray, under logs (AM KS69379); 1 male, 10 females, Unicup Nature Reserve, Mordalup Road, 34°19'01"S, 116°31'49''E, 15 October 1999 – 1 June and 31 October 2000, wet pitfall traps, P. van Heurck, CALM Salinity Action Plan, site UN 2, traps 5+5 (WAM T56149); 1 female, Walpole, 4mi W, 34°58'S, 116°40'E, 22 October 1969, R. W. Taylor, ANIC Berlesate No. 143, karri forest, leafmould (ANIC ); 25 females, 9 juv., spiderlings, Walpole- Normalup National Park, Hill Top Road, 34°57'S, 116°15'E, 28 January – 5 March 1979, pitfall trap. M. R. Gray, FN1494, litter (AM KS15395); Walpole National Park, Hilltop Road, 12 January 1987, R. J. Raven, open forest (QM S13166); 4 males, 1 female, Wansbrough Nature Reserve, West, 34°21'38"S, 117°33'43"E, 15 October 1999 – 1 November 2000, wet pitfall traps, P. van Heurck *et al.*, CALM Salinity Action Plan, site ST 3 (WAM T56163); 1 female, Wilson Inlet, 34°59'S, 117°22'E, 2 February 1986, G. Harold, site 1 (WAM T553131); 1 male, 1 juv., Yarina Spring Road, 28°06'09"S, 114°20'06"E, 30 March – 18 October 1999, wet pitfall traps, L.

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Figure 5 *Artoria cingulipes* Simon, 1909, male (WAM T56223 from ‘Glenbourne’ farm, S of Gracetown, Western Australia): A – left pedipalp, ventral view; B – left pedipalp, retrolateral view; C – left pedipalp, apical part of bulbous. Female: D – epigyne (WAM T56224 from ‘Glenbourne’ farm, S of Gracetown, Western Australia) ventral view; E – epigyne (WAM T56224), dorsal view. Scale bar: A, B – 0.91 mm; C – 0.76 mm; D, E – 1.53 mm.
King, CALM Salinity Action Plan, site NO 12, traps 1–5 (WAM T56162).

Diagnosis
The morphology of male and female genitalia of *A. cingulipes* is unique amongst the described species of *Artoria*. However, there are some undescribed species present in Australian collections that closely resemble this species and dissection of the male pedipalp (shape of the terminal apophysis) and female epigyne (shape of spermathecae and copulatory ducts) may be required to accurately identify this species. The male has a very stout embolus resting in a heavily sclerotized terminal apophysis, the female spermathecae form large round spheres and the copulatory ducts are attached laterally.

Description
**Male** (based on WAM T56223). Carapace: Very dark brown, posterior flanks darker; head region bordered posteriorly by dark lines that touch in median band; indistinct light brown median and submarginal bands; dark grey radial pattern; carapace covered with few black and white setae, dense white setae on median band; one long brown bristle between AME, two long brown bristles below AE. Sternum: Brown; few black setae increasing in length towards margins. Labium: Dark brown; front end truncate and white. Chelicerae: Dark brown, basally lighter; sparsely covered with white setae of variable length; three retromarginal teeth, with the basal shortest; three promarginal teeth, with the middle largest. Pedipalp (Figures 5A–C): Cymbium dorsally with pairs of macrosetae in apical third; median apophysis a curved triangle with ventrally bent tip; terminal apophysis very strong (Figure 5C). Abdomen: Very dark olive-grey with irregular dark patches; covered with whitish and longer black setae; light heart mark in anterior half very distinct through a dense layer of white setae; venter dark brown, lateral borders lighter, two indistinct longitudinal yellow stripes forming a V that opens anteriorly; covered with whitish and brown setae; spinnerets dark grey. Legs: Leg formula IV > I > II > III; brown, with distinct dark annulations; spination of leg I: Femur: 2 dorsal, 1 apicoprolateral; tibia: 3 ventral pairs, 2 prolateral; metatarsus: 3 ventral pairs, 1 prolateral, 1 retrolateral, 1 apicoventral, 1 apicoprolateral, 1 apicoretralateral.

Female (based on WAM T56224). Carapace: As male, generally lighter. Sternum: Light brown, some dark pigmentation towards margins; setae as male. Labium: Brown, front end truncate and white. Chelicerae: Dark brown, some grey setae of variable length and few long brown bristles. Epigyne (Figures 5D, E): Ventral view: simple oval atrium
and light yellow median septum that fills out the whole opening (Figure 5D); dorsal view: distinct bulbous spermathecae, copulatory ducts connected laterally (Figure 5E). Abdomen: Light olive-brown with orange-brown lanceolate heart mark; four additional black patches in posterior half; covered with brown setae; venter yellowish-brown, covered with brown setae; spinnerets yellow-brown. Legs: Leg formula IV > I > II > III; brown, distinct dark annulations less obvious dorsally; spination of leg I: Femur: 3 dorsal, 1 apicoproximal; tibia: 2 ventral pairs, third pair reduced to 1 apicoventral, 1 prolateral; metatarsus: 3 ventral pairs, 1 apicoventral.

Measurements. Male WAM TS6223 (female WAM TS6224): TL 5.03 (6.60), CL 3.50 (2.70), CW 2.18 (2.1). Eyes: AME 0.09 (0.07), ALE 0.09 (0.09), PME 0.30 (0.27), PLE 0.21 (0.23). Row of eyes: AE 0.50 (0.53), PME 0.80 (0.77), PLE 0.97 (0.94). Sternum (length/width) 1.50/1.05 (1.35/0.98). Labium (length/width) 0.37/0.37 (0.40/0.40). AL 2.10 (3.75), AW 1.65 (2.55). Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 0.86+0.87+ + +0.94 = 2.67, I 1.95+2.48+1.52+0.83 = 7.78, II 1.88+2.25+1.49+0.74 = 6.36, III 1.73+2.03+1.58+0.74 = 6.08, IV 2.25+2.78+1.8+1.00 = 7.83 (Pedipalp 1.09+0.92+ + +0.63 = 2.64, I 1.65+2.10+1.20+0.75 = 5.70, II 1.65+1.95+1.13+0.75 = 5.48, III 1.50+1.65+1.43+0.75 = 5.33, IV 2.10+2.63+2.25+0.83 = 7.81).

Variation. Males (females) (range, mean ± s.d.): TL 3.90 – 5.70, 4.79 ± 0.50; n = 20; CL 2.25 – 3.00, 2.66 ± 0.21; n = 20; CW 1.65 – 2.25, 1.93 ± 0.23; n = 20 (TL 4.35 – 8.25, 6.36 ± 0.87, n = 20; CL 2.55 – 3.75, 3.08 ± 0.33, n = 20; CW 1.80 – 3.00, 2.30 ± 0.32; n = 20).

Remarks

The holotype female of A. cingulipes was redescribed by Framenau (2002), then the only specimen known of this species. Examination of the collections at the WAM and SAM provided a large amount of material, including males, which are here illustrated for the first time. In addition, the internal genitalia of a representative female are depicted. Artoria cingulipes appears to prefer open forests and woodlands (e.g. karri, Eucalyptus diversicolor), where it inhabits the ground litter layer. Adult spiders were mainly found in summer, with highest numbers reported between October and December. Occasionally, adults have also been found in June and August.

Distribution

Coastal Western and South Australia (Figure 6).

Artoria gloriosa (Rainbow, 1920), comb. nov.

Figures 7A–F, 8


Type


Other material examined

New South Wales, Lord Howe Island: 1 female, 1 female with egg sac, no exact location, no date (AM KS86485-6); 1 male, Anderson Road, south end, 31°30’S, 159°04’E, 16 November 1979, G. B. Monteith, QM Berlese 149, calcareous soil, 40m alt, Pickard veg: DaCt, sieved litter (QM S64113); 1 female, behind Research Station, 31°31’37’S, 159°03’58’E, 2 February 2001, litter trap, J. Tarnawski, LHI/JT/08L, leaf litter in forest (AM KS79096); 1 male, Boat Harbour Beach, E end, 31°33’37’S, 159°05’53’E, 26 November – 2 December 2000, pitfall trap, AM CBCR, LHS032/05 (AM KS76114); 3 males, 1 female, 6 juv., Dawson Point Ridge, summit, 31°30’, 159°04’E, 7 November 1979, G. B. Monteith, QM Berlese 128, volcanic soil, 150m alt, Pickard veg: DaCt, sieved litter (QM S64115); 2 females, Dawsons Point Ridge, E slope, near top, 31°30’58’S, 159°02’58’E, 1 – 11 December 2000, pitfall trap, AM CBCR, LHS008/02, 05 (AM KS75906, KS75909); 1 male, 1 female, Erskine Valley, trail, 31°34’37’S, 159°04’33’E, 25 November – 2 December 2000, pitfall trap, AM CBCR, LHS045/01, 04 (AM KS76170, KS76175); 1 female, Goat House track, 400m from Goat House Cave, 31°33’15’S, 159°04’57’E, 23 February 2001, litter trap, J. Tarnawski, M. Shea, LHI/JT/09LAlli, Howeia forsteriana, leaf litter (AM KS79103); 1 female, Kims Lookout Trail and North Beach Trail junction, 31°31’08’S, 159°03’00’E, 2 – 11 December 2000, pitfall trap, AM CBCR, LHS010/03 (AM KS75913); 18 males, 1 female, Lagoon Beach between rubbish tip and airstrip, 31°32’31’’S, 159°04’31’’E, 27 November – 4 December 2000, pitfall trap, AM CBCR, LHS022/01-05 (AM KS75989, KS75996, KS76001, KS76007, KS76010, KS79107); 1 male, 1 female, Lagoon Road, opposite hospital, 31°30’S, 159°04’E, 4 November 1979, G. B. Monteith, QM Berlese 119, alluvial soil, 2m alt, Pickard veg: DaCt, sieved litter (QM S64116); 1 male, same data, QM Berlese 122 (QM S64119); 1 female, 1 juv., Lagoon Road, N of Blinky Beach Road turnoff, 31°32’30’S, 159°04’30’E, 3 February 1971, M. Gray, station 25 (AM KS56); 1 female, Leanda-Lei, behind, 31°30’S, 159°04’E, November 1979, G. B. Monteith, QM Berlese 127, calcareous soil, 45m alt, Pickard veg: HF, sieved litter (QM S64109); 1 female, 13 juv.,
Little Island, beside, 31°30'S, 159°04'E, 7 November 1979, G. B. Monteith, QM Bereslate 129, volcanic soil, 2m alt, Pickard veg: Hf, sieved litter (QM S64118); 2 females, Little Slope, 31°35'12"S, 159°04'03"E, 30 November – 7 December 2000, pitfall trap, AM CBCR, LHIS051/03-04 (AM KS76229, KS76231); 1 male, same location, 30 November 2000, beating, AM CBCR, LHIS051L, broad megaphyllous closed sclerophyll forest, Howeia belmoreana (AM KS75849); 1 female, Lord Howe Island, 31°30', 159°04'E, M. R. Gray, station 38, on ground (AM KS55); 2 females, Malabar Ridge above Neds Beach, E slope, 31°31'03"S, 159°03'38"E, 25 November – 2 December 2000, pitfall trap, AM CBCR, LHIS011/01, 03 (AM KS75918, KS75922); 1 male, 2 females, 2 juv., Malabar Ridge Saddle, 31°30'S, 159°04'E, 25 November 1979, G. B. Monteith, QM Bereslate 167, volcanic soil, 120m alt, Pickard veg: DaCt, sieved litter (QM S64108); 1 female, 1 juv., Malabar Summit, 31°30'S, 159°04'E, 25 November 1979, G. B. Monteith, QM Bereslate 168, volcanic soil, 200m alt, Pickard veg: DaCt, sieved litter (QM S64110); 1 male, 1 female, Malabar Ridge, W slope, S of Kims Lookout, 31°30'57"S, 159°03'31"E, 24 November – 1 December 2000, pitfall trap, AM CBCR, LHIS007/05 (AM KS75899, KS75902); 3 males, Mt Eliza, 50m S of summit, W face, 31°30'57"S, 159°02'25"E, 25 November – 2 December 2000, pitfall trap, AM CBCR, LHIS005/01, 04 (AM KS75873, KS75885); 4 males, 1 female, 2 juv., Mt Gower, bottom of ridge, S of igloo, 31°35'08"S, 159°04'30"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG009 (AM KS85172); 7 males, Mt Gower, bottom of ridge, N of igloo, 31°35'05"S, 159°04'34"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG006 (AM KS85171); 6 males, 3 females, Mt Gower, bottom of ridge, near of igloo, 31°35'04"S, 159°04'31"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG003, ca. 772m (AM KS85174); 1 female, Mt Gower, end of ridge, 31°35'11"S, 159°04'21"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG015/01 (AM KS85176); 2 males, 1 female, Mt Gower, midway down gully near igloo, 31°35'06"S, 159°04'32"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG002, ca. 782m (AM KS85170, KS86841); 4 males, Mt Gower, midway down ridge, N of igloo, 31°35'05"S, 159°04'35"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG002, ca. 819m, MG005 (AM KS85178); 2 males, 2 females, Mt Gower, midway down large gully with waterfall, 31°35'08"S, 159°04'27"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG011, ca. 850m (AM KS85175); 10 males, 2 females, Mt Gower, midway down ridge, S of igloo, 31°35'09"S, 159°04'31"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG008, ca. 838m (AM KS85181); 1 male, Mt Gower summit, 31°35'23"S, 159°04'22"E, 28 November – 5 December 2000, pitfall trap, AM CBCR, LHIS052/03 (AM KS76235); 1 male, 3 females, 11 juv., Mt Gower summit, NE area, 31°35'12"S, 159°04'42"E, 12 – 15 February 1971, M. Gray, station 45 (AM KS552-4); 1 male, Mt Gower summit, near igloo, 31°31'16"S, 159°05'01"E, 26 February 2001, litter trap, M. Shea, LH/MS/07L, leaf litter (AM KS79109); 1 female, Mt Gower summit, near lookout, 31°35'06"S, 159°04'32"E, 14 December 2000, H. M. Smith (AM KS70559); 1 male, 9 juv., Mt Gower summit (NE), 31°30'S, 159°04'E, 9 November 1979, G. B. Monteith, QM Bereslate 133, volcanic soil, 850m alt, Pickard veg: GMF, sieved litter (QM S64117); 1 female, same data, QM Bereslate 135 (QM S64114); 1 male, Mt Gower, Razorback, 31°35'30"S, 159°04'18"E, 5 – 14 December 2000, pitfall trap, AM CBCR, LHIS056/05 (AM KS76249); 1 male, Mt Gower, top of ridge, S of igloo, 31°35'11"S, 159°04'31"E, 20 November 2001, litter trap, I. Hutton, P. Flemons, C. Reid, MG007L (AM KS79104); 1 male, same location, 18 – 31 January 2002, pitfall trap, I. Hutton, MG007 (AM KS85180); 21 males, 1 female, Mt Gower, top of gully, N or igloo, 31°34'02"S, 159°04'05"E, 18 – 31 January 2002, pitfall trap, I. Hutton, MG005, ca. 802m (AM KS85179); 1 male, Mt Lidgbird, 30m below main cliff, 31°34'25"S, 159°04'05"E, 10 May 2001, litter trap, I. Hutton, IH009B, leaf litter, 380m (AM KS79105); 1 male, Mt Lidgbird, E face, base of summit plateau, 31°34'27"S, 159°05'04"E, 3 December 2000, litter trap, AM CBCR, LHIS039L, ex closed rainforest, Cryptocarya gregsonii (AM KS75882); 1 female, same location, December 2000, AM CBCR, LHIS039, closed rainforest, Cleistocalyx-Chionanthus (AM KS75167); 2 males, 2 females, Mt Lidgbird, Far Flats, base of Round Face, 31°34'09"S, 159°04'35"E, 27 November – 4 December 2000, pitfall trap, AM CBCR, LHIS036/02-04 (AM KS76127, KS76134, KS76136); 7 males, 1 female, same location, 4 – 14 December 2000, pitfall trap, AM CBCR, LHIS036/01, 02-04 (AM KS79097, KS76126, KS76128, KS76131, AM KS79108); 1 male, Mt Lidgbird, footslopes, 200m E of Goat House Trail, 31°33'41"S, 159°05'15"E, 24 November – 1 December 2000, pitfall trap, AM CBCR, LHIS029/05 (AM KS76084); 1 male, Mt Lidgbird, S face, summit tabletop base, 31°34'37"S, 159°05'04"E, 26 November – 3 December 2000, pitfall trap, AM CBCR, LHIS044/01 (AM KS76166); 1 male, Peach Tree Ridge, below Intermediate Hill, 31°33'01"S, 159°05'06"E, 3 – 13 December 2000, pitfall trap, AM CBCR, LHIS023/02 (AM KS76026); 2 females, Phillip Point (North Head), E slope, 31°31'20"S, 159°02'29"E, 24 November – 1 December 2000, pitfall trap, AM CBCR, LHIS015/01 (AM KS75937); 1 female, Roach Island, E slopes, 31°30'08"S, 159°04'09"E, 29 November – 7 December 2000, pitfall trap, AM CBCR, LHIS003/03 (AM KS75866); 1 male, Rocky Run Creek, N bank, Boat Harbour
Wolf spiders of the genus *Artoria* in Australia

trail, 31°33'19"S, 159°05'33"E, 3 – 13 December 2000, pitfall trap, AM CBCR, LHIS024/05 (AM KS76059); 1 female, Salmon Beach, S end, 31°34'08"S, 159°04'28"E, 27 November 2000, litter trap, AM CBCR, LHIS035L, ex narrow closed sclerophyll forest, *Hovea forsteriana* (AM KS75816); 2 males, 1 female, same location, 4 – 14 December 2000, pitfall trap, AM CBCR, LHIS35/01, 05 (AM KS79098-9, KS79110); 7 males, 1 female, Stephens Reserve, New Settlement, 31°31'33"S, 159°03'53"E, 4 – 14 December 2000, pitfall trap, AM CBCR, LHIS059/01-04 (AM KS76253-4, KS76263, KS76268, KS76270-1); 1 female, 2 juv., The Clear Place, 31°30'S, 159°04'E, 22 November 1979, G. B. Monteith, QM Berlesate 157, calcareous soil, 30m alt, Pickard veg: Hf and DaCt, sieved litter (QM S64112); 1 male, The Saddle, Erskine Valley, 31°34'49"S, 159°04'58"E, 25 November – 2 December 2000, pitfall trap, AM CBCR, LHIS046/05 (AM KS76190); 1 female, track to Erskine Valley, opposite Salmon Beach, 31°33'39"S, 159°04'31"E, 10 December 2000, litter trap, G. Cassis, LHI/GC/L18, leaf litter (AM KS79106); 3 males, 3 females, trail to Mt Gower, 31°35'06"S, 159°04'45"E, 28 November – 5 December 2000, pitfall trap, AM CBCR, LHIS049/02-3 (AM KS76211, KS76213, KS79101); 1 female, same location, 5 – 14 December 2000, pitfall trap, AM CBCR, LHIS049/01 (AM KS76208); 5 males, trail to Mt Gower, 31°35'12"S, 159°04'35"E, 28 November – 5 December 2000, pitfall trap, AM CBCR, LHIS050/02, 05 (AM KS76218, KS76227); 4 males, same location, 5 – 14 December 2000, pitfall trap, AM CBCR, LHIS050/03-04 (AM KS76219, KS76223, KS79100); 1 male, 2 females, trail to Mt Gower, base of Scaly Bark Ridge, 31°34'37"S, 159°04'40"E, 25 November – 2 December 2000, pitfall trap, AM CBCR, LHIS047/01, 05 (AM KS76192, KS79102); 2 males, 1 female, 1 female with spiderlings, same

diagram: Figure 7  *Artoria gloriosa* (Rainbow, 1920), male (AM KS86841 from Mt Gower, Lord Howe Island, New South Wales): A – left pedipalp, ventral view; B – left pedipalp, retrolateral view; C – left pedipalp, apical part of bulbus. Female: D – epigyne of holotype (SAM038 from Lord Howe Island, New South Wales), ventral view; E – epigyne (AMKS85170 from Mt Gower, Lord Howe Island, New South Wales), ventral view; F – epigyne (AMKS85170), dorsal view. Scale bar: A, B – 0.55 mm; C – 0.63 mm; D, E, F – 0.57 mm.
Diagnosis

Artoria gloriosa is very similar to A. albopilata. However, the median apophysis of the male pedipalp of A. gloriosa lacks the apical lower tip that is present in A. albopilata. In addition, the tip of the embolus of A. gloriosa is blunt, whereas it is sharp and sickle-shaped in A. albopilata. The median septum of the female epigyne of A. gloriosa does not fill out the whole atrium as in A. albopilata, but is truncated anteriorly.

Description

Male (based on KS86841). Carapace: Dark brown, head and posterior flanks darker; distinct light brown median band anteriorly as wide as PLE, narrowest around fovea; indistinct brown submarginal bands; indistinct dark grey radial pattern; carapace covered with black setae, white setae in head region and on median band, black bristles between and lateral of eyes and medially between eyes and fovea, one long brown bristle between AME, two long brown bristles below AE. Sternum: Brown; brown bristles increasing in length towards margins. Labium: Dark brown; front end truncate and white. Chelicerae: Dark brown; sparsely covered with brown setae, particularly long mediobasally; four retromarginal teeth, with the two median slightly larger; three promarginal teeth, with the middle largest. Pedipalp (Figures 7A–C): Median apophysis with double tip and longitudinal ridge in basal half; embolus blunt (Figure 7C). Abdomen: Dark olive-grey and covered with black setae; yellow-brown, lanceolate heart mark in anterior half; indistinct darker irregular patches; four larger patches in a rectangle in posterior half, two light patches between the lateral of the four black patches; venter brown, lateral borders lighter; spinnerets brown. Legs: Leg formula IV > I > II > III; brown, with dark annulations in particular ventrally; spination of leg I: Femur: 3 dorsal, 1 (small) retrolateral, 1 prolateral; tibia: 4 ventral pairs, 2 prolateral; metatarsus: 3 ventral pairs, 3 prolateral.

Female (based on AM KS85170). Carapace: As male, generally lighter, submarginal bands less distinct. Sternum: Yellow-brown, brown bristles increasing in length towards margins. Labium and chelicerae: as male, slightly lighter. Epigyne (Figures 7D–F): Ventral view: simple atrium, anterior border

Figure 8  Records of Artoria gloriosa (Rainbow, 1920).
undulating, median septum truncated anteriorly (Figures 7D, E); dorsal view: indistinct spermathecae, copulatory ducts directed anteriorly (Figure 7F). Abdomen: As male but much lighter (light brown) and therefore colouration more distinct; no light patches between posterior black patches; venter yellow-brown, brown setae; spinnerets yellow. Legs: Leg formula IV > I > III > II; light brown, indistinct dark annulations; spinulation of leg I: Femur: 3 dorsal, 1 prolateral; tibia: 4 ventral pairs, 2 prolateral, 2 retrolateral; metatarsus: 3 ventral pairs, 3 prolateral, 3 retrolateral.

Measurements. Male AM KS86841 (female AM KS85170): TL 7.35 (9.45), CL 3.68 (4.5), CW 2.93 (3.75). Eyes: AME 0.07 (0.07), ALE 0.09 (0.11), PME 0.22 (0.37), PLE 0.26 (0.27). Row of eyes: AE 0.62 (0.74), PME 0.89 (1.00), PLE 1.12 (1.27). Sternum (length/width) 1.65/1.5 (1.95/1.8). Labium (length/width) 0.49/0.49 (0.69/0.63). AL 3.3 (4.95), AW 2.1 (3.45). Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp I.28+1.20+ - +1.17 = 3.65, II 2.40+3.30+1.95+1.13 = 8.78, III 2.25+2.78+1.95+1.13 = 8.11, IV 2.93+3.60+3.45=+1.43 = 11.41 (Pedipalp 1.58+1.65- - +1.13 = 4.36, I 2.85+3.68+1.95=+1.28 = 9.76, II 2.70+3.45+1.95+1.20 = 9.30, III 2.7+3.15+2.40+1.20 = 9.45, IV 3.60+3.98+3.75+-1.16 = 12.98).

Variation. Males (females) (range, mean ± s.d.): TL 3.75 - 9.15, 6.21 ± 1.16; n = 37; CL 2.40 - 4.05, 3.27 ± 0.50; n = 37; CW 1.65 - 3.60, 2.47 ± 0.48; n = 37; (TL 4.5 = 12.15, 8.94 ± 2.16 n = 19; CL 2.55 = 5.70, 4.35 ± 1.05; n = 19; CW 1.80 - 4.35, 3.30 ± 0.88; n = 19).

The colouration of A. gloriosa can be quite variable from plain brown to more distinctly coloured specimens that may have some white patches as described for the male above. Some specimens have only three retromarginal teeth and three ventral pairs of spines on tibia I. There is also a distinct variation in size. Very small spiders do not have the median band on the carapace but are uniformly dark brown.

Remarks

McKay (1979a) redescribed A. gloriosa but he illustrated the male pedipalp only in its expanded condition. Consequently, his description did not allow an accurate identification of males without dissecting their genitalia. The pedipalp morphology of A. gloriosa with its strong basoembolic apophysis clearly identifies this species as an Artoria and consequently it is here transferred from Lycosa.

The species appears to be summer-mature. Most adults have been found between November and January.

Distribution

Artoria gloriosa is only known from Lord Howe Island (Figure 8).

Artoria impedita (Simon, 1909), comb. nov.

Figures 9A–F, 10


Type

Holotype female of Lycosa impedita Simon, 1909: Gooseberry Hill, Western Australia, 31°57′S, 116°03′E, W. Michaelson, R. Hartmeyer ('Hamburger Süd-West Australische Expedition'), Station 152 (Michaelson and Hartmeyer (1907), from German: '31 May 1905, mountainous bushland with creeks, alt. 238m, Darling Ranges'), ZMB 11076. Examined.

