

Memoirs

of the Queensland Museum | **Nature**



ISSN 0079-8835
brisbane | 17 february 2012

56(1)

Memoirs of the Queensland Museum | **Nature**

Volume 56 Part 1

Minister: The Honourable Rachel Nolan, Minister for Finance, Natural Resources and the Arts

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National Library of Australia card number
ISSN 0079-8835

COVER: *Polyrhachis (Polyrhachis) bellicosa* Fr. Smith photographed by Hans Peter Katzmann
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A Queensland Government Project
Typeset at the Queensland Museum
Printed by Harding Colour,
7 Proprietary St, Tingalpa Qld 4173



Polychelid lobsters (Decapoda: Polychelida: Polychelidae) collected by the CIDARIS expeditions off Central Queensland, with a summary of Australian and New Zealand distributions

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Citation: Ahyong, S.T. 2012 02 17: Polychelid lobsters (Decapoda: Polychelida: Polychelidae) collected by the CIDARIS expeditions off Central Queensland, with a summary of Australian and New Zealand distributions. *Memoirs of the Queensland Museum – Nature* 56(1): 1-8. Brisbane. ISSN 0079-8835. Accepted: 10 November 2010.

ABSTRACT

The polychelid lobsters collected by the CIDARIS expeditions from outer shelf and slope waters off the central Great Barrier Reef are reported. Eight species in four genera are reported, including the first Queensland record of *Stereomastis nana*, the first Australian record of *Pentacheles obscurus*, and the first Indo-Pacific record of *Willemoesia forceps*.
□ *Crustacea, Polychelidae, lobsters, Queensland, Australia, New Zealand.*

The lobsters of the infraorder Polychelida are characterised by having chelate pereopods 1–4 (often also pereopod 5). Although Polychelida includes five families, with the earliest recorded from the Triassic, only one family is currently extant, Polychelidae (see Ahyong 2009; De Grave *et al.* 2009). Thirty-seven polychelid species in six genera are known worldwide, all of which are restricted to outer slope or abyssal depths worldwide. The Australian polychelids have been reported by Griffin & Stoddart (1995), Galil (2000), Ahyong & Brown (2002) and Poore *et al.* (2008), together enumerating four genera and 17 species. In New Zealand waters, 10 species in four genera are known, most of which also occur off eastern Australia (Galil 2000; Ahyong 2007).

The CIDARIS expeditions (I–III) were conducted by James Cook University between 1986 and 1992 in outer shelf and slope waters off the central Great Barrier Reef. Eight species in four genera of polychelids were collected, of which two species and one genus are first records for Australia. The collection is reported below.

MATERIALS AND METHODS

Measurements of specimens are millimetres and refer to carapace length (cl.) measured along the midline from the apices of the rostral spines to the posterior margin of the carapace. Specimens are deposited in the collections of the Museum of Tropical Queensland, Townsville (MTQ) a campus of the Queensland Museum (QM). Synonymies are restricted to primary synonyms, studies published after 2000, and regional works.

SYSTEMATICS

POLYCHELIDA Scholtz & Richter, 1995

POLYCHELIDAE Wood-Mason, 1874

Pentacheles laevis Bate, 1878

Pentacheles laevis Bate, 1878a: 278 [type locality: Moluccas, Indonesia, 4°33'N, 127°06'E]; Galil, 2000: 291 (key), 301–305, fig. 7; Ahyong & Brown, 2002: 54–56, figs 1A, B; Ahyong & Chan, 2004: 171–173, figs 1A–C, 4A; Poore, 2004: 152, 154, fig. 39A; Ahyong & Galil, 2006: 758; Boyko, 2006:

39–40, figs 1B, 2; Ahyong, 2007: 47–49, fig. 24B; Ahyong & Chan, 2008: 64, fig. 1A; Poore et al., 2008: 91.

Pentacheles gracilis Bate, 1878b: 279 [type locality: off Fiji, 19°07.50'S, 178°19.35'E].

Polycheles granulatus Faxon, 1893: 197 [type locality: off Panama, 4°03'N, 81°31'E]; Griffin & Stoddart, 1995: 240–242, figs. 4–5.

Pentacheles beaumontii Alcock, 1894: 236 [type locality: off Colombo, Sri Lanka].

Polycheles dubius Bouvier, 1905a: 480 [type locality: off the Azores, 44°04'N, 9°81'W].

Polycheles eryoniformis Bouvier, 1905b: 644 [type locality: Madeira].

Material examined. MTQ W13540, 1 female (cl. 18.7 mm), 18°09.40'S, 148°22.08'E, 1122–1117 m, CIDARIS I, stn 9-4, beam trawl, 7 May 1986; MTQ W13755, 1 male (cl. 24.2 mm), 1 ovigerous female (cl. 55.9 mm), 17°51.71'S, 147°09.93'E, 920–881 m, CIDARIS I, stn 49-3, beam trawl, 17 May 1986; MTQ W30296, 1 female (cl. 18.9 mm), CIDARIS III, stn 8-4, 1175–1255 m, beam trawl, 12 Feb 1992; MTQ W31055 1 damaged specimen (cl. 17.0 mm), 11°13.01'S, 146°07.38'E, 1432–1503 m, CIDARIS III, stn 12-3, beam trawl, 14 Feb 1992.

Remarks. The lateral carapace spination of the present series (8-12:3-4:14-16) slightly extends the documented range (7-10:3-5:12-17; Ahyong & Brown 2002; Ahyong 2007) to 7-12:3-5:12-17. In Australian waters, *Pentacheles laevis* has been reported from Western Australia to South Australia, Victoria, Tasmania, New South Wales and southern Queensland. The present records extend the known range of *P. laevis* to central Queensland.

Distribution. Worldwide, from the Indo-West Pacific, Eastern Pacific, Western and Eastern Atlantic; 212–2505 m.

Pentacheles obscurus Bate, 1878

Pentacheles obscura Bate, 1878a: 279; 1878b: 484; 1878c: 563; 1888: 143, pl. 15: fig. 2 [type locality: off New Guinea, 2°33'S, 144°04'E, 1857 m].

Pentacheles carpenteri Alcock, 1894: 235; 1901b: 174 [Carpenter's Ridge, Bay of Bengal, 2505–2616 m]; Alcock & Anderson, 1895, pl. 10: fig. 1; Galil, 2000: 305–306, fig. 8.

Material examined. MTQ W13785, 1 female (cl. 67.6 mm), 11°12.88'S, 146°07.36'E, 1426 m, CIDARIS III, stn 12-2, sledge, coll. M. Pichon, A. Birtles & P. Arnold, 14 Feb 1992; MTQ W30257, 1 ovigerous female (cl. 59.8 mm), 11°13.01'S, 146°07.38'E, 1432–1503 m, CIDARIS III, stn 12-3, beam trawl, 14 Feb 1992.

Remarks. The two specimens are the first records of the species from Australian waters and have carapace spination 5–6:3:18–20. The spination of the carapace margin posterior to the postcervical groove in the Australian specimens is lower (18–20) than that reported by Galil (2000) (27–28). In other respects, the specimens agree well with Galil's account.

Distribution. Madagascar and Gulf of Aden to Papua New Guinea, the Moluccas, Wallis and Futuna, New Caledonia and now from Queensland, Australia; 1100–3080 m (Galil 2000).

Polycheles kermadecensis Sund, 1920

Stereomastix kermadecensis Sund, 1920: 224 [type locality: Kermadec Islands, New Zealand, 29°55'S, 178°14'E, 951 m]; Ahyong & Brown, 2002: 68–71, figs. 7A–B, 8, 9; Poore, 2004: 156, fig. 40d.

Polycheles [sic] *eutlirix* – Griffin & Tranter, 1995: 239–240, figs 2–3 [part, not *P. eutlirix* (Bate, 1878)].

Material examined. MTQ W13544, 2 males (cl. 23.4–35.3 mm), 18°08.69'S, 147°33.97'E, 966–962 m, CIDARIS I, stn 1-4, beam trawl, 6 May 1986; MTQ W30101, 1 male (cl. 23.3 mm), 17°45.99'S, 148°39.09'E, 964–958 m, 17°45.99'S, 148°39.09'E, 964–958 m, CIDARIS I, stn 15-4, 9 May 1986; MTQ W30059, 1 male (cl. 13.5 mm), 17°36.98'S, 146°57.43'E, 672–744 m, CIDARIS I, stn 44-3, beam trawl, 16 May 1986; MTQ W30095, 1 female (cl. 22.4 mm), 17°50.679'S, 147°18.164'E, 703 m, CIDARIS I, stn 48-2, sledge, 17 May 1986; MTQ W13429, 1 female (cl. 34.1 mm), 17°51.06'S, 147°09.85'E, 904–976 m, CIDARIS I, stn 49-2, sledge, 17 May 1986; MTQ W13428, 1 male (cl. 19.8 mm), 17°51.71'S, 147°09.93'E, 920–881 m, CIDARIS I, stn 49-3, beam trawl, 17 May 1986.

Remarks. All specimens have a distinct dorso-median antrorse spine on abdominal somites 1–4. The lateral carapace spination (7–9:3–4:12–15) is within or close to the reported range (7–11: 4–5:12–17) (Ahyong & Brown 2002).

Distribution. Kermadec Islands, and eastern Australia from central Queensland to the vicinity of Newcastle, New South Wales; 549–976 m (Ahyong & Brown 2002; present results).

Stereomastis Bate, 1888

Stereomastis aculeata (Galil, 2000)

Stereomastis phosphorus – Griffin & Stoddart, 1995: 246–248, figs. 9–11 [part, not *S. phosphorus* (Alcock, 1894)].

Polycheles aculeatus Galil, 2000: 312–315, fig. 11 [type locality: New Caledonia, 22°35.6'S, 166°26.2'E]; Ah Yong & Chan, 2004: 173, figs 3D, 4B; Poore, 2004: 154, fig. 40a, 41d; Ah Yong & Galil, 2006: 759.

Material examined. MTQ W31058, 1 male (cl. 20.6 mm), 17°36.98'S, 146°57.43'E, 672–744 m, CIDARIS I, stn 44-3, beam trawl, 16 May 1986.

Remarks. The lateral carapace spination (6–7:3:8–9) of the single specimen of *S. aculeata* is within the documented range (6–7:3–4:8–11) (Ah Yong & Chan 2004). In Australia, *S. aculeata* ranges from Western Australia to Tasmania, New South Wales and Queensland.

Distribution. Vanuatu, New Caledonia, Lifou, the Solomon Islands, Indonesia, Australia, the East China Sea and Taiwan; 144–1053 m (Ah Yong & Chan 2004).

Stereomastis auriculata (Bate, 1878)

Pentacheles auriculatus Bate, 1878a: 280 [type locality: off Kandavu Island, Fiji, 19°07.50'S, 178°19.35'E]; 1878b: 484; 1878c: 563.

Stereomastis auriculata – Bate 1888: 159.

Pentacheles auriculata – Bate 1888, pl. 16, figs 3, 4.

Polycheles auriculatus – Galil 2000: 293, 315–317, fig. 12; Ah Yong & Chan 2004: 176, figs. 3A–C, 4D; Ah Yong & Galil, 2006: 762; Poore *et al.*, 2008: 91.

Material examined. MTQ W30220, 1 male (cl. 24.9 mm), 1 female (cl. 17.0 mm), 17°49.45'S, 148°39.51'E, 990–1006 m, CIDARIS I, stn 14-1, beam trawl, 8 May 1986; MTQ W14172, 1 female (cl. 25.4 mm), 10°31.86'S, 145°37.67'E, 1172–1140 m, CIDARIS III, stn 9-2, beam trawl, M. Pichon, A. Birtles, P. Arnold, 12 Feb 1992.

Remarks. As reported by Ah Yong & Galil (2006), the specimens in the present series have an anterior spine on the second pleuron. Lateral carapace spination (6:3–4:7) is consistent with the reported range (5–7:3:7–8) (Ah Yong & Galil 2006).

Distribution. Western Australia to New Caledonia, Vanuatu, Fiji, the Philippines, Taiwan

and the Marquesas Archipelago; 435–1598 m (Ah Yong & Galil 2006).

Stereomastis helleri (Bate, 1878)

Polycheles helleri Bate, 1878a: 277 [type locality: N of New Guinea, 2°33'S, 144°04'E, by lectotype selection (Ah Yong & Brown 2002)]; Galil 2000: 327–329, fig. 18; Ah Yong & Chan 2004: 179, figs 3H, I, 4G; Ah Yong & Galil, 2006: 764.

Stereomastis helleri – Griffin & Stoddart, 1995: 245–246.

Material examined. MTQ W14171, 2 males (cl. 19.5–22.1 mm), 10°29.21'S, 144°49.23'E, 1503–1520 m, CIDARIS III, stn 5-1, beam trawl, 10 Feb 1992; MTQ W13789, 1 female (cl. 20.1 mm), 10°54.01'S, 144°39.75'E, 1502–1475 m, CIDARIS III, stn 4-1, 10 Feb 1002; MTQ W31057, 2 females (cl. 19.4–27.7 mm), 10°51.30'S, 145°48.64'E, 1377–1362 m, CIDARIS III, stn 11-2, beam trawl, M. Pichon, A. Birtles, P. Arnold, 13 Feb 1992; MTQ W14173, 2 males (cl. 20.6–25.6 mm), 5 females (cl. 18.6–36.1 mm), 11°13.01'S, 146°07.38'E, 1432–1503 m, CIDARIS III, stn 12-3, beam trawl, 14 Feb 1992; MTQ W30262, 1 female (cl. 22.7 mm), 11°13.01'S, 146°07.38'E, 1432–1503 m, CIDARIS III, stn 12-3, beam trawl, 14 Feb 1992.

Remarks. The documented range of lateral carapace spination (5–6:3–4:6–10; Ah Yong & Chan 2004) is extended in the present series (5–6:3:7–12). The species was reported from the Coral Sea by Griffin & Stoddart (1995).

Distribution. Western Indian Ocean to Australia, Indonesia, New Guinea, New Caledonia, the Solomon Islands, Japan, and Taiwan; 797–2947 m (Ah Yong & Chan 2004).

Stereomastis nana (Smith, 1884)

Pentacheles nanus Smith, 1884: 359 [type locality: north-eastern United States of America, 38°44'N, 72°38'W].

Pentacheles andamanensis Alcock, 1894: 239 [type locality: off Cape Comorin, 7°04'N, 76°34'15"E].

Polycheles grimaldii Bouvier, 1905a: 481 [type locality: off Senegal, 17°16'N, 19°19'W].

Stereomastis andamanensis – Griffin & Stoddart, 1995: 244–245 [except for Coral Sea specimen = *S. galil* (Ah Yong & Brown, 2002)].

Polycheles nanus – Galil 2000: 329–332, fig. 19; Ah Yong & Brown 2002: 71; Poore, 2004: 156, fig. 41c; Ah Yong & Galil, 2006: 765; Boyko, 2006: 41.

Material examined. MTQ W13505, 1 male (cl. 22.3 mm), 1 female (cl. 35.9 mm), 18°07.82'S, 148°15.39'E, 1115–1119 m, CIDARIS I, stn 8-1, beam trawl, 7 May 1986;

MTQ W13504, 1 male (cl. 21.2 mm), 6 females (cl. 19.7–25.2 mm), 18°09.40'S, 148°22.08'E, 1122–1117 m, CIDARIS I, stn 9–4, beam trawl, 7 May 1986; MTQ W30073, 2 females (cl. 21.0–26.9 mm), 18°10.06'S, 148°32.44'E, 1121–1123 m, CIDARIS I, stn 11–4, beam trawl, 8 May 1986; MTQ W31059, 1 female (cl. 24.2 mm), 17°45.99'S, 148°39.09'E, 964–958 m, CIDARIS I, stn 15–4, 9 May 1986; MTQ W13543, 1 female (cl. 36.0 mm), 17°45.44'S, 148°01.30'E, 1147–1132 m, CIDARIS I, stn 18–1, beam trawl, 10 May 1986; MTQ W30166, 1 male (cl. 22.6 mm), 17°46.53'S, 147°48.82'E, 1224–1223 m, CIDARIS I, stn 20–3, sledge, 10 May 1986; MTQ W300803, 1 male (cl. 17.3 mm), 17°45.04'S, 147°48.14'E, 1228–1223 m, CIDARIS I, stn 20–4, beam trawl, 10 May 1986; MTQ W30226, 2 males (cl. 22.3–22.7 mm), 1 female (cl. 21.1 mm), 17°19.58'S, 147°47.61'E, 1187–1200 m, CIDARIS I, stn 24–2, beam trawl, 11 May 1986; MTQ W30187, 2 females (cl. 20.9–26.9 mm), 17°18.73'S, 147°37.20'E, 1128–1178 m, CIDARIS I, stn 25–1, 11 May 1986; MTQ W30132, 1 damaged female, 17°19.76'S, 147°28.05'E, 1310–1357 m, CIDARIS I, stn 27–2, beam trawl, 11 May 1986; MTQ W30207, 1 male (cl. 21.2 mm), 1 female (cl. 20.5 mm), 17°18.21'S, 147°19.76'E, 1414–1400 m, CIDARIS I, stn 28–1, 12 May 1986; MTQ W30217, 1 female (cl. 20.7 mm), 17°18.96'S, 147°11.16'E, 1406–1402 m, CIDARIS I, stn 30–2, 12 May 1986; MTQ W31060, 1 female (cl. 24.3 mm), 16°58.67'S, 147°11.40'E, 1564–1545 m, CIDARIS I, stn 33–1, beam trawl, 13 May 1986; MTQ W30213, 1 female (cl. 20.2 mm), 16°58.67'S, 147°11.40'E, 1564–1545 m, CIDARIS I, stn 33–1, 13 May 1986; MTQ W13339, 1 male (cl. 18.2 mm), 16°50.83'S, 147°10.61'E, 1609–1607 m, CIDARIS I, stn 35–3, sledge, 14 May 1986; MTQ W30170, 1 male (cl. 19.4 mm), 1 female (cl. 23.3 mm), CIDARIS I, stn 35–4, 1473–1590 m, 14 May 1986; MTQ W30051, 1 male (cl. 25.0 mm), 14°08.66'S, 147°00.04'E, 1444–1454 m, CIDARIS II, stn 9–3, beam trawl, 2 Sep 1988; MTQ W13784, 1 female (cl. 30.3 mm), 10°51.30'S, 145°48.64'E, 1377–1362 m, CIDARIS III, stn 11–2, beam trawl, M. Pichon, A. Birtles, P. Arnold, 13 Feb 1992; MTQ W31056, 4 males (cl. 20.9–21.9 mm), 3 females (cl. 19.7–22.2 mm), 11°13.01'S, 146°07.38'E, 1432–1503 m, CIDARIS III, stn 12–3, beam trawl, 14 Feb 1992.

Remarks. In Australia, *S. nana* is known from Tasmania, Victoria and New South Wales (Griffin & Stoddart, 1995, as *S. andamanensis*; Ahyong & Brown 2002). Records of *S. nana* from Western Australia (George, 1983) and the Coral Sea (Griffin & Stoddart 1995, as *S. audamanensis*) are referable to *S. galil* (Ahyong & Brown, 2002). Thus, the series of *S. nana* collected by CIDARIS I–III constitute the first reliable

records of *S. nana* from Queensland waters. The lateral carapace spination of the present series (5–6:3:6–9) extends the previously documented range (5–6:3:6–7) (Ahyong & Galil 2006).

Distribution. Widely distributed throughout the Indo-West Pacific region and Atlantic Ocean; 300–4000 m (Galil 2000).

Willemoesia Grote, 1873

Willemoesia forceps A. Milne Edwards, 1880

Willemoesia forceps A. Milne Edwards, 1880: 64 [type locality: off Santa Cruz, Cuba, 24°33'N, 84°23'W, 3512 m]; Galil, 2000: 361–362, fig. 31.

Material examined. MTQ W13561, 1 female (cl. 35.6 mm), 16°54.54'S, 147°14.35'E, 1473–1590 m, CIDARIS I, stn 35–4, no. 129, 14 May 1986.

Remarks. The specimen is in delicate condition and lacks both major chelipeds. Diagnostic features, however, are clearly visible in the distinct oblique grooves on the abdominal tergites, lateral carapace spination (14:13–15:27–30), unsculptured abdominal tergite 5, and rounded telson apex. Carapace spination is similar to the reported range (14–19:14–15:29–40) (Galil 2000).

Of the four recognised species of *Willemoesia*, only *W. leptodactyla* (Thomson, 1873) occurs in both the Atlantic and Indo-West Pacific; *W. inornata* Faxon, 1893, is known only from the eastern Pacific; *W. pacifica* Sund, 1920, ranges across the Indo-Pacific. *Willemoesia forceps* was previously known only from the Atlantic Ocean, so the present specimen constitutes the first record of the species from the Indo-Pacific region, and the second species of *Willemoesia* known from Australia after *W. pacifica* (see Griffin & Stoddart 1995, as *W. bonaspei* Kensley, 1968).

Galil (2000) reported an upper capture depth for *W. forceps* at 1760 m, so the present record expands the known bathymetric range into shallower water.

Polychelid lobsters off central Qld

TABLE 1. Geographical distribution of polychelids from New Zealand and around Australia according to States and Territories (+ indicates presence). Based on Galil (2000), Ahyong & Brown (2002), Ahyong (2007), Poore *et al.* (2008). New Zealand is abbreviated as NZ. Australian States are abbreviated as follows: NSW = New South Wales, NT = Northern Territory, QLD = Queensland, SA = South Australia, TAS = Tasmania, VIC = Victoria, WA = Western Australia.

	QLD	NSW	VIC	TAS	SA	WA	NT	NZ
<i>Pe. laevis</i> Bate, 1878	+	+	+	+	+	+		+
<i>Pe. obscurus</i>	+							
<i>Pe. validus</i> A. Milne-Edwards, 1880		+		+	+			+
<i>P. baccatus</i> Bate, 1878	+	+						
<i>P. coccifer</i> Galil, 2000						+		
<i>P. enthrix</i> (Bate, 1878)	+	+						+
<i>P. kermadecensis</i> (Sund, 1920)	+	+						+
<i>P. martini</i> Ahyong & Brown, 2002		+						
<i>P. typhlops</i> Heller, 1862	+	+				+		
<i>S. aculeata</i> Galil, 2000	+	+		+		+		
<i>S. auriculata</i> (Bate, 1878)	+					+		
<i>S. galil</i> (Ahyong & Brown, 2002)	+					+		
<i>S. helleri</i> Bate, 1878	+							
<i>S. nana</i> (Smith, 1884)	+	+		+				+
<i>S. sculpta</i> (Smith, 1880)	+							+
<i>S. sulmi</i> (Bate, 1878)		+						+
<i>S. surda</i> (Galil, 2000)		+	+					+
<i>W. pacifica</i> Sund, 1920					+			+
<i>W. forceps</i> A. Milne Edwards, 1880	+							
<i>W. leptodactyla</i> (Willemoes-Suhm, 1873)								+

Distribution. West Africa, Azores, Sargasso Sea to the Caribbean Sea (Galil 2000) and now from Queensland, Australia; 1473–4064 m.

GENERAL REMARKS

The results of the present study include the first Queensland record of *Stercomastis nana*, the

first Australian record of *Pentacheles obscurus*, and the first Indo-Pacific record of *Willemoesia forceps*. Nineteen species in four genera of Polychelidae are now known from Australia. Ten species in four genera are known from New Zealand waters (Galil 2000). None are endemic to Australia, but the majority occur in eastern Australia with some also occurring off

South Australia and Western Australia. None are presently recorded from the Northern Territory. In Australian waters, *Polycheles coccifer* is presently known only from Western Australia and *Willemoesia pacifica* only off South Australia. Most New Zealand polychelids, apart from *W. leptodactyla*, also occur off eastern Australia. Most polychelids occurring in Australian and New Zealand waters are widespread in the Indo-West Pacific or beyond. Only *P. kermadecensis* is regionally endemic, being presently known only from localities between eastern Australia, the Kermadec Islands, and mainland New Zealand (Ahyong & Brown 2002). General Australian and New Zealand distributions are summarised in Table 1.

ACKNOWLEDGEMENTS

This study was partially supported by a Visiting Curatorship from the Museum of Tropical Queensland, Townsville and the New Zealand Foundation for Research, Science and Technology (CO1X0502). Niel Bruce and Barbara Done are thanked for their hospitality and assistance in Townsville.

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Southerly range extension of the poorly known, Queensland endemic yellow-naped snake *Furina barnardi* (Squamata: Elapidae) into the Mulga Lands

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Citation: Ferguson, D., Mathieson, M. & Eyre, T. 2012 02 17: Southerly range extension of the poorly known, Queensland endemic yellow-naped snake *Furina barnardi* (Squamata: Elapidae) into the Mulga Lands. *Memoirs of the Queensland Museum-Nature* 56(1): 9-12. Brisbane. ISSN 0079-8835. Accepted: 3 September 2010.

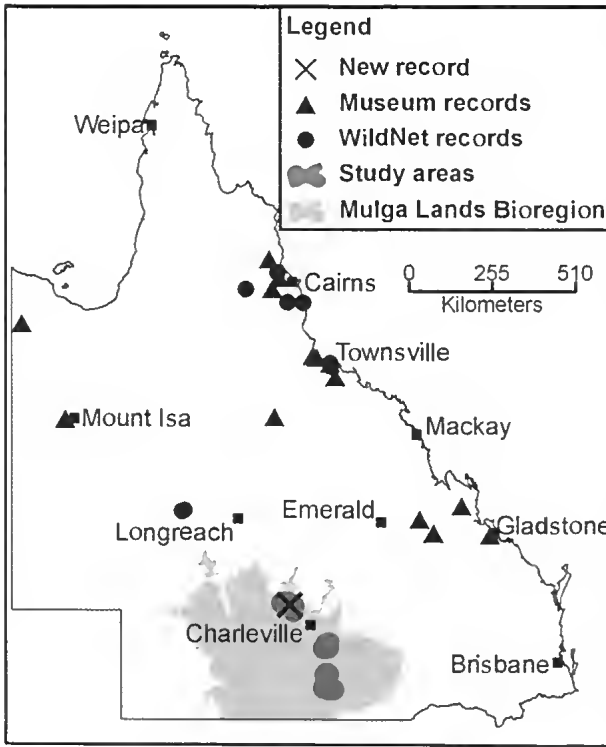
ABSTRACT

The range of *Furina barnardi* is extended more than 200 km south to Mount Morris Station (25.84°S, 145.63° E) near Charleville, southwestern Queensland. Despite recent concentrated survey effort in the region, this is the first record for this rarely encountered species in the Mulga Lands biogeographic region. The specimen was collected from mulga (*Acacia aneura*) woodland which generally matches other dry woodland areas where the species has previously been recorded. Comment is made on the incorrect usage of the divided nasal scale, an apparent key feature used in many current field guides to separate *F. barnardi* from its congeners. □ *Furina barnardi*, range extension, Mulga Lands.

The genus *Furina* consists of five nocturnal Australian species all of which favour drier forests and woodlands (Wilson 2005). Two of these species (*F. barnardi* and *F. dunmalli*) are infrequently recorded and relatively little of their ecology is known (Shine 1981; Wilson 2005; Greer 2006). While *F. dunmalli* appears to be confined to the Brigalow Belt biogeographic region of Queensland and adjacent northern New South Wales (Wilson 2005; Swan *et al.* 2004), *F. barnardi*, a species endemic to Queensland, has been recorded in the State's Brigalow Belt, Einasleigh Uplands, Wet Tropics, Desert Uplands and Northwest Highlands biogeographic regions (Queensland Museum records; Wilson 2005). Despite this broad distribution, the species is currently listed as 'near threatened' under the *Queensland Nature Conservation Act 1992*,

an interim measure until the status can be reviewed by the Species Technical Committee (DERM 2010). The species was previously listed as rare due to insufficient knowledge on population size and threatening processes with sparsely scattered records across a large area (Cogger *et al.* 1993). Currently only 23 specimens are held by Australian museums (21 in the Queensland Museum), including a clutch of 10, bred from a pair collected near Gladstone in mid-eastern Queensland (Fig. 1). There are a further three specimens held by the California Academy of Sciences (CAS), including the holotype (CAS77798).

In October 2007, a large (approximately 40 cm) specimen of *F. barnardi* was found during a nocturnal search at Mount Morris Station



(25.84°S, 145.63°E), approximately 80 km WNW of Charleville, southwestern Queensland. This animal has been lodged at the Queensland Museum (QMJ86740). Table 1 outlines the morphological information for the vouchered animal, collected at one of 83 sites established on grazing properties in the eastern Mulga Lands biogeographic region (Fig. 1). Sites were established to examine faunal responses across broad vegetation condition states in remnant and non-remnant mulga *Acacia aneura* ecosystems (Eyre *et al.* 2008). At each site, systematic fauna surveys were conducted over two six-day survey periods between 2007 and 2008, one during 'spring/summer' (September to December) and again during 'summer/autumn' (February to May). These surveys included pitfall trapping, funnel trapping and active, diurnal and

FIG. 1. Distribution of *Furina barnardi* records in relation to the new specimen (cross) collected from the Mulga Lands biogeographic region, Queensland. Museum records (triangles) from the Queensland Museum, California Academy of Sciences and the Australian Museum. WildNet records (circles) are sighting records held by the Department of Environment and Resource Management wildlife database.

TABLE 1. Comparative morphological data for the Mount Morris Station voucher specimen (QMJ86740), the holotype (CAS77798), other *Furina barnardi* records, and other *Furina* species: observed numbers of mid-body, subcaudal, ventral, upper labial, lower labial and temporal scales; whether the nasal scale is divided (div) or undivided (undiv); and whether the mid-body pattern consists of pale-edged scales or dark-edged scales forming a reticulated pattern. Morphological data from Cogger (2000), Ferguson & Mathieson (unpublished data), Kinghorn (1939), and Scanlon (2003). **Furina barnardi* usually has six upper labials, sometimes seven when the temporolabial (lower anterior temporal) reaches the lip, also changing the temporal scale count in the first row, as exhibited by the holotype.

Species	Midbody	Subcaudal	Ventral	Upper Labial	Lower Labial	Nasal	Temporal	Mid-body scale pattern
QMJ86740	15	38	196	6*	7	undiv	2+2+3*	Pale-edged
Holotype - CAS77798	15	40	183	7*	7	undiv	1+2+3*	Pale-edged
<i>F. barnardi</i>	15	35-58	157-221	6*	7	undiv	2+2+3*	Pale-edged
<i>F. diadema</i>	15	35-54	156-203	6	7	undiv	2+2+3	Dark-edged
<i>F. dunmalli</i>	21	37-46	166-189	6	7	div	2+2+3	Absent
<i>F. ornata</i>	15 or 17	37-63	164-217	6	7	undiv	2+2+3	Dark-edged
<i>F. tristis</i>	17	44-51	171-181	6	7	div	2+2+3	Pale-edged

nocturnal searching for reptiles. Considerable effort was invested in these reptile surveys with more than 2700 pit trap nights, nearly 4000 funnel trap nights and over 280 hours spent actively searching, resulting in only a single record of *F. barnardi* in the Mulga Lands bioregion.