Other material examined

Western Australia: 7 males, 1 female, Buntine Nature Reserve, 29°58′16″S, 116°35′05″E, 15 September 1998 – 7 April and 25 October 1999, wet pitfall trap, B. Durrant, CALM Salinity Action Plan, site WU3 (WAM T47374); 1 female, 1 juv., Kwolyin Hill, 31°51′28″S, 117°46′54″E, 7 July 2004, M. S. Harvey, J. M. Waldock, R. Engel, granite outcrop, under granite rocks (WAM T58487); 2 females, Kwolyin, ca. 15 km NW, Munyard Road, 31°51′56″S, 117°36′39″E, 7 July 2004, M. S. Harvey, J. M. Waldock, R. Engel, granite outcrop (WAM T58485); 3 males, 3 females, 1 juv., Lake Ninan Shire Reserve East, 30°57′09″S, 116°39′29″E, 15 September 1998 – 28 April and 25 October 1999, wet pitfall trap, B. Durrant, CALM Salinity Action Plan; site WH1, traps 1–5 (WAM T47367); 1 male, Mackie Creek Reserve, 31°59′33″S, 117°01′19″E, 20 May – 5 November 1998, wet pitfall trap, B. Durrant, CALM Salinity Action Plan; site YOI, traps 1, 5, 7, 9, 10 (WAM T47370); 1 male, Moorajin Soak Nature Reserve, 30°45′17″S, 117°14′30″E, 15 September 1998 – 18 October 1999, wet pitfall trap, N. A. Guthrie, CALM Salinity Action Plan, site WH13, traps 1–5 (WAM T47369); 1 male, 2 females, Mt Caroline Nature Reserve, 31°47′36″S, 117°38′34″E, 7 July 2004, M. S. Harvey, J. M. Waldock, R. Engel, under granite rock (WAM T58484, T58493); 1 female, Mt Hampton Nature Reserve Dam, 31°45′40″S, 119°04′21″E, 30 October 1997 – 28 April 1998, wet pitfall trap, P. van Heurck et al., CALM Salinity Action Plan, site MN6 (WAM T47372); 1 female, Mt Sterling Nature Reserve, 31°49′59″S, 117°35′41″E, 7 July 2004, M. S. Harvey, J. M. Waldock, R. Engel, under granite rocks (WAM T58486); 1 female, near

Diagnosis

The male pedipalp with a gaping bifurcate median apophysis is most similar to that of *A. avona* Framenau 2002, however, it is overall wider. The female epigyne with its distinct median septum resembles that of *A. avona* but also *A. flavimana* Simon, 1909. However, the epigyne opening of *A. avona* is narrow with parallel lateral borders but triangular and widening posteriorly in *A. impedita*. The median septum in *A. flavimana* is usually pentagonal (sometimes triangular), whereas it is rectangular in *A. impedita*.
Description

Male (based on WAM T58460). Carapace: Very dark brown, wide and distinct yellow-brown median band with irregular lateral borders, constricted and narrower behind fovea; remnants of light brown submarginal bands; carapace covered with black setae, white setae in median band, head region and very few towards lateral carapace margins; one long brown bristle between AME, two long brown bristles below AE. Sternum: Shiny grey pigmented, margins with yellow-brown narrow rim; black bristles mainly towards margins. Labium: Dark brown; front end truncate and white. Chelicerae: Brown, basal third light brown; sparsely covered with black setae, few white setae basally and laterally; three retromarginal teeth, with the basal smallest; three promarginal teeth, with the middle largest. Pedipalp (Figures 9A–C): Median apophysis wide gaping bifurcate with serrated apical edge; embolus strong and blunt (Figure 9C). Abdomen: Dark olive-grey and covered with silverish setae; distinct yellow-brown lanceolate heart mark covered with white setae; venter yellow; spinnerets light brown. Legs: Leg formula IV > I > II > III; very light brown, with distinct dark annulations in particular on femora; spination of leg I: Femur: 3 dorsal, 1 retrolateral, 1 apicoprolateral; tibia: 3 ventral pairs, 2 prolateral, 2 retrolateral; metatarsus: 3 ventral pairs, 2 prolateral, 2 retrolateral (only 1 on left leg), 1 apicoventral, 1 apicoprolateral, 1 apicoretrolateral.

Female (based on holotype). Carapace: Brown, with distinct yellow-brown median band of two-fifth carapace width but constricting posteriorly of fovea; indistinct light brown submarginal bands; head region black; dark grey radial pattern; carapace covered with brown setae in dark parts and white setae in median and submarginal bands; few long brown bristles lateral of PE and above AME; two very long bristles below AME. Sternum: Yellow-brown with dark grey pigmentation; few brown bristles marginally mainly in anterior half. Labium: Brown; front end truncate and white. Chelicerae: Massive; uniformly brown; few brown bristles of various length in basal half; three retromarginal teeth, with the apical largest; three promarginal teeth, with the middle largest. Epigyne (Figures 9D–F): Ventral view: triangular opening, wider than long, with rectangular median septum; dorsal view (WAM T51402): Bulbous spermathecae; copulatory ducts directed anteromedially and connected to the spermathecae posteriorly (Figure 9F). Abdomen: Olive-grey, darker medially; very distinct yellow lanceolate heart mark in anterior half; indistinct pattern of grey wedges in posterior half; covered with few brown setae; venter yellow, few light setae; all spinnerets yellow. Legs: Leg formula IV > I > II > III; light brown, distinct annulations on

Figure 10 Records of Artoria impedita (Simon, 1909).
femora and tibae, in particular ventrally; spination of leg I: Femur: 3 dorsal, 1 apicoprolateral; 1 apicoretrolateral, 1 retrolateral; tibia: 3 ventral pairs, 2 prolateral; metatarsus: 3 ventral pairs, 1 prolateral, 1 apicoprolateral, 1 apicoretrolateral, 1 apicoventral.

Measurements. Male WAM T58460 (Female holotype ZMB 11076): TL 5.25 (8.12), CL 3.5 (3.99), CW 2.33 (2.86). Eyes: AME 0.10 (0.16), ALE 0.09 (0.14), PME 0.26 (0.33), PLE 0.23 (0.23). Row of eyes: AE 0.63 (0.79), PME 0.79 (0.94), PLE 1.03 (1.23). Sternum (length/width) 1.5/1.2 (1.65/1.50). Labium (length/width) 0.46/0.46 (0.50/0.53). AL 2.18 (4.51), AW 1.8 (3.46). Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 1.09+1.00+ - +1.06 = 3.15, I 2.29+2.95+2.15+1.12 = 8.51, II 2.29+2.83+2.17+1.09 = 8.38, III 2.26+2.60+2.40+1.06 = 8.32, IV 2.83+3.43+3.26+1.14 = 10.95 (Pedipalp 0.80+0.85+ +0.95 = 2.6, I 2.65+3.15+2.05+1.00 = 8.85, II 2.50+3.05+2.05+1.05 = 8.65, III 2.45+2.90+2.30+1.05 = 8.7, IV 3.25+4.05+3.45+1.40 = 12.15).

Variation. Males (females) (range, mean ± s.d.): TL 3.90 - 7.20, 5.07 ± 0.89; n = 11; CL 2.10 - 3.60, 2.73 ± 0.44; n = 12; CW 1.50 - 2.85, 2.13 ± 0.44; n = 12 (TL 5.25 - 9.90, 7.99 ± 1.38; CL 2.70 - 4.20, 3.75 ± 0.40; CW 2.10 - 3.30, 3.00 ± 0.34; n = 17).

Remarks

McKay (1979b) considered A. impedita a subspecies of Trochosa expolita (L. Koch, 1877), Trochosa expolita impedita (Simon, 1909). However, a comparison of the holotype of A. impedita and the female syntypes of T. expolita (MHNT AR0824) clearly showed that these species are not congeneric. It is evident that McKay (1979b) misinterpreted the epigyne structure of the holotype of A. impedita. The presence of a basoembolic apophysis and the bifurcate median apophysis in the male pedipalp clearly identify this species as Artoria and it is here removed from the lycosine genus Trochosa.

Distribution

Western Australia (Figure 10).

Artoria parvula Thorell, 1877

Figures 11A-B, 12


Types

Holotype male of Artoria parvula Thorell, 1877: Kandari, Selebes (= Sulawesi), Indonesia, 3°58'S, 122°35'E, 1874, O. Beccari, MSNG. Examined.


Other material examined

Northern Territory: 2 males, Annaburro, 12°54'S, 131°40'E, April 1997, T. B. Churchill, Natt, grid 1, trap 14, clay site (NTMAG A858); 1 female, Douglas Daly, 13°50'S, 131°11'E, T. B. Churchill, April 1997 (NTMAG A857).

![Figure 11](image-url)

Figure 11 Artoria parvula Thorell, 1877, male (NTMAG A858 from Annaburro, Northern Territory): A – left pedipalp, apical part of bulbus. Female (NTMAG A857 from Douglas Daly, Northern Territory): B – epigyne, ventral view. Scale bar: A – 0.22 mm; B – 0.20 mm.
Wolf spiders of the genus *Artoria* in Australia

Description

**Male.** The male of *A. parvula* was redescribed in detail by Framenau (2002), then known only from two males, the holotypes of *A. parvula* from Indonesia and its junior synonym *A. luwamata* from the Philippines. The collection of non-type material from Australia allowed the dissection of the male pedipalp and a detailed illustration of the apical section of the bulb. The embolus is slender resting in a groove formed by the terminal apophysis (Figure 11A).

**Female** (based on NTMAG A857). **Carapace:** Brown, with distinct yellow-brown submarginal bands; narrow yellow median band restricted to posterior half; black between eyes; indistinct grey radial pattern; few silver-white setae in eye region; long bristle between AME; two very long bristles below AME. **Sternum:** Yellow; few brown bristles marginally. **Labium:** Light brown; front end white. **Chelicerae:** Yellow-brown; grey pigmentation frontally; few whitish setae; two retromarginal teeth, with the apical larger; one promarginal tooth. **Epigyne** (Figure 9B): Wide posterior lip with no visible sclerotization; spermathecae large, spermathecal organs large and visible laterally. **Abdomen:** Uniformly dark olive-grey; covered with few brown setae; venter light olive-yellow; spinnerets yellow. **Legs:** Leg formula IV > I > III > II; light brown, indistinct annulations mainly on femora; spinnerets of leg I: Femur: 3 dorsal, 1 apicoprolateral; tibia: 2 ventral pairs, 1 prolateroventral; metatarsus: 3 ventral pairs.

**Measurements.** Female (NTMAG 857): TL 2.52, CL 1.37, CW 0.99. Eyes: AME 0.06, ALE 0.04, PME 0.22, PLE 0.17. Row of eyes: AE 0.32, PME 0.60, PLE 0.57. **Sternum (length/width) 0.66/0.54. Labium (length/width) 0.20/0.22. AL 0.77, AW 1.03.** Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 0.43+0.46− +0.34 = 1.23 I 0.97+1.14+0.72+0.44 = 3.27, II 0.89+1.00+0.66+0.43 = 2.98, III 0.83+0.94+0.72+0.43 = 2.92 IV 1.26+1.57+1.32+0.57 = 4.72.

**Variation.** Males (range, mean ± s.d.): TL 2.70−3.15, 2.90 ± 0.21; CL 1.55−1.73, 1.62 ± 0.09; CW 1.05−1.15, 1.11 ± 0.04; n = 4.

**Distribution**

Northern Territory (Figure 12); also in Indonesia and the Philippines.

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**Figure 12** Records of *Artoria parvula* Thorell, 1877 in Australia. This species is also known from Indonesia and the Philippines.
Remarks
The female described above has only been found in close proximity to a locality of males of *A. parvula* but not with them, however, it agrees very well in all somatic characters with these males. Therefore, I consider it the female of *A. parvula*, which is here described for the first time.

*Artoria pruinosa* (L. Koch, 1877), comb. nov.

*Lycosa pruinosa* L. Koch, 1877: 925–927, plate 80, figures 2, 2A; Rainbow, 1911: 271; McKay, 1985: 82.


Type
*Holotype* male of *Lycosa pruinosa* L. Koch, 1877: Sydney, New South Wales, 33°53'S, 151°13'E, Bradley Collection, considered lost. Not examined.

Remarks
The holotype male of *Lycosa pruinosa* (L. Koch, 1877) from Sydney was part of the Bradley Collection and must be considered lost. The examination of the lycosid material of the AM did not reveal a species that I could confidently identify as *L. pruinosa*. A detailed examination of all *Artoria* material as part of a complete revision of this genus may disclose the identity of this species. However, Koch’s (1877) illustration of the male pedipalp clearly shows the generic characters of the genus *Artoria*, in particular the apically directed median apophysis that is narrowly spoon-shaped. Previous placements in *Lycosa* and *Dingosa* are certainly erroneous, as both genera belong to the subfamily Lycosinae with a very different pedipalp structure. Consequently, this species is here transferred to *Artoria*.

*Artoria taeniifera* Simon, 1909

Figures 13A–B, 14


Type

Other material examined

Description
The holotype female of *A. taeniifera* was redescribed in detail by Framenau (2002). The presence of a number of other females in Australian collections allowed the dissection and illustration of the internal genitalia of this species. The epigyne forms an ovoid median septum with strongly sclerotized posterior lips (Figures 13A). The spermathecae are large and bulbous and the

Figure 13  *Artoria taeniifera* Simon, 1909, female (WAM T55329 from Sues Bridge, Western Australia): A – epigyne, ventral view, B – epigyne, dorsal view. Scale bar: 0.39 mm.
Wolf spiders of the genus *Artoria* in Australia

Copulatory ducts attach posterolaterally (Figure 13B).

**Variation.** The holotype displays an inverted colour pattern of the abdomen with a dark median band instead of a yellow lanceolate heartmark in comparison with all other known *Artoria* (see Framenau, 2002; Figure 21A). This inverted pattern seems to be an artifact of its preservation, as all other females display the typical *Artoria* pattern, a light heart mark in the anterior half of the abdomen.

**Females** (range, mean ± s.d.): TL 4.95 – 7.65, 6.39 ± 1.17; CL 2.25 – 3.15, 2.64 ± 0.33; CW 1.65 – 2.40, 1.95 ± 0.28; n = 5.

**Distribution**
Western Australia and New South Wales (Figure 14).

**Updated distribution of Artoria in Australia**
Since the first review of the genus *Artoria* (Framenau 2002) a large amount of material has been examined in all the major collections in Australia. Therefore, new record maps are provided here to update the distribution of all species of *Artoria* in Australia (Figures 15, 16). For some species, range extensions are considerable. For example, *A. avona*, previously known only from the floodplain of the Avon River in East Gippsland (Victoria), has now been found in considerable numbers in South Australia (Figure 15). Whereas most currently named *Artoria* are widespread, for example *A. albopilata*, *A. flavimana* and *A. berenice*, some have a very restricted distribution. *Artoria gloriosa*, for example, appears to be endemic to Lord Howe Island, and *A. albopedipalpis* is currently only known from riparian gravel banks in alpine floodplains in Victoria.

**ACKNOWLEDGEMENTS**
This study would not have been possible without the kind and generous support from the following individuals and their institutions: Graham Milledge and Mike Gray (AM), Bruce Halliday (ANIC), Janet Beccaloni (BMNH), Christine Rollard (MNHP), Pascal Leblanc (MNHT), Ken Walker, Peter Lillywhite, and Richard Marchant (MV), Owen Seeman and Rob Raven (QM), Lisa Joy Boutin (QVMAG), David Hirst (SAM), Liz Turner (TMAG), Mark Harvey and Julianne Waldock (WAM), Jason Dunlop and Shahin Nawai (ZMB), Alberto Barrion (IRRI), Gavin Dally (NTMAG), and Hieronymus Dastych (ZMH). I am in particular grateful to Tracey Churchill (Darwin) and Barbara Baehr Rob and Raven (Brisbane) for their hospitality during recent visits to the NTMAG and...
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REFERENCES


Wolf spiders of the genus *Artoria* in Australia


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Lohmannella and Simognathus (Halacaridae: Acari) from Western Australia: description of two new species and reflections on the distribution of these genera

Ilse Bartsch
Deutsches Zentrum für Marine Biodiversitätsforschung, Forschungsinstitut Senckenberg, Notkestr. 85, 22607 Hamburg, Germany, e-mail: bartsch@meeresforschung.de

Abstract – Two new littoral species, Lohmannella septemsetosa sp. nov. and Simognathus cruciferus sp. nov. are described and the description of L. pinggi Otto, 1994 is supplemented. The genera Lohmannella and Simognathus are distributed world-wide. More species are recorded from the southern than northern hemisphere. Lohmannella is abundant in warm-temperate to polar regions but rare in the tropics. In contrast, most records of Simognathus are from tropical and warm-temperate areas. According to external morphological characters and distribution, different lineages of Lohmannella species developed in the north and south. Simognathus demonstrates no such north-south discrimination.

INTRODUCTION
The two genera Lohmannella and Simognathus include 35 and 43 species and subspecies, respectively (to the end of 2004). Representatives of both are distributed world-wide, but there is a distinct difference between the faunas of the northern and southern hemisphere. Simognathus is more diverse in the south than in the north (Bartsch 1994, 2004). More marine Lohmannella species are recorded from the southern than northern hemisphere, though locally species diversity is high in the north, too. Both genera are present in Western Australia. One Lohmannella species has been described from Rottnest Island, off Perth (Bartsch 1993b). A record of another species and the description of a new species, from Esperance, will be presented in this paper. Ten Simognathus species are already known to belong to the Western Australian fauna (Bartsch 1993b, 1994, 2003b), and a new species from Esperance is described below.

MATERIAL AND METHODS
The material studied was collected during Marine Biological Workshops held in Western Australia, on Rottnest Island and in Esperance. The fauna and flora around Rottnest Island is dominated by warm-temperate species, although strongly influenced by tropical elements (Wells and Walker 1993). Esperance lies within the warm-temperate zone (Knox 1963; Wilson and Allen 1987; Ponder and Wells 1998; O’Hara and Poore 2000).

The material was collected by the author. The mites were cleared in lactic acid and mounted in glycerine jelly. Slides with holotypes and voucher specimens are deposited in the Western Australian Museum, Perth (WAM), apart from one Lohmannella specimen in the Zoological Institute and Museum in Hamburg (ZMH).

Abbreviations used in the descriptions are as follows: AD, anterior dorsal plate; AE, anterior epimeral plate; ds-1 to ds-5, first to fifth pair of dorsal setae numbered from anterior backward; GA, genitoanal plate; glp-1 to glp-5, pair of gland pores numbered 1 to 5 from anterior backward; GO, genital opening; GP, genital plate; OC, ocular plate(s); P-2 to P-4, second to fourth palpal segment; pas, parambulacral seta(e); PD, posterior dorsal plate; PE, posterior epimeral plate(s); pgs, perigenital setae; sgs, subgenital setae. The legs, their segments and claws are numbered I to IV. The leg segments 1 to 6 are trochanter, basifemur, telofemur, genu, tibia, and tarsus. The setation formula of the legs is presenting the number of setae from trochanter to tarsus.

The position of a seta is given in a decimal system, with reference to the length from anterior to posterior or basal to distal.

SYSTEMATICS
Family Halacaridae Murray, 1877
Subfamily Lohmannellinae Viets, 1927
Genus Lohmannella Trouessart, 1901
Lohmannella septemsetosa sp. nov.
Figures 1A–K, 2A–F
**Material Examined**

**Holotype**
Male, Lucky Bay, Cape le Grand, 33°59'S, 122°13'E, near Esperance, Western Australia, Australia; algal tufts with sediment, 30 cm below water edge, 15 February 2003 (WAM T62841).

**Paratype**
One deutonymph, same data as for holotype (WAM T62842).

**Diagnosis**
Idiosomal length 410 μm, gnathosomal length 284 μm, ratio idiosoma:gnathosoma 0.69. Surface of plates with reticulate and maze-like ornamented epicuticula. Gland pores large. Pair of ds-1 posterior to level of gland pores. OC with gland pore in middle of plate. P-2 without spiniform ventral process. Genu and tibia I with four and seven bipectinate ventral setae. Tarsi I to IV with 2, 2, 3, 2 bipectinate ventral setae. Claws with accessory process.
Lohmannella and Simognathus from Western Australia

Description

Male

Idiosoma. Length 410 μm, width 302 μm. Dorsal plates covered by delicately reticulate or maze-like epicuticula. Length of AD 142 μm, width 159 μm; pair of gland pores with wide, oblong alveolus, almost 10 μm in width (Figure 1C). Length of OC 102 μm, width 57 μm. Gland pore in middle of plate, pore canaliculus at the same level but in lateral margin (Figure 1A). A very faint, cornea-like structure near anterior margin. Length of PD 202 μm, width 150 μm, anterior margin truncate, with broadly rounded corners. With two pairs of large gland pores as illustrated. Pair of ds-1 (setae broken) posterior to the level of pair of gland pores. Following pairs of setae small; ds-2, ds-3 and ds-4 within striated integument, ds-5 immediately anterior to glp-4. Adanal setae on anal cone.

Ventral plates with maze-like or irregularly reticulate or foveate epicuticula. Length of AE 137 μm, width 269 μm. Pair of platelets between AE and PE, each platelet with large gland pore (Figure 1B). Length of PE 179 μm; each plate with two dorsal and three ventral setae. Length of GA 207 μm, width 144 μm; anterior margin truncate. Plate with about nine outlying setae and 52 setae close around GO (Figure 1D). Length of GO 63 μm, width 43 μm; distance between anterior margin of GO and that of GA equalling 1.5 times length of GO. Genital sclerites with four pairs of spurlike sgs. Three pairs of internal genital acetaiba shining through genital sclerites.

Gnathosoma. Slender, length 284 μm, or 0.69 times of idiosomal length. Width of gnathosoma 107 μm, length:width ratio 1:0.27. Lateral flank of gnathosomal base with an area with maze-like ornamented epicuticula (Figure 1F). Pharyngeal plate far from reaching posterior margin of gnathosoma (Figure 1G). Rostrum slender, much

Figure 2  A–F. Lohmannella septemsetosa sp. nov. A, Leg III, medial, male; B, leg IV, medial, male; C, tarsus I, lateral, male (medial setae and claw in broken line); D, tarsus II, medial, male (lateral setae and claw in broken line); E, idiosoma, dorsal, deutonymph; F, idiosoma, ventral, deutonymph. Scale = 50 μm.
longer than gnathosomal base. Both pairs of maxillary setae short and situated in posterior quarter of rostrum. Palps slender. P-2 with two setae, basal setae near segment's base, at 0.2. P-3 with spur-like process (no spine). Basal portion of P-4 with two slender setae and one spur, apical portion with solenidion, small seta and spur-like tip (Figure 1B).

**Legs.** Slender, integument with maze-like sculpturing. Leg I slightly longer, leg IV shorter than idiosoma. Telofemur I about 3.4 times longer than high (Figure 1H). Leg chaetotaxy (pas excluded, solenidia included): leg I, 1, 3, 9, 9, 14, 11 (Figure 1H); leg II, 1, 3, 9, 9, 13, 9 (Figure 1K); leg III, 1, 3, 6, 5, 10, 8 (Figure 2A); leg IV, 1, 3, 4, 5, 10, 6 (Figure 2B). Several of short dorsal setae delicately serrate. Genua I to IV with 4, 4, 2, 2 ventral setae; setae of genua I, II and IV bipectinate. Tibiae I to IV with 7, 6, 5, 5 ventral setae; 7, 4, 2, 3 of these setae bipectinate. Tarsi I to IV with 4, 4, 4, 3 dorsal setae, solenidia included. Solenidion of tarsus I 11 μm in length and in dorsolateral position (Figure 2C); on tarsus II solenidion 14 μm in length and in dorsal position (Figure 2D). Tarsi I to IV with 2, 2, 3, 2 bipectinate ventral setae and 5, 3, 1, 1 slender setae. Tarsus I with pair of doubled pas; tarsus II with medial pass doubled, lateral pass single; tarsus III with spiniform lateral pas and a seti- plus a spiniform median pass; pair of pas of tarsus IV spiniform.

Claws with accessory process. Central sclerite small, without claw-like process. All tarsi with carpite between end of tarsi and claws (Figure 11 and J). Carpite divaricate, 9 μm in length.

**Deutiosomal**

Idiosomal length 290 μm. Shape of AD similar to that of male. OC shorter; pair of gland pores close to posterior corner of plate (Figure 2E). PD shorter and more narrow than that plate of male. AE with four pairs of setae (Figure 2F); PE with one dorsal and three ventral setae. GP and anal plate separated. GP with three pairs of pgs and two pairs of minute, seta-like sgs. Length of gnathosoma 116 μm, i.e. 0.80 of idiosomal length. Leg chaetotaxy: leg I, 1, 3, 5–6, 5–6, 10, 9; leg II, 1, 3, 5–6, 6, 9, 7; leg III, 1, 3, 4, 4, 7, 6; leg IV, 1, 1, 2, 3, 6, 4, 4. Genu I with pair of bipectinate setae. On genu II ventromedial seta bipectinate, ventrolateral seta slender and very faintly pectinated. Ventral seta of genu III slender, that seta of genu IV bipectinate. Tibia I with two ventromedial and three ventrolateral setae, these five setae bipectinate. Tibia II with two pairs of bipectinate setae. Tibia III with one large bipectinate and one short, slightly pectinate seta, and tibia IV with two to three strong, bipectinate setae. Tarsi I–IV with 2, 2, 2, 1 bipectinate ventral setae and 3, 1, 0, 0 eupathid ventral setae.

**Etymology**

The specific name is derived from *septem* (Latin), seven, and *setosus* (Latin), with setae, as tibia I of this species bears seven ventral setae.