Faecal material collected from QMJ86740 contained a large quantity of unidentified reptile scales, concurring with previous reports of the species feeding on skinks (Kinghorn 1939; Shine 1981). The vegetation at the collection site was open mulga *Acacia aneura* and poplar box *Eucalyptus populnea* woodland that had been pulled for stock fodder during the previous three to four months and was within 100 m of an intact remnant block of the same vegetation type, defined as Regional Ecosystem 6.5.18 (Queensland Herbarium 2009). The habitat does not differ greatly from the other dry woodlands in which the species is known to occur (Wilson 2005; Emmott & Wilson 2009). The ground layer was dominated by hard, bare earth (reddish brown light clay) with shrubs (Charleville turkey bush *Eremophila gilesii*, emu bush *E. glabra* and *Sida cunninghamii*) and grasses (Jericho wiregrass *Aristida jerichoensis*, woodland love grass *Eragrostis sororia* and dainty love grass *E. microcarpa*) sparsely distributed. Due to the recent fodder harvesting of mulga, there was a high volume of fallen timber (22 m³/ha versus 7.5 m³/ha pre-harvesting) and an abundance of exposed mulga root balls, leaving large (>1 m deep) holes.

This is the first record for the species in the Mulga Lands biogeographic region and lies (1) approximately 410 km SE of the nearest published sight record for the species near Opalton in SW Queensland (Wilson & Knowles 1988; Wilson 2005); (2) approximately 450 km WSW of the nearest Queensland Museum specimen collected from Taunton National Park and (3) approximately 200 km south of the speculated range detailed in Wilson (2005).

It should be noted that *F. barnardi* as a species is ill-defined with specimens being comparable to

F. ornata (Ehmann 1992; P. Couper pers. comm.). The two species have been distinguished in the past by *F. barnardi* having a divided nasal scale (Wilson & Knowles 1988; Cogger 2000) or at least a large nostril taking up the entire nasal scale (Wilson 2005) whereas *F. ornata* has an entire undivided nasal scale. This differs from the original description by Kinghorn (1939), which states the nasal shield is single and 'slightly grooved, especially on its lower half, and sharply pointed posteriorly' (Kinghorn 1939).

However, Scanlon (2003) highlights that, although widely cited in the identification of *F. barnardi*, the diagnostic characteristic of a divided nasal is incorrect as *F. barnardi* has a single undivided nasal scale. This was confirmed by examination of images of the CAS specimens, including the holotype, and the specimens held in the Queensland Museum by the authors (DF, MM), which revealed each specimen had undivided nasal scales. In addition to the holotype, three specimens (J33570, J54477 and J67850) showed a slight groove or crease on the lower half, below the nostril. This crease was not present on both nasal scales of any of these specimens, and may be a consequence of preservation.

The Charleville specimen was identified as *F. barnardi* by comparison with morphological details of the holotype and the specimens held by the Queensland Museum (Table 1). Fifteen midbody scales and an undivided nasal scale separate it from *F. dunnalli* (21) and *F. tristis* (17). *Furina barnardi* can be distinguished from *F. ornata* and *F. diadema* by a pale yellow to brown nape, with a dark grey-brown head (Emmott & Wilson 2009; Wilson 2005; Cogger 2000), and a sometimes indistinct, pale edge to the midbody scales (P. Tremul pers. comm.; pers. obs.). *Furina ornata* and *F. diadema* both have a glossy dark brown to black head and neck with a red to orange nape (Emmott & Wilson 2009; Wilson 2005; Cogger 2000). The red to orange nape colouration is known to fade in larger older *F. ornata* specimens (Ehmann 1992), however the

mid-body scale pattern of both *F. ornata* and *F. diadema* contrasts strongly to that of *F. barnardi* in having dark edges forming a distinct reticulated pattern. The voucher specimen from Mount Morris Station has an almost indistinguishable pale band on the nape and, more importantly, pale edged mid-body scales, like those of the holotype and other *F. barnardi* specimens.

ACKNOWLEDGEMENTS

The authors would like to thank the following for their contribution to our work: the owners and managers of Mount Morris Station; Land & Water Australia and Meat and Livestock Australia (research funding); Peter Tremul for discussions on identification; Patrick Couper, Andrew Amey and Steve Van Dyck of the Queensland Museum for their advice, assistance and for reviewing a draft; California Academy of Sciences herpetology, particularly Ricka Stoelting and Dr Robert Drewes for kindly providing photographs and scale counts of CAS specimens; and Ross Sadlier of the Australian Museum for his assistance.

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Fishes from fresh and brackish waters of islands in Torres Strait, far north Queensland

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Citation: Hitchcock, G., Finn, M.A., Burrows, D.W. & Johnson, J.W. 2012. 02 17: Fishes from fresh and brackish waters of islands in Torres Strait, far north Queensland. *Memoirs of the Queensland Museum – Nature* 56(1): 13-24. Brisbane. ISSN 0079-8835. Accepted: 26 July 2011.

ABSTRACT

Until recently the freshwater fish fauna of Torres Strait was virtually unknown. This paper reports on museum collections of fishes obtained in the area prior to 2005 and on several collections made in the period 2005-2011 from fresh and brackish waters on seven islands in the region: Boigu, Saibai, Mabuiag, Badu, Mua, Thursday and Horn. Eight of the fifteen freshwater fish species reported are new records for the Torres Strait Islands. Information on other aquatic fauna is presented, and the potential threats of introduced (exotic) species and sea-level rise associated with climate change, are considered. □ *Torres Strait; north Queensland; fresh and brackish water fishes; pest fish.*

The Torres Strait Islands are an archipelago located in the epicontinental seaway between Cape York Peninsula, far north Queensland and central-southern New Guinea, a north-south distance of 150 km. While the role of Torres Strait as biogeographical bridge or barrier has been the subject of considerable discussion (e.g. Mackey et al. 2001; Heinsohn & Hope 2006; Walker 1972), the islands' fauna is not well known (Strahan 1995: 444; McNiven & Hitchcock 2004).

The fresh- and brackish water (i.e. non-marine) fishes of Torres Strait are a case in point. While the species composition of Cape York is relatively well

known, and some research has been undertaken in central-southern New Guinea (e.g. Allen 1991, 2004; Herbert & Peeters 1995; Herbert *et al.* 1995; Hitchcock 2002; Pusey *et al.*, 2004), the fish fauna of aquatic systems on the Torres Strait Islands have largely been unexplored to date. Only four native freshwater fish species have been recorded from the islands: *Melanotaenia nigrans* from Muralag (Allen & Cross 1982), *M. splendida inornata* from Badu and Muralag (Prince of Wales Island) (Allen & Cross 1982), *M. rubrostriata* from Daru (Allen & Cross 1982) and Saibai (Hitchcock 2008), and *Ambassis agrammus* from Saibai

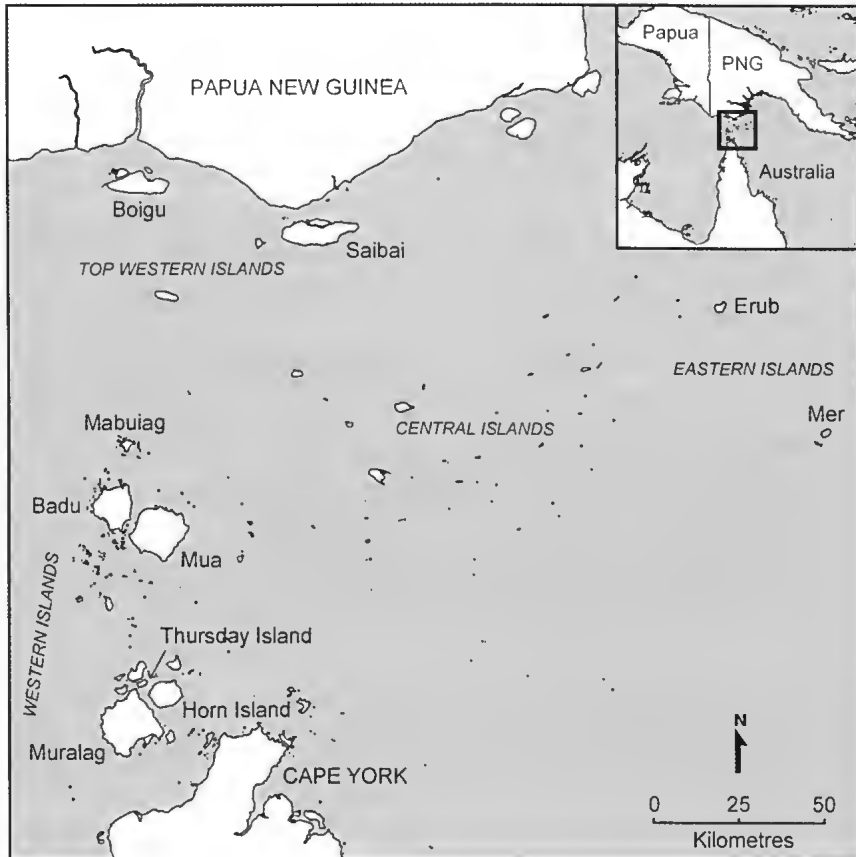


FIG. 1. Torres Strait, showing islands mentioned in the text.

(Hitchcock 2008). Among museum records, twelve species appear to have been collected from four islands in the region prior to 2005, with specimens held in the collections of the Australian Museum, Commonwealth Scientific and Industrial Research Organization and Queensland Museum. This paper reports the results of opportunistic fish collections made in freshwater and brackish streams, ponds and dams on seven islands in Torres Strait by Garrick Hitchcock (GH), Marcus Finn (MF) and Damien Burrows (DB) between 2005-2011, the collecting efforts of G. and K. Aland at Mabuiag and Mua in

March-April 2008 and a review of museum holdings in Australia.

ENVIRONMENT AND COLLECTION SITES

Torres Strait (Fig. 1) was formed by rising sea levels in the early Holocene (c. 8000-6500 years before present) that inundated the Arafura Plain, the low-lying land bridge connecting Australia and New Guinea (Barham 1999; Jennings 1972; Woodroffe *et al.* 2000). Prior to the recent formation of the Strait, southern New Guinea and northern Australia were linked during low sea level periods for much of recent geological history, accompanied by

a degree of hydrological connectivity (Allen & Hoese 1980; Heinsohn & Hope 2006). Consequently, there is a strong correlation between the freshwater fish fauna on either side of the Strait: central-southern New Guinea and northern Australia share approximately 50% of species in common (Unmack 2001; see also Allen 1991, 2004). According to Unmack (2001), the aridity of the land bridge during the Pleistocene and presence of brackish water in the vast Lake Carpentaria, which existed on the western Arafura Plain, prevented freshwater fish migrations and hence the major exchanges of Australian and New Guinea fishes occurred during the warmer and wetter late Miocene. However, a recent paper by Baker *et al.* (2008), examining the genetic relationships between northern Australia and southern New Guinea freshwater crayfish, suggests that Lake Carpentaria did provide a late Pleistocene-early Holocene connection between a considerable number of north-eastern Australian rivers and at least one river in central-southern New Guinea (see also Keenan 1994; Ride 1972).

The islands of Torres Strait can be grouped into four main geographical types. Two of these are remnants of what were once hills and elevated lands on the Arafura Plain: a group of granitic continental islands found mostly in the west and south, and a volcanic group in the east. The other two groups were formed over the last several thousand years: sandy cays on reefs in the central part of the Strait, and in the far north, alluvial or sedimentary islands, created by Holocene deposition of terrigenous muds (Barham 1999; Jennings 1972; Woodroffe *et al.* 2000).

Torres Strait has a monsoonal climate, with approximately 90% of rainfall occurring in a wet season from December to April. Average annual precipitation, based on Thursday Island records, is 1700 mm. Seasonal creeks occur on several continental islands, with rock pools and waterfalls on the largest, e.g. Muralag, Badu and Mua (Garnett & Jackes 1983; Singe 1979). Freshwater, brackish and marine swamps occur on Boigu and

Saibai, and large, anthropogenic, earth-rimmed wells were also constructed on these islands to provide a supply of potable water during the dry season (Barham 1999; Clarke 2004).

No freshwater environments exist on the sand cay islands; although small, anthropogenic, hand-dug wells were used by the local population on inhabited islands prior to the installation of water tanks and dams in the twentieth century. Several small, perennial streams occur on the eastern islands of Erub (Darnley Island) and Mer (Murray Island) (Haddon *et al.* 1894), but no freshwater fishes are known with the exception of eels, *Anguilla* sp., which have been reported from Erub. According to local people, eels formerly lived in a freshwater spring at Mogor, on the southwest side of Erub, until it was capped as a water supply measure in the twentieth century. The eels were not consumed, and are said to have kept the well 'clean' (Kapua Gutchen, Erub, pers. comm. 2008). Protection of freshwater eels, to ensure clean water sources, has also been reported from the Solomon Islands (BBC 2009).

More detailed descriptions of the collection sites appear below.

Continental Islands

Thursday Island. The administrative centre of the Torres Strait Islands, Thursday Island is approximately 3.7 km² and has the largest population (2551 at the 2006 Census). The island is relatively built up, with the exception of central and eastern lightly wooded areas in the vicinity of Milman Hill and the emergency town water supply impoundment. The indigenous name for Thursday Island is Waiben, which is said to mean 'no water'. As expected given this name, Thursday Island has no naturally permanent freshwater. There are three anthropogenic, permanent freshwater waterbodies on the island: the emergency water supply; the school irrigation supply (a smaller waterbody sitting immediately below the emergency water supply reservoir wall); and a nineteenth century dam below Green Hill.

Horn Island. Horn Island consists of approximately 54 km² of lightly wooded, low hills fringed by a narrow strip of mangrove on the northern and western sides of the island. Collecting was undertaken in Vidgen Creek, the largest freshwater stream on the island, which drains to the northern coast. This creek appears to dry out completely in the dry season. There are also two large water supply dams and an inundated former mining quarry, in which freshwater fish are known to occur (Burrows & Perna 2009).

Badu. Badu is a lightly forested, rocky granite island around 11 km in diameter, with an area of 100 km². Mangrove swamps are present on the north coast, and some areas on the east and south. Pools of water remain in the well-defined creeks that drain to the northern and western coasts throughout the dry season (Garnett & Jackes 1983). Collecting was undertaken at Sirip Koesa ('Sirip Creek'), located on the southwest side of the island.

Mabuiag. Mabuiag is a hilly, roughly triangular-shaped island of approximately 6 km², situated in the middle of the narrowest part of the Strait. Collecting was undertaken at two very small, perennial streams, Sau Koesa and Kubarau Koesa, on the northeast and southwest sides of the island respectively.

Mua. The second-largest island in the Strait, after Prince of Wales Island, Mua (formerly known as Moa) is a rocky, lightly vegetated island of about 17 km diameter, with an area of around 172 km². The island is fringed by mangroves on the south, west and north coasts. It is home to the largest freshwater creek among the islands, Koey Kussa ('Big Creek'), which drains into the narrow passage that separates Mua from Badu (Wannan 2008). Collecting here was undertaken at three locations: a small perennial creek among *Pandanus* grassland, located near the Kubin cemetery, on the southwest side of the island, at Bubu Creek, located just north of St Pauls settlement, on the eastern side of the island, and in a small tributary of Koey Kussa.

Sedimentary Islands

Saibai. Saibai Island, located just under 4 km off the south New Guinea coast, is 21 km long and up to 6 km wide, with an area of approximately 104 km². It is fringed by tidally inundated mangroves. The interior consists of seasonally inundated, permanent and semi-permanent fresh-and brackish-water sedge swamps, salt pans, and non-inundated claylands covered by *Pandanus* grasslands and open woodland. The interior swamps are connected to the sea by a system of mangrove creeks. (Barham 1999; Barham & Harris 1985; CONICS 2009; Environmental Science & Services 1994). Collection was undertaken at a sledged pool (former water supply) next to a water pump plant and several brackish, sedge-lined pools near the south-eastern end of the airstrip.

Boigu. This island is approximately 17 km long and 6 km wide, with an area of around 72 km² and lies less than 7 km south of the New Guinea mainland. It is lower and swampier than Saibai; there is much less in the way of non-inundated plains and most of the interior comprises marine swamplands: salt pans, tidal flats and mangrove forests (Clarke 2004; CONICS 2009; Stanton *et al.* 2008). Prior to the creation of modern dams, there were three wells on the island (Ingui 1991). Collecting was undertaken in an artificial lagoon, south of and adjacent to the airstrip, which was created when the earth in this location was excavated to build up the airstrip.

METHODS

Fish were caught using the following techniques: collection by hand (of fish above or near waters edge), deployment of collapsible rectangular baited traps, use of dip nets, improvised small mesh flat seine (shade cloth) and throw nets. Collecting efforts were opportunistic and often limited by the extent of available aquatic habit at the locations and on the islands visited. The number of collecting days on each island was approximately as follows: Boigu (seven), Saibai (seven), Badu (two),

Torres Strait fresh and brackish water fishes

Mua (seven), Mabuiag (three), Thursday Island (two) and Horn Island (ten). Limited backpack electrofishing was carried out on Saibai Island to obtain species recorded by Burrows & Perna (2009).

Specimens were preserved in solutions of either 10% formalin or 90% ethanol, and forwarded

to the Queensland Museum for entry into their freshwater fish collection.

RESULTS

Thirty-one species, including two exotic introduced taxa (Eastern Gambusia, *Gambusia holbrooki* and Climbing Perch, *Anabas testudineus*), have been identified from fresh and brackish

TABLE 1. Fishes collected or recorded in fresh and brackish waters of Torres Strait Islands. Shaded rows denote strictly freshwater species; AMS = Australian Museum, Sydney; CSIRO = Commonwealth Scientific and Industrial Research Organization (Marine & Atmospheric Research), Hobart; QM = Queensland Museum, Brisbane; 1 = information sourced from Froese & Pauly (2011).

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
Megalopidae				
<i>Megalops cyprinoides</i> Oxeye herring	Boigu	CSIRO H 665-3 QM I.38040	Adults generally found in the sea, but juveniles inhabit freshwater habitats	CSIRO (1984) Hitchcock, 2008
	Saibai	CSIRO H 664-3		CSIRO (1984)
	Badu	-		This study
	Mua	-		This study
	Horn Island	QM I.38158		This study
	Muralag	CSIRO B 723	CSIRO (1959)	
Anguillidae				
<i>Anguilla</i> sp. Freshwater Eel	Boigu	-	Freshwater streams, lakes and swamps; adults spawn in marine waters	Burrows, 2010
	Saibai	-		Burrows & Perna, 2009
	Horn Island	-		This study
Chanidae				
<i>Chanos chanos</i> Milkfish	Boigu	CSIRO H 665-01	Offshore marine waters and shallow coastal embayments; frequently enter estuaries and occasionally penetrates freshwater	CSIRO (1984)
	Horn Island	QM I.38160		This study
Ariidae				
<i>Neoarius leptaspis</i> Boofheaded Catfish	Horn Island	QM I.38164	Lakes, rivers, muddy coastal seas and estuaries	This study
Mugilidae				
<i>Mugil cephalus</i> Sea Mullet	Horn Island	QM I.38159	Coastal species that often enter estuaries and rivers	This study
Pseudomugilidae				
<i>Pseudomugil gertrudae</i> Spotted Blue Eye	Mua	QM I.36731	Small creeks, marshes, rainforest streams, lagoons and backwaters adjacent to major water courses	This study
		QM I.38847		This study
		QM I.38850		This study
		QM I.38286		Aland collection (2008)
		QM I.38288		Aland collection (2008)

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>Pseudomugil signifer</i> Pacific Blue Eye	Mabuiag	QM I.38283	From clear, fast-flowing streams to brackish mangrove estuaries and tidal mangrove creeks	Aland collection (2008)
		QM I.38439		This study
	Mua	QM I.38285		Aland collection (2008)
		QM I.36730		This study
		QM I.38146		This study
	Horn Island	QM I.38849		This study
		QM I.38142-3		This study
		QM I.38166		This study
	Muralag	QM I.38172		This study
		QM I.6558		QM record (1938)
CSIRO B 705		CSIRO (1959)		
CSIRO B 13	CSIRO (1960)			
Melanotaenidae				
<i>Melanotaenia maccullochi</i> McCulloch's Rainbowfish	Mua	QM I.38845	Lowland swamps and small streams. Usually clear acidic waters (e.g. <i>Pandanus</i> swamps)	This study
		QM I.38290		Aland collection (2008)
<i>M. nigrans</i> Blackbanded Rainbowfish	Muralag	QM I.12830 B 639-641	Inhabits rainforest streams, lagoons and small streams	QM record (1968) CSIRO (1959)
<i>M. splendida inornata</i> Chequered Rainbowfish	Badu	QM I.38173	Freshwater streams and lakes	This study
		CSIRO B 647		CSIRO (1962)
	CSIRO B 648	CSIRO (1960)		
	Mua	QM I.38846		This study
		QM I.38287		Aland collection (2008)
Muralag	CSIRO B 4146 CSIRO B 4147	CSIRO (1959) CSIRO (1959)		
<i>M. rubrostriata</i> Redstriped Rainbowfish	Boigu	QM I.38183	Freshwater	This study
	Saibai	QM I.38037		Hitchcock, 2008
		QM I.38149		This study
Hemiramphidae				
<i>Zenarchopterus buffonis</i> Northern River Garfish	Horn Island	QM I.38165	Coastal waters, estuaries and rivers	This study
Poeciliidae (Introduced)				
<i>Gambusia holbrooki</i> Eastern Gambusia	Thursday Island	QM I.38709 -	Fresh and brackish water	This study Burrows & Perna, 2009
Ambassidae				
<i>Ambassis agrammus</i> Sailfin Glassfish	Saibai	QM I.38038 QM I.38147	Freshwater streams, ponds, swamps and lakes	Hitchcock, 2008 This study
	Horn Island	QM I.38141		This study
<i>A. elongatus</i> Elongate Glassfish	Horn Island	QM I. 38144-5 QM I.38169 QM I.38711	Freshwater streams that frequently have moderate to high turbidity	This study This study This study

Torres Strait fresh and brackish water fishes

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>A. vachellii</i> Vachell's Glassfish	Horn Island	QM I.38167	Brackish waters of bays, estuaries and tidal mangrove creeks. Sometimes entering freshwater	This study
Kuhliidae				
<i>Kuhlia rupestris</i> Jungle Perch	Muralag	CSIRO C 3193 - 3201	Primarily a freshwater inhabitant but may penetrate adjacent marine habitats; estuaries and the middle reaches of rivers, usually in relatively fast-flowing, clear streams as well as in rocky pools below waterfalls	CSIRO (1959)
Lutjanidae				
<i>Lutjanus russelli</i> Moses Snapper	Horn Island	QM I.38161	Adults offshore and inshore coral and rocky reefs; juveniles mangrove estuaries and lower reaches of freshwater streams	This study
Terapontidae				
<i>Amniataba caudavittata</i> Yellowtail Grunter	Boigu Saibai Horn Island	QM I.38184 QM I.38039 QM I.38043 QM I.38174 CSIRO H 664-2 QM I.38163	Coastal marine waters, but also found in estuaries and freshwater sections of rivers	This study Hitchcock, 2008 Hitchcock, 2008 This study CSIRO (1984) This study
Eleotridae				
<i>Bostrychius zonatus</i> Sunset Gudgeon	Saibai Horn Island	QM I.38041 CSIRO H 664-1 QM I.38155	Freshwaters and estuaries	Hitchcock, 2008 CSIRO (1984) This study
<i>Hypseleotris compressa</i> Empire Gudgeon	Horn Island Muralag	QM I.38156 QM I.38710 CSIRO B 718	Usually flowing streams amongst aquatic vegetation; juveniles often found in brackish waters and adults can withstand salinities equal to seawater	This study This study CSIRO (1959)
<i>Mogurnda mogurnda</i> Northern Trout Gudgeon	Mua	QM I.38848	Rivers, creeks and billabongs, in quiet or slowly flowing sections among vegetation or rocks	This study
<i>Ophiocara porocephala</i> Spangled Gudgeon	Muralag	AMS I.34586-001	Brackish estuaries, river mouths and freshwater creeks	AMS record (1976)
<i>Oxyeleotris nullipora</i> Poreless Gudgeon	Mua	QM I.38851 QM I.38289	Backwaters of rivers, creeks, small swamps and lagoons	This study Aland collection (2008)
Gobiidae				
<i>Mugilogobius filifer</i> Threadfin Mangrovegoby	Mabuiag	QM I.38284 QM I.38438 QM I.38440	Mangrove creeks and estuaries, sometimes well into the freshwater influence	Aland collection (2008) This study This study

TABLE 1. Continued ...

Species	Island	Museum No.	Aquatic habitat preference ¹	Reference/origin
<i>M. platystomus</i> Island Mangrovegoby	Horn Island	QM I.38157 QM I.38171	Mangrove estuaries and clear rainforest streams near the sea	This study This study
<i>Periophthalmus novaeguineensis</i> New Guinea Mudskipper	Boigu	QM I.38185	Intertidal and amphibious air-breather; inhabits tidal estuaries and sometimes enters lower reaches of freshwater streams	This study
<i>Pseudogobius cf poecilosoma</i> Northern Fatnose Goby	Saibai Horn Island	QM I.38148 QM I.38168 QM I.38170	Brackish waters	This study This study This study
<i>Pseudogobius</i> sp.1 Goby	Boigu Saibai	QM I.38182 QM I.38175	Usually rivers and estuaries	This study This study
Anabantidae (Introduced)				
<i>Anabas testudineus</i> Climbing Perch	Boigu Saibai	- -	Often found in turbid stagnant waters (fresh), and estuaries	Burrows, 2010 Burrows & Perna, 2009; Hitchcock, 2008
Scatophagidae				
<i>Selenotoca multifasciata</i> Banded Scat	Saibai Horn Island	QM I.38042 QM I.38162	Mangrove creeks and the lower reaches of freshwater streams	Hitchcock, 2008 This study

water habitats in the Torres Strait islands, on the basis of a review of museum specimens collected prior to 2005 and field investigations undertaken from 2005-2011 (Table 1). Eight of the fifteen species generally regarded as primarily freshwater inhabitants are new records from the Torres Strait islands: *Pseudomugil gertrudae*, *P. signifer*, *Melanotaenia maccullochi*, *Ambassis elongatus*, *Kuhlia rupestris*, *Hypseleotris compressa*, *Mogurnda mogurnda* and *Oxyeleotris nullipora*. The full list of species is shown in Table 1.

Specimens of *Megalops cyprinoides* were photographed at Mua but not collected. A specimen of *M. cyprinoides*, measuring approximately 200 mm TL, hand-collected from a small (c. 2 m diameter) pool in a perennial swamp known as Gai Gawath, located directly adjacent to the township on Badu Island, was subsequently lost. Freshwater eels, *Anguilla* sp., were observed on several occasions in Vidgen Creek, Horn Island (GH pers. obs.) and at Boigu and Saibai (Burrows 2010; Burrows & Perna 2009), but specimens were not collected and positive identification to species level was not made.

Additional aquatic fauna were collected where encountered, and deposited in the collections of the Queensland Museum. From Vidgen Creek, these were: freshwater crab *Austrothelphusa* sp. (QM W.28481); freshwater mussel *Velsunio angasi* (QM MO.78577); freshwater prawn *Macrobrachium* sp. (QM W.28482); freshwater crayfish *Cherax* sp. (QM W.28363, W.28483, W.28485); freshwater shrimp *Cardina* sp. (QM W.28284); and the aquatic insects *Dinentus (Cyclous) australis* (Coleoptera) and *Limnometra ciliodes* (Hemiptera). Specimens of *Cherax* sp. were also collected at Badu (QM W.28361) and Mua (QM W.28362). *Austrothelphusa* sp. was collected from Mabuiag (QM W.28906) and specimens were also observed on Mua and Erub but not collected. The aquatic beetle *Cybister godeffroyi* (Coleoptera) was collected at Badu. Local people state that freshwater turtles are present on Horn Island, Badu, Mua and Saibai, although none were observed or collected. Saltwater crocodiles *Crocodylus porosus* are also common in the creeks and swamps of the Torres Strait Islands.

DISCUSSION

The small size of the Torres Strait islands, lack of permanent freshwater environments of any significant size, and the region's palaeo-geography, -climate and -ecology have contributed to a freshwater fauna that is depauperate compared to the adjoining mainlands.

Twenty-two of the 31 species recorded are known to inhabit brackish or saline waters (Table 1), making them well adapted to living in small island habitats where freshwater may not be permanently available. The remaining nine species are not known to inhabit or tolerate brackish or saline waters, and were collected from Boigu, Saibai, Badu, Mua, Horn and Muralag. We suggest two possible explanations for their presence in our samples. The first is that, over a long period of time, these islands maintained at least some refugial freshwater habitats. The maintenance of non-anthropogenically spread populations of these species requires freshwater habitats that must not dry out between wet seasons. Mua, Muralag and Badu all appear to have permanent pools in their freshwater systems. The situation is less clear on other islands: the freshwater streams on Horn Island appear to dry completely most years. Saibai has extensive inland freshwater systems (Boigu much less so), some of which are permanent (Barham 1999). It may also be the case that the small wells supported fish, and that repopulation on Boigu and Saibai also occurs during periodic large flood plumes from Papua New Guinea. A fuller examination of freshwater refuges and fish species inhabiting the islands may resolve this issue.

Some traditional knowledge of local freshwater fish was obtained during the study, including vernacular names in the Western-Central Torres Strait Language. On Badu, 'yamu' was said to be the name for all small freshwater fish. The lack of specific names probably reflects the economic unimportance of these fish, to people who were highly specialised marine hunters and fishers (McNiven & Hitchcock 2004). The

1898 Cambridge Anthropological Expedition to Torres Straits recorded 'iam' as the name in this language for Oxeye Herring *Megalops cyprinoides* (Ray 1907: 100). On Saibai Island the Sunset Gudgeon *Bostrychus zonatus* is called 'kunu' (Teske 1998), and another, similar but larger, species, called 'abadam', is also said to inhabit the inland swamps. Other local language names for aquatic fauna are: 'koedal' (Saltwater Crocodile, *Crocodylus porosus*); 'kobi' (freshwater turtle); and 'koti' (freshwater crab, *Austrothelphusa augustifrons*). At Badu, *Cherax* sp. are called 'kag'.

Threats

Two introduced pest fish have now been identified in Torres Strait: Climbing Perch *Anabas testudineus* on Boigu and Saibai (Burrows 2010; Hitchcock 2008, 2007) and Eastern Gambusia *Gambusia holbrooki* on Thursday Island (Burrows & Perna 2009). Hitchcock (2008) reported on the occurrence of *Anabas testudineus* at Saibai, from a digital photograph and oral accounts by Islanders. Specimens were subsequently captured by Burrows at Saibai and Boigu in 2008 and 2010 respectively; these are held in the collection of the Australian Centre for Tropical Freshwater Research (ACTFR), James Cook University, Townsville (Burrows 2010; Burrows & Perna 2009).

Burrows and Perna (2009) identified *Gambusia* in the emergency water supply and school irrigation dam on Thursday Island, and collected a specimen which is currently held in the ACTFR collection. It was also collected (by GH) from the Green Hill dam, the island's original water supply. The fish was likely introduced during the Second World War as an anti-malaria measure, when Torres Strait was under military administration; *Gambusia* was introduced by American and Australian forces across the Pacific (including the Australian mainland) for this purpose (e.g. Ball 1996; Sholdt *et al.* 1972; Whitley 1951).