**Remarks**

The most conspicuous characters of *Lohmannella septemsetosa* are the gland pores with large alveoli and the seven bipectinate ventral setae on tibia I. A similar combination of characters is present in *L. dictyota* Bartsch, 1992, *L. gaussi* Lohmann, 1907, *L. kerguelensis* Lohmann, 1907, and *L. pinggi* Otto, 1994. Records of *L. dictyota* are from the southwestern Pacific, from the Society Islands, the Coral Sea and Great Barrier Reef (Bartsch 1992; Otto 2000). *L. pinggi* is known from Victoria and New South Wales, Australia (Otto 1994), *L. gaussi* from Antarctica and sub-Antarctica, from off Wilhelm II Land, the islands Crozet, Marion and South Sandwich (Lohmann 1907; Bartsch 1979a, 1993a; Newell 1984), and *L. kerguelensis* from the Kerguelen Islands and Palmer Archipelago (Lohmann 1907; Bartsch 1993a). *Lohmannella dictyota* has an unusual elongate PD with a prominent ornamentation, the ds-3 are situated on the PD, the pair of gland pores 2 are in the medial corners of the OC, and the P-2 has a spiniform ventral process. *Lohmannella gaussi* is, compared with congeners, large-sized, its legs and gnathosoma are long and slender; the glp-2 are near the lateral margin of the OC, and the PD bears a V-shaped porous area, characters not present in *L. septemsetosa*. In contrast to *L. septemsetosa* the OC of *L. kerguelensis* has a cornea and the ds-3 are in the anterior rounded margin of PD. *Lohmannella pinggi* has much shorter legs than *L. septemsetosa*, elongate OC and the ds-1 are situated distinctly anterior to the level of gland pore 1.

**Lohmannella pinggi** Otto, 1994

Figure 3A–G


**Material Examined**

One female, Rottnest Island, Cape Vlamingh, ca 32°02'S, 115°27'E, Western Australia. Australia; from corallines on rocky platform, 10 January 1991 (WAM T62843). One female, Rottnest Island, Cape Vlamingh; from corallines on rocky platform, 9 January 1991 (WAM T62844). One female (damaged), Rottnest Island, Cape Vlamingh, Western Australia, Australia; from corallines on rocky platform, 9 January 1991 (ZMH).

**Diagnosis**

Idiosomal length 279–303 μm, gnathosomal length 192–197 μm. Dorsal plates delicately reticulated. OC oblong, its length more than twice the width. With five pairs of large gland pores; glp-
Figure 3  A–G. *Lohmannella pinggi* Otto, 1984, female. A, Idiosoma, dorsal; B, idiosoma, ventral; C, leg I, medial; D, gnathosoma, dorsal; E, tip of tarsus II, medial; F, idiosoma, dorsal, G, gnathosoma, lateral. Scale = 50 μm.

3 near medial margin of OC. Pair of ds-1 anterior to level of gland pores. Female GA with nine pairs of pgs. Gnathosoma 2.4 times longer than wide, length ratio idiosoma to gnathosoma 1:0.65. No ventral spiniform process on P-2. Basal seta of P-2 strong, situated in basal half. Genu I with two pairs of bipectinate setae; tibia I with seven such setae. Tarsi I to IV with 2, 2, 4, 2 bipectinate ventral setae. Accessory process of claws with minute tines.

Supplementary Description

Idiosomal length 279 and 303 μm, gnathosomal length 192 and 197 μm. Dorsal plates delicately reticulated and with scattered deep canalculi (Figure 3A). OC oblong, length more than twice its width; anterior cornea distinct, posterior one faint. Gland pores distinct, their alveoli 7 μm in width; glp-2 in ventral position, glp-3 on OC near its medial margin, at about 0.57. Pair of ds-1 anterior to the level of gland pores. Two females (WAM T62843 and ZMH) with ds-2, ds-3 and ds-4 within striated integument (Figure 3A); ds-5 adjacent to glp-4. One female (WAM T62844) with pair of ds-4 situated on PD (Figure 3F). PE long, extending anteriad beyond middle of OC. Female with 18 pgs. Interval between anterior margin of GA and GO equalling 1.1 times the length of the latter. Gnathosomal length 192 and 197 μm, i.e., 0.65–0.69 of idiosomal length. P-2 without ventral process (Figure 3G); its basal seta situated at 0.22 (Figure 3D). Legs short. Genua and tibiae with articular membranes; tarsi with small fossa membranes. Length:height ratio of telofemora I and II 2.0, that of telofemora III and IV 1.6. Leg chaetotaxy (solenidia included, pas excluded): leg I, 1, 3, 8, 8, 13, 10; leg II, 1, 3, 8, 8, 12, 9; leg III, 1, 3,
Remarks

Three females were taken amongst shallow water corallines, of which two agree almost perfectly with the description of L. pinggi by Otto (1994). Differences are: the somewhat smaller size (303 μm vs 378–437 μm), shape of ds-1 (long and slender vs spiniform), number of corneae (two vs one), presence of the ds-5 (vs absence), number of setae on AE (four vs three pairs) and number of dorsal setae of the legs. The five last mentioned differences are thought to be due to either a range of great variability in the type series or inadequate description; the difference in size may partly be due to the mounting.

One of the present females has the ds-4 inserted on the PD instead, as usual, within the striated integument posterior to the OC. Apart from this character, that female agrees with the other specimens. In most of the Lohmannella species the ds-2, ds-3 and ds-4 are situated on tiny sclerites within the striated integument; intraspecific variations, if present at all, are expected to be within a very limited range. The ds-2 in general are between the AD and OC, in some few species the ds-2 are in or on the lateral margin of the AD. The ds-3 are anterior to the PD, in ten species the setae are in the margin or on the PD; the ds-4 are inserted immediately posterior to the OC; one exception is L. multispina Newell, 1984 where the setae are found in the corner of the OC, other exceptions are the freshwater species, i.e., L. andreii (Angelier, 1951), L. heptapgoni Petrova, 1966, L. curvimandibulata (Petrova, 1969), L. cretikovi (Petrova, 1965), and L. stammeri Viets, 1939. In these species both the ds-4 and ds-5 are inserted on the PD. These five species live in nearshore and continental waters in countries around the Mediterranean (Bartsch 1996; Pesic 2004).

Subfamily Simognathinae Viets, 1927

Genus Simognathus Trouessart, 1889

Simognathus cruciferus sp. nov.

Figure 4A–L

Material Examined

Holotype

Female, Duke of Orleans Bay, ca 33°55’S, 122°35’E, near Esperance, Western Australia, Australia; demersal overgrown with green algae and corallines, just below water line, 17 February 2003 (WAM T62845).

Diagnosis

Idiosomal length 375 μm. Dorsal plates colourless, almost uniformly foveate and with numerous delicate canaliculi. AD and OC with cornea-like structures. OC almost triangular. Pair of ds-4 on PD. Adanal setae in ventral position. AE with marginal areolae with foveae and canaliculi, integument in a cross-shaped median area almost smooth. GA with such smooth integument in a T-shaped area. Anterior margin of female GA arched. P-2 with ventral protuberance and bristle. Tibia I with wide but short, bluntly ending spine.

Description

Female

Idiosoma. Length 375 μm, width 200 μm. Dorsal plates almost uniformly foveate (Figure 4A), each fovea surrounded by delicate canaliculi. All plates colourless. Length of AD 157 μm, width 97 μm; its posterior margin truncate. First pair of gland pores small, slightly posterior to the level of insertion of leg I. An ovate smooth area near anterior margin. Length of OC 40 μm, width 24 μm, with ovate cornea. Length of PD 165 μm, width 95 μm, 1.7 times longer than wide. Dorsal setae small. Pair of ds-1 on AD close to pair of gland pores. Pair of ds-2 within striated integument immediately anterior to OC. Pair of ds-3 in distolateral corners of AD; ds-4 and ds-5 on PD; adanal setae on anal cone, in ventral position.

AE marginally foveate but smooth immediately posterior to insertion of legs I and II and in a ventral cross-shaped area (Figure 4B). Foveae surrounded by delicate canaliculi. Two pairs of internal scars (muscle attachment) in middle of cruciform area. Length of AE 142 μm, width 199 μm; epimeral processes I large, slightly raised, epimeral vesicles large, with three pairs of ventral setae, posteriormost pair only slightly posterior to second pair of setae. Length of PE 177 μm. Length of GA 155 μm, width 108 μm, integument in a T-shaped area almost smooth, remainder foveate. Length of GO 43 μm, width 25 μm; distance between anterior margin of GO and that of GA 1.7 times length of GO. With four pairs of pgs on either side of GO.
Gnathosoma. Length 97 μm, width 85 μm. Integument of gnathosomal base foveate. Rostrum short. Basal pair of maxillary setae near base of rostrum, apical pair of setae shorter, in posterior third of rostrum (Figure 4D). Tip of rostrum with two pairs of rostral setae. Palps three-segmented; inserted adjacent. In dorsal aspect tectum with median keel, else scale-like and partly obscuring palpal base (Figure 4C). P-2 with ventral protuberance and one bristle-like seta (Figure 4D).
Third segment short, with one basal seta and three short, stout apical setae.

Legs. Integument almost smooth. Length:height ratio of telofemora 1.4. Tibiae club-shaped, length:height ratio of tibiae I and II 1.5, that of tibiae III and IV 2.2 (Figure 4E–H). Tibiae longer than telofemora. Leg chaetotaxy (solenidia excluded, pas included): leg I, 1, 2–3, 2, 4, 5, 6; leg II, 1, 2, 2, 4, 5, 6; legs III and IV, 1, 1, 2, 3, 5, 5. Spine of tibia I wide but short, ending bluntly (Figure 4I). Tibia II with two stout, roughly bipectinate setae (Figure 4K); tibiae III and IV each with pair of bipectinate setae. Tarsus I with tapering ventral seta and pair of pas singlets, three dorsal setae, a short dorsolateral solenidion adjacent to digitiform famulus (Figure 4J). Tarsus II with slender ventral seta, pair of pas singlets, three dorsal setae and a solenidion, 6 µm long, adjacent to short medial fossa membrane (Figure 4K). Tarsi III and IV each with three dorsal setae, single ventral seta, one medial pas, but no lateral pas.

Paired claws of tarsus I rather slender, scythe-shaped, smooth, median claw stout. Paired claws of tarsi II to IV similar in width, claw-shaped with accessory process. Median claw minute.

Abnormality
One of the fourth legs is five-segmented (Figure 4L), its genu is absent, the telofemur bears a ventral seta (which is absent in ‘normal’ legs), the tibia is somewhat longer than its counterpart.

Etymology
The specific name is derived from crux (Latin), a cross, and ferre (Latin), to bear, as on the AE the shape of the area with smooth integument resembles a cross.

Remarks
The species belonging to Simognathus can roughly be divided into those with distinct, more or less triangular OC and those with the OC reduced to narrow sclerites, Simognathus cruciferus is a species with distinct OC. Other easily recognized characters are (1) the ornamentation of the dorsal plates, (2) the ornamentation of the ventral plates, and (3) the absence or presence of a ventral protuberance on P-2 and the insertion of the seta relative to the protuberance. In S. cruciferus the dorsal plates are uniformly foveate; a rather narrow cruciform central area of the AE is smooth, its large marginal areas are foveate; P-2 bears a distinct protuberance separated from the seta. With recently described species included (Chatterjee and Chang 2004; Pepato and Tiago 2004; Bartsch 2004, present paper), 44 species are known, 18 of them having the OC reduced to sclerites. In the remaining 26 species, with rather large OC, the AE is either foveate in the margins as well as in the median, or the foveate ornamentation is present only marginally and the integument in a large median area is delicately porose or almost smooth. Simognathus cruciferus is at present the only species with smooth integument in a narrow cruciform area.
Lohmannella and Simognathus from Western Australia

**GEOGRAPHICAL DISTRIBUTION OF THE GENERA LOHMANNELLA AND SIMOGNATHUS**

With the inclusion of the above described species, 36 Lohmannella subspecies/species are known (Tables 1 and 2). The genus is spread all over the globe. Apart from marine representatives (Table 1) there are also five freshwater species (Table 2). Lohmannella inhabits cavernicolous or mesopsamal habitats, and is present amongst tufts of epiphytic and epilithic algae, corallines or colonies of bryozoans and hydrozoans, coarse sand and rubble. The genus inhabits a depth range from the lower tidal zone to the abyss. The genus seems to be diverse in Antarctic, sub-Antarctic and cold-temperate South American waters and in the Mediterranean and English Channel area (Figure 5). In contrast, a single species is recorded from the north-western Atlantic (Newell 1947; Bartsch 1979b) and one (?) species from the Northern Pacific Ocean, from Alaska, Kamchatka and the Kuril Islands (Newell 1951; Makarova 1977, 1978). The genus seems to be rare in the tropics. One record is from shallow water, viz. *L. dictyota* from the Society Islands and tropical Queensland (Bartsch 1992; Otto 2000). Other species from low latitudes, *L. cygna* Bartsch, 1988, from ca 9°S, 12°E, and *Lohmannella* sp. from 11°S, 47°E, are from depths greater than 400 m (Bartsch 1982, 1988a). There is a predominance of species in the south, with 21 vs 10 marine subspecies/species in the north (Table 1).

To the latter figure three more species might be added: the specimens from the depth in the Norwegian Basin, from 64–69°N, 0–10°E (Bartsch 1978), from the Sula coral reef off Norway, 64°N, 8°E (Bartsch 2003a), and an undescribed species from eastern Greenland. The freshwater species are not included.

One very obvious character of *Lohmannella* species is the presence and size of the gland pores. All five pairs may be distinct, often within large alveoli (as described above), or one or more pairs of gland pores are minute, hardly recognizable and hence often not mentioned in species descriptions. All northern Atlantic species have minute or inconspicuous gland pores, whereas many southern shallow water species have pores within large alveoli. In the deep-water species all five pairs of pores are present (although they may be replaced by setulae) but the pores are small. Spiniform processes on the second palpal segment are present in about one-third of southern hemisphere species, in species living in tidal and shallow subtidal coarse sand and rubble. Northern species have four to six bipecinate ventral setae on tibia 1, southern species five to eight such setae.

The genus *Simognathus* is distributed in all oceans, in tropical, warm- and cold-temperate and sub-Antarctic biogeographical provinces. Its absence from the Arctic and Antarctic regions may be due to restricted sampling. Records of *Simognathus* are from the low water edge to

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**Figure 6** Distribution of the genus *Simognathus* and number of species in relevant areas.
### Table 1  The genus *Lohmannella*. List of marine species, morphological characters and collecting data.

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<td>S. Sandwich</td>
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<td>475, 38E</td>
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Lohmannella and Simognathus from Western Australia

Table 2  Freshwater Lohmannella species and collecting data.

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<td>curvimanuandibulata (Petrova, 1966)</td>
<td>Bulgaria</td>
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<td>cvetkovi (Petrova, 1965)</td>
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<td>heptapegoni Petrova, 1966</td>
<td>Israel</td>
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<td>stammeri Viets, 1939</td>
<td>Italy, Monte Negro</td>
<td>fresh, slightly brackish</td>
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Table 3  The genus *Simognathus*. List of species, morphological characters and collecting data.

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<th>Species</th>
<th>I</th>
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<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
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<td>p+s</td>
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<td></td>
</tr>
<tr>
<td><em>L. pygmaeus</em> Otto, 2000</td>
<td>NW Australia</td>
<td>10-15</td>
<td>tidal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>L. salebrosus</em> Bartsch, 2003</td>
<td>SW Australia</td>
<td>2-13</td>
<td>tidal</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>L. scutatus</em> Bartsch, 1993</td>
<td>SW Australia</td>
<td>3-15</td>
<td>medium to coarse sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>L. specialis</em> Otto, 2000</td>
<td>SW Australia</td>
<td>10</td>
<td>tidal</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>L. subbotaurus</em> Newell, 1984</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>L. tener</em> Bartsch, 2003</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>L. trachys</em> Otto, 2000</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><em>L. variolus</em> Bartsch, 1994</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
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<tr>
<td><em>L. versicolor</em> Otto, 2000</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
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<tr>
<td><em>L. xandaros</em> Otto, 2000</td>
<td>Australia</td>
<td>52S-58W</td>
<td>Macquarie Ridge, tidal-190</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I. Shape of OC: re, reduced; la, large, triangular or rounded.
II. P-2: p/s, with protuberance and distal seta; p/s+p, with protuberance and distal seta and a small distal protuberance; p+s, protuberance and seta at same level; s, seta only, protuberance lacking.
III. 1-5, shape of ventromedial seta: pe, bipunctate; sl, slender; sp, spiniform; w, wide though setiform.
IV. III-6, number of ventral and paramural setae: 1+1, either one ventral and one paramural seta or two ventral setae and paramural setae lacking; 1+2, one ventral seta and pair of paramural setae; 1+2(d), one ventral seta and pair of paramural setae, one of pas doubled; 2+2, two ventral and pair of paramural setae.
V. IV-6, number of ventral and paramural setae: character states as above.
VI. Collecting area, coordinates:
VII. Collecting area, state/province/island or sea area:
VIII. Depth (in m):
IX. Habitat: *
* doubtiful records excluded; ?, information lacking or in need of confirmation.
bathyal (0–500 m). Representatives of the genus inhabit coarse sand, rubble, crustose and other algae, seagrasses, colonies of polychaetes and barnacles. There is a strikingly high diversity in the Australian fauna (Figure 6), 12 species being recorded from Queensland and 10 species from Western Australia. Though knowledge of the halacarid fauna of New Zealand is meagre, two of the 23 marine species recorded are representatives of *Simognathus*. From the southern South American continent six *Simognathus* species are recorded (Newell, 1984). Almost 70 marine halacarid species are known in total (Newell 1984; Bartsch 1988b, 1989). In contrast, only two of 90 species in the Mediterranean, and two out of the known 120 shallow water halacarid species in the northeastern Atlantic, belong to the genus *Simognathus*. From eastern North America there is just a single record (Bartsch 1979b).

Table 3 presents a list of *Simognathus* species, their geographical areas and habitats, and some of their morphological characters. *Simognathus* species can roughly be divided into those with large OC, round or triangular in shape, and those with the OC reduced to narrow sclerites which often are obscured by the striated integument. Other characters are the shape of P-2, with or without any protuberance, and the number and arrangement of tarsal setae. Both in the north and south there are species with reduced OC, and the reduction seems to be correlated with a mesopsammal life style. Palps with the seta of P-2 and the protuberance situated at the same level are present in northern as well as in southern species. According to the setation of tarsi III and IV, *S. leiomerus* and *S. minor* are closely related. Other siblings are *S. abnormalis* and *S. salebrosus*; they share the characters: tibia I widest near its base, tarsus I very short and rotated versus the leg’s axis, and presence of epimeral fossae. These characters are absent in other species.

Looking at the present day distributional records, one may expect *Simognathus* to be a Gondwanan genus with several founder species dispersing to the European, North American and Asian coastlines. More detailed analysis is necessary to elucidate these patterns.

ACKNOWLEDGEMENTS

The three species described were collected during two Marine Biological Workshops in Western Australia, on Rottnest Island and in Esperance. The workshops were organized by Dr F. Wells and colleagues. The travel expenses were covered by the Deutsche Forschungsgemeinschaft. To all my sincerest thanks.

REFERENCES


Manuscript received 4 August 2004; accepted 21 January 2005
A new species of Bothriembryon (Mollusca: Gastropoda: Bulimulidae) from the Pliocene Roe Calcarenite, Eucla Basin, Western Australia

George W. Kendrick
Department of Earth and Planetary Sciences, Western Australian Museum, Francis Street, Perth, Western Australia 6000, Australia and
School of Earth and Geographical Sciences, The University of Western Australia, Crawley, Western Australia 6009, Australia

Abstract — Bothriembryon kremnovates sp. nov., a terrestrial snail, is described from the marine Roe Calcarenite of the southern Eucla Basin. This constitutes a first Pliocene record for the genus, hitherto known only from the Miocene? and Quaternary.

INTRODUCTION

The Roe Calcarenite (Lowry 1970) is a thin (up to 7.5 m thick but usually much less), bioclastic, sandy limestone, which mantles at shallow depth most of the Roe Plains along part of the southern, onshore Eucla Basin in Western Australia, between about Twilight Cove and Eucla (approximate longitudes 126°–129° E). The formation is richly fossiliferous, notably of mollusc shells; the miliolid foraminifer Marginopora sp. is conspicuously large and abundant throughout. The Roe Calcarenite overlies unconformably an erosion surface of, variously, either Wilson Bluff (Eocene) or Abakurrie (Oligo-Miocene) Limestone (Lowry 1970; Li et al. 1996). The Roe substrata was formed by a fine (toward the base, silty) to medium grained, transgressive, carbonate, sand, with extensive seagrass growth, in shallow, inshore, well-circulated water along an open rocky coast. At the time of principal deposition, the shoreline was probably a high sea cliff, now represented by the broadly arcuate Hampton Escarpment, separating the Roe Plains from the more elevated Hampton Tableland and Nullarbor Plain (Lowry 1970).

The study material, from the palaeontological collections of the Western Australian Museum, was collected between 1976 and 1980 from excavations in the Roe Calcarenite, all in proximity to the Hampton Microwave Repeater Tower, a conspicuous landmark (lat. 31°57′57″S, long. 127°34′45″E) located 50 km east of the Madura road house and seven km south of the Eyre Highway.

Stratigraphy

The type locality of the present species is a pit, excavated for road fill, and 0.5 km north from the Hampton Microwave Repeater Tower. There, beneath a thin, brown soil cover, the Roe Calcarenite measures 2.84 m in thickness. The uppermost 1.1 m of the formation presents a strong, top-down, weathering profile.

Here, the base of the Roe Calcarenite overlies unconformably a pitted erosion surface of hard, white limestone, probably the Wilson Bluff Limestone. The basal unit of the Roe is an un lithified, free-running, pale, silty, carbonate sand, 0.55 m thick and richly fossiliferous, including occasional specimens of the arcaoid bivalve Cucullaea sp. This is overlain conformably by a greyish to yellowish, horizontal, shelly calcarenite, 0.15 m thick and without internal bedding. Passing upward, between 0.7 and 1.1 m above the base, is a carbonate sand (0.4 m thick), weakly and unevenly lithified and with numerous, large bivalve shells. The holotype of the present species (WAM 81.847) was collected in situ from this unit.

Higher units show the effect of strong, subaerial weathering, with increasing lithification and calcretisation toward the top. The fourth unit (from the base) is a pink, shelly calcarenite, 0.7 m thick, with extensive, pink, calcrete encrustation of fossil shells and the formation of calcare nodule. Paratype WAM 81.1774, from an adjacent excavation, appears to have originated from an extension of this unit. The top of the Roe Calcarenite at the type locality is a hard, dense, greyish-brown, shelly, pisolith calcite with a laminar surface capping and about 0.4 m thick.

Age

Early studies of the Mollusca of the Roe Calcarenite (Ludbrook 1958a,b) supported an Early Pleistocene age for the formation and this conclusion was followed by Lowry (1970), Playford et al. (1975) and Ludbrook (1978). However, subsequent collecting enlarged significantly the
known fauna, enabling a re-evaluation of age in favour of the Late Pliocene (Kendrick et al. 1991: 424). Endorsing this conclusion, Beu and Darragh (2001, figure 6) located the Roe Calcarenite in the Late, though not latest, Pliocene, a view with which the writer fully concurs.

Systematics

Family Bulimulidae Wenz, 1938

Genus Bothriembryon Pilsbry, 1894

Type species: By original designation, Bulimus melo (Quoy and Gaimard) = Helix melo Quoy and Gaimard.

Bothriembryon kremnobates sp. nov.

Figure 1A

Material examined

Holotype

WAM 81.847, from Roe Plains, Madura district, Western Australia. Excavation 0.5 km north of Hampton Microwave Repeater Tower. Taken in situ from carbonate sand with large marine shells, 0.7–1.1 m above base of Roe Calcarenite. Late Pliocene. Map reference: Yalganirimra 1:100,000 topographical series (1966), 655 630. Collected V.A. Ryland and G.W. Kendrick, 29 September–4 October, 1980. Shell damaged on part of fourth whorl.

Paratypes


Table 1 Dimensions (mm) of Bothriembryon kremnobates sp. nov.

<table>
<thead>
<tr>
<th>Specimens</th>
<th>Shell height</th>
<th>Apertural height</th>
<th>Max. diameter</th>
<th>Total whorls</th>
<th>Protoconch whors</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAM 81.847 holotype</td>
<td>21.5</td>
<td>12.4</td>
<td>14.7</td>
<td>5.5</td>
<td>2.0</td>
</tr>
<tr>
<td>WAM 81.1762 paratype</td>
<td>20.3</td>
<td>12.0</td>
<td>13.6</td>
<td>5.4</td>
<td>1.7</td>
</tr>
<tr>
<td>WAM 81.1774 paratype</td>
<td>19.3</td>
<td>10.9</td>
<td>12.9</td>
<td>5.0</td>
<td>1.6</td>
</tr>
<tr>
<td>WAM 81.1796 paratype</td>
<td>22 (est.)</td>
<td>13.0 (est.)</td>
<td>14.7 (est.)</td>
<td>5.4</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Whorl counts (protoconch and teleoconch) followed the method of Kendrick and Wilson, (1975: 314, figure 1).

Figure 1 A, Bothriembryon kremnobates sp. nov. Holotype, WAM 81.847. From Roe Plains, Madura district, W.A. Pit 0.5 km north of Hampton Microwave Repeater Tower: calcarenite with large marine shells, 0.7–1.1 m above base of Roe Calcarenite. Late Pliocene. Natural size. B, Bothriembryon barretti Iredale. WAM 70.2160d. Large specimen, from excavation, 1–3 m deep, beside Eyre Highway, 78 km west of Eucla motel, W.A. Probably from colluvium/soil mantle above Roe Calcarenite. Probably Pleistocene. Natural size.


Diagnosis

Medium sized, ovate-conical species of Bothriembryon, with about 5.5 whorls in height of 22 mm; higher than wide, maximum diameter exceeding apertural height; spire short, apex blunt, rounded; teleoconch sculpture of weak co-labral growth ridges, lacking subsutural spiral granulation; protoconch with very fine axial wrinkling and punctuation.