The occurrence of *Gambusia* and Climbing Perch in Torres Strait means that extra vigilance is required to keep exotic fishes out of Cape York Peninsula. *Gambusia* is widespread in Queensland but not yet known from Cape York. In addition to Climbing Perch, two other air-breathing, land-mobile species are known from catchments in the lowlands of Papua New Guinea: Snakehead *Channa striata* and Walking Catfish *Clarias batrachus* (Hitchcock 2002). The potential for introduction of these hardy species is of considerable concern, as they can survive out of water for extended periods, greatly simplifying the logistics of transporting live specimens south through Torres Strait, and into Cape York (Burrows & Perna 2009; Hitchcock 2002, 2008). If introduced to the mainland, they could invade new catchments via overland dispersal (and via flood events) and have the potential to go around or over natural barriers (e.g. waterfalls). The available evidence suggests that they would pose a considerable threat to native fish species through competition and predation (Allen 1991: 216; Lever 1996: 147,184).

While there is some monitoring of pest fish from north to south (i.e. from New Guinea into Torres Strait) as part of the region's quarantine measures (Burrows & Perna 2009; Hitchcock 2008), there are no legislative restrictions on the import of alien freshwater fishes into the Strait. A retail store on Thursday Island currently sells a range of exotic aquarium species including goldfish (*Carassius auratus*), gourami (*Trichogaster* sp.), neon tetra (*Paracheirodon innesi*), angelfish (*Pterophyllum scalare*), guppy (*Poecilia reticulata*), swordtail (*Xiphophorus helleri*), platy (*X. maculatus*) and bristlenose catfish (*Ancistrus* sp.), as well as aquatic snails and plants. Other aquarium fish are known to have been brought to the islands directly from the Australian mainland. In 2005 GH observed aquarium fish that had been purchased in Cairns by non-indigenous workers in a large, open watertank next to a house at Kubin village, Mua. Burrows and Perna (2009) also noted that red claw crayfish (*Cherax quadricarinatus*),

sourced from the mainland, have been released into a dam on Thursday Island as part of a school aquaculture project. The potential therefore exists for the unintentional or deliberate release of exotic fish, invertebrates and plants into aquatic environments of the Torres Strait Islands. Further research on the Islands will be required to identify the potential impacts of the spread of alien species.

Eustatic sea-level rise associated with climate change may also pose a threat to the native freshwater fishes of the Torres Strait region, particularly low-lying islands such as Boigu and Saibai. In January 2006 and January 2009 king tides resulted in extensive flooding of Saibai (Hitchcock 2009). If the freshwater species found on these islands are natural populations maintained in refugial freshwater habitats, sea level rise and storm surge may eventually inundate these low-lying environments, turning them brackish or saline and extinguishing local populations.

CONCLUSION

More detailed information about the fresh- and brackish water fish fauna of Torres Strait, and the aquatic environments they inhabit, await future, more detailed research. DNA analysis of specimens, comparing fish from the adjoining mainlands may also help to elucidate the connectivity of freshwater environments across northern Australia and southern New Guinea in earlier periods of low sea level (see Baker et al. 2008). Further work should also more fully account for the freshwater fish fauna of the Torres Strait and the possible sources of immigration of these species, both to clarify the longer-term colonisation history of freshwater fish in the Strait and allow an assessment of potential sources of pest fish species in to and out of the region.

It is recommended that surveys focus on the largest islands in the Strait: Saibai, Badu and Mua in the central cluster; and Muralag in the southwest cluster. This is all the more urgent when the potential impacts of sea-level rise on

freshwater environments are considered. The presence and potential spread of exotic species from the Australian and New Guinea mainlands will also require close monitoring in order to facilitate timely response by fisheries authorities.

ACKNOWLEDGEMENTS

We wish to thank Mark McGrouther for providing information on the freshwater fish specimen in the Australian Museum, and Alastair Graham and John Pogonoski for data, digital images and information on specimens held by CSIRO. Glynn and Kieran Aland are thanked for donating specimens collected on Mabuiag and Mua to the Queensland Museum. Helen Larson, formerly of the Northern Territory Museum and Art Gallery, kindly provided assistance with identification of gobiid fishes. Thanks are also due to Peter Davie and Christine Lambkin (Queensland Museum) for identification of crustaceans and aquatic insects respectively. The assistance of David Fell, Tony O'Keefe and David Stanton in collecting specimens on Mua in March 2011 is also gratefully acknowledged.

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A review of the Australian *Polyrhachis* ants of the subgenera *Myrma* Billberg, *Myrmatopa* Forel, *Myrmotherinax* Forel and *Polyrhachis* Fr. Smith (Hymenoptera: Formicidae: Formicinae)

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Citation: Kohout, R.J. 2012 02 17: A review of the Australian *Polyrhachis* ants of the subgenera *Myrma* Billberg, *Myrmatopa* Forel, *Myrmotherinax* Forel and *Polyrhachis* Fr. Smith (Hymenoptera: Formicidae: Formicinae). *Memoirs of the Queensland Museum - Nature* 56(1): 25-59. Brisbane. ISSN 0079-8835. Accepted: 7 June 2011.

ABSTRACT

Australian *Polyrhachis* species of the subgenera *Myrma*, *Myrmatopa*, *Myrmotherinax* and *Polyrhachis* are reviewed. A total of ten Australian species are recognised; four in the subgenus *Myrma*, three in *Myrmatopa*, two in *Myrmotherinax* and a single species in *Polyrhachis*. *Polyrhachis inusitata* Kohout and *P. yarrabahensis* are reinstated as valid species. *Polyrhachis sericeopubescens* Donisthorpe and *P. lombokensis* are considered extralimital and removed from the list of Australian species. *Polyrhachis alpeha* Fr. Smith and *Polyrhachis menozzii* Karavaiev are reported from Australia for the first time. The extralimital species *Polyrhachis dolomedes* Fr. Smith is considered a senior synonym of *Polyrhachis schang* var. *amboinae* Santschi. The former subspecies, *P. relucens* var. *breviorspinosa* Donisthorpe is raised to specific status. A replacement name, *Polyrhachis luteogaster*, is proposed for the former subspecies and junior primary homonym *P. alpeus* var. *rufiventris* Emery. A lectotype of *P. semitestacea* Emery is designated. All species are illustrated and their known distributions and nesting habits summarised. Keys to the Australian species of the subgenera *Myrma*, *Myrmatopa*, *Myrmotherinax* are included. □ *Polyrhachis*, *Myrma*, *Myrmatopa*, *Myrmotherinax*, *Australia*, *distribution*.

This is the third in a series of papers reviewing the Australian ants of the genus *Polyrhachis* (Kohout 2007, 2010). It includes four subgenera that are essentially exotic, having a very limited distribution within the Australian mainland. Species included in these subgenera are confined mostly to the lowland tropical rainforests of north Queensland, including a few, more-or-less isolated patches of monsoonal rainforest on Cape York Peninsula and in the Northern Territory. Most of the species are arboreal nesters, except for the mostly lignicolous species of the subgenus *Myrma*.

METHODS

Publication dates and the spelling of species epithets and authors' names follow Bolton *et al.* (2007). This study is principally based on the worker caste but notes are provided on associated queens. Males of some species are known and their presence in the ANIC and/or QM spirit collections is noted under the particular species headings. However, the diagnosis of males is beyond the intended scope of this paper and has not been attempted.

Localities at which ants were collected by the Bishop Museum's collectors, were checked against that institution's list of New Guinean localities (BPBM, 1966, *unpublished*). In some cases the latitude and longitude co-ordinates, or altitude, are only roughly approximate. The use of the terms 'Moluccas', 'Bismarck Archipelago' and 'New Guinea' alone indicates the delimitation of these islands in a biogeographic sense regardless of current political boundaries.

Illustrations. Photographs of specimens were taken with a digital camera attached to a stereomicroscope. The images were then processed using Helicon Focus (Mac OSX version) or Auto-Montage (Synchrosopy, Division of Synoptics Ltd, USA) and Adobe Photoshop CS2 (Adobe Systems Inc., USA) software. The holotype of *P. inusitata* Kohout; paratype of *P. foreli* Kohout; syntypes of *P. alpheus rufiventris* Emery, *P. antoniae* Stitz, *P. dahlii* Forel, *P. dahli unisculpta* Viehmeyer, *P. delicata* Crawley, *P. litigiosa* Emery, *P. lombokensis* Emery, *P. uenozzii* Karavaiev, *P. onyrmex* (Donisthorpe), *P. queenslandica* Emery, *P. relucens sericeopubescens* Donisthorpe and *P. schang amboinae* Santschi; paralectotype of *P. semitestacea* Emery; and type-compared voucher specimens from Australian localities of *P. alpheia* Fr. Smith, *P. andromache* Roger, *P. bellicosa* Fr. Smith and *P. rufofemorata* Fr. Smith are illustrated.

Standard measurements and indices. Measurements and indices follow those of Kohout (2008a): TL = Total length (the necessarily composite measurement of the outstretched length of the entire ant measured in profile); HL = Head length (the maximum measurable length of the head in perfect full face view, measured from the anterior-most point of the clypeal border or teeth, to the posterior-most point of the occipital margin); HW = Head width (width of the head in perfect full face view, measured immediately in front of the eyes); CI = Cephalic index ($HW \times 100/HL$); SL = Scape length (excluding the condyle); SI = Scape index ($SL \times 100/HW$); PW

= Pronotal width (greatest width of the pronotal dorsum measured at the bases of the pronotal spines, or across the humeri in species without spines); MTL = Metathoracic tibial length (maximum measurable length of the tibia of the hind leg). All measurements were taken using a Zeiss SR stereomicroscope with an eyepiece graticule calibrated against a stage micrometer. All measurements are expressed in millimetres (mm).

Abbreviations. Names of the most frequently listed collectors are abbreviated as follows: ANA - Alan N. Andersen; CJB - C.J. Burwell; DJC - D.J. Cook; EOW - E.O. Wilson; GBM - G.B. Monteith; JEF - J.E. Feehan; RJK - R.J. Kohout; RWT - R.W. Taylor; SKR - S.K. Robson. Other abbreviations used in specimen data are: Ck - Creek; I. - Island; Is - Islands; NP - National Park; nr - near; Pen. - Peninsula; PNG - Papua New Guinea; Plant. - Plantation; Prov. - Province; Pt - Point; R. - River; Ra. - Range; Rd - Road; rf. - rainforest; Stn - Station; V. - Valley; w - worker/s.

Institutions and depositories. (Including the names of cooperating curators): AMNH - American Museum of Natural History, New York, NY, USA (Dr J.M. Carpenter); AMSA - Australian Museum, Sydney, NSW, Australia (Drs D. Britton, D. Smith); ANIC - Australian National Insect Collection, CSIRO, Canberra, Australia (Dr S.O. Shattuck); BMNH - The Natural History Museum, London, UK (B. Bolton); BPBM - Bernice P. Bishop Museum, Honolulu, HI, USA (K.T. Arakaki); FISF - Forschungsinstitute Senckenberg, Frankfurt am Main, Germany (Drs J.-P. Kopelke, W.H.O. Dorow); HNHM - Hungarian Museum of Natural History, Budapest, Hungary (Dr J. Papp); JCUT - James Cook University, Townsville, Queensland, Australia (Dr S.K.A. Robson); JWGU - Johan Wolfgang Goethe-Universität, Frankfurt am Main, Germany (Prof. Dr U. Maschwitz); MCZC - Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA (Dr S. Cover); MHNG - Muséum d'Histoire Naturelle, Geneva, Switzerland (Drs C. Besuchet, I. Löbl, B. Mertz); MNHA - Museum of Nature and Human

Activities, Hyogo Pref. University, Hyogo, Japan (Dr Y. Hashimoto); MNHN – Muséum National d’Histoire Naturelle, Paris, France (Dr J. Casevitz Weulersse); MNHU – Museum für Naturkunde, Humboldt-Universität, Berlin, Germany (Dr F. Koch); MSNG – Civic Museum of Natural History ‘G. Doria’, Genova, Italy (Drs R. Poggi, F. Penati); MVMA – Museum of Victoria, Melbourne, Vic., Australia (Dr K. Walker); NHMB – Naturhistorisches Museum, Basel, Switzerland (Drs M. Brancucci, D.H. Burckhardt); NMNH – National Museum of Natural History, Washington, DC, USA (Dr T.R. Schultz); NRMS – Naturhistoriska Riksmuseet, Stockholm, Sweden (Drs K.-J. Hedquist, F. Ronquist, B. Viklund); OXUM – Hope Entomological Collections, University Museum, Oxford, UK (Drs C. O’Toole, D.J. Mann); QM – Queensland Museum, Brisbane, Australia (Dr C.J. Burwell); TERC – Tropical Ecosystems Research Centre, CSIRO Sustainable Ecosystems, Darwin, NT, Australia (Dr A.N. Andersen).

SYSTEMATICS

NOMENCLATURAL CHANGES AND NOTES ON EXTRALIMITAL TAXA

During the course of this study it was necessary to examine numerous extralimital taxa, notably from New Guinea, Bismarck Archipelago, Solomon Islands and eastern Indonesia, which directly or indirectly relate to the Australian fauna. As a result, I propose a number of nomenclatural changes and include additional notes on earlier proposed synonymies of the following species.

Polyrhachis (Myrma) breviorspinosa

Donisthorpe, 1947 stat. nov.

(Fig. 5B, F-G)

Polyrhachis (Myrma) relucens v. *breviorspinosa* Donisthorpe, 1947: 194. Syntype workers. Type locality: NEW GUINEA, Liki I., Maffin Bay, viii.1944 (E.S. Ross), CASC (examined).

Donisthorpe (1947) described *P. relucens breviorspinosa* in one short sentence by stating that it 'Differs from the typical form in having

shorter spines to the pronotum and the petiole'. During a visit to the CASC, I examined the syntypes and additional specimens from the original series (E.S. Ross coll.) and compared them with a type compared voucher specimen of *Polyrhachis relucens* (Latreille). The two taxa are rather dissimilar and I am confident they represent separate species. *Polyrhachis breviorspinosa* is clearly distinguished by its more gracile stature, markedly slender pronotal spines and propodeum, which lacks a distinct border between the dorsum and declivity. In contrast, *P. relucens* has a distinctly broader body, notably across the mesosoma, broadly based pronotal spines and a propodeal dorsum that is clearly separated from the declivity. *breviorspinosa* is armed with distinctly short and slender spines and the dorsum between them is relatively narrow, weakly concave and without an intercalary spine or tooth. In contrast, the petiolar spines in *P. relucens* are relatively thick and the petiolar dorsum furnished with a distinct intercalary tooth. *Polyrhachis breviorspinosa* is more similar to *P. litigiosa* Emery (Fig. 5C, H-I) from New Guinea; both are slender in stature and have a uniformly black body and appendages. However, *P. breviorspinosa* has a distinctly less transverse mesonotal dorsum, shorter petiolar spines and markedly less abundant erect pilosity that is much diluted on the mesosomal dorsum and the gaster, and is completely missing from the antennal scapes and petiole. In contrast, the mesonotal dorsum in *P. litigiosa* is distinctly wider, the petiolar spines longer, the dorsum of the petiole has a minute intercalary tooth or distinct tubercula and erect to semierect, medium length hairs are abundant over most of the body surfaces, with a fringe of short hairs lining the leading edges of the antennal scapes.

Polyrhachis breviorspinosa appears to be a rather uncommon species, endemic to the islands along the north-western coast of New Guinea. Besides the specimens of the original series from Liki Island, the only other comparable specimens seen were collected on Biak Island (Biak I., beach area, 17.vii.1957, D. Elmo Hardy; Biak I., 22-30.vi.1962, J.L. Gressitt – all BPBM).

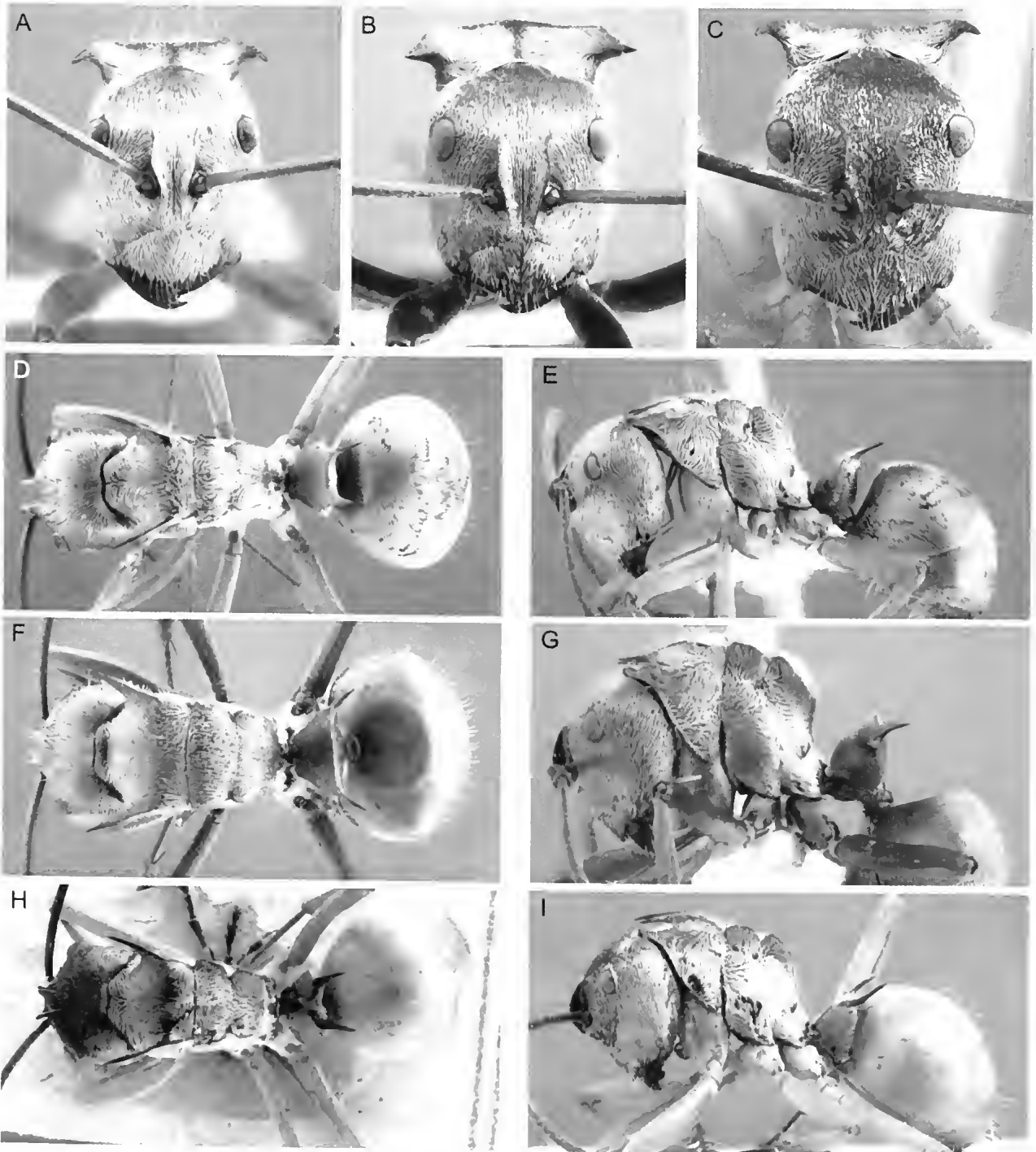


FIG. 1. *Polyrhachis* (*Myrma*) species from Australia and New Guinea. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. andromache* Roger; B, F-G, *P. foreli* Kohout (paratype); C, H-I, *P. semitestacea* Emery (paralectotype) (not to scale).

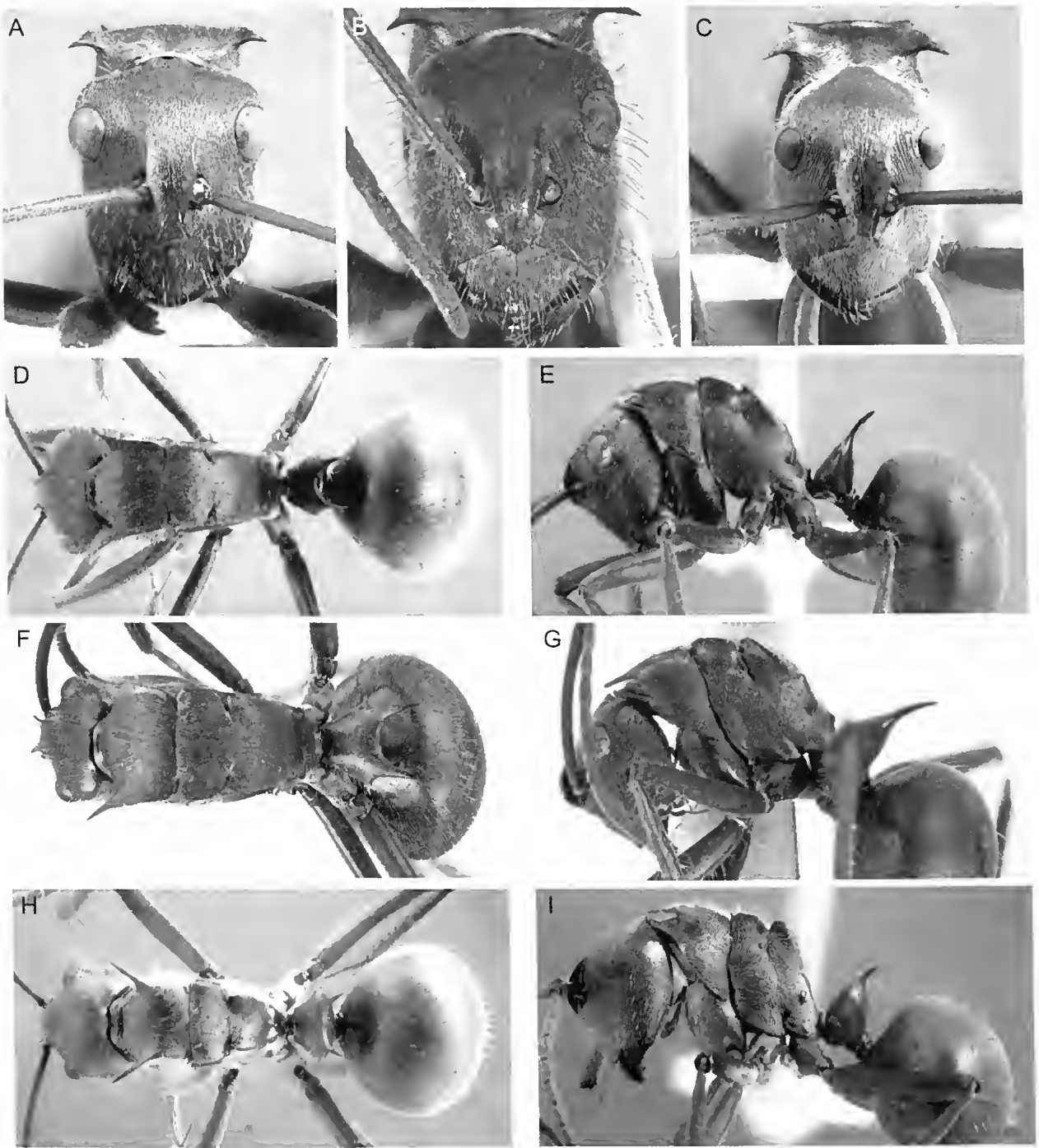


FIG. 2. *Polyrhachis* (*Myrma*) species from Australia and New Guinea. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. imsitata* Kohout (holotype); B, F-G, *P. sericeopubescens* Donisthorpe (syntype); C, H-I, *P. rufemorata* Fr. Smith (not to scale).

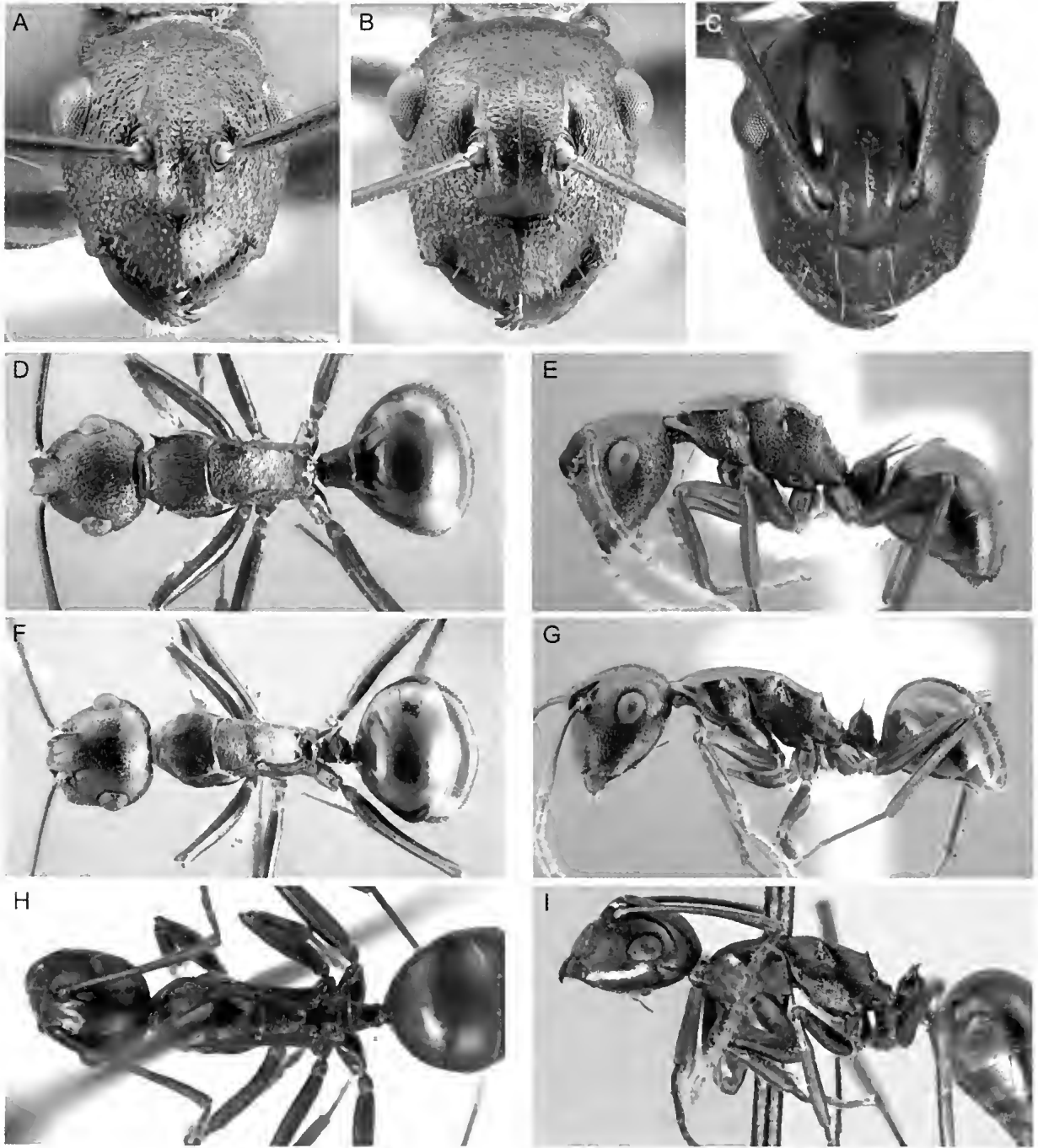


FIG. 3. *Polyrhachis* (*Myrmatopa*) species from Australia and Indonesia. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. alphaea* Fr. Smith; B, F-G, *P. yarrabahensis* Forel (topotype); C, H-I, *P. lombokensis* Emery (syntype) (not to scale).

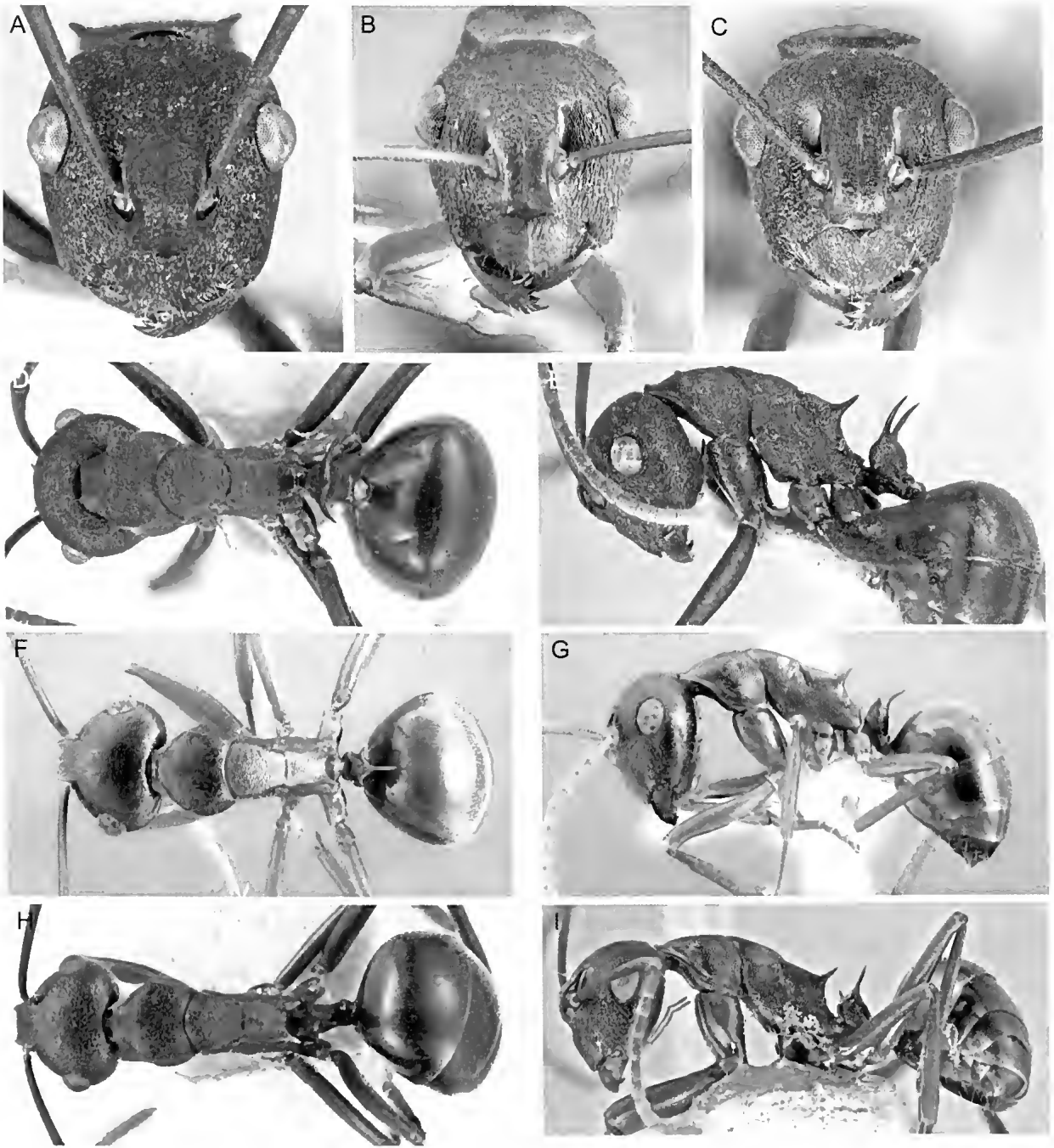


FIG. 4. *Polyrhachis* species from Australia. Head in full face view (top); Dorsal habitus (left), lateral habitus (right). A, D-E, *P. (Myrmatopa) menozzii* Karavaiev (syntype); B, F-G, *P. (Myrmothrinax) delicata* Crawley (syntype); C, H-I, *P. (Myrmothrinax) queenslandica* Emery (syntype) (not to scale).