Description

Shell of medium size for genus, robust, ovate-conical, height exceeding maximum diameter, about 5.5 convex whors in height of 22 mm; last whorl inflated, spire short, suture impressed; apertural height less than maximum diameter and
greater than half total shell height; columella short, reflexed across narrow umbilical fissure; teleoconch sculpture of weak, irregular, axial (co-labral) growth ridges, each with a prominent subsutural flexure; no spiral sculpture or subsutural granulation apparent; protoconch of 1.6–2.0 whorls, blunt, tip slightly immersed; microsculpture of very fine, axially aligned wrinkles and punctuation.

Etymology
The name of the species is derived from the Greek kremnobates, a cliff dweller; from the presumed habitat of the species in life.

DISCUSSION
The presence of a land snail, represented by four separately collected specimens, from a typical marine formation such as the Roe Calcarenite, is noteworthy and invites attention. The formation accumulated along a shallow, near-shore, energised inner shelf in proximity to a cliffed, limestone coastline, now represented by the Hampton Escarpment, a conspicuous land-form of the southern Nullarbor Region (Lowry 1970).

There can be little doubt that the present species lived near or even on the Hampton sea cliff of the Late Pliocene, with the inevitable collapse, from time to time, of rock, soil and associated snail shells into the eroding, transgressive sea below.

Unknown from any other source, the present species is clearly distinct from all known congenors, in particular those now inhabiting the southern Nullarbor Region (Iredale 1939) (Figure 2). Bothriembryon distinctus Iredale differs from the present species in its markedly narrower, more elevated spire (up to seven whorls), its more acute apex and weak subsutural, spiral granulation. Immature (to about five whorls) shells of the large B. dux (Pfeiffer 1861) from the western Nullarbor Region differ strongly in their greater size and in the presence of subsutural spiral granulation. B. mastersi (Cox 1867) from western South Australia differs in its smaller, thinner shell, more acute spire with fewer, less inflated whorls, more elevated protoconch with very fine, even micropunctuation.

The common, widespread and variable B. barretti Iredale, 1930 more closely resembles the present species than any of the foregoing, especially specimens (of B. barretti) from the wider end of its size-range. It differs consistently however in its

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**Figure 2**  Morphometric comparison (shell height against total whorl count) of Bothriembryon kremnobates sp. nov. with modern and fossil congenors from the southern Nullarbor Region and western South Australia. 1. Bothriembryon mastersi (Cox), WAM S3017, Ceduna, South Australia. Coll. A.R. Main, 21.xii.1952. Modern. 2. B. distinctus Iredale, WAM S2197, 1 km east of Caiguna, W.A. Coll. S.M. Slack-Smith, 2.1.1977. Modern. 3. B. dux (Pfeiffer), WAM S2526, immature shells from 22.5 km east of Cocklebiddy, W.A. Coll. W.K. Youngson and A. Baynes, 4.ix.1969. Modern. 4. B. barretti Iredale, WAM S1728, 28 km west of Madura, W.A. Coll. G.W. Kendrick, 18.ix.1976. Modern. 5. B. barretti Iredale, WAM 70.2160d, large specimens from excavation, 1–3 m deep, beside Eyre Highway, 78 km west of Eucla motel, W.A. Probably from colluvium/soil mantle above Roe Calcarenite. Probably Pleistocene. 6. B. kremnobates sp. nov., WAM 81.847 (holotype), WAM 81.1762 (paratype), WAM 81.1774 (paratype) and WAM 81.1796 (paratype). For localities, see text. Roe Calcarenite. Late Pliocene.
more elevated spire and apex and in the well-developed, subsutural, spiral granulation. The protoconch of *B. barretti* shows a distinct axial alignment of its microsculpture, not unlike that of the present species.

Ludbrook (1978: 193–194, plate 23, figures 17–19) recorded *Bothriembryon barretti barretti* Iredale, 1930 and *B. barretti indictus* Iredale, 1939 from several disturbed surface sites of the Roe Calcarenite, crediting these records to that formation. Specimens of these taxa, often considerably larger (e.g., WAM 70.2160d, of six whors in a height of 43 mm) than any known modern example of the species, are commonly found on the disturbed surfaces of the many, shallow bulldozer scrapes that characterise the Roe Plains sector of Eyre Highway (Figure 1 B). Such excavations, many of which entered the upper levels of the Roe Calcarenite, were a significant source of the marine fossil material described in Ludbrook’s (1978, figure 1, table 2) study of the molluscan assemblage.

The stratigraphic provenance of marine fossils from these disturbed, shallow, roadside sites is beyond challenge but the same cannot be assumed for the associated *Bothriembryon* specimens, few of which were collected in situ from undisturbed sources (see Kendrick, G.W. in Lowry 1970: 114). Examination of the sedimentary infilling of all *B. barretti* specimens to hand from these disturbed situations (Figure 1B) has shown this infilling invariably to be of non-marine origin and consistent with pedogenic processes located within the colluvium overlying the marine fossil bed. Without knowledge of the precise stratigraphic source of these large *B. barretti* specimens, it would be prudent to view their attribution to the Roe Calcarenite as doubtful and subject to confirmation. A biometric comparison of the above species with *B. kremnobates* is shown in Figure 2.

By contrast, each of the four known specimens of *B. kremnobates*, comprising the type material, retains, as cavity infilling, sediment typical of the Roe Calcarenite, including small marine fossils. This, and the collection of the holotype from *situ*, confirms their stratigraphic authenticity and age.

Lowry (1970: 114, fig. 39) reported poorly preserved fossil *Bothriembryon*, comparable with *B. barretti*, from a palaeosol (“oolitic and pisolithic kankar”) overlying Nullarbor Limestone, located 80 miles (128 km) north of Rawlinna, a locality well beyond the modern geographic range of Iredale’s species and possibly significant to regional palaeoclimate.

Fossil records of bulimulid snails in Australia are few. *Bothriembryon praecursor* McMichael, 1968 was described from Tertiary, possibly Miocene, sediments in the southern Northern Territory (McMichael 1968, Solem 1988) and reported also from dolomitic limestones of the Miocene Etadunna Formation of northern South Australia (Ludbrook 1980). This species is known only from internal and external moulds and its affinities with other species of the genus and precise age remain to be clarified.

*Bulimus giunii* G.B. Sowerby in Strezelecki, 1845 from travertine limestones of uncertain but possible Tertiary age near Hobart, Tasmania, was referred to *Bothriembryon* by Ludbrook (1980). This species is extremely rare, poorly known and, likewise, its affinities with congeners remain speculative (Solem 1988).

Four fossil species of *Bothriembryon* from palaeosols in the Pleistocene Tamala Limestone of coastal Western Australia have been described by Kendrick (1978). Two of these, from the Shark Bay district, appear to represent lineages that have become extinct since the Middle Pleistocene.

The present species from the Roe Calcarenite provides the first confirmed record of the genus *Bothriembryon* from the Pliocene.

ACKNOWLEDGEMENTS

Contributions in photography and graph preparation by Ms Karen Edward and Mr Corey Whisson are acknowledged with thanks. Access to the collection of modern land snails of the Western Australian Museum was kindly provided by Mrs S.M. Slack-Smith. Mrs A. Nevin prepared the manuscript.

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New species of *Bothriembryon*


*Manuscript received 30 June 2004; accepted 31 January 2005*
A troglomorphic species of the centipede *Cryptops* (*Trigonocryptops*) (Chilopoda: Scolopendromorpha) from Western Australia

Gregory D. Edgecombe
Australian Museum, 6 College Street, Sydney, NSW 2010, Australia

Abstract – Among the 152 named species of the cosmopolitan centipede genus *Cryptops* Leach, 1815, a few troglomorphic species have been described from caves in Europe, the Canary Islands, and Cuba. Caves in the Roe Plains in the Nullarbor Region of Western Australia have yielded a new troglomorphic species, *C. (Trigonocryptops) roopainsensis* sp. nov. The subgenus *Trigonocryptops*, known from Spain, North Africa, tropical West, Central and East Africa, Peru, Brazil, Cuba, India, Indonesia, and New Caledonia, has not previously been identified in Australia. Among Australian species, *Cryptops spinipes* Pocock, 1891, is most similar to *C. roopainsensis*, is likewise a member of *C. (Trigonocryptops)*, and provides records for this subgenus in New Zealand, the Solomons and Fiji.

INTRODUCTION

The scolopendromorph centipede genus *Cryptops* has been recorded from numerous caves, but among the 152 named species of the genus (Lewis 2002) only a few are troglomorphic. They include *C. (Cryptops) jeanneli* Matic, 1960, from France, *C. (C.) vulcanicus* Zapparoli, 1990, from the Canary Islands, *C. (Trigonocryptops) longicornis* Ribaut, 1915, from Spain, and the Cuban *C. (T.) caureniculus* Matic et al., 1977, and *C. (T.) troglibus* Matic et al., 1977. Other species collected in caves are troglobenes, more typically epigean in occurrence (see Ribaut 1915; Matic 1960; Negra 1993; Stoev 2001, for occurrences of various species of *C. (Cryptops)* in European and North African caves). *Cryptops* (*Cryptops*) omissus Ribaut, 1915, *C. (C.) kempi* Silvestri, 1924, and *C. (Trigonocryptops) numidicus aelenti* Manfredi, 1956, were described from caves (in Kenya, Assam and Morocco, respectively), but none is troglomorphic. The Australasian species *C. (C.) australis* Newport, 1844, was reported from a Tanzanian cave (Ribaut 1915), though the single small specimen was considered to be of uncertain specific identity by Lewis (1999) and its morphology displays no troglomorphic characters. Cave surveys by the Western Australian Museum have uncovered a remarkable troglomorphic species of *Cryptops* in caves in the Roe Plains in the Nullarbor Region of Western Australia (Figure 1), described herein as *Cryptops (Trigonocryptops) roopainsensis* sp. nov. This new species is the first member of *C. (Trigonocryptops)* recorded in Australia. All cited material of the new species is deposited in the Western Australian Museum (prefix WAM), Perth. Specimens of *C. (T.) spinipes* in the Australian Museum are prefixed AM KS.

Scanning electron micrographs were captured digitally with a LEO VP435 using a Robinson backscatter collector. Morphological terminology follows Lewis et al. (2005).

SYSTEMATICS

Family Cryptopidae Kohlrausch, 1881
Subfamily Cryptopinae Kohlrausch, 1881
Genus *Cryptops* Leach, 1815

Type species
*Scolopendra hortensis* Donovan, 1810, by monotypy.

Remarks
*Cryptops* was divided by Attems (1930) into the nominate subgenus, *C. (Trigonocryptops)* Verhoeff, 1906, and *C. (Chromatinops)* Verhoeff, 1906. Subsequently, three additional subgenera have been referred to *Cryptops*: *C. (Haplocryptops)* Verhoeff, 1934, *C. (Trichocryptops)* Verhoeff, 1937a, and *C. (Paratrigonocryptops)* Demange, 1963.

Subgenus *Trigonocryptops* Verhoeff, 1906

Type species
*Cryptops gigas* Kraepelin, 1903, by subsequent designation of Attems (1930).

Remarks
Following Attems (1930), the subgenus *Trigonocryptops* is identified by trigonal sutures in
front of the endosternite (Figure 19), a transverse ridge on the sternites between the coxae, generally bipartite tarsi, the head overlying tergite 1, a transverse suture on tergite 1, a divided katopule, and mostly yellow or brown colour. These characters are all possessed by C. (Trigonocryptops) roeplainensis sp. nov. Other characters shared by members of C. (Trigonocryptops) roeplainensis are an anterior setose area on the clypeus delimited by sutures (Figure 4), a projection at the anterolateral corner of the endosternite (Figure 19), and slit-like spiracles (all cited in Verhoef’s original diagnosis of Trigonocryptops). Paired distal spinose processes on the ultimate leg (Figure 9) are also shared by many species of C. (Trigonocryptops).

Attempts (1930) reviewed records of Cryptops (Trigonocryptops) from Spain, North Africa (Morocco, Algeria), tropical West and East Africa, Brazil and New Caledonia. Subsequently described species have extended the distribution of this subgenus to India (Jangi 1955), Peru (Bücherl 1950; Kraus 1957), Sumba, Indonesia (Würmli 1972) and Cuba (Matic et al. 1977), and expanded its diversity and distribution in tropical West and Central Africa (Kraus 1958; Demange 1965, 1968).

Cryptops (Trigonocryptops) roeplainensis sp. nov.

Figures 2–34

Material Examined

Holotype

Australia: Western Australia: Roe Plains, Nurina Cave 6N-46, 32°01'S 127°01'E, 19 September 1999, N. Poulter, on guano-covered rock (WAM 99/3011: Figures 3–5, 7–12, 16).

Paratypes

Australia: Western Australia: Roe Plains: Burnabnie Cave, vicinity of Eyre Bird Observatory, 32°14'S 126°18'E, 18 May 2004, P. Hosie, on small rock above water in chamber, 100 m into cave (WAM T60506, T60507); cave 6N-1327, c. 32°01'S 127°01'E, 31 December 1998, S.M. Eberhard, deep zone (WAM 99/1374).

Diagnosis

Antenna 9 times length of head plate; paramedian sutures continuous on head plate; continuous paramedian sutures on tergites 4–19; complete oblique sutures on tergites 2–5; 9–15 setae on each margin of maxillipede coxosternum; tergites, sternites and legs relatively elongate; ultimate leg with pair of distal spinose processes on prefemur, femur and tibia; 20–25 saw teeth on tibia, 10–18 saw teeth on tarsus 1.

Description

Length (anterior margin of head plate to posterior margin of telson) 46–78 mm. Holotype (largest specimen) with head plate 3.0 mm long, antenna 26.7 mm long.

Head, proximal part of antenna, and anterior trunk segments pale orange; distal part of antenna and posterior trunk segments yellowish-orange; deeper orange band across posterior margin of head plate and trunk tergites.

Head plate overlaps tergite 1; length and width of head plate nearly equal, posterior corners strongly rounded, sides convex outwards, anterior apex indented, bisected by longitudinal median furrow; paramedian sutures diverging anteriorly on head plate (Figures 2, 3); head punctate, densely covered with fine setae.

Antenna composed of 17 articles (Figure 3); basal two articles relatively stout, articles then increase in length to a maximum at articles 7–10, then gradually shortening except that article 17 is less than half length of article 16; articles 4–16 all much longer than wide, length up to 6.5 times width. All surfaces of antennal articles 1–5 with scattered long setae, densest on article 1 (Figure 7); short, fine setae abundant on all articles except for dorsomedial side of articles 1 and 2; becoming more densely concentrated up to article 4; then of even density to form a fur-like covering (Figures 29, 30); from article 4, long setae (Figure 28) confined to an irregular ring (variably two-deep) around proximal end of each article and occasional seta more distally.

Anterior setose area on clypeus diamond shaped (Figure 4), with its anterior convergent sutures meeting at a point. Longer setae on anterior setose area arranged 2.2.4.1 (WAM T60506), 2.4.2.2.1 (WAM T60507) or less regular (Figure 4), with a large seta just outside suture at widest point of setose area. Prelabral setae in two rows of 13–14;
Figures 2-7 Cryptops (Trigonocryptops) roeplainsensis sp. nov.: 2, 6, WAM T60507, scales 1 mm. 2, head plate and tergites 1-3; 6, tergites 19-21 and coxopleuron of ultimate leg. 3-5, 7, holotype WAM 99/3011. 3, head and tergites 1-6, scale 1 mm; 4, clypeus, scale 0.25 mm; 5, leg 1, scale 0.5 mm; 7, proximal part of antenna, scale 0.5 mm.
Figures 8–12 Cryptops (Trigonocryptops) roeplainsensis sp. nov.: holotype WAM 99/3011. 8, leg 20, scale 1 mm; 9–12, leg 21. 9, spinose processes at distal end of femur, scale 0.25 mm; 10, leg 21, scale 1 mm; 11, tarsus 1, scale 0.25 mm; 12, tibia, scale 0.25 mm.
numerous short setae between apical cluster and prelabral rows, variably arranged into a medial cluster and lateral bands (Figure 4) or more evenly scattered. Labrum with shallow incision against rounded sclerotised bulge in sidepiece, not strongly tridentate; margin densely fimbriate; a translabral ruga just behind anterior margin.

Maxillipede with anterior edge of coxosternum slightly convex on each side, fringed by row of 9–15 marginal setae (13+15, 13+14 in larger specimens, 10+9 in smallest specimen, WAM 99/1374) (Figure 17); median incision weak. Surface of coxosternum and trochanterprefemur (Figure 15) evenly covered with abundant short setae, relatively longer setae concentrated on anterior third of coxosternum. Single band of short setae on each femur and tibia. Tarsungulum articulated with trochanterprefemur along wide hinge.

Apical claw of second maxilla with slender hook distally, lacking a flange along its inner edge (Figure 16). Dorsal brush dense, running along distal three-quarters of article 3.

First maxillary coxal process isolated by a narrow desclerotised band.

Mandible with 11 comb lamellae (Figures 20, 21), each composed of up to 16 distally pointed spines (Figure 25). Fringe of branching bristles of even width against comb lamellae and ventral two pairs of teeth, abruptly narrowing against third tooth pair (Figure 22), narrow against fourth tooth pair; branches confined to 3–6 spine-like projections at distal end (Figure 24). Abundant blunt accessory denticles on two dorsal paired teeth (Figure 26). Haarpolster (=pulvillus) a small, dense pad of bristles, some with spine-like marginal and distal branches (Figure 27).

Tergite 1 with complete anterior transverse suture; posterolateral sutures directed backwards medially, extending to posterior margin of tergite (Figure 2). Lateral longitudinal sutures on tergites 2–19, becoming submarginal by about tergite 5. Complete oblique sutures on tergites 2–5 (Figure 3); incomplete oblique sutures on tergites 6 and 7. Paramedian sutures on posterior 25% of tergite 3, complete on tergites 4–19, including anteriorly-divergent sutures on pretergites; paramedian sutures confined to anterior 25% and posterior margin of tergite 20 (Figure 6). Shallow crescentic sulci on tergites 5–19. Tergites 1 and 2 with dense, mostly fine, short setae, a few moderately long setae; remaining tergites evenly scattered with mostly short setae and numerous longer setae. Tergite 21 slightly longer than wide, posterior margin triangular with rounded apex; shallow longitudinal median depression along posterior two-thirds of tergite (Figure 6).

Sternites 2–19 with median longitudinal and curved transverse sulci equally developed (Figure 19). Mostly short setae densely scattered over most of sternite; setation variably sparser laterally. Anterior branch of trigonal suture complete on sternite 2, incomplete from sternite 3, terminating at about half width of sternum by sternite 10, indistinct from sternite 15. Endosternite with several moderately long setae near anterior margin, two parallel rows of short setae along length of endosternite (Figure 19).

Spiracles elongate, slit-like.

Legs long and thin, e.g., leg 10 with prefemur 1.9 mm long, femur 2.2 mm, tibia 2.6 mm, tarsus 1 2.4 mm, tarsus 2 0.7 mm compared to tergal width of 3.6 mm. All tarsi strongly bipartite. Leg 1 (Figure 5) with strong, nearly subspiniform setae on all surfaces of prefemur and femur, on all but dorsal surface of tibia; from leg 2, mix of strong setae and short, fine setae on prefemur and femur, mostly fine setae on tibia, and shorter, denser, fine setae on tarsus; legs 19–20 with more consistently strong setae on prefemur and femur. Leg 20 prefemur and femur about equally long; tarsus 2 50% length of tarsus 1 (Figure 8); no specimen with dense tufts of setae ventrally. Ultimate leg: prefemur slightly longer than femur; tarsus 2 1.8 times length of tarsus 1; prefemur seven times longer than its maximal width at distal end; femur six times longer than its maximal width at distal end (Figure 10); numerous robust spiniform setae along anterior and posterior sides of prefemur, cluster of spiniform setae on proximal ventral part of prefemur; a few spiniform setae on posterior side of femur; all segments with abundant fine, slender setae of mostly uniform length; number of saw teeth on tibia (Figure 12) and tarsus 1 (Figure 11), respectively, as follows: 22/24, 13/18 (WAM 99/3011), 23/20, 13/12 (WAM T60506), 25/23, 10/11 (WAM T60507); saw teeth on tarsus 1 variably arranged in two rows; proximal part of tarsus 2 swollen, inner margin a crest.

Pair of accessory spurs usually slightly more than 50% length of pretarsus on legs 1–20 (Figures 31–34); anterior accessory spur slightly longer than posterior spur; accessory spurs lacking on ultimate leg. Accessory spurs oriented subparallel to main claw or gently divergent (Figure 32).

Sternite 21 with sides gently convex and converging posteriorly; posterior corners rounded, hind edge moderately convex backward (Figure 13). Coxopleural pore field elliptical, extending nearly to posterior margin of coxopleuron, with 169 pores in only specimen with fully visible pore field (Figure 14). Short and moderately long setae in pore field less numerous than pores. One or two robust spiniform setae variably present above pore field, approximately aligned with cleft in posterolateral margin of coxa (Figure 14). Long setae grouped at posterior margin of coxopleuron and along entire dorsal margin, the latter with up to two spiniform setae amidst the simple setae.
Figures 13–19  Cryptops (Trigonocryptops) roepainsensis sp. nov.: scales 0.5 mm except 16, 17, 0.25 mm. 13–15, 17–19, WAM T60507. 13, 14, ventral and ventrolateral views of sternite and coxopleuron of segment 21; 15, forcipule; 17, margin of maxillipede coxosternum; 18, sternite 1; 19, sternite 4. 16, holotype WAM 99/3011. Tarsus and claw of second maxilla.
Figures 20-34 Cryptops (Trigonocryptops) roeplainsensis sp. nov.: 20-27, WAM T60506, mandibular gnathal edge. 20-22, anterior views, scales 20 μm; 23, medial view, scale 30 μm; 24, fringe of branching bristles, scale 10 μm; 25, comb lamellae, scale 2 μm; 26, paired teeth, scale 20 μm; 27, Haarpolster, scale 10 μm. 28-34, WAM T60507. 28-30, sensilla on antennal articles 5 and 6, scales 20 μm except 30, 10 μm; 31-34, pretarsus of leg from middle of trunk, scales 20 μm except 34, 10 μm. 31, posterior view; 32, dorsal view; 33, anterior view; 34, posterior accessory spur.
DISCUSSION

Like the highly troglobomorphic congeners, Cryptops (Trigonocryptops) longicornis Ribaut, 1915, and C. (T.) troglonius Matic et al., 1977, C. roepleinesensis is distinguished from other members of C. (Trigonocryptops) by its very long antennae and legs, and elongate body (relatively long tergites and sternites). The Spanish Cryptops longicornis was transferred to C. (Trigonocryptops) by Attems (1930). Verhoeff (1937b) instead considered it a member of C. (Cryptops), but it has been more recently reinstated as C. (Trigonocryptops) (Serra 1981). The extreme elongation of the legs in C. (T.) roepleinesensis, as in C. (T.) troglonius, is associated with a greater number of saw teeth than in non-troglobomorphic species. Cryptops roepleinesensis differs from C. (T.) longicornis in its continuous paramedian sutures on the head plate, more numerous setae on the maxillipede coxosternal margin, more saw teeth (12–13 on the tibia, 5 on tarsus 1 in C. (T.) longicornis) (Serra 1981), and much more abundant pores on the coxopleuron of the ultimate leg (about 60 in C. longicornis versus 170 in C. roepleinesensis). Compared with the Cuban C. (T.) troglonius, the new species lacks paramedian sutures on tergite 1 and has incomplete paramedian sutures on tergite 20, has more numerous setae on the head plate, maxillipede, trunk tergites and sternites, has a narrower non-cirriiform area on the dorsal part of the ultimate leg coxopleuron, and a shorter posteromedian projection of tergite 21.

Among named Australian species, Cryptops spinipes Pocock, 1891, known from New South Wales and Queensland (Kraepelin 1916; Chamberlin 1920), is most similar to C. (T.) roepleinesensis. The two species share the anteriorly-divergent paramedian sutures on the head plate, anterior transverse suture on tergite 1, and trigonal sutures on anterior sternites (segments 2–6 in C. spinipes). Cryptops spinipes was treated as a member of C. (Cryptops) by Attems (1930) but the trigonal sutures on the sternites, a diamond-shaped anterior setose area on the coxopleure, and pair of distal spine projections on the tibia of the ultimate leg instead indicate membership in C. (Trigonocryptops). As such, C. spinipes provides records of C. (Trigonocryptops) in New Zealand (Archey 1924), the Solomon Islands and Fiji (Chamberlin 1920), as well as eastern Australia. Material of C. (T.) spinipes used to confirm the presence of the trigonal sutures and anterior setose area on the coxopleure is from New Zealand (AM KS 90634) and north Queensland (AM KS 58457). In addition to its troglobomorphic characters involving elongation of the antennae, legs and trunk sclerites, C. (T.) roepleinesensis is distinguished from C. (T.) spinipes by the following: much denser setation on the coxopleure (only three large setae on the anterior setose area in C. (T.) spinipes plus up to three small setae), maxillipede (e.g., coxosternum and trochanteroprefemur), and sternites; trigonal sutures on the sternites developed further posteriorly on the body; distal spine projections on the ultimate leg prefemur and femur, not just the tibia; and greater number of coxopleural pores.

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Troglomorphic Cryptops species from Western Australia


New species of *Periclimenaeus* Borradaile (Crustacea: Decapoda: Pontoniinae) from Ashmore Reef, North Western Australia, with remarks on *P. pachydentatus* Bruce, 1969

A.J. Bruce
Queensland Museum, P.O. Box 3300, South Brisbane, Queensland 4101, Australia
e-mail: abruce@broad.net.au

Abstract — Two new species of the pontoniine shrimp genus *Periclimenaeus*, from ascidian hosts from Ashmore Reef, Western Australia, are described and illustrated. *Periclimenaeus kottae* sp. nov., an associate of *Didemnum membranaceum* Sluiter, is one of the smallest pontoniine shrimps known. *Periclimenaeus matherae* sp. nov. is an associate of *Hypodistoma decorata* (Sluiter). Comparative figures are provided of *P. pachydentatus* Bruce, 1969, the range of which is extended to the Philippines.

INTRODUCTION

The genus *Periclimenaeus* Borradaile, 1915, includes a number of small pontoniine shrimps that occur mainly in all tropical waters, particularly on coral reefs, and live in association with a variety of sponge and ascidian hosts, generally as heterosexual pairs living in internal cavities of their hosts. They are characterised by the presence of grossly unequal chelae on the second pereiopods, the larger of which has a conspicuous molar process on the dactylus, which opposes into a fossa on the fixed finger, the combination forming an effective sound-producing mechanism remarkably convergent with that found in the pontoniine genus *Coralliocaris* Dana and some genera of the Alpheidae.

*Periclimenaeus* is the second most speciose genus in the subfamily Pontoniinae, after *Periclimen es* Costa, 1844. At present 48 species are known from the Indo-West Pacific region where they are found mainly as associates of marine sponges, although a number are also known from ascidian hosts. The hosts of several species are yet to be identified. From Australian waters 19 species have so far been reported by Davie (2002) and *P. minutus* Holthuis, 1952, reported by Berggren (1997), was not included, making a total of 20 species. The discovery of further species from ascidian hosts collected at Ashmore Reef, northwestern Australia now raises the Australian *Periclimenaeus* fauna to 22 species, most of which are associated with sponges.

Four species of the genus *Periclimenaeus* have been previously reported from Western Australia. *Periclimenaeus hecate* was reported from Cape Jaubert by Bals (1921, as *Coralliocaris hecate*, and later from Maret Island, Western Kimberley (Berggren, 1997), followed by *P. bidentatus* Bruce, 1970, and *P. pachydentatus* Bruce, 1969, from Hibernia Reef (Bruce 1992) and more recently, *P. minutus*, from Churchill and Albert Reefs, Western Kimberley (Berggren 1997). *Periclimenaeus bidentatus* and *P. minutus* are sponge associates, the others are associates of ascidians.

Further information is also provided on *P. pachydentatus*, with a record from the Philippines, the first occurrence outside Australian waters.

CL refers to the post-orbital carapace length; NTM, Northern Territory Museum, Darwin; WAM, Western Australian Museum, Perth; ZMUC, Zoology Museum, University of Copenhagen.

SYSTEMATICS

Subphylum CRUSTACEA

Order DECAPODA Latreille, 1802

Family PALAEMONIDAE Rafinesque, 1815

Subfamily PONTONIINAE Kingsley, 1878

Genus *Periclimenaeus* Borradaile, 1915

*Periclimenaeus* Borradaile, 1915: 207.

*Periclimenaeus kottae* sp. nov.
Figures 1–3

Material Examined

Australia, Western Australia: 1 ovig. ♀, holotype, stn WAM 174.93, Ashmore Reef, outer slope, 6–16 m, coll. L. Marsh, 16 September 1986, WAM C 34444.
Diagnosis
Rostral dentition 3/0, without supraorbital spines, first pereiopod chela distally subspatulate, major second pereiopod with chela smooth, dactylar cutting edge distally finely denticulate, merus ventrally spinulate, minor second pereiopod dactyl cutting edge coarsely dentate, ambulatory dactyls completely unarmed, with rounded boss proximally, exopod of uropod laterally unarmed.
Description

A very small pontoniine shrimp of subcylindrical body form.

Rostrum (Figure 1B). Short, about 0.45 of CL, to level of anteverved corneal margin, not reaching to distal margin of proximal segment of antennular peduncle, slender, without distinct carinae, dorsal margin with small proximal tooth at about 0.25 of rostral length, with two larger acute teeth at about 0.5 and 0.75, with sparse interdental setae, ventral margin unarmed.

Carapace (Figure 1A). Smooth, orbit feebly developed, inferior orbital angle obsolete, supraorbital spines or tubercles and hepatic spines absent, antennal spine acute, marginal, anterolateral margin of branchiostegite not produced, broadly rounded.

Abdomen. Smooth, first segment without anterodorsal lobe, pleura broadly rounded, sixth segment about 0.4 of CL, 1.4 times longer than deep, 1.2 times longer than fifth segment, posterolateral angle blunt, posteroventral angle well developed, acute.

Telson (Figure 1H). About 0.85 of CL, 1.9 times longer than anterior width, lateral margins sublinear, converging strongly posteriorly, with two pairs of small subequal dorsal spines, about 0.08 of telson length, at 0.24 and 0.62 of telson length, posterior margin (Figure 1I) rounded, without acute median point, about 0.35 of anterior width, with small lateral spines, slightly smaller than dorsal spines, well developed intermediate spines, about 0.25 of telson length, submedian spines subequal to dorsal spines in length, more slender and setulose.

Antennule (Figure 1C). Short, robust, proximal segment about 1.5 times longer than basal width, with small ventromedial tooth, lateral border concave, without distinct distolateral tooth, stylocerite short, broad, acute, reaching to about 0.3 of segment length; statocyst present; intermediate and distal segments short and stout, combined equal to about 0.5 of proximal segment length, upper flagellum short, biramous, proximal three segments stout, fused, shorter free rami with single short segment, longer ramus with four subcylindrical segments, about seven groups of aesthetasc; lower flagellum of similar length, with seven subcylindrical segments.

Antenna (Figure 1D). Short, stout, coxal segment with conspicuous medial tubercle, basicerite laterally unarmed, carapocerite subcylindrical, about 6.0 times longer than width, extending to level of distal margin of antennular peduncle, flagellum short; scaphocerite (Figure 1E) small, about 2.6 times longer than distal width, not exceeding carapocerite, lateral margin straight, with small acute distolateral tooth reaching to level of distal margin of lamella.

Eye (Figure 1F). Cornea well pigmented, globular, without accessory pigment spot, diameter about 0.25 of CL, stalk short, robust.

Mandible (Figure 2A). Rather weak, corpus without palp: molar process (Figure 2B) subcylindrical, tapering slightly distally, obliquely truncate, with two acute teeth posteriorly, margins setose: incisor process (Figure 2C) slender, tapering distally, terminating in two small acute teeth.

Maxillula. Lost in dissection. Lower lacinia short, stout, with few long robust distal spines.

Maxilla (Figure 2D). Palp about 3.2 times longer than wide, without preterminal plumose setae, with sparse short plumose setae proximo-laterally; basal endite simple, distally expanded, with about 8 slender simple setae, coxal region convex, scaphognathite normal, about 2.25 times longer than broad.

First maxilliped (Figure 2E). Palp subcylindrical, with preterminal seta medially, basal endite sparsely setose distally, glabrous proximally, coxal endite not distinguishable, non-setose, caridean lobe broad, sparsely setose, with about 12 short plumose setae, flagellum slender with four terminal plumose setae; epipod small, deeply bilobed.

Second maxilliped (Figure 2F). Of normal form, dactylar segment about 2.5 times longer than broad, with numerous long coarsely serrulate spines, exopod slender with four plumose terminal setae, epipod small, simple, elongate, without podobranch.

Third maxilliped (Figure 2G). Short, stout, reaching to about half length of proximal segment of antennular peduncle, ischiomerus fully fused to basis, combined segment about 3.3 times longer than broad centrally, medial margin sparsely setose, basal region strongly convex, penultimate segment about 0.8 of combined segment length, 2.5 times longer than width, sparse slender spines medially, distal segment 2.5 times longer than proximal width, tapering distally with few groups of slender spines; exopod normal, with four plumose terminal setae; coxa without medial process, lateral plate suboval, elongate, without arthrobranch.

Thoracic sternites. Narrow, without special features.

First pereiopod (Figure 2A). Short, robust, exceeding carpocerite by about half propod length; chela (Figure 2B) with compressed palm, about 1.4 times longer than deep, fingers subequal to palm length, slightly subspatulate, sparsely setose, cutting edges sharp distally, entire, medially and laterally, tips bidentate: carpus short, stout, 2.5 times longer than wide, tapering proximally, about 0.7 of palm length; merus subcylindrical, 3.4 times longer than width, 1.2 times carpal length, slightly shorter than chela; proximal segments without special features.

Major second pereiopod (Figure 2C). Well developed, chela about 2.0 times CL, palm smooth,

glabrous, 1.7 times longer than deep, moderately compressed, tapering slightly distally, fingers (Figure 2D) about 0.37 of palm length, dactylus about 1.5 times longer than deep, outer margin semicircular, cutting edge with large low molar process proximally, anterior margin slightly bilobed, distal cutting edge (Figure 2E) short, concave, finely denticulate with blunt imbricate denticles, tip stout, acute, fixed finger with large deep fossa proximally, cutting edge distally straight, entire, tip acute, strongly hooked; carpus about 0.38 of palm length, broadly expanded distally and tapered proximally, about as long as wide distally, unarmed; merus (Figure 2F) about 0.3 of palm length, 1.5 times longer than deep, tapering slightly distally, with 4 small acute ventral denticles; ischium slightly longer than merus, robust, tapering proximally, 2.0 times longer than central width, unarmed; basis and coxa robust, without special features.
Minor second pereiopod (Figure 3G). Smaller than major pereiopod; chela about 0.8 of major chela palm length, 1.2 of CL, palm 2.0 times longer than deep, subuniform, slightly compressed, smooth, glabrous, fingers (Figure 3H) about 0.27 of palm length, dactylus over-reaching fixed finger, about 2.0 times longer than central depth, outer margin strongly convex, cutting edge sinuous with about 12 coarse, blunt teeth of increasing size distally, tip bluntly hooked; fixed finger about 1.2 times longer than proximal depth, cutting edge not grooved, concave, entire, with small acute tooth proximally, tip curved, acute; carpus about 0.38 of palm length, 1.2 times longer than distal width, tapered proximally, expanded distally, unarmed; merus about 0.6 of palm length, 2.5 times longer than greatest depth, tapering slightly proximally, without ventral denticulations; ischium about 0.8 of meral length, 2.8 times longer than distal width, tapering proximally, unarmed; basis and coxa without special features.

Third pereiopod (Figure 3I). Short, robust, exceeding antennular peduncle by chela length, dactyl (Figure 1G) about 0.27 of propod length, corpus (Figure 3K) compressed, twice as long as central depth, tapering distally, distal width about 0.5 of proximal width, dorsal margin feebly convex, ventral margin without distal accessory tooth, distally almost straight, proximally with large rounded boss, with pair of distolateral sensory setae, unguis stout, simple, curved, about 1.75 times longer than basal width, 0.33 of corpus length; propod (Figure 3J) about 0.3 of CL, stout, 2.5 times longer than maximal depth at about 0.33 of length, with stout similar distomedial, distoventral and distolateral spines, about 0.12 of propod length; carpus stout, 1.5 times broader than propod, 2.4 times longer than wide, unarmed; merus 1.5 times propod length, 2.5 times longer than width, unarmed; ischium subequal to carpus length, 2.5 times longer than distal width, tapering proximally, unarmed; basis and coxa robust, without special features. Fourth pereiopod similar. Fifth pereiopod dactyl without ventral boss, 0.5 of propod length, propod 2.8 times longer than deep.

Uropod (Figure 1J). Protopodite unarmed; exopod 2.6 times longer than broad, lateral margin mainly straight, unarmed, with well developed acute distal tooth (Figure 1K), with mobile spine medially, reaching almost to level of distal margin of lamella; endopod subequal to exopod length, 2.6 times longer than wide.

Ova. Few, about 10, of normal size.

Measurements (mm)
Post-orbital carapace length, 0.9; carapace and rostrum, 1.4; total body length (approx.), 4.7; major second pereiopod chela, 1.85; minor second pereiopod chela, 1.15; length of ovum, 0.4.

Systematic Position

Periclimenaeus kottae sp. nov. is most closely related to P. hecate (Nobili, 1904) and P. crassipes (Calman, 1939). It may be distinguished from the former species by its much smaller size, CL 0.9 mm, and rostral dentition 3/0 as opposed to 3.5 mm and 4-5/0, in P. hecate. Also, rostrum more slender, not reaching distal margin of proximal segment of antennular peduncle vs distinctly exceeding distal margin of proximal segment; first pereiopod with carpus and merus shorter than chela vs much longer; major second pereiopod with distal cutting edge of dactylus minutely denticulate, merus ventrally spinulate, vs entire and non-spinulate; minor second pereiopod chela with palm twice as long as deep, with dactylar cutting edge sinuous with about 12 coarse teeth vs three times, and straight with about 40 finely acute teeth; ambulatory dactyl with corpus twice as long as basal width, with pronounced rounded ventral swelling proximally vs subcircular, without proximal ventral swelling. From P. crassipes, P. kottae may again be distinguished by its much smaller size, total length 4.7 mm and rostral dentition 3/0, vs 10.5 mm and 4/0. Periclimenaeus crassipes has only been illustrated with a whole animal figure, and the dactyl of the fifth pereiopod provided by Calman (1939) and the third pereiopod, figured by Bruce (1974). The latter shows the “massive and flattened” appendage described by Calman, with the propod 2.7 times longer than proximal width and tapering very strongly distally, where its width is about 0.25 of the proximal width, quite unlike P. kottae. The carpus is even more inflated, length about 0.9 of the propod length, and almost twice as long as wide. The dactyl is, as remarked by Calman, without a basal protuberance, unlike P. kottae.

Colouration

No data.

Host

Didemnum membranaceum Sluiter, 1909. The host is a commonly occurring species from the tropical western Pacific, in Australia down to Houtman’s Abrolhos on the west coast and Caloundra on the east; and it has also been recorded from Hong Kong.

Etymology

The species is dedicated to Dr Patricia Kott, A.O., in recognition of her contribution to the study of the Ascidiae.

Remarks

Periclimenaeus kottae must be one of the smallest pontoniine shrimps recorded, with an adult total length of only 4.7 mm.
The vast majority of *Periclimenes* species have a biunguiculate dactyl on the ambulatory pereiopods, often with additional ornamentation. In the Indo-West-Pacific region, only four species are known that lack biunguiculate dactyls on these appendages. Most of these are rare and two are known from the type material only. These species do not appear to be closely related or to constitute a distinct group and the loss of the distal accessory tooth on the ambulatory dactyl has possibly occurred independently in several different evolutionary lines.

*Periclimenes arthroptilus* Holthuis, 1952, is still known only from the holotype specimen collected from Pulau Sailus ketijil, Kepulauan Tenga, Indonesia, in 1899, from 18 m or less, from an unknown host. *Periclimenes hecate* (Nobili, 1904) was first reported from Djibouti and has been subsequently reported from Kenya, Comoro Islands, Seychelle Islands, Réunion, Maldive Islands, Indonesia, China and Western Australia in *Dipsoma molle* (Herdmann, 1886). *Periclimenes serrula* has been reported from off Oman and from Darwin Harbour, Northern Territory, in association with the ascidian *Didemnum psammatoideus*. *Periclimenes serrula* Bruce and Coombes, 1995, is known only from the type material from Orontes Reef, Port Essington, Northern Territory, from 12 m, from *Leptoclinides incertus* Sluiter. It may be noted that these species are found in association with three different ascidian host genera.

It may also be noted that the mouthparts of *P. kottae* closely resemble those of *P. robustus*. Borradaile, 1915, as illustrated in Borradaile (1917, plate 55 figures 20f–i), the type species of the genus *Periclimenes*. The mandible and maxillula of *P. robustus* were not illustrated.

These species do not appear to be closely related or to constitute a distinct group and the loss of the distal accessory tooth on the ambulatory dactyl has probably occurred independently in several different evolutionary lines.

These species may be conveniently distinguished from *P. kottae* by the following key.

**Key to Indo-West Pacific *Periclimenes* species with ambulatory dactyls lacking a distal accessory tooth**

1. Supraorbital spines present, third pereiopod dactyl large and slender, with articulated unguis, with minute ventral denticles; R 5/0 .................. *P. arthroptilus* Holthuis
   - Supraorbital spines absent, third ambulatory dactyl with simple, non-articulated tip ......... 2

2. Dactyl of minor second pereiopod with cutting edge entire, of major second pereiopod minutely denticate; R 4/0 .................. *P. serrula* Bruce and Coombes
   - Dactyl of minor second pereiopod with cutting edge dentate ................................. 3
3. Dactyl of minor second pereiopod with cutting edge with numerous small teeth, about 40, along whole cutting edge; R 4–5/0 .................. *P. hecate* (Nobili)
   - Dactyl of minor second pereiopod with cutting edge with few large teeth (about 10–12) ..... 4

4. Large species, dactyl of minor second pereiopod much longer than fixed finger, with about 10 blunt teeth distally; carpus and propod of third pereiopod greatly swollen, propod 3 times broader proximally than distally; dactylus without basal process; R 4/0 .................. *P. crassipes* (Calman)
   - Small species, dactyl of minor second pereiopod slightly longer than fixed finger, with about 12 blunt teeth distally; carpus and propod of third pereiopod not greatly swollen, propod less than twice broader proximally than distally; dactylus with rounded basal process; R 3/0 .................. *P. kottae* sp. nov.

*Periclimenes matherae* sp. nov.

Figures 4–8

**Material Examined**

**Australia, Western Australia**: 1 ♂, holotype, Ashmore Reef, West Lagoon entrance. 12°013.26' S 122°059.28' E, 4–7 m, coll. K. Gowlett-Holmes, 1 October 2002, AJB #3225, NTM Cr013631.

**Diagnosis**

Rostrum well developed, slender, dentition 7/0; supraorbital tubercles present; inferior orbital angle produced; antennal spine large; first abdominal segment without anterodorsal lobe; first pereiopod slender, chela fingers subpatulate, cutting edges entire; major second pereiopod massive, dactyl with large molar process, cutting edge distally entire, palm finely asperulate, merus ventrally entire; minor second pereiopod dactyl elongate, exceeding fixed finger, cutting edge concave, finely denticulate, fixed finger grooved, inner cutting minutely denticulate; third pereiopod dactylus biunguiculate, ventral border minutely denticulate, without acute basal process, propod with 3 distal spines, 5 ventral spines; uropodal exopod laterally unarmored; telson with large dorsal spines at 0.2 and 0.6 of telson length.

**Description**

A medium sized species of *Periclimenes*, of subcylindrical body form.

*Rostrum* (Figure 4B). Slender, compressed, acute,
reaching to about to middle of distal segment of antennular peduncle, about 0.5 of CL, dorsal margin sublinear, with 7 acute teeth, first tooth situated over posterior orbital margin, slightly transversely broadened, distal tooth small, intervening teeth long, slender, acute, with short plumose setae on dorsal edges, teeth longer than rostral depth, ventral border mainly straight, slightly up-curved distally, unarmed, non-setose.

Carapace (Figure 4A). Smooth, glabrous, with small subacute supraorbital tubercles, antennal spine large robust, inferior orbital angle (Figure 7A) produced as small blunt process, hepatic spine absent, anterolateral branchiostegite not produced, broadly rounded.

Abdomen. Smooth, glabrous; first segment without anterodorsal lobe, pleura broadly rounded, sixth segment (Figure 4C) about 0.3 of CL, 2.8 times longer than deep, 1.2 times longer than fifth segment, posterolateral angle blunt, posteroventral angle well developed, acute.

Telson (Figure 4K). About 0.6 of CL; dorsal surface sparsely setose; 2.0 times longer than anterior width, lateral margins feebly concave, posteriorly convergent, with 2 pairs of submarginal dorsal spines (Figure 8G), at about 0.2 and 0.6 of telson length, spines about 0.15 of telson length, posterior spines slightly more slender than anterior, posterior margin (Figure 4L) about 0.4 of anterior margin width, lateral spines small, acute, about 0.75 of dorsal spine length, intermediate spines robust, about 5.5 times longer than basal width, 0.25 of telson length, 1.8 times lateral spine length, submedian spines 0.75 of intermediate spine length, setulose.

Antennule (Figure 4D). Short, robust, proximal segment (Figure 4E) with medial length about 1.6 times longer than basal width, with large slender acute ventromedial tooth (Figure 4F, 8F inset), lateral border angular, distally concave, with well developed distolateral lobe (Figure 8F) with acute distolateral tooth, stylocerite short, broad, subacute, reaching to about 0.4 of segment length, distolateral margin setose; statocyst present, granular statolith; intermediate and distal segments short and stout, combined equal to about 0.6 of proximal segment length, upper flagellum short, biramous, proximal 7 segments stout, fused, shorter free ramus with single short segment, longer ramus with 4 subcylindrical segments, about 16 groups of aesthetascs medially, with short simple spiniform setae laterally; lower flagellum of similar length, with about 20 subcylindrical segments.

Antenna (Figure 4G). Short, stout; coxal segment with conspicuous medial tubercle, basicerite laterally unarmed, carapcerite subcylindrical, about 4.0 times longer than distal width, extending to slightly beyond distal margin of scaphocerite, flagellum short; scaphocerite (Figure 4H) small, about 2.2 times longer than distal width, not exceeding carpocerite, lateral margin straight, with well developed acute distolateral tooth at about 0.68 of lamellar length.

Eye (Figure 4I). Cornea hemispherical, well pigmented, diameter about 0.16 of CL, without accessory pigment spot; stalk subcylindrical, 1.2 times corneal diameter proximally, tapering distally, about 1.2 times longer than basal width.

Mandible (Figure 5A). Corpus normal, without palp; molar process (Figure 8A,B) subcylindrical, tapering slightly, transversely oblique distally, with single acute ventral tooth, margins fringed with dense long slender setae; incisor process (Figure 8C) slender, curved, transversely truncate distally with five small subequal acute teeth.

Maxillula (Figure 5B). Palp (Figure 8D) slender, feebly bilobed distally, lower lobe with small tubercle bearing single short simple seta; upper lacinia (Figure 8E) short, broad, distal margin transversely truncate, with 11 slender acute simple teeth, fully fused to lacinia, with sparse simple setae; lower lacinia short, blunt, with numerous distal setae.

Maxilla (Figure 5C). Palp elongate, slender, non-setose; basal endite bilobed, upper lobe short, broader than lower, with 9 simple setae distally; lower lobe damaged; coxal endite obsolete, medial margin convex, non-setose; scaphognathite well developed, 2.5 times longer than broad, anterior lobe broad, 1.2 times longer than wide.

First maxilliped (Figure 5D). Of normal form; palp slender, elongate, flattened, extending well beyond distal margin of basal endite, with single short simple seta at 0.66 of medial margin length; basal endite basal endite sparsely setose distally, glabrous proximally, coxal endite not distinguishable, sparsely setose, exopod with caridean lobe broad, 2.5 times longer than wide, with numerous plumose marginal setae; flagellum slender, with 7 plumose terminal setae; epipod small, deeply bilobed, distal lobe larger than proximal.

Second maxilliped (Figure 5E). Of normal form; dactylar segment narrow, 4.0 times longer than wide, with numerous finely serrulate spines medially; propodal segment well developed, distomedial border convex, with numerous finely serrulate spines; carpus, ischiomerus and basis without special features; exopod with well developed flagellum, with 7 plumose distal setae; coxa angularly produced medially, with few simple setae, epipod small, suboval, without podobranch.

Third maxilliped (Figure 5F). Of normal form, reaching to about distal end of carpocerite; endopod with ischiomerus semi-fused to basis, combined segment about 4.4 times longer than central width, medial border sparsely setose, with simple setae, coxal border convex, penultimate segment subcylindrical, about 4.0 times longer
Figure 5  *Periclimenaens matherae* sp. nov., holotype male. A, mandible. B, maxillula. C, maxilla. D, first maxilliped. E, second maxilliped. F, third maxilliped. Scale bar 0.5 mm.
than central width, scarcely tapering distally, about 0.66 of antepenultimate segment length, with double rows of spiniform setae medially, terminal segment about 0.9 of penultimate segment length, 4.5 times longer than basal width, tapering distally, with double rows of spiniform setae medially; exopod flagellum as in second maxilliped, with 8 distal setae; coxa with oval lateral plate, medial margin convex, not produced, rudimentary arthrobranch present.

Thoracic sternites. Narrow, without discernable armament.

First pereiopod (Figure 6A). Slender, exceeding antennular peduncle by about 0.4 of meral length; chela (Figure 6B) slender, palm subcylindrical, slightly compressed, about 2.5 times longer than depth, sparsely setose, fingers (Figure 6C) 0.8 of palm length, slender, tapering, with numerous tufts of short setae, feebly spatulate, lateral margins entire, tips feebly bidentate; carpus about 1.5 times chela length, subcylindrical, 8.0 times longer than distal width, tapering proximally, unarmed; merus subequal to carpal length, subcylindrical, 7.5 times longer than maximal width, unarmed; ischium
subequal to chela length; basis and coxa without special features.

Major second pereiopod (Figure 6D). Second pereiopods well developed, grossly unequal and dissimilar. Major chela (Figure 6E) about 2.0 times CL, palm inflated, oval in section, 2.0 times longer than central depth, tapering distally, glabrous, densely covered with minute asperities except on ventral aspect, fingers (Figure 7B,C,D) about 0.32 of palm length, dactylus robust proximally, compressed distally, about 1.8 times longer than deep, lateral margin hemispherical, stout, smooth, cutting edge with large molar process proximally, distal margin feebly bilobed, about 0.25 of dactyl length, concave, sharp, entire, tip very acute; fixed finger about 0.8 of dactylus length, 1.3 times longer than proximal depth, cutting edge with deep fossa on proximal half, dorsal margin with large subacute process, ventral margin with broad lobe, distal half entire, blunt, unarmed, tip strongly curved, acute; carpus about 0.27 of palm length, robust, about 2.0 times broader than proximal width, distally expanded, unarmed; merus robust, 0.33 of palm length, 1.6 times longer than central width, slightly swollen centrally, unarmed; ischium about 0.92 of meral length, 1.2 times longer than distal width, tapering proximally, basis and coxa slender, without special features.