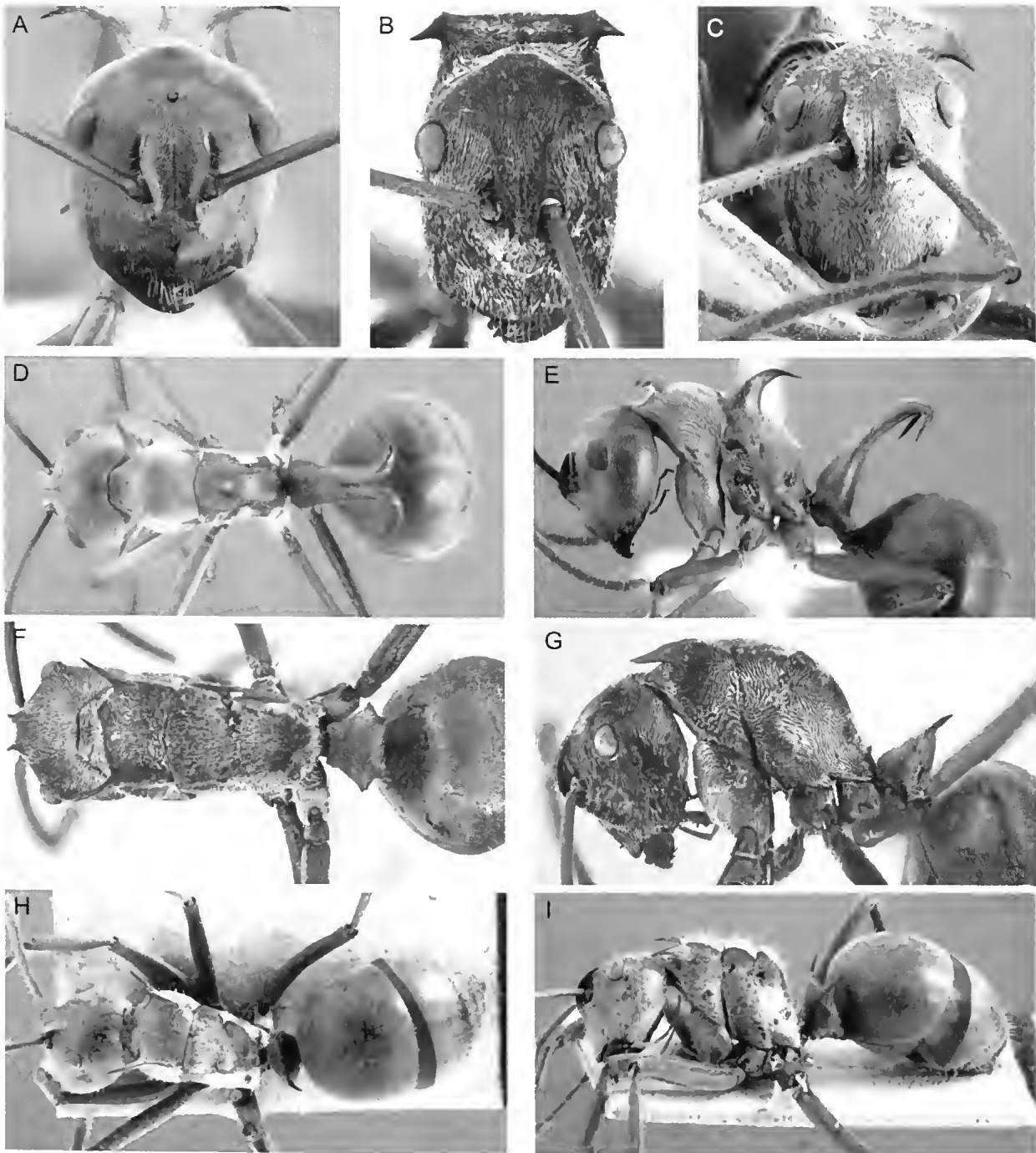


FIG. 5. *Polyrhachis* species from Australia and New Guinea. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. (Polyrhachis) bellicosa* Fr. Smith; B, F-G, *P. (Myrma) breviorspinosa* Donisthorpe (original series); C, H-I, *P. (Myrma) litigiosa* Emery (syntype) (not to scale).

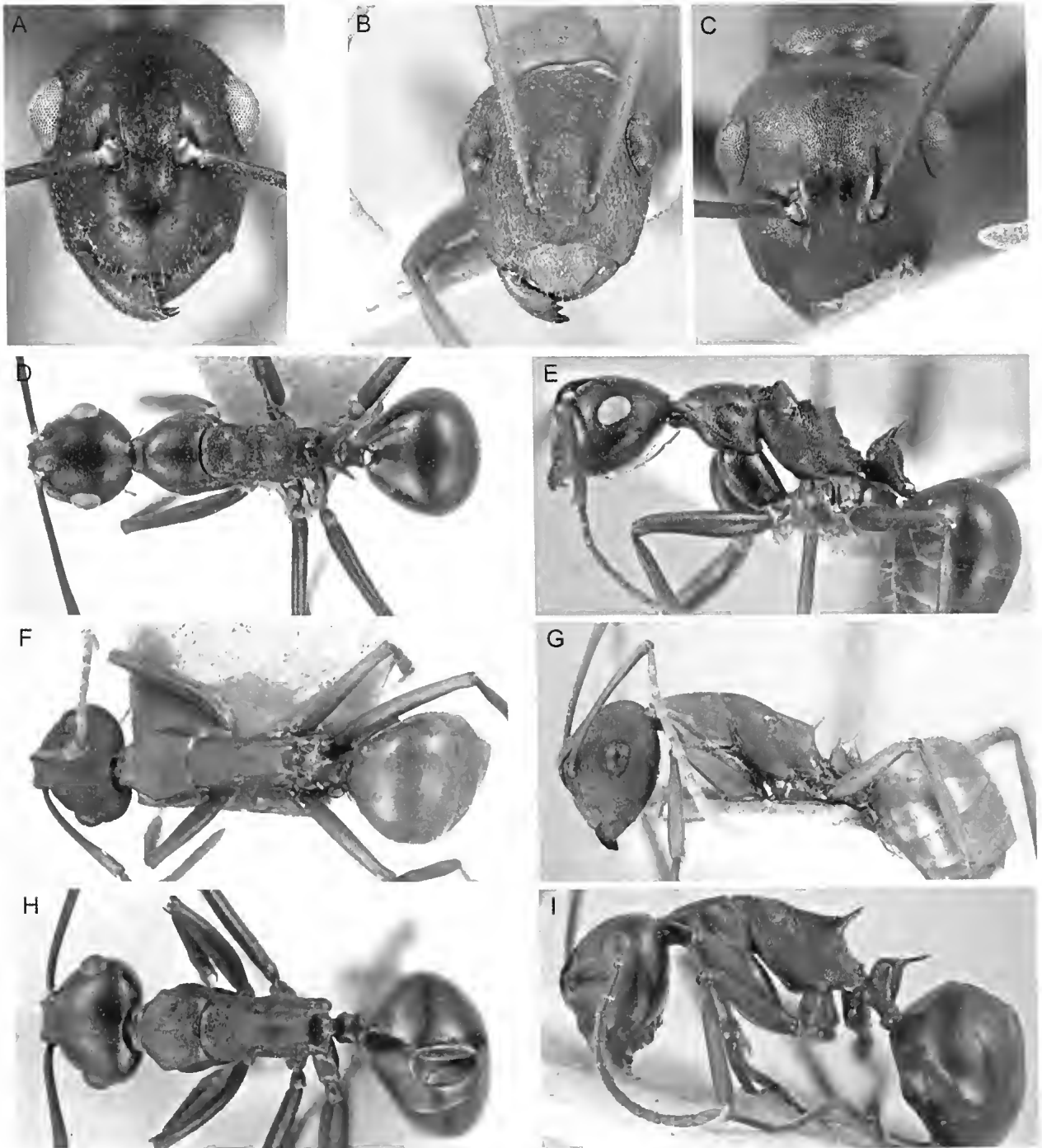


FIG. 6. *Polyrhachis* species from Indonesia and New Guinea. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. (Myrmatopa) schang amboinae* Santschi (= *P. dolomedes* Fr. Smith); B, F-G, *P. (Myrmothrinax) dahlii* Forel; C, H-I, *P. (Myrmothrinax) dahli unisculpta* Viehmeyer (= *P. queenslandica*) (all syntypes) (not to scale).

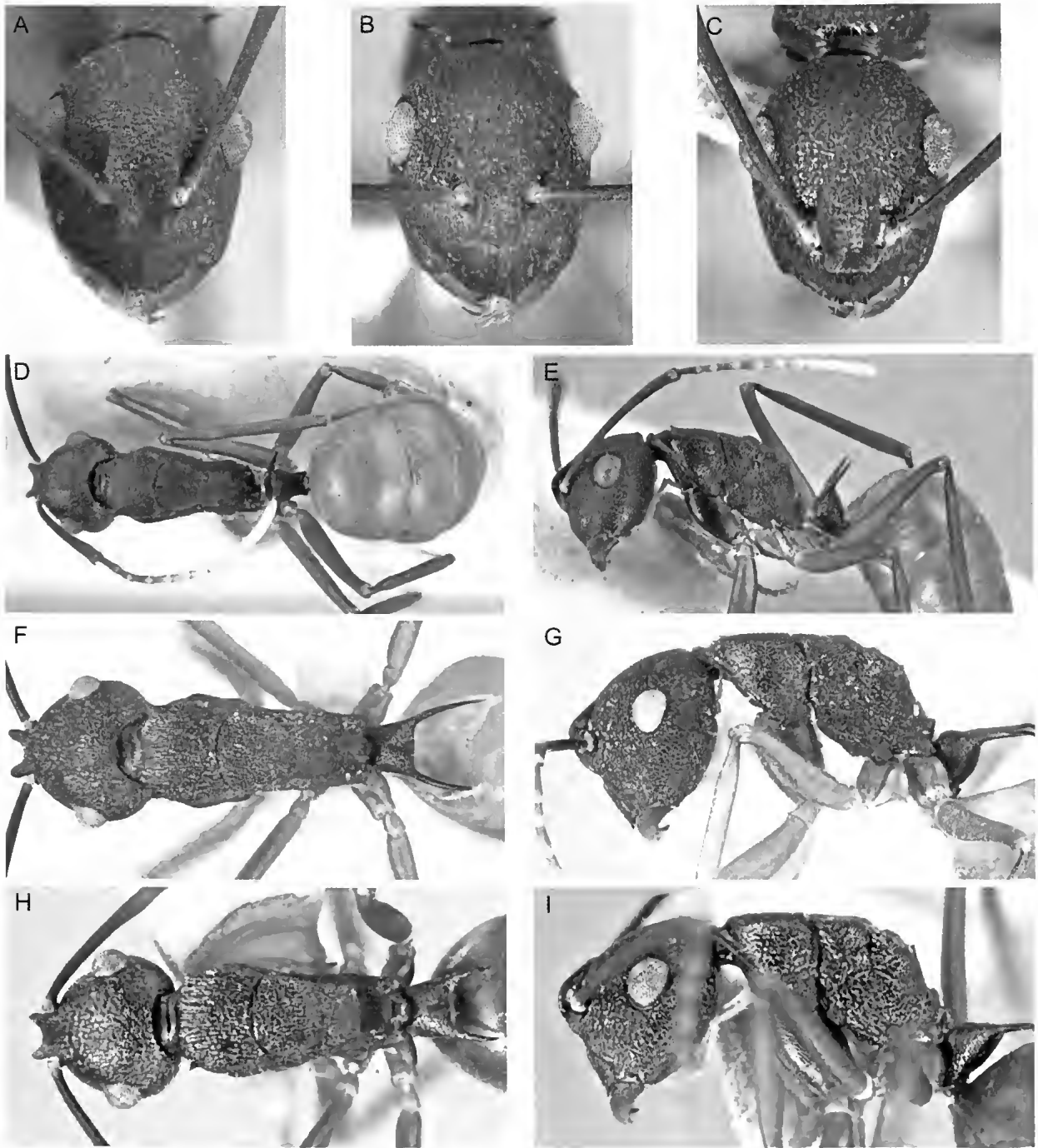


FIG. 7. *Polyrhachis* (*Myrmatopa*) species from New Guinea. Head in full face view (top), dorsal habitus (left), lateral habitus (right). A, D-E, *P. luteogaster* Kohout (= *P. alpheus rufiventris* Emery); B, F-G, *P. antoniae* Stütz; C, H-I, *P. omymex* (Donisthorpe) (all syntypes) (not to scale).

Polyrhachis (Myrmothrinax) dahlia Forel, 1901
(Fig. 6B, F-G)

Polyrhachis dahlia Forel, 1901: 30. Syntype workers. Type locality: BISMARCK ARCHIPELAGO, Ralum, 17.iii.97 (F. Dahl), MNHU, MHNG, QM (examined).

Polyrhachis (Myrmothrinax) dahlia (sic.) Forel; Mann, 1919: 378. Combination in *P. (Myrmothrinax)*.

Kohout (1998) suggested *P. dahlia unisculpta* (Fig. 6C, H-I) to be a junior synonym of *P. queenslandica* and, consequently, a separate taxon from *P. dahlia*. To verify the identity of the three names, I directly compared the syntypes of all taxa and can confirm that *P. queenslandica* and *P. dahlia unisculpta* are undoubtedly conspecific and *P. dahlia* is a distinct species. The most obvious character separating *P. dahlia* from *P. queenslandica* is colour which, in the former, is yellow or very light yellowish-brown with only the mandibular teeth, anterior clypeal margin, frontal carina and the lateral margins of pronotum and mesonotum narrowly bordered with brown. In contrast, *P. queenslandica* is virtually black or dark reddish-brown with the head a shade darker. The sculpturation of the head and mesosoma in *P. dahlia* is rather coarsely reticulate-punctate, while it is distinctly finer in *P. queenslandica*. The gaster in both species is very finely shagreened and highly polished.

As already noted by Mann (1919), *P. dahlia* appears to be a relatively rare species, with its distribution centred on the Bismarck Archipelago. However, there are a few records of the species from New Britain (Gazelle Peninsula, Vunakanau, 11-20.v.1955; Kerevat, 2.ix.1955; Baining Mts, St Pauls, 4.ix.1955 – all J.L. Gressitt), and from the Solomons (San Christoval, Wainoni Bay; Three Sisters, Malapaina; Malaita, Auki; Florida, Tulagi – all W.M. Mann; Guadalcanal, Honiara, 13-16.xi.1953, J.D. Bradley).

Polyrhachis (Myrmatopa) dolomedes Fr.
Smith, 1863
(Fig. 6A, D-E)

Polyrhachis dolomedes Fr. Smith, 1863: 14. Syntype workers, queen. Type locality: INDONESIA, Seram I. (A.R. Wallace), OXUM, BMNH (see note below) (examined).