Minor second pereiopod. Much smaller than major pereiopod. Chela (Figure 6F) about 0.85 of CL, 0.44 of major chela length, palm subcylindrical, slightly compressed, tapering slightly distally, about 2.4 times longer than maximal width, smooth, glabrous, dactylus (Figure 6G) about 0.4 of palm length, compressed, about 2.8 times longer than central depth, extending well beyond end of fixed finger, dorsal margin convex, sparsely setose, cutting edge sinuous, finely denticulate with about 45 small acute teeth throughout length, size increasing distally, minute proximally, tip acute, small, feebly hooked; fixed finger (Figure 6G) about 2.2 times longer than basal width, cutting edge deeply grooved proximally, medial and lateral margins each with blunt processes, ventral process larger than dorsal, both minutely denticulate distally, dorsal margin obsolete distally, ventral margin minutely denticulate over most of length, tip stout, acute, strongly hooked; proximal segments similar to major second pereiopod but smaller.

Third pereiopod (Figure 6H). Robust, exceeding antennular peduncle by propod and dactyl; dactyl (Figure 4J) with corpus short, about 0.14 of propod length, strongly compressed, dorsal length about 0.95 of basal width, tapering strongly distally, almost subcircular, dorsal margin convex, ventral margin (Figure 7E) with strong acute recurved accessory tooth distally, convex proximally, with four minute denticulations, without acute proximal tooth, ungus clearly demarkated, about 2.0 times longer than basal width, 0.56 of dorsal corpus margin length; propod (Figure 6I) about 0.38 of CL,

![Figure 8 Periclimenaeus matherae sp. nov., holotype male. A, mandible, molar process, dorsal aspect. B, same, ventral aspect. C, same, distal incisor process. D, maxillula, palp. E, same, distal upper lacinia. F, antennule, proximal segment, distolateral angle; adjacent inset, ventromedial tooth, to same scale. G, dorsal telson spines, posterior spine, upper; anterior spine, lower. H, distolateral tooth.](image-url)
about 4.3 times longer than maximal depth, tapering slightly distally, dorsal margin feebly convex, sparsely setose, ventral border straight, with short stout acute distomedial spine and much longer distolateral spine, ventral margin with 7 spines throughout length, spines larger distally, smaller and more slender proximally; carpus 0.7 of propod length, 3.2 times longer than distal width, unarmed; merus 1.2 times propod length, 3.0 times longer than central depth, unarmed; ischium about 0.85 of propod length, 2.4 times longer than distal width, unarmed; basis and coxa without special features. Fourth pereiopod similar to third, dactylar corpus without minute ventral denticulations, propod (Figure 6J) length subequal, more slender, about 4.7 times longer than depth, with distolateral and 3 distal ventral spines only. Fifth pereiopod generally similar to fourth, propod without spines, with dense distoventral setal brushes.

First pleopod. Of normal form, endopod (Figure 7F) about 3.3 times longer than width, distal third tapering, with 11 short, sparsely plumose setae, medial margin with proximal two-thirds bearing 10 short simple spiniform setae.

Second pleopod. Of normal form, appendix masculina (Figure 7G) short, about 0.12 of endopod length, bearing 3 long finely setulose spines, longest spine about 3.0 times the corpus length, appendix interna subcyhndrical, about 3.0 times longer than corpus of appendix masculina, with few cincinnuli distally.

Uropod (Figure 1M). Protopodite posterolaterally unarmed; exopod 2.0 times longer than broad, lateral margin feebly convex, unarmed, sparsely setose, with stout acute distolateral tooth with longer robust spine medially (Figure 8H), falling well short of distal margin of lamella, diaeresis feebly indicated; endopod of subequal length, 2.1 times longer than broad.

Measurements (mm)
Post-orbital carapace length, 3.9; carapace and rostrum, 5.8; total body length (approx.), 12.0; major second pereiopod chela, 7.5; minor second pereiopod chela, 3.3.

Systematic Position
This species is most closely related to P. pachydentatus Bruce, 1969, but can be distinguished by the following features. Rostrum with seven teeth all anterior to orbital margin, vs six, with first tooth posterior to orbital margin, acute supraorbital tubercles present vs absent, inferior orbital angle bluntly produced, vs obsolete, proximal segment of antennular peduncle with very well developed ventromedial tooth, vs small tooth only in this position, major second pereiopod chela with palm asperulate vs smooth, third pereiopod dactyl with ventral corpus with minute denticles, vs non-denticulate, minor second pereiopod dactyl with about 45 denticle of increasing size distally, without denticulate thickened proximal region vs 50 of decreasing size distally, with denticulate proximal thickened region, third pereiopod propod with 7 ventral spines vs 3 spines only present.

Colouration
No data.

Host
Hypodistoma decrata (Sluiter, 1895), [Ascidiacea], NTM E243, det. P. Kott. Known from NW Australia NE Australia, Northern Territory, Torres Strait, Papua New Guinea and the Philippines.

Etymology
The species is dedicated to Patricia Mather, A.O., née Kott, a friend and colleague over many years.

Remarks
It may be noted that the mouthparts are closely similar to those of P. hecate (Nobili, 1904), as described by Bruce (1976: 25-27, figure 10). However, in that species, the molar process of the mandible is multidentate, and lacks the dense marginal fringes of fine long setae; the basal endite of the maxilla is simple, not bilobed, the distal scaphognathite is narrow, rather than broad, the first maxilliped has a smaller epipod, with subequal lobes, the second maxilliped has a reduced epipod (although this may be abnormal) and the third maxilliped has a row of short erect submarginal setae on the proximal medial ischial region. The upper lacinia of the maxillula has the distal spines fully fused to the lacinia as in P. matherae.

Periclimenaeus pachydentatus Bruce, 1969
Figures 9-10


Material examined

Diagnosis
Large species. Rostrum well developed, very slender, up-curved, dentition 6/0, teeth subcyhndrical, proximal tooth postorbital,
transversely broadened; supraorbital tubercles present; inferior orbital angle not produced; antennal spine large; first abdominal segment without anterodorsal lobe; scaphocerite with small distolateral tooth, first pereiopod slender, chela fingers subspatulate, cutting edges entire; major second pereiopod massive, palm smooth, dactyl with large molar process, cutting edge distally entire, fixed finger with shallow fossa, merus ventrally entire; minor second pereiopod dactyl elongate, exceeding fixed finger, cutting edge concave, finely denticulate, about 50 denticulations, fixed finger grooved, inner cutting minutely denticulate; third pereiopod dactylus short, subcircular, biunguiculate, ventral border non-denticulate, without acute basal process, propod with 2 distal spines, 3 ventral spines; uropodal exopod laterally unarmed; telson with large dorsal spines at 0.25 and 0.65 of telson length.

Description
A general description has been provided by Bruce (1969).

First pereiopod (Figure 9A). Slender, exceeding antennal peduncle and carpocerite by about 0.2 of merus length; chela (Figure 9B) slender, palm subcylindrical, slightly compressed, about 3.0 times longer than deep, with few short cleaning setae proximally, fingers about 0.8 of palm length, slender in lateral view, feebly subspatulate, broad in dorsal view, with numerous groups of short setae distally, dorsal aspect of dactylus flattened, cutting edges entire, dactylus tip with two small teeth, fixed finger with three; carpus slender, about 1.6 times longer than chela, 7.0 times longer than distal width, tapering proximally; merus subequal to carpal length, about 6.5 times longer than central width, ischium subequal to chela length, 3.0 times longer than central width, all unarmed; basis about
0.8 of ischial length, ischium more robust, without processes.

Major second pereiopod (Figure 10). Greatly enlarged, with massive chela (Figure 10A); chela about 2.6 times CL (♂), 1.9 times (♀), palm smooth, glabrous, oval in section, 1.85 times longer than deep, tapering slightly distally, fingers (Figure 10BC) about 0.3 of palm length, dactylus massive, 1.7 times longer than deep, dorsal margin semicircular, proximal dorsal surface with distinct groove, cutting edge with large molar process proximally, distally feebly bilobed, distally thickened with stout blunt hooked tip, preterminal cutting edge thick, entire, fixed finger about 1.2 times longer than proximal depth, medial surface with acute tooth proximally, lateral surface with blunt tooth proximally, fitting into groove on dactylus, cutting edge with shallow fossa proximally, distal cutting edge stout, expanded laterally, margin feebly crenulate (Figure 10D), cutting edge medially entire, blunt, tip stout, feebly hooked, blunt; carpus about 0.33 of palm length, as broad as long, distally expanded, excavate, tapering strongly proximally, unarmed; merus unarmed, about 0.38 of palm length, stout, swollen, 1.6 times longer than width, dorsal border concave, ventral margin straight, without tubercles or denticles; ischium unarmed, about 0.28 of palm length, 1.8 times longer than distal width, tapering proximally; basis and coxa robust, without special features.
Minor second pereiopod (♀). Not greatly enlarged, much smaller than major pereiopod, chela (Figure 9C) about 0.93 of CL, 0.48 of major chela length, palm smooth, glabrous, 2.0 times longer than depth, at about 0.3 of length, tapering distally, fingers (Figure 9D) unequal, dactylus (Figure 9E) far exceeding fixed finger, about 0.5 of palm length, compressed, about 3.0 times longer than proximal depth, dorsal margin convex, tip acute, cutting edge concave distally, sharp, with about 50 minute acute denticles (Figure 9F), largest centrally, decreasing in size proximally and distally, proximal fourth of cutting edge thickened, covered with minute denticulations, fixed finger about 1.6 times longer than basal width, cutting edge shallowly grooved proximally, medial margin entire with blunt tooth proximally, lateral margin minutely denticate (Figure 10F), with small rounded denticulations, much smaller than denticulations of dactylus, tip stout, hooked, acute. Proximal segments similar to major second pereiopod but smaller.

Third pereiopod (Figure 9G). Robust, exceeding carpo-cephalite by propod and dactyl, dactylus (Figure 9H) short, stout, compressed, about 0.15 of propod length, corpus dorsal length about 1.1 times basal width, dorsal margin convex, ventral margin strongly convex, with strong recurved blunt accessory tooth distally, proximally unarmed, unguis about 0.8 of corpus length, stout, curved, 2.1 times longer than basal width, unarmed; propod (Figure 9G) about 0.3 of CL, 4.5 times longer than deep, tapering slightly distally, sparsely setose, with stout ventromedial distal spine, longer distolateral spine, subequal to dactylar corpus length, ventral margin with preterminal spine and 2 ventral spines.

Measurements (mm)
Holotype ♀, CL 6.5; major chela, 12.6; minor chela, 6.1; allotype ♂, CL 6.1; major chela, 15.8.

Colouration
Generally whitish with a pink tinge, densely covered with uniform minute chromatophores, female more markedly pinkish than male (from colour slide).

Host
The type specimens were found in the ascidian Hypodisma debratum (Sluiter), det. P. Kott, and the Philippines specimen in the same host, det. R.H. Millar.

Remarks
The original preliminary description by Bruce (1969) was unillustrated. The anterior carapace, rostrum and antennae, in dorsal and lateral view, and the telson have been illustrated by Bruce (1993). Bruce (1986) provides a colour photo of a pair of specimens, which well illustrates the massive major chela of the second pereiopods in both sexes. In this photograph the major second pereiopod is 2.2 times the CL in the male and 1.5 times in the female.

The second pereiopod chela are noted as smooth. Those of P. mathevice are minutely asperulate. These minute asperities may be difficult to see. They can be more easily detected by touch, by passing the tip of a dissecting needle over the surface of the palm, when they are readily felt when present.

The type specimens are in good condition. The allotype male lacks the minor second pereiopod. The Jolo specimen show no significant differences from the type specimens.

Distribution
Known from the type locality and from Gulf of Carpentaria, Queensland, and from Hibernia Reef, Western Australia (Bruce 1981, 1992). Now also known from the Philippines.

ACKNOWLEDGEMENTS
I am most grateful to Pat Mather for the opportunity to report on these two new shrimps and for the identification of their hosts. Miranda Lowe kindly made the type material of P. pachydentatus available and Dr Torben Wolff, the Philippines specimen. This study was facilitated by support from the Australian Biological Resources Study.

REFERENCES


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A new species of Melo (Gastropoda: Volutidae) from northwestern Australia

Hugh Morrison and Fred E. Wells
Department of Aquatic Zoology, Western Australian Museum, Francis Street, Perth, Western Australia 6000, Australia

Abstract – A new species of volutid gastropod, Melo (Melocorona) ashmorensis, is described from Ashmore Reef off northern Western Australia. The new species is compared with three known tropical species of Melo (Melocorona): M. aethiopica (Linnaeus, 1758), M. amplora (Lightfoot, 1786), and M. broderipii (Gray in Griffith and Pidgeon, 1834). Key features of Melo ashmorensis are its large size (up to 283 mm long), and the spire is raised above the spines and above the top of the outer lip of shell. There are 13–16 very low, uniform spines per whorl which cease at or near the aperture line before the adult whorl. Melo amplora differs in being larger with a depressed spire, with 16–20 straight or curved spines which do not extend to the body whorl, and gradually increase in size, with the final spine often being very long and the highest of all. The protoconch is white in M. ashmorensis, compared to yellowish in M. broderipii. Spines are more numerous on M. broderipii (about 50 per whorl) and reach the end of the whorl on all specimens. The key characteristic of M. aethiopica is the very swollen outer lip which is flared in adults. The spire of M. aethiopica is depressed, and there are 28–34 spines per whorl.

Key words: new species, Melo, Volutidae, northwestern Australia, Ashmore Reef, Cartier Island, Hibernia Reef

INTRODUCTION

The continental shelf off northwestern Australia is one of the widest in the world, with a maximum width of 350 km. The shelf is a continuous structure that extends from North West Cape, Western Australia, across the top of the continent to the tip of Cape York, Queensland. Open ocean atolls are located near the outer edge of the shelf in northwestern Australia. There are no signs of volcanic stacks in the centre, so the reefs are not classic Darwinian atolls. Instead they originated in shallow water and have grown vertically to remain in the shallows as the surrounding area became deeper (Carrigy and Fairbridge 1954). The fauna of these open ocean atolls was almost totally unknown until a series of expeditions was mounted by the Western Australian Museum to Rowley Shoals (1982), Scott and Seringapatam Reefs (1984) and Ashmore Reef and Cartier Island (1986) (Berry 1986; 1993). A few years later, the Northern Territory Museum worked at Ashmore Reef, Hibernia Reef and Cartier Island (Russell and Vail 1988; Russell and Hanley 1993). Results obtained were spectacular, and included the first specimen of the largest species of giant clam, Tridacna gigas (Linnaeus, 1758) collected in Western Australia (Wells and Slack-Smith 1986). From the various animal phyla examined about 20–25% of species recorded were new to Western Australia. In addition there were genera and species which were new to Australia. Many of the new Australian records were species commonly recorded on oceanic atolls throughout the Indo-Pacific, but which had not been recorded in the Australian continental coastline. The fauna was more closely related to that of the Great Barrier Reef in eastern Queensland than it was to the adjacent continental coastline in northwestern Australia (Wells 1986).

Molluscs collected in the surveys were recorded by a series of papers (Wilson 1985; Wells 1986; 1993; Wells and Slack-Smith 1986; Wells and Bryce 2000; Wells and Allen 2005; Willan 2005). Altogether these papers recorded over 900 species of shallow water molluscs from the offshore atolls. Since then there have been several species described from the atolls.

One feature of the molluscs was that there have been very few species of Volutidae collected from the offshore atolls (Wells 1993). Volutes lack a planktonic distributional phase in their life cycle; instead crawling young emerge from benthic egg masses (Wilson 1994). This severely restricts the dispersal capability of volutes and tends to lead to allopatric speciation. It appears that the atolls being located so far offshore presents a considerable barrier to the distribution of volutes. The single
species of *Melo* collected was listed by Wells (1993) and Wilson (1994) as *Melo amphora* (Lightfoot, 1786) and by Willan (1993) as *M. broderipii* (Gray in Griffith and Pidgeon, 1834) and more recently as *M. aethiopicn* (Linnaeus, 1758) (Willan 2005). Closer inspection of WAM material has led us to conclude this is in fact a new species, which is described here. Recently four additional volutes have been reported from Ashmore Reef. *Amoria spenceriana* (Gatliff, 1908) was originally described without a type locality, but Ludbrook (1953) subsequently designated Port Denison, north Queensland. *Amoria spenceriana* was considered to be a synonym of *A. maculata* (Swainson, 1822) by Wilson (1994). However, *A. spenceriana* is now regarded as being a valid species which is endemic to Ashmore Reef (Willan 1995; Bail and Poppe 2001). Two additional species of *Amoria* have been recorded by Willan (2005): *A. cf. grayii* (Ludbrook, 1953) and *A. cf. damonii* (Ludbrook, 1953). A new species, *Cymbiola baili* Prati-Muzetti and Raybaudi-Massilia, 1996, has also been described from Ashmore Reef. Thus the three of the five volutes now known from Ashmore Reef have been new taxa. It is likely that further collecting on these atolls will discover more undescribed species of molluscs.

All specimens examined during this study are lodged in the collections of the Western Australian Museum, Perth (WAM), the Hugh Morrison Collection (HMC), and the Merv Cooper Collection (MCC).

**TAXONOMY**

*Family Volutidae* Rafinesque, 1815

*Genus Melo* Broderip in Sowerby, 1826

*Subgenus Melo* (*Melocorona*) Pilsbry and Olsson, 1964

*Melo* (*Melocorona*) *ashmorensis* sp. nov.

Figures 1–4

**Material Examined**

Holotype, Ashmore Reef (12°10'S, 122°58'E), collected in sand at 3 m depth, 1984, H. Morrison (WAM S.14955).

Paratypes: 1 specimen, Hibernia Reef (11°55'S, 123°28'E), collected in sand on coral, 2 m depth, 19 September 1994, H. Morrison (WAM S.14956); 1

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**Figure 1** Apertural and dorsal views of holotype of *Melo ashmorensis* (WAM S. 14955).
Figure 2  Comparison of apertural views of: A. Holotype of Melo asinorensis (WAM S. 14955); B. M. broderipii (WAM S. 14959) (Balabac Island, Palawan, Philippines; 7°59'N, 117°06'E); C. M. aethiopica (MCC; locality unknown); D. M. amphora (WAM S. 14960) (Broome, Western Australia; 17°58'S, 122°14'E).
specimen, Hibernia Reef (11°55'S, 123°28'E), collected in sand on coral, 2 m depth, 19 September 1994, H. Morrison (WAM S.14957); 1 specimen, Hibernia Reef (11°55'S, 123°28'E), collected in sand on coral, 2 m depth, 19 September 1994, H. Morrison (HMC); 1 specimen, Ashmore Reef (12°10'S, 122°58'E), Station 16, transect from west of north lagoon to reef front, 17 September 1984, F.E. Wells and C.W. Bryce (WAM S.14958).

Type locality
Ashmore Reef (12°17'S, 123°02'E) off northern Western Australia (Figure 5).

Etymology
Named after Ashmore Reef, northwestern Australia, where the species was first found.

Table 1  Details of the type material of Melo ashmorensis.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Repository</th>
<th>Locality</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Length/Width</th>
<th>Shoulder spines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype</td>
<td>WAM S.14955</td>
<td>Ashmore Reef</td>
<td>276</td>
<td>174</td>
<td>1.59</td>
<td>16</td>
</tr>
<tr>
<td>Paratype</td>
<td>WAM S.14956</td>
<td>Hibernia Reef</td>
<td>283</td>
<td>179</td>
<td>1.58</td>
<td>13</td>
</tr>
<tr>
<td>Paratype</td>
<td>WAM S.14957</td>
<td>Hibernia Reef</td>
<td>223</td>
<td>132</td>
<td>1.69</td>
<td>16</td>
</tr>
<tr>
<td>Paratype</td>
<td>HMC</td>
<td>Hibernia Reef</td>
<td>184</td>
<td>112</td>
<td>1.64</td>
<td>14</td>
</tr>
<tr>
<td>Paratype</td>
<td>WAM S 14958</td>
<td>Ashmore Reef</td>
<td>98</td>
<td>56</td>
<td>1.75</td>
<td>16</td>
</tr>
</tbody>
</table>

Figure 3  Comparison of apertural view of spines of: A. Holotype of Melo ashmorensis (WAM S. 14955); B. M. broderipii (WAM S. 14959); C. M. aethiopica (MCC); D. M. amphora (WAM S. 14960).

Diagnosis
Large Melo, up to 283 mm long. Ovate, outer lip not extended dorsally. Protoconch white, 3 whorls. Teleoconch whorls with 13-16 low spines, 4-8 mm high, widely spaced, terminate at or near aperture line Spire extends above spines on body whorl and above top of outer lip of shell. 3 columellar plaits. Body whorl background colour mottled beige to brown. Two wide distinct dark brown bands divide shell into three roughly equal sections. Aperture bright orange.

Description
Shell
Typical Melo shape, large, ovate, outer lip not extended dorsally. Up to 283 mm long and 179 mm wide (Table 1). Protoconch white, of three whorls, 7
mm high, 12 mm across. Three juvenile and adult whorls expand rapidly. Spire raised above spines on shoulder of upper whorls, and above top of outer lip of shell, 13–16 very low spines per whorl, widely spaced, of relatively uniform size (about 4–8 mm), do not reach outer edge of whorl, instead cease at or near aperture line before adult whorl. Body whorl mottled beige to brown background with two wide distinct bands, which divide shell into three roughly equal sections. Bands on ventral surface are blocks of dark brown, become complete on body whorl. Aperture bright orange.

Animal
Not known.

Distribution
Known only from Ashmore Reef and Hibernia Reef (11°27'S, 123°30'E). Not known from nearby Cartier Island (12°32'S, 123°33'E).

Remarks
The genus Melo has two subgenera: the monospecific Melo, with M. melo (Lightfoot, 1786) and Melocorona with all the remaining species, including M. ashmorensis. Poppe and Goto (1992) and Bail and Poppe (2001) recognise the following species in the subgenus: M. miltonis (Gray in Griffith and Pidgeon, 1834), M. amphora (Lightfoot, 1786), M. georgiana (Gray in Griffith and Pidgeon, 1834), M. umbilicatus (Broderip in Sowerby, 1826), M. aethiopica (Linnaeus, 1758) and M. broderipii (Gray in Griffith and Pidgeon, 1834). Melo miltonis is a southern Australian species which is very similar to the tropical Australian species Melo amphora (Lightfoot, 1786).
### Table 2  Comparison of relevant species in the volute subgenus *Melocorona*. Shell lengths after Poppe and Goto (1992).

<table>
<thead>
<tr>
<th>Species</th>
<th>Range (after Poppe and Goto, 1992)</th>
<th>Shell length (mm)</th>
<th>Columellar plaits</th>
<th>Spire</th>
<th>Outer aperture</th>
<th>Shoulder spines</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. ashmorensis</em></td>
<td>Ashmore Reef and Hibernia Reef, northwestern Australia</td>
<td>270</td>
<td>3</td>
<td>Spire raised above spines and above top of outer lip of shell. Protoconch largely eroded, white, 3 whors</td>
<td>Ovate, outer lip not swollen.</td>
<td>13–16 very low spines, widely spaced, uniform size; do not reach outer edge of whorl, cease at or near aperture line before adult whorl</td>
<td>Juvenile and adult shell expands rapidly, 3 whors. Body whorl mottled beige to brown background with 2 wide distinct bands, which divide shell into three roughly equal sections. Bands on ventral surface are locks of dark brown, become opaque on body whorl. Aperture bright orange</td>
</tr>
<tr>
<td><em>M. aethiopica</em></td>
<td>Java, Indonesia to Papua New Guinea</td>
<td>200–250 maximum 348</td>
<td>3–4</td>
<td>Spire very depressed. Large white protoconch white, 3 1/2 whors</td>
<td>Ovate, very swollen outer lip, flared in adults</td>
<td>Up to 28–34 spines per whorl. Very low, equal height, generally face in towards spire</td>
<td>Juvenile and adult shell expands rapidly, 3 whors. Dull dark brown on body whorl, little or no banding. Aperture pale cream to orange</td>
</tr>
<tr>
<td><em>M. amphora</em></td>
<td>Shark Bay, Western Australia to Moreton Bay, Queensland. Also southern Papua New Guinea</td>
<td>300–468 maximum 524</td>
<td>3</td>
<td>Spire depressed, surrounded by coronet of spines higher than spire. Large protoconch white, 3 whors</td>
<td>Ovate, outer lip of mature specimens usually higher than spire.</td>
<td>Straight or curved, usually erect 16–20 per whorl, do not extend to body whorl, gradually increase in size, final spine often the highest, very long</td>
<td>Juvenile and adult shell expands rapidly swollen, 3 whors. Colour colour and pattern on body whorl variable, juveniles often with wavy, zigzag, banding but body whorl of mature shells generally uniform pale cream to brown, aperture uniformly pale yellow to straw colour</td>
</tr>
<tr>
<td><em>M. broderipii</em></td>
<td>Primarily Philippines, also Papua New Guinea</td>
<td>250–350 maximum 371</td>
<td>4</td>
<td>Low but raised. Large yellow protoconch, 4 whors</td>
<td>Ovate spines numerous, low</td>
<td>About 50 spines per whorl, equidistant, low equal height, erect, reach end of whorl on all specimens examined</td>
<td>Juvenile and adult shell expands rapidly, 3 whors. Body whorl pale yellow to straw colour, 2 indistinct bands, generally central to body whorl. Aperture uniform pale yellow</td>
</tr>
</tbody>
</table>
New *Melo* from northwestern Australia

Figure 5  Map of northern Australia and the western Pacific Ocean showing the distribution of species of *Melo* (*Melocorona*) discussed in the text.

Apparent hybrids between the two species occur in the Shark Bay region of Western Australia (Wilson 1994). Similarly, Wilson (1994) considers *M. georgiana* to be a synonym of *M. amphora*. Weaver and duPont (1970) and Wilson (1994) regard the Queensland species *M. umbilicatus* as closest to *M. aethiopica*. None of these species (*M. miltonis*, *M. georgiana* or *M. umbilicatus*) are discussed further.

As indicated on Table 2, *M. ashmorensis* is restricted to Ashmore Reef and Hibernia Reef, where no other species of *Melo* are known to occur.

*Melo ashmorensis* is closest to *M. amphora*, and both Wells (1986) and Wilson (1994) considered it to be *M. amphora*. While juveniles are in fact very close in appearance (Plate 4; Table 2), *M. amphora* grows twice as large as *M. ashmorensis*. Key differences are that the spire is raised above the shoulder spines in *M. ashmorensis* while it is depressed in *M. amphora*, and is well below the spines. There are 13–16, very low, widely spaced shoulder spines of uniform size which do not reach the outer edge of the body whorl in *M. ashmorensis*. In fact, the spines cease at, or near, the aperture line before the adult whorl. In contrast, the spines of *M. amphora* are straight or curved, usually erect, 16–20 per whorl, do not extend to the body whorl, and gradually increase in size, with the final spine often being very long and the highest of all. The colour of *M. ashmorensis* is relatively uniform. The body whorl background colour is mottled beige to brown, with two, wide, distinct bands which divide shell into three roughly equal sections. On the ventral surface the bands start as blocks of dark brown and become continuous on the body whorl. The aperture is bright orange. In contrast, the basal colour and pattern on the body whorl are variable in *M. amphora*. Juveniles often have wavy or zigzag banding. The body whorl of mature shells is generally uniform pale cream to brown. The aperture is uniformly pale yellow to straw colour.

Willan (1993) originally identified Ashmore specimens as *M. broderipii*. The protoconch is white in *M. ashmorensis*, compared to yellowish in *M. broderipii*. Shoulder spines are much more numerous on *M. broderipii* (about 50 per whorl compared to 13–16) and reach the end of the whorl.
on all specimens, instead of not occurring on the body whorl in *M. ashmorensis*. The body whorl of *M. broderipii* is pale yellow to straw in colour, with two indistinct bands, which are central to the body whorl and do not divide the whorl into thirds. The aperture is a uniform pale yellow, not orange. Willan (2005) later tentatively identified *M. ashmorensis* as *M. aethiopica*. The key characteristic of *M. aethiopica* is the very swollen outer lip which is flared in adults. The spire of *M. aethiopica* is depressed instead of raised, and there are 28–34 spines per whorl which face in towards the spire, compared to only 13–16 spines per whorl on *M. ashmorensis*.

The shell is a dull dark brown on the body whorl of *M. aethiopica* with little or no banding and the aperture is pale cream to orange.

**DISCUSSION**

*Melo ashmorensis* is clearly not one of the presently recognised species of *Melo* (*Melocorona*). There is a possibility that the species has been given a name which is currently regarded as a synonym of another species. We believe this is very unlikely for a number of reasons. Many individuals in the population are small, and closely resemble *M. amphora*. Publications by Wells (1993) and Wilson (1994) incorrectly identified *M. ashmorensis* as *M. amphora*. The species is restricted to the very small area of Ashmore Reef and Hibernia Reef. The reefs were discovered in 1811, and were under British jurisdiction. They were not visited by the very early expeditions to Australia which resulted in nonexistent or vague type localities such as “New Holland”. The most likely location for a *Melo* type from Ashmore is the Natural History Museum, London. The type of *A. spenceriana* is in the Museum Victoria. During the nineteenth century the Australian Museum, Sydney had the largest mollusc collection in Australia; there are no *Melo* types from Ashmore or Hibernia Reefs in the three museums. Nor are there types in the present collections which have extensive Sahul Shelf material, the Western Australian Museum and the Northern Territory Museum.

Willan (1993) originally identified Ashmore specimens as *M. broderipii*. He later (Willan, 2005) has independently examined the taxonomic status of *Melo* from Ashmore and Hibernia Reefs, and tentatively identified the material as *M. aethiopica*. He concluded that “either these populations represent a new species ... or the separation between *M. aethiopica* and *M. broderipii* is artificial and the two are conspecific. I do not have enough material of *Melo* specimens from Asia to decide between these two alternatives, and so for the time being I have used the name *M. cf. aethiopica*.” Examination of Figures 2 and 3 and Table 2 demonstrate that *M. aethiopica* and *M. broderipii* are in fact separate species and are distinct from *M. ashmorensis*.

**ACKNOWLEDGEMENTS**

We are pleased to thank Glad Hansen (WAM), Allan Limbus, Peter Clarkson and Mike Claydon and Dr Henry Chaney of the Santa Barbara Museum of Natural History for discussions and reviewing specimens, Clay Bryce for taking the photographs, Corey Whisson for technical assistance, and Merv Cooper the loan of a specimen. Information on *Melo* types came from Drs John Taylor, Mark Norman and the website of the Australian Museum, and personal knowledge of the collections of the Western Australian Museum and Northern Territory Museum. We also thank Drs. John Taylor, Natural History Museum, London, and Richard Willan, Northern Territory Museum, for very helpful comments on the manuscript.

**REFERENCES**


Wells, F.E. (1986). Zoogeographic affinities of
New Melo from northwestern Australia


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Two new subterranean Parastenocarididae (Crustacea, Copepoda, Harpacticoida) from Western Australia

T. Karanovic
Western Australian Museum, Locked Bag 49, Welshpool DC, Western Australia 6986, Australia
E-mail: karanovic@museum.wa.gov.au

Abstract – Two new species of the genus Parastenocaris Kessler, 1913 are described from Australian subterranean waters, both based upon males and females. Parastenocaris eberhardi sp. nov. has been found in two small caves in southwestern Western Australia. It belongs to the “minuta”-group of species, having five large spinules at base of the fourth leg endopod in male. The integumental window pattern of P. eberhardi is the same as for the first reported Australian representative (P. solitaria), which helps to establish its affinities too, since only females of the latter species were described. Parastenocaris eberhardi has a clear Eastern Gondwana connection, like many other Australian copepods of freshwater origins. Parastenocaris kimberleyensis sp. nov. is described from a single water-monitoring bore in the Kimberley district, northeastern Western Australia. It belongs to the “brevipes”-group of species, for which a key to world species is given. The present state of systematics within the family Parastenocarididae is briefly discussed.

INTRODUCTION

Until relatively recently the groundwater fauna of Australia was very poorly known (Marmonier et al. 1993), and that mostly from the investigation of cave faunas in the eastern portion of the continent (Thurgate et al. 2001a; 2001b). Western Australia has been considered to have poor prospects for supporting subterranean faunas, owing to the lack of water and low nutrient input from xeric plant communities (Moore 1964; Hamilton-Smith 1967; Barr 1973; Howarth 1980). Knowledge of this region, however, has developed substantially in the last decade, such that it is now recognized to include one of the world’s most diverse and notable subterranean faunas (Holthuis 1960; Poore and Humphreys 1992, 1998; Wilson and Ponder 1992; Bartsch 1993; Humphreys 1993a, 1993b, 1993c, 2000, 2001; Bruce and Humphreys, 1993; Harvey et al. 1993; Aubrecht and Kozur 1995; Baltanas and Danielopol 1995; Yager and Humphreys 1996; Bradbury and Williams 1996a, 1996b, 1997a, 1997b; Harvey 1998; Knott and Halse 1999; Bradbury 2000, 2002; Watts and Humphreys 2000, 2001, 2003; Moore et al. 2001; Karanovic and Marmonier 2002, 2003). Recently, a number of stygial copepods have been described from ancient freshwater habitats (Pesce et al. 1996a; Pesce and De Laurentis 1996; De Laurentis et al. 1999, 2001; Karanovic 2003, 2004), as well as anchialine waters (Pesce et al. 1996b; Jaume and Humphreys 2001; Jaume et al. 2001; Karanovic et al. 2001; Lee and Huys 2002; Karanovic and Pesce 2002).

The family Parastenocarididae Chappuis, 1940 is almost exclusively freshwater in distribution (Boxshall and Jaume 2000) and has six well recognized genera: Parastenocaris Kessler, 1913; Forficatocaris Jakobi, 1969; Paraforficatocaris Jakobi, 1972; Potamocaris Dussart, 1979; Murunutucaris Reid, 1994; and Simpicaris Galassi and De Laurentiis, 2004. Few species have been recorded from slightly brackish environments (Wells 1986), but none from marine littoral or meiofauna. Jakobi (1972) proposed a new system for the family by splitting it into 26 different genera, which was strongly criticized by Schminke (1976) and has not been adopted by Dussart and Defaye (1990) nor any other modern taxonomist. Although the phylogenetic relationships within the Parastenocarididae are still uncertain (Martinez Arbizu 1997), the system of eight phyletic groups proposed by Lang (1948) seems to be the most appropriate at this time, although it requires knowledge of males, and many species are still known only from females (more precisely, the “proserpina”-group was established by Kunz (1938) and Lang (1948) established the remaining seven groups). Lang’s (1948) system was later supplemented by Noodt (1962, 1963, 1972), but with limited success. While one of Noodt’s groups was consequently accepted and elevated to the generic level (Forficatocaris), others (although possibly phylogenetically correct) are morphologically hard to distinguish from previously known groups. However, all these groups are Neotropical and not related to the Australian Parastenocarididae. The genera Forficatocaris, Paraforficatocaris, Potamocaris

and *Murunducaris* contain only a few species and are exclusively Neotropical (Reid 1994). Currently, the genus *Parastenocaris* contains around 220 species and subspecies (Galassi and De Laurentis 2004), although some of them are very inadequately described. Representatives of this genus are distributed over all continents, although interestingly they have never been recorded in New Zealand (Huys and Boxshall 1991). Recently, Ranga Reddy (2001) reported the first *Parastenocariididae* from the Indian subcontinent (three new species of *Parastenocaris*), hardly surprising considering more than 20 species already known from Asia, including six of them from Sri Lanka (Enckell 1970). The taxonomic impediments surrounding the genus *Parastenocaris* was recently discussed by Galassi and De Laurentis (2004), who also proposed a list of phylogenetically informative characters for this genus on the family as a whole. They also followed Reid’s (1994) rejection of the Chappuis’s (1933) description of the family as unavailable “until a cursory diagnosis was eventually supplied (Chappuis 1940)”. Although this sounds taxonomically relatively just, it should be pointed out that Reid (1994), or any other author before 2000, did not expressly applied Article 13 of the then current edition of the ICZN Code and, therefore, is not completely satisfying Article 13.2.1 now (see ICZN 1999).

*Parastenocaris solitaria* Karanovic, 2004 is the only other representative of the family *Parastenocarididae* described from the Australian continent. It is known only from females, so its affinities could not be properly evaluated (Karanovic 2004). Schminke (1981) reported “four species belonging to three genera” of *Parastenocarididae* from Australia, but unfortunately they all remain undescribed and unnamed. In this paper two new Australian species of *Parastenocaris* are described, luckily based on both females and males. One of these is morphologically very similar to *P. solitaria*, which helps to establish the affinities of the latter, while the other belongs to a different group of species.

**MATERIAL AND METHODS**

The sample from the Kimberley district was collected by a haul-net (mesh size 250 micrometers) from a water monitoring bore. Haul-nets are simple plankton nets of different sizes suitable for the borehole, which can range from 30 to 180 mm in diameter. A weighted net was lowered down the borehole with a bottle screwed to its distal end, then hauled through the water column several times. The sample was sorted live under a dissecting microscope and the copepods picked out and fixed in 70% ethanol and assigned a field number (prefix BES). Samples from the Margaret River caves were collected with a hand net, directly from the water body, or by washing tree roots and interstitial sand. Those samples were also assigned field numbers (prefix CW). Specimens were dissected and mounted on microscope slides in Faure’s medium, which was prepared following the procedure discussed by Stock and Von Vaupel Klein (1996), and dissected appendages were then covered with a coverslip. For the urosome or the entire animal two human hairs were mounted between the slide and coverslip, so the parts could not be compressed. By manipulating the coverslip carefully by hand, the whole animal or a particular appendage could be positioned in different aspects, making possible the observation of morphological details. During examination water slowly evaporated, and appendages eventually remained in completely dry Faure’s medium. All material has been deposited in the Western Australian Museum, Perth (WAM). Except for the abbreviations mentioned above and connected to the materials assignment, no others have been used. All drawings were prepared using a drawing tube attached to a Leica-DMLS brightfield compound microscope, with C-PLAN achromatic objectives. Morphological terminology follows Huys and Boxshall (1991), except for small differences in the spelling of some appendages (antennula, mandibula, maxillula instead of antennule, mandible, maxillule), as an attempt to standardize the terminology for homologue appendages in different groups of crustaceans.

**SYSTEMATICS**

**Order Harpacticoida Sars, 1903**

**Family Parastenocarididae Chappuis, 1940**

**Genus Parastenocaris Kessler, 1913**

*Parastenocaris eberhardi* sp. nov.

*Figures 1–33*

**Material examined**

*Holotype*

Female (WAM C28618), Western Australia, Margaret River Region, Strongs Cave, monitoring well, interstitial with tree roots, 6 July 2002, leg. S. Eberhard, 34°08′40″S 115°03′45″E (CW00265); dissected on 1 slide.

*Allotype*

Male (WAM C28619), Western Australia, Margaret River Region, Strongs Cave, monitoring well, interstitial with tree roots, 6 July 2002, leg. S. Eberhard, 34°08′40″S 115°03′45″E (CW00265); dissected on 1 slide.
Other paratypes
Western Australia, Margaret River Region, Strongs Cave, monitoring well, interstitial with tree roots, 6 July 2002, leg. S. Eberhard, 34°08'40"S 115°03'45"E (CW00265): 1 female in alcohol (WAM C28620).

Other material
Western Australia, Margaret River Region, Kudjal Yolgah Cave, root mat in a deep stream, 23 June 2002, leg. S. Eberhard, 34°05'55"S 115°02'22"E (CW00270): 1 female dissected on 1 slide (WAM C28621).

Description
Female (holotype)
Total body length, measured from tip of rostrum to posterior margin of caudal rami (excluding caudal setae), 374 μm. Preserved specimen colourless. Nauplius eye absent. Habitus (Figures 1 and 2) cylindrical and very slender, without demarcation between prosome and urosome; prosome/urosome ratio 0.8; greatest width very hard to locate. Body length/width ratio about 9.3; cephalothorax about 1.1 times as wide as genital double-somite. Free pedigerous somites without expansions laterally or dorsally. Integument not strongly chitinized, covered with minute pits (except cephalothorax, caudal rami and appendages), pattern becoming more dense towards posterior end of body; integumental windows on third and fourth urosomites (fourth and fifth urosomites, if second and third would not be fused into genital double-somite) laterally and on cephalothorax dorsally. Rostrum small, membranous, linguiform, reaching middle of first antennular segment, about as long as wide and not demarcated at base; with 2 dorsal sensilla. Cephalothorax about 1.9 times as long as wide; equaling 20% of total body length. Surface of dorsal shield covering cephalothorax with several very long sensilla and with large integumental window dorsally, inside which additional small area with even thinner integument visible. Tergites of 3 free pedigerous somites also with few large sensilla, but without integumental windows. Hyaline fringes of all somites smooth, except preanal somite, which hyaline fringe finely serrated both dorsally and ventrally. Genital double-somite (Figures 16 and 17) about as long as wide (ventral view), without any trace of subdivision, ornamented just with pair of median sensilla dorsally and 6 posterior sensilla (2 dorsal, 2 ventral and 2 lateral). Genital complex occupying anterior ventral half of genital double-somite. Genital apertures paired, each closed off by small, unarmed operculum derived from vestigial sixth leg. Median copulatory pore located anteriorly between genital apertures (Figure 16). Seminal receptacles not discernable. Third urosomite ornamented with 6 long posterior sensilla (2 dorsal, 2 ventral and 2 lateral) and with 2 lateral cuticular windows (no ventral groups of large spinules at middle). Preanal somite without surface ornamentation, with 2 lateral cuticular windows similar to those on previous somite (Figures 16 and 17). Anal somite with pair of large dorsal sensilla and pair of lateral (1 on each side) cuticular pores in proximal half. Anal operculum (Figure 1) with almost straight posterior margin, smooth, not reaching posterior end of anal somite and representing 71% of somite’s width. Anal sinus smooth.

Caudal rami (Figures 10, 11 and 16) relatively long, semicylindrical (with greatest width at 3/5 of ramus length), divergent, with space between them about twice width of ramus, and about 2.9 times as long as greatest width (ventral view): unornamented and armed with 7 armature elements (3 lateral, 1 dorsal and 3 apical). Dorsal rami relatively long, inserted slightly closer to inner margin at about 3/5 of ramus length, about 1.5 times as long as caudal ramus, biarticulate at base and smooth. Lateral setae thin and smooth, all shorter than ramus, inserted close to each other slightly posterior to dorsal seta. Inner apical seta smooth, slightly shorter than ramus. Middle apical seta strongest, without breaking plane, smooth, about 2.5 times as long as outer apical seta, and 0.3 times as long as whole body. Outer apical seta also without breaking plane, but pinnate along outer margin.

Antennula (Figure 3) 7-segmented, unornamented, approximately as long as cephalothorax, with broad aesthetasc on fourth segment not reaching beyond tip of appendage; more slender apical aesthetasc on seventh segment fused basally to apical seta; setal formula as follows: 0.4.4.1.0.9. Proximalmost seta on second segment unipinnate and articulating on basal part; all other setae smooth and without breaking plane or articulation. Length ratio of antennular segments, from proximal end, 1 : 3 : 1.3 : 1.4 : 0.7 : 0.8 : 1.4.

Antenna (Figure 4) short and robust, composed of coxa, allobasis, 1-segmented endopod, and 1-segmented exopod. Coxa small, unornamented. Allobasis about 2.8 times as long as wide, unarmed, and ornamented with 2 bunches of spinules on anterior surface. Endopod about 2.7 times as long as wide, with surface frill subdistally, ornamented with few long spinules along anterior surface, armed laterally with 2 spines and apically with 5 strong armature elements (2 of which geniculate). Exopod minute, cylindrical, about 3 times as long as wide, unornamented, armed with only 1 apical bipinnate seta, about 2.5 times as long as segment.

Mandibula (Figure 6) with narrow cutting edge on elongated coxa, armed with 3 coarse teeth
Figures 1–9  *Parastenocaris eberhardi* sp. nov., holotype (female): 1, habitus, dorsal view; 2, habitus, lateral view; 3, antennula; 4, antenna, 5, exopod of antenna; 6, mandibula; 7, maxillula; 8, maxilla; 9, maxilliped. Scales = 0.1 mm.
Figures 10–16 Parastenocaris eberhardi sp. nov., holotype (female): 10, left caudal ramus, lateral view; 11, left caudal ramus, dorsal view; 12, first swimming leg; 13, endopod of second swimming leg; 14, endopod of fourth swimming leg; 15, third swimming leg; 16, third free pedigerous somite and urosome, ventral view. Scales = 0.1 mm.
ventrally, 1 smooth seta dorsally, and several smaller teeth in between. Palp 1-segmented, cylindrically, about 4 times as long as wide, unornamented, and armed apically with 2 smooth subequal setae.

Maxillula (Figure 7) with large praecoxa, its arthrite rectangular, long, unornamented, and armed with 1 strong anterior surface setae, 1 lateral and 4 apical elements (probably 3 spines and 1 strong seta). Coxl endite small, armed with 2 smooth armature elements of about same length. Basis longer than coxl endite, armed with 3 naked setae apically. Endopod and exopod completely reduced.

Maxilla (Figure 8) with 2 endites on syncoxa; proximal one armed apically with only 1 bare seta; distal endite twice as long as proximal one, with naked seta and 1 pinnate spine. Basis drawn out into strong claw, without seta at base. Endopod represented by minute but distinct segment, with 2 bare subequal apical setae.

Maxilliped (Figure 9) with short syncoxa, ornamented with transverse row of long spinules; basis about 4 times as long as wide, unornamented and unarmed; endopod represented by distally pinnate curved claw, about 0.8 times as long as basis.

First swimming leg (Figure 12) with smooth coxa and intercoxal sclerite. Basis ornamented with few large spines around insertion of outer spine. Exopod 3-segmented, armed with 1 outer spine on first segment and 4 armature elements on third segment (2 outer spines and 2 apical geniculate setae); ornamented with few large spines along outer margin on all segments. Endopod 2-segmented, longer than exopod; first segment reaching slightly beyond distal margin of second exopodal segment, about 4.2 times as long as wide, armed with single smooth seta on inner margin, ornamented with large spines along outer margin; second segment armed apically with long geniculate seta and much shorter spine.

Second swimming leg with smooth coxa, intercoxal sclerite and basis; basis armed with short outer spine. Exopod 3-segmented, ornamented with large spines along outer margin, and with hyaline frills on each segment distally on inner side; first segment armed with single outer spine; second segment unarmed, third segment armed with 3 long armature elements (probably outer spine and 2 apical setae). Endopod (Figure 13) 1-segmented, slender, unornamented, reaching to middle of first exopodal segment, armed apically with 2 smooth thin setae; outer seta about 3 times as long as inner one.

Third swimming leg (Figure 15) also with smooth coxa, intercoxal sclerite and basis; basis armed with very long, smooth outer seta, about 1.4 times as long as exopod. Exopod 2-segmented, ornamented with few large spines along outer margin, both segments with hyaline frills distally on inner side; first segment armed with single outer spine; second segment armed with outer spine and apical strong seta. Endopod 1-segmented, unarmed and unornamented, in form of spiniform process, not reaching middle of first exopodal segment.

Fourth swimming leg with smooth coxa, intercoxal sclerite and basis; basis armed with long smooth outer seta. Exopod 3-segmented, ornamented with few large spines along outer margin, and second and third segment with hyaline frills distally on inner side; first segment armed with single outer spine; second segment unarmed; third segment armed with outer spine and very long apical seta. Endopod (Figure 14) 1-segmented, in form of spiniform process, reaching 3/4 of first exopodal segment length; ancestral apical spine completely fused to somite, with 2 spines at its ancestral distinction.

Fifth leg (Figure 18) simple triangular cuticular plate, ornamented with small cuticular pore basally and larger cuticular window; distal part protruding posteriorly as very long, outwardly curved, spiniform process, reaching almost middle of genital double-somite. Armature consists of very long outer basal seta and 3 additional small setae along outer margin.

Sixth leg (Figures 16 and 19) small cuticular plate, covering gonopore, ornamented with single cuticular pore and unarmed.

Male (allotype)

Body length, excluding caudal setae, 308 μm. Habitus, ornamentation of prosomal somites, colour and nauplius eye similar to female. Genital and first abdominal somite not fused; genital somite about twice as wide as long; first abdominal (third urosomal) somite ornamented with 2 ventrolateral bunches of 3–4 spines at middle (Figure 25). Single large, completely formed, longitudinally-placed spermatophore (Figure 23) visible inside fifth pedigerous and genital somites. Cuticular windows, caudal rami (Figure 25), antenna, mandibula, maxillula, maxilla, maxilliped, first swimming leg (Figure 29) and fifth leg (Figure 25) similar to female.

Antennula (Figures 24 and 33) prehensile, 7-segmented, with very strong geniculation between fifth and sixth segment. Proximal anterior corner of fifth segment and distal anterior corner of sixth segment protruding like strong, spiniform processes, forming very powerful pincers. Proximal aesthetasc (in male of fifth segment instead on fourth) much wider than in female, while aesthetasc on apical segment similar to that of female. Setal formula as follows: 0.4.4.2.3.0.9.

Second swimming leg (Figure 30) without seta on outer margin of basis; segment ornamented with
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Figures 17–24 Parastenocaris eberhardi sp. nov., 17–19, holotype (female); 20–22, paratype (female); 23 and 24, allotype (male): 17, urosome, lateral view; 18, fifth leg; 19, sixth leg; 20, endopod of third swimming leg; 21, fifth legs; 22, abdomen, lateral view; 23, spermatophore; 24, antennula. Scales = 0.1 mm.
Figures 25–33  *Parastenocaris eberardi* sp. nov., allotype (male): 25, urosome, semilateral view; 26, third swimming leg, anterior view; 27, distal part of third swimming leg, semilateral view; 28, distal part of third swimming leg, seminterior view; 29, first swimming leg; 30, second swimming leg; 31, fourth swimming leg; 32, endopod of fourth swimming leg; 33, part of antennula. Scales = 0.1 mm.
several large spinules. Exopod and endopod similar to female.

Third swimming leg (Figures 26, 27 and 28) with smooth praecoxa, coxa and intercoxal sclerite. Basis robust, armed with long outer seta and ornamented with longitudinal row of spinules along distal part of inner margin and diagonal row of spinules close to outer margin. Endopod completely reduced. Exopod with both segments fused; ancestral proximal segment about 3.5 times as long as wide, curved inward, ornamented with 2 short rows of spinules along outer margin, armed subapically with large, smooth, curved and sharp spine, which reaching beyond end of whole exopod; ancestral distal segment (apophysis) small, terminating with outward curved tridimensional structure and forming pincers with armature element of first segment.

Fourth swimming leg (Figure 31) with exopod very similar to female. Endopod (Figure 32) also 1-segmented, but unornamented, curved and characteristically modified, with swollen and less sclerotized distal part; 5 large spinules at base of endopod, on inner side of basis.

Sixth leg (Fig 25) simple triangular plate, unarmed and unornamented; both sixth legs distinct at base and with close inner margins, but not fused.

Variability

Body lengths of females range from 339 μm to 383 μm (365 μm average; n=3); only one male was collected and studied. Cuticular windows on preanal somite of the paratype female (Figure 22) is larger than in holotype. The same female has somewhat curved endopod of the third swimming leg (Figure 20), as well as slightly shorter setae on the fifth leg (Figure 21).