Polyrhachis (Myrmatopa) schang var. *gracilior* Karavaiev, 1927: 11. Syntype workers, queens, males, ergatogynes.

Type locality: INDONESIA, Ambon I. (Leitimor, Hito) (V. Karavaiev # 2501, 2503), IZAS, QM (examined). Junior homonym of *P. gracilior* Forel, 1893: 25.

Polyrhachis (Myrmatopa) schang var. *amboinae* Santschi, 1928: 139. Replacement name. Syn. nov.

I have examined two workers and a queen of *P. schang amboinae* and compared them with earlier type-compared voucher and additional specimens of *P. dolomedes* (Seram I., Manusela NP, Wae Mual Plain, 25.vii.-9.ix.1987, M.J.D. Brendel; Seram I., 8.viii.1989, M.C. Day). All specimens are virtually identical and I am confident that there is no justification for *P. schang amboinae* to be recognised as a separate taxon from *P. dolomedes*.

Barry Bolton supplied me with a copy of his unpublished 'Catalogue of F. Smith type-material from UM, Oxford' which contains the following notes on the syntype material of *P. dolomedes*: 'Syntypes 1 worker and 1 ♀ in UM, Oxford. One further syntype (worker) in BMNH. The UM Oxford specimens bear a Donisthorpe type-label and the BMNH specimen a 'compared with type' label of Donisthorpe. However, if the writing on the underside of the stage cards is consulted it becomes obvious that all three specimens were originally mounted together and that the card has been divided at a later date. The underside of the stage card of the BMNH specimen has 'P. /' (part of the 'D') and 'Ceram'. The Oxford specimens have 'Dolomedes' (with part of the 'D' missing). The two cards fit together perfectly to read 'P. Dolomedes. Ceram' (Bolton unpublished data).

Polyrhachis (Myrmatopa) luteogaster nom. nov.
(Fig. 7A, D-E)

Polyrhachis alpheus var. *rufiventris* Emery, 1911: 256. Syntype workers, queen. Type locality: NEW GUINEA, Merauke, MSNG (examined). Junior primary homonym of *P. gestroi* var. *rufiventris* Forel, 1911: 391.

According to Article 60.1 of 'The Code', and in the absence of any potentially valid synonyms, I am replacing the junior primary homonym *Polyrhachis alpheus rufiventris* Emery, 1911 with *Polyrhachis luteogaster* nom. nov. Also, according to Recommendation 60A of 'The Code', I have

used the original syntype specimens to establish the new name as an objective replacement.

The two syntype specimens in the Emery collection (MSNG) are card-mounted on a single pin. Both are in relatively good condition, although one has the head detached from the body. The specimens are furnished with the following hand written original labels: 'N. Guinea, Merauke' and '*Polyrhachis alpheus* F. Sm. var. *rufiventris* Emery'. Also attached are the following printed labels of later origin: 'SYNTYPI, *Polyrhachis alpheus* var. *rufiventris* C. Emery, 1911' (red tag) and 'MUSEO GENOVA coll. C. Emery (dono 1925)'.

Other material. INDONESIA, IRIAN JAYA, Vogelkop, Kebar, W of Manokwari, 00°52'S, 134°05'E, 550 m, 4-31.i.1962 (S. Quate) (w). PAPUA NEW GUINEA, North Distr., Managalese Area, 2500-3000ft, viii.1965 (R. Pullen) (w); Bulolo, 07°12'S, 146°39'E, 3000', 18.xii.1967 (B.B. Lowery) (w, ♀); Central Prov., Karema, Brown R., 09°12'S, 147°14'E, 8/11.iii.1955 (E.O. Wilson) (w, ♀) (compared with type by EOW).

Direct comparison of syntypes of *P. luteogaster*, *P. antoniae* Stitz (Fig. 7B, F-G) and a type-compared specimen of *P. omyrmex* (Donisthorpe) (Dutch New Guinea, Japen Is., Mt. Baduri, 1,000ft, viii.1938, L.E. Cheesman, B.M.1938-593, identified by H. Donisthorpe, 14.ix.1939) (Fig. 7C, H-I), showed all specimens to be remarkably similar but not conspecific. Their small size and striking colour scheme, with black body and yellow gaster, immediately separate them from the closely allied *P. alpheus* Fr. Smith (Fig. 3A, D-E) and all other described species of the *P. flavicornis*-group. *Polyrhachis luteogaster* is most similar to *P. antoniae* but differs in several characters, including the shape of the anterior clypeal margin. The median portion of the anterior clypeal margin in *P. luteogaster* is only shallowly emarginate and laterally flanked by rather obtuse angles, while in *P. antoniae* the margin is deeply 'V' shaped and flanked by rather prominent acute teeth (see Fig. 7B). The clypeus in *P. luteogaster* is convex in profile, widely rounding into a moderately impressed basal margin (Fig. 7E), while in *P. antoniae* the

clypeus is straight, only narrowly rounding into a rather shallow basal margin (Fig. 7G). The head and body in both species are distinctly reticulate-punctate. However the sculpturation in *P. antoniae* forms more-or-less regular, longitudinal striae, notably on mesosomal dorsum, while it is mostly irregular in *P. luteogaster*. *Polyrhachis omyrmex* is similar to both the previous species but is smaller (HL 1.43-1.59 in *P. antoniae* and *P. luteogaster* versus 1.28 in *P. omyrmex*) and has distinctly shorter pronotal and petiolar spines with the later virtually parallel. The gaster and appendages in *P. omyrmex* are medium yellowish-brown, while they are light yellow in *P. antoniae* and *P. luteogaster*.

A short series of specimens in MCZC that are very similar to *P. luteogaster* (Papua, Karema, Brown R., Mar. 8/11-1955, lowl. rainfor., E.O. Wilson #586, 588, w, ♀), are furnished with the label '*P. rufiventris* Emery, comp. w. type, Wilson, 1955'. However, in spite of the obvious similarity in their colour scheme, they are much larger (HL 1.72) and probably represent an undescribed species.

Polyrhachis (Myrma) semitestacea Emery, 1900 (Fig. 1C, H-I)

Polyrhachis andromache var. *semitestacea* Emery, 1900: 334. Lectotype and paralectotype workers. Type locality: NEW GUINEA, Friedrich-Wilhelmshafen (= Madang) (L. Biró), HNHM, MSNG, QM (examined).

Polyrhachis semitestacea Emery; Kohout, 1998: 524. Raised to species.

Other material. PAPUA NEW GUINEA, West Sepik Prov., Pes Mission, c. 12 km WSW of Aitape, 03°11'S, 142°15'E, <50 m, 31.vii-3.viii.1984 (RJK accs 84.200, 206) (w, ♀); Torricelli Mts, Lumi, 03°28'S, 142°02'E, 400-550 m, 4-13.viii.1984 (RJK accs 84.249, 272, 283) (w, ♀); Morobe Prov., nr Wampit, c. 35 km W of Lae, 06°45'S, 146°40'E, c. 50 m, 24-27.viii.1984 (RJK acc. 84.353) (w); Kar Kar I., Kurum, Bagiai Crater Trail, viii.1968 (N.L.H. Krauss) (w); Bulolo-Lae Rd., 200 m, 1.v.1965 (J. Sedláček) (w).

Kohout (1998) raised *P. semitestacea* to specific rank but did not designate a lectotype. In order to ensure the stability of the species and as a result of a request by the curator of the Hungarian Natural History Museum, Budapest, I have

decided to designate a lectotype from a syntype series lodged in that institution, that houses the bulk of the material collected by Lajos Biró (as per Recommendation 74D of 'The Code').

Lectotype designation. The lectotype was selected from 25 available syntypes lodged in the Biró collection (HNHM). The specimen is card mounted and in good condition. It bears the following printed labels: 'N. Guinea, Biró 96' and 'Friedrich-Wilh.-hafen'. In addition it also bears an original name-tag in Emery's handwriting, reading '*Polyrhachis andromache* Rog. var. *semitestacea* Emery'. It has been furnished with an additional tag indicating its new status, with the remaining 24 specimens deemed paralectotypes and labelled appropriately. Two of the paralectotypes were generously donated to the QM collection.

As mentioned earlier (Kohout, 1998), *P. semitestacea* is rather similar to *P. andromache* Roger (Fig. 1A, D-E), with relatively subtle differences separating them. However, these differences appear constant and serve to clearly separate the species. The most obvious difference is the colour of the gaster which is honey-yellow in *P. semitestacea* and contrasts with the dark mesosoma (Fig. 1H-I), while in *P. andromache* the gaster is black and concolorous with the rest of the body. When directly compared, *P. semitestacea* is distinctly more slender and has a petiole armed with more closely spaced spines and lacking a dorsal intercalary tooth. In contrast, *P. andromache* appears more robust, has more widely spaced petiolar spines and the dorsal edge of petiole is armed with a minute intercalary tooth.

Queen. (not yet described) Dimensions: TL c. 10.53-10.89; HL 2.62-2.72; HW 2.07-2.17; CI 79-80; SL 3.02-3.12; SI 144-146; PW 2.02-2.17; MTL 3.28-3.33 (2 measured).

Apart from sexual characters, very closely resembling worker. Pronotal humeri armed with moderately long, acute and weakly downturned spines; their dorsolateral margins continued posteriorly only for a short distance.

Mesoscutum wider than long with lateral margins converging anteriorly into moderately rounded anterior margin; median line well indicated, relatively short; parapsides rather flat; mesoscutum in profile relatively low with anterior margin rounding onto weakly convex dorsum; mesoscutellum weakly convex, only marginally elevated above dorsal plane of mesosoma. Propodeal dorsum with lateral margins rounded posteriorly and continued inwards for a short distance, but not meeting; dorsum descending rather abruptly into vertical declivity. Petiole armed with two short, somewhat flattened, blunt spines and distinct intercalary tooth. Sculpturation, pilosity and colour virtually as in worker.

AUSTRALIAN SPECIES

Genus *Polyrhachis* Fr. Smith, 1857

Polyrhachis Fr. Smith, 1857: 58. Type species: *Formica bihamata* Drury, 1773: 73, pl. 38, figs 7, 8, worker; by original designation.

Subgenus *Myrma* Billberg, 1820

Myrma Billberg, 1820: 104. Type species: *Formica militaris* Fabricius, 1781: 493; by subsequent designation of Wheeler, 1911: 859.

Myrma Billberg; Wheeler, 1911: 859 (as genus and senior synonym of *Polyrhachis* Fr. Smith, 1857).

Myrma Billberg; Wheeler, 1922: 993 (as subgenus of *Polyrhachis* Fr. Smith, 1857).

(For full list of citations with synonymy see Dorow, Kohout & Taylor, 1997).

The Australian species of the subgenus *Myrma* were reviewed by Kohout (1989) who listed four species. He described *Polyrhachis inusitata* as a new species, but later (Kohout, 1998) synonymised it with *P. sericeopubescens* Donisthorpe, 1941 from Japen Island, New Guinea (= Pulau Yapen, Irian Jaya). However, a subsequent direct comparison of the types of both species, and the examination of several additional specimens, has confirmed they represent separate taxa. As a result, *P. inusitata* is reinstated to its original specific status. All four Australian species were described at length by Kohout (1989) and their diagnoses are not repeated here.

Diagnosis. Worker. Australian species of the subgenus are medium to relatively large-sized ants (HL >1.90) with characteristics of the genus. Mandibles with 5 teeth, finely longitudinally striate at their bases. Anterior clypeal margin arcuate, often bluntly truncate medially. Frontal carinae distinctly raised with central area between them relatively narrow. Eyes rather large, situated well back, giving the face a somewhat elongated appearance. Ocelli generally lacking with median ocellus only rarely indicated (as in *P. rufofemorata* Fr. Smith). Dorsum of mesosoma distinctly laterally marginate with margins interrupted only at promesonotal suture and metanotal groove. Pronotum armed with a pair of relatively long, anterolaterally and weakly downwards directed, acute spines, their outer edges continuous basally with pronotal margins. Propodeum unarmed or with tubercles or small teeth. Petiole scale-like, usually armed with a pair of dorsal spines, each with laterally oriented tooth or blunt angle below its base; dorsum of petiole often with more-or-less distinct intercalary tooth (e.g. *P. andromache* Roger). First gastral tergite basally truncate or shallowly concave. Head, mesosoma and petiole mostly finely reticulate; gaster shagreened. Body black with appendages black or dark reddish-brown (as in *P. foreli*), or black with appendages yellow or light yellowish-brown (as in *P. andromache*), or distinctly bicoloured with petiole, base of gaster and legs light to medium reddish-brown (as in *P. rufofemorata*).

Queen. Apart from sexual characters, closely resembling worker except: distinctly larger (HL > 2.40); pronotal spines distinctly shorter; petiolar spines reduced to short teeth or mere denticles (as in *P. rufofemorata*). Sculpturation, pilosity and colour essentially as in worker.

Male. Males of most Australian species are known and present in the ANIC and/or QM spirit collections, but their diagnosis is beyond the purpose and scope of this paper.

Distribution and biology. The distribution of the subgenus *Myrma* ranges throughout the

Indo-Malayan, Oriental and Australian regions extending east to the Solomons and south to northern Australia. In Asia its range extends northwards to China and westwards into the countries of the Middle East. *Myrma* is the only known subgenus of *Polyrhachis* known from Africa with numerous species inhabiting the tropics (Bolton 1973). The nesting habits of species of *Myrma* are extremely varied, ranging from arboreal and lignicolous to terrestrial, with both mono- and polydomous nests reported (Robson & Kohout 2007).

KEY TO AUSTRALIAN SPECIES OF MYRMA

1. Mesosoma in profile evenly convex, without distinct ridge-like border between dorsum and propodeal declivity (Fig. 2E); head with distinct postocular carinae; antennal scapes relatively long (SL >180) (*P. continua*-group) *inuitata* Kohout
 - Mesosoma in profile with more-or-less distinct border dividing dorsum from rather abrupt declivity (e.g. Fig. 1G); head without postocular carinae; antennal scapes relatively shorter (SL <170) (*P. reluceus*-group) 2.
2. Petiolar spines arising from dorsolateral angles of node, widely separated by transversely convex dorsum (Fig. 1F) *foreli* Kohout
 - Petiolar spines arising sublaterally from dorsal edge of node, situated relatively closer together (e.g. Fig. 1D) 3.
3. Propodeal dorsum transversely narrow, concave, with lateral margins forming vertically raised laminate flanges; antennal scapes with numerous short erect hairs *rufofemorata* Fr. Smith
 - Propodeal dorsum relatively wide, virtually flat, with lateral margins distinct, but not laminate; antennal scapes without erect hairs *andromache* Roger

Polyrhachis continua species-group

Polyrhachis inusitata Kohout, 1989 stat. rev.
(Figs 2A, D-E, 8C)

Polyrhachis inusitata Kohout, 1989: 513, figs 4, 5, 9. Holotype and paratype workers. Type locality: AUSTRALIA, QUEENSLAND, Cape York Pen., West Claudie R., Iron Range area, 12°44'S, 143°14'E, 3-10.xii.1985 (G.B. Monteith & D. Cook), QM (examined).

Polyrhachis (*Myrma*) *sericeopubescentis* Donisthorpe, 1941: 61. Erroneous synonymy by Kohout, 1998: 520.

Other Material. AUSTRALIA, QUEENSLAND, Cape York Pen., 6 km ENE of Mt Tozer, 12°44'S, 143°16'E, 30.vi.1986 (T. Weir & A. Calder) (w); McIlwraith Ra, Leo Ck Rd, 13°43'S, 143°19'E, 10-20.vii.1976 (P. Filewood) (paratype w).

Remarks. *Polyrhachis inusitata* is closely related to *P. sericeopubescentis* (Fig. 2B, F