Etymology

The species is named in honour of Mr Stefan Eberhard from the "Cave Works" (an ecotourism project of the Augusta Margaret River Tourism Association, Western Australia), who collected the material in which this species has been found.

Distribution

At present Parastenocaris eberhardi sp. nov. is known only from two caves in the Margaret River Region, southwestern Western Australia (Figure 63).

Parastenocaris kimberleyensis sp. nov.

Figures 34–63

Material examined

Holotype


Allotype


Other paratypes


Topotype


Description

Male (holotype)

Total body length, measured from tip of rostrum to posterior margin of caudal rami (excluding caudal setae), 500 μm. Preserved specimen colourless. Nauplius eye absent. Habitus (Figure 34) cylindrical and very slender, without demarcation between prosome and urosome; prosome/urosome ratio 0.9; greatest width at posterior end of cephalothorax, but not very obvious. Body length/width ratio about 8.3; cephalothorax just slightly wider than genital somite. Free pedigerous somites without any expansions laterally or dorsally. Integument very weakly chitinized; integumental windows absent. Rostrum small, membranous, ovoid, reaching middle of first antennular segment, about as long as wide and not demarcated at base; with 2 dorsal sensilla. Cephalothorax about 1.6 times as long as wide; representing 20% of total body length. Surface of dorsal shield covering cephalothorax ornamented with only few small sensilla. Tergites of free pedigerous somites also ornamented with few small sensilla, except completely smooth first one. Hyaline fringes of all somites smooth. Genital somite ornamented with 2 small sensilla dorsally, about 1.5 times as wide as long, with single, large, completely formed, longitudinally-placed spermatophore (Figures 34 and 35) visible inside. Third and fourth urosomites ornamented with pair of dorsal and ventral spinules each. Fifth urosomal (preanal) somite
Parastenocaris kimberleyensis sp. nov., holotype (male): 34, habitus, dorsal view; 35, urosome, ventral view; 36, antennula, with enlarged detail of third segment armature; 37, antenna, without distal part of endopod; 38, rostral area, dorsal view. Scales = 0.1 mm.
without any visible ornamentation. Anal somite ornamented with pair of large dorsal sensilla, 2 ventral cuticular pores, and 2 short ventral rows of spinules at 1/3 of somite length. Anal operculum (Figure 41) strongly convex, smooth, not reaching posterior end of anal somite, representing 63% of somite's width. Anal sinus smooth.

Caudal rami (Figures 35, 41 and 42) long, cylindrical (slightly narrowing towards distal end), divergent, with space between them about 2 ramus width, and about 3.3 times as long as greatest width (ventral view); armed with 6 armature elements (2 lateral, 1 dorsal and 3 apical). Ornamentation consists of small cuticular pore laterally at anterior part. Dorsal seta relatively long, inserted somewhat closer to inner margin at about 2/3 of ramus length, about 1.3 times as long as caudal ramus, biarticulated at base and smooth. Lateral setae thin and smooth, inserted close to each other at 2/3 of ramus length. Proximal lateral seta placed more dorsally, about 3 times as long as distal one, and about 0.4 times as long as ramus. Inner apical seta small, smooth, about 0.5 times as long as ramus. Middle apical seta strongest, without breaking plane, bipinnate, about 6 times as long as outer apical seta and 0.4 times as long as whole body. Outer apical seta also without breaking plane, unipinnate along outer margin, about 0.8 times as long as ramus.

Antennula (Figures 36 and 44) 8-segmented, prehensile, not strongly geniculate, unornamented, approximately as long as cephalothorax. Broad aesthetasc on fourth segment reaching tip of appendage. Slender and short apical aesthetasc on eighth segment. Setal formula as follows: 0.5.5.2.4.0.0.9. Inner margin of fifth segment protruding into small spiniform process. One of setae on third segment very short, spiniform (Figure 36). All setae smooth and without breaking planes. Only 1 seta on second segment articulating on basal part.

Antenna (Figure 37) relatively slender and long, composed of coxa, allobasis, 1-segmented endopod, and 1-segmented exopod. Coxa small, unornamented. Allobasis about 3.3 times as long as wide, unarm, and ornamented with 2 short rows of long spinules along anterior surface. Endopod about 2.8 times as long as wide, with surface frill subdistally, ornamented with few large spinules along anterior surface, armed laterally with 2 spines and apically with 5 strong armature elements (2 of which geniculate). Exopod minute, cylindrical, about 3 times as long as wide, unornamented, armed with only 1 bipinnate apical seta, about 2.3 times as long as segment.

Mandibula (Figure 39) with narrow cutting edge on elongated coxa, armed with 3 coarse teeth ventrally, 1 smooth seta dorsally, and several smaller teeth in between. Palp 1-segmented, cylindrical, about 3 times as long as wide, unornamented, and armed apically with 2 smooth and subequal setae.

Maxillula (Figure 43) with relatively small precoxica, arthrite of which rectangular, long, unornamented, and armed with 1 strong anterior surface setae, and 4 apical elements (probably 3 spines and 1 strong seta). Coxal endite armed with 1 smooth armature element apically, which about 1.5 times as long as endite. Basis longer than coxal endite, armed with 3 naked setae apically. Endopod and exopod completely reduced.

Maxilla (Figure 40) with 2 endites on syncoxoa; proximal one armed apically with only 1 bipinnate seta; distal endite twice as long as proximal one, armed apically with 2 naked and 1 unipinnate setae. Basis fused basally with syncoxoa, drawn out into strong claw, without seta at base. Endopod represented by minute but distinct segment, armed with 2 bare subequal apical setae.

Maxillipede (Figure 45) with unornamented short syncoxoa; basis about 3 times as long as wide, unornamented and unarmed; endopod represented by short curved claw, which ornamented with row of spinules along concave side distally, about 0.7 times as long as basis.

First swimming leg (Figure 46) with smooth coxa and intercoxal sclerite. Basis ornamented with few large spinules around insertion of outer spine. Exopod 3-segmented, armed with 1 outer spine on first segment and 4 armature elements on third segment (2 outer spines and 2 apical geniculate setae); ornamented with few large spinules along outer margin on all segments. Endopod 2-segmented, somewhat longer than exopod; first segment reaching slightly beyond distal margin of second exopodal segment, about 3.4 times as long as wide, unarmed, ornamented with few large spinules along outer margin and 1 long row of large spinules along inner margin; second segment armed apically with long geniculate seta and much shorter spine.

Second swimming leg (Figure 47) with smooth coxa and intercoxal sclerite; basis unarm, ornamented with row of large spinules on outer margin. Exopod 3-segmented, ornamented with large spinules along outer margin, and with hyaline frills on each segment distally on inner side; first segment armed with single outer spine; second segment unarmed; third segment armed with 3 long armature elements (probably outer spine and 2 apical setae), innermost one about 1.3 times as long as exopod. Endopod 1-segmented, linguiform, reaching to middle of first exopodal segment, ornamented with several spinules along apical margin, armed apically with 1 smooth seta, which about 1.5 times as long as segment.

Third swimming leg (Figure 48) with smooth precoxoa, coxa and intercoxal sclerite. Basis robust, armed with long outer seta and ornamented with
Figures 39–45 *Parastenocaris kimberleyensis* sp. nov., holotype (male): 39, mandible; 40, maxilla; 41, anal somite and caudal rami, dorsal view; 42, anal somite and left caudal ramus, lateral view; 43, maxillula; 44, antennula; 45, maxilliped. Scale = 0.1 mm.
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Figures 46–52 Parastenocaris kimberleyensis sp. nov., 46–50, holotype (male); 51 and 52, topotype (male): 46, first swimming leg; 47, second swimming leg; 48, third swimming leg; 49, fourth swimming leg; 50, fifth leg; 51, second swimming leg; 52, basis, endopod and first exopodal segment of fourth swimming leg. Scale = 0.1 mm.
longitudinal row of very large spinules along distal part of inner margin (distalmost strongest) and diagonal row of spinules close to outer margin. Endopod minute, 1-segmented, smaller than largest spine on inner margin, unornamented and armed apically with smooth seta, which twice as long as segment. Exopod with both segments fused; ancestral proximal segment about 4 times as long as wide, somewhat swollen at distal part of inner margin, armed subapically with strong, short, smooth and curved spine, which reaching middle of apophysis; ancestral distal segment (apophysis) much smaller, oriented inward, unarmed and unornamented, terminating in U-shaped thin chitinous structure.

Fourth swimming leg (Figure 49) with smooth coxa, intercoxal sclerite and basis; basis armed with slender and smooth outer seta, inner-distal corner of basis produced into 2 large, heavily sclerotized claws, longer one as long as endopod. Exopod 3-segmented, ornamented with few large spinules along outer margin, and first and third segment with hyaline frills distally on inner side; first segment with swollen distal part of inner margin, armed with single outer spine; second segment unarmed; third segment armed with outer spine and very long and strong apical seta. Endopod 1-segmented, about 0.6 times as long as first exopodal segment, claw-like, curved inwards, unarmed and ornamented with longitudinal row of very long and slender spinules. Endopod and basal claws resembling powerful pincers.

Fifth leg (Figure 50) simple semitrapezoidal cuticular plate, unornamented and armed with 3 smooth setae along distal margin; outermost seta (ancestral basal one) longest, about 4 times longer than median one (which slightly shorter than plate) and about 6.5 times as long as innermost seta. Fifth legs distinct at base (Figure 35) with space between them of about 2 legs width.

Sixth legs (Figure 35) completely fused, forming single large operculum covering gonopore, which represents 80% of genital somite width, ornamented with transverse row of spinules along posterior margin and unarmed.

Female (allotype)

Body length, excluding caudal setae, 473 μm. Habitus, ornamentation of prostomial somites, colour and nauplius eye similar to male. Genital double-somite (Figures 63) about as long as wide (ventral view), without any trace of subdivision, ornamented only with 6 posterior sensilla (2 dorsal, 2 ventral and 2 lateral). Genital complex (Figure 58) occupying anterior ventral half of genital double-somite; genital apertures paired, each closed off by small, unarmed operculum derived from vestigial sixth leg; median copulatory pore located anteriorly between genital apertures; seminal receptacles trapezoidal, small; copulatory duct not clearly visible inside somite. Caudal ramus (Figure 62), antenna (Figure 61), mandibula, maxillula, maxilla, maxillipod, first swimming leg (Figure 53) and second swimming leg (Figure 55) similar to male.

Antennula (Figure 56) 7-segmented, unornamented, approximately as long as cephalothorax, with broad aesthetasc on fourth segment, reaching middle of seventh segment, and more slender apical aesthetasc on seventh segment, which fused basally to apical seta; setal formula as follows: 0.5.5.2.1.0.9. Proximalmost seta on second segment and 1 seta on seventh segment articulating on basal part; all setae smooth and without breaking plane. Length ratio of antennular segments, from proximal end, 1 : 2.6 : 1.5 : 1.6 : 0.8 : 0.9 : 1.5.

Third swimming leg (Figure 54) with smooth intercoxal sclerite; coxa and basis ornamented with row of spinules near outer margin; basis armed with long and smooth outer seta, which about 0.7 times as long as exopod. Exopod 2-segmented, ornamented with large spinules along outer margin, both segments with hyaline frills distally on inner side; first segment armed with single outer spine; second segment armed with outer spine and apical strong seta. Endopod 1-segmented, with ancestral apical spine completely fused to segment, but still bipinnate; reaching 2/3 of first exopodal segment.

Fourth swimming leg (Figures 57 and 59) with first exopodal segment with inner margin straight and without spiniform processes on basis. Endopod 1-segmented, with ancestral apical spine fused to segment, with 3 large spinules at its base and unipinnate along inner margin. Other details similar to male.

Fifth leg (Figures 60 and 63) bilobate simple cuticular plate, ornamented with cuticular pore at base of outer (basal) lobe and with ring of spinules around acute extension of inner (endopodal) lobe. Basal lobe armed with long basal seta and small spine (or maybe spine); inner lobe armed with two smooth and much shorter setae on outer margin (probably ancestral exopodal armature). Fifth legs separated medially, space between them less than one leg width.

Sixth leg (Figure 58) small cuticular plate, covering gonopore, unornamented and unarmed.

Variability

Body lengths of males range from 408 μm to 500 μm (467 μm average; n=4); only one female was collected and studied. Topotype male with comparatively longer spines on second swimming leg (Figure 51) and with smaller basal processes on fourth swimming leg (Figure 52), although they are drawn in slightly different positions than those in the holotype. No other form of variability was observed.
Figures 53–63  *Parastenocaris kimberleyensis* sp. nov., allotype (female): 53, first swimming leg; 54, third swimming leg; 55, endopod of second swimming leg; 56, antennula; 57, endopod of fourth swimming leg; 58, genital area, ventral view; 59, first exopodal segment of fourth swimming leg; 60, fifth leg; 61, antenna; 62, right caudal ramus, lateral view; 63, fifth pedigerous and genital double-somite, lateral view. Scale = 0.1 mm.
Etymology
The species is named after the Kimberley Region, where it was collected.

Distribution
*Parastenocaris kimberleyensis* sp. nov. is so far known from a single monitoring bore in the Kimberley district, northeastern Western Australia (Figure 64).

DISCUSSION
Of the 224 or so described species and subspecies (together with the two new species described above) of the genus *Parastenocaris*, 18 (8%) are still known only from females, including the first Australian representative *P. solitaria* Karanovic, 2004. This, in conjunction with the high level of convergence in subterranean interstitial habitats, makes phylogenetic analyses of this genus very difficult. Furthermore, some recent publications have added unnecessary confusion in this field. For instance Martinez Arbizu (1997) assigned his new species *P. hispanica* to the "fontinalis"-group. Moreover he analyzed the "phylogenetic relationships within the fontinalis-group", but considered only five species and subspecies, despite the fact that the "fontinalis"-group contains more than 60 taxa. However, based on the Lang’s (1948) classification, *P. hispanica* is an obvious member of the "proserpina"-group. Large harpacticoid genera usually accumulate numerous synonyms during the course of their taxonomic history, and the genus *Parastenocaris* is certainly no exception; for example Reid (1995) established at least three new synonyms of *P. brevipes* Kessler, 1913. Sexual dimorphism and even polymorphism in caudal rami shape (Schminke 1991) is another phenomenon of this
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genus which could contribute to further discoveries of new synonyms, but it is clear that the present number of species is only a small fraction of the total number to be expected (Reid 1982; Boxshall and Jaume 2000). Typical Parastenocaris habitats are only fragmentarily investigated on most continents, including Australia (Karanovic 2004). Future genetic investigations of similar morphological forms (considered now as one species) may even double the final number of species. So, even an estimation of 1000 or more species does not sound impossible (although it is only a speculation). However, the number of different phylogenetic lineages in the genus is limited to around a dozen (depending on how we treat some of the South American groups established by Noodt (1962, 1963, 1972)), indicating a very slow rate of evolution in this genus. Thus the assumption made by Boxshall and Jaume (2000) “that tectonic events have shaped modern distributions more than subsequent dispersal events” sounds so acceptable for Parastenocaris. Even the two Australian species described in this paper are not some bizarre creatures, but fit well into two existing groups of species originally defined by Lang (1948).

Parastenocaris eberhardi belongs to the “minuta”-group of species, the fourth leg basis having five large spinules around the base of the endopod in male. Although this group was originally defined by Lang (1948) to have “Einwärts von En.P4 Männchen sitzen 2–4 Borsten”, this diagnosis was slightly emended by Karanovic and Bobic (1998) to include those species with only one inner basal spine around the endopod. Also some species with more than four basal spinules have been described and assigned to the “minuta”-group: P. arenicola Chappuis, 1954 from Madagascar; P. cornuta Chappuis, 1955 from Lake Tanganyika; P. forficulata Chappuis, 1952 from Madagascar; P. lusitanica Noodt and Galhano, 1969 from Portugal; P. madagascarensis Chappuis, 1952 from Madagascar; P. marlieri Chappuis, 1955 from Lake Tanganyika; P. oligoalina Cottarelli, Bruno and Venanzetti, 1995 from Sardinia; and even in some populations of P. vicesima Klie, 1935 from Helgoland (Kiefer, 1960), which Lang (1948) had previously included in the “minuta”-group. Galassi and De Laurentis (2004) were probably unaware of this fact, since they did not include Parastenocaris serbica Karanovic and Bobic, 1998 into their list of the “minuta”-group, nor the abovementioned P. arenicola, P. forficulata, P. lusitanica, P. madagascarensis and P. marlieri, although they included P. cornuta and P. oligoalina. However, I do agree with their conclusion that “the evidence already available strongly suggest polyplyetic origin of the minuta-group”, a constatation nicely demonstrated by separating a new genus Simplicaris.

Parastenocaris eberhardi has the same combination of a “double” integumental window on the cephalothorax and paired lateral windows on the third and fourth (preanal) urosomites in female as Parastenocaris solitaria Karanovic, 2004, a species described also from Western Australia, but almost 800 km NNE from the former species (Figure 64). Because of the occurrence of integumental windows in distantly related taxa, as well as of similar structures in several other crustacean groups other than copepods, Lang (1948) stated that they have no phylogenetic significance. However, within the Harpacticoida at the alpha-taxonomic level their form and location on the body are constant within species, and have been useful in species discrimination in the Canthocamptidae (Hamond 1987; Por and Hadel 1986; Hosfeld 1999). Although it is reasonable to assume that P. solitaria also belongs to the “minuta”-group, its position cannot be verified withouth males. Females of P. eberhardi can be distinguished from those of P. solitaria by the following 13 characters: cuticular pits present; sensilla much longer; short rows of ventrolateral spinules on the third urosomite absent; anal somite longer; caudal rami shorter and less cylindrical; caudal rami armed with three lateral setae instead of two; innermost apical setae on caudal rami much longer; allobasis of antenna shorter; maxillula with three armature elements on coxal endite instead of two; distal endite of maxilla not reduced; endopod of fourth swimming leg ornamented with two spinules; fifth leg with somewhat shorter distal spiniform process; and cuticular window on fifth leg present (see Karanovic 2004). Actually, the cuticular window on the fifth leg in both sexes of P. eberhardi is something not previously recorded in the genus Parastenocaris, except perhaps in P. pasquinii Cottarelli, 1972 (see Bruno and Cottarelli 1998, figure 11F), but these two species differ remarkably from each other. The new Australian species can be easily distinguished from its congeners also by the characteristic shape of the third leg in male, which is somewhat similar only to that of P. madagascarensis from Madagascar and P. athiopica Cottarelli and Bruno, 1995 from Ethiopia (see Chappuis 1952; Cottarelli and Bruno 1995). These two species seem to be most closely related to P. eberhardi and P. solitaria, and they all have the same pattern of integumental windows on the urosomites. However, they can be easily distinguished from P. eberhardi by a number of characters, including caudal rami shape, male fourth leg shape of endopod and third legs endopods not completely reduced. Paired lateral integumental windows on the third and fourth urosomites in females (and/or on the fourth and fifth in males) have also been described for the following three species: P. arenosa Fryer, 1956 from sandy beaches of Lake Nyasa; P. forficulata
Chappuis, 1952 from Madagascar; and *P. quolensis* Cottarelli and Bruno, 1995 from Ethiopia. This character should be considered in all future phylogenetic analyses of *Parastenocaris*, since it shows a clear Eastern Gondwana connection for the two Australian species, as well as many other Australian copepods with freshwater origins (see Karanovic 2003, 2004). Conversely, the cephalothoracic integumental window has no phylogenetic importance in this family, as noted in general by Lang (1948), since it has been recorded in completely unrelated taxa (Karanovic 2004).

*Parastenocaris kimberleyensis* belongs to the “brevipes”-group of species (having the characteristic endopodal complex of the male fourth leg; the long distally serrate endopod of the female fourth leg; the tapering caudal ramus with dorsal and lateral setae inserted around midlength; the sixth legs in male fused into a single operculum; and the bilobate fifth leg in female), which was defined by Lang (1948) and named after the type species of the genus. Most recently Galassi and De Laurentiis (2004) proposed “retaining within *Parastenocaris* only those species belonging to the *brevipes*-group (as revised by Reid 1995), and to relegate the remainder presently assigned to this genus as *Parastenocaris* s.l., pending the revision of the family”. I prefer to wait for that revision instead of using *sensu stricto* and *sensu lato* terms, because they provide no real advancement to our knowledge on this complex taxon. Besides *P. brevipes*, which is the only member of the genus with a Holartic distribution (see Lang 1948; Reid 1995), 16 species have been described so far in the “brevipes”-group: five of them from Sri Lanka by Enckell (1970) (*P. brincki, P. irenae, P. lanceolata, P. noodti* and *P. singhalensis*); four from the United States by Pennak (1939), Borthzky (1952), Whitman (1984) and Reid (1991) (*P. starretti, P. wilsoni, P. texana* and *P. palmerae* respectively); three from Japan by Miura (1962, 1969) and Kikuchi (1970) (*P. oshimaensis, P. biwae* and *P. hinumaensis* respectively); two from India by Ranga Reddy (2001) (*P. gayatri* and *P. savita*); one from China by Shen and Tai (1973) (*P. longipoda*); and one from Sumatra by Chappuis (1931) (*P. feuerborni*). *Parastenocaris biwae, P. starretti* and *P. wilsoni* were consequently synonymized with *P. brevipes* by Reid (1995), who also recognized “the possible origin of the *brevipes* group in tropical Asia”. *Parastenocaris texana*, because of the incomplete original description, should be placed as *incertae sedis* until a proper redescriptions of the type material is presented. Reid (1995) expressed doubts about the position of her *P. palmerae* in the “brevipes”-group, but there are currently no strong reasons to exclude this species. Galassi and De Laurentiis (2004) also included *P. longicaudis* Chappuis, 1931 and *P. arctica* Borthzky, 1952 in this group, although they are known only as females and their statuses could not be verified (see Lang 1948; Borthzky 1952). Together with *P. kimberleyensis* 14 valid species could be recognized today in the “*brevipes*”-group, and a key to aid in their difficult determination is given below (based solely on the morphology of males, since females of *P. brincki, P. lanceolata* and *P. singhalensis* are still unknown).

Key to the “brevipes”-group of *Parastenocaris*

1. Third leg in adult male without endopod .......... 9
   - Same appendage with endopod .......................... 2
2. Third leg endopod reduced to single slender seta ........................................ 4
   - Third leg endopod small but distinct segment. ........................................ 3
3. Fourth leg endopod with transverse subapical row of 3 long spinules .......................... 6
   - Same segment with longitudinal row of 5–6 long setules .......................... *P. kimberleyensis* sp. nov. 4.
4. Fifth leg with inner-distal corner produced posteriorly as spiniform process .......................... 5
   - Same appendage lacking spiniform process .......................... 6
5. Fifth leg with only 2 setae .......................... *P. brincki* Enckell, 1970
   - Same leg armed with 4 setae .......................... *P. palmerae* Reid, 1991
6. Fourth leg endopod 2-segmented, with 2 apical spinules .......................... 7
   - Same ramus 1-segmented, with more than 2 spinules .......................... 8
7. Third leg first exopodal segment without subapical spine .......................... *P. longipoda* Shen and Tai, 1973
   - Same segment with well developed outer spine apically .......................... *P. savita* Ranga Reddy, 2001
8. Third leg first exopodal segment armed with large dentate process on inner margin .......................... *P. gayatri* Ranga Reddy, 2001
   - Same segment with smooth inner margin .......................... *P. brevipes* Kessler, 1913
9. Anal operculum smooth .......................... 11
   - Anal operculum with row of spinules .......................... 10
   - Same ramus sickle-shaped, with 1 long spine .......................... *P. hinumaensis* Kikuchi, 1970
11. Fifth leg inner-distal corner produced posteriorly as spiniform process .......................... *P. irenae* Enckell, 1970
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- Same appendage lacking spiniform process 12

12. Anal somite with 2 dorsal rows of spinules......
   .................................................. P. noodti Enckell, 1970

- Anal somite without ornamentation.............. 13

13. Fourth leg endopod with 4 long spinules........
   .................................................. P. singhalensis Enckell, 1970

- Same ramus smooth, conical, sharply pointed.
   .................................................. P. lanceolata Enckell, 1970

In his revision of the family Parastenocarididae, Jakobi (1972) divided this group of species into five separate genera (all, except the first one, described as new): Parastenocaris, Oshimaenicaris, Biwaecaris, Enkellcaris and Brinckicaris. The superficial nature of this revision is highlighted by the fact that the type species of his genus Biwaecaris is synonymous with the type species of Parastenocaris (see Reid 1995). Although it is generally accepted that some of the species groups within Parastenocaris will be elevated to the generic level (Enckell 1970; Schminke 1976; Por and Hadel 1986; Reid 1994; Cottarelli et al. 1995; Martinez Arbizu 1997; Galassi and De Laurentiis 2004) it is currently untenable to base such a revision solely on morphology. Numerous convergences are normally expected in genera that have invaded freshwater habitats during or before the Pangaeas era and partly (or completely?) already stygomorphic (from the marine psammon). However, the "brevipes"-group is one of the best defined and most compact groups and, since it contains the type species the generic name of Parastenocaris will probably persist for a long time. Galassi and De Laurentiis (2004) even defined the members of this group as Parastenocaris s.s. and provided an overview of all major important morphological characters. Their ecological niche is generally very close to the surface (P. brevipes in Europe even inhabits Sphagnum bogs), which enables them to grow bigger than other members of the genus, reaching usually 0.5 or 0.6 mm. The main reason for this is probably the bigger sand particle size near the surface (a consequence of natural process of sedimentation), but a more abundant food input may be responsible as well. The presence of this group in northern part of Australia may suggest their relatively recent arrival, if the hypothesis of the origin of this group in tropical Asia is correct (Reid 1995). But, in order to arrive at more reliable zoogeographic conclusions a lot more work is required on the taxonomy, ecology and ethology of this group.

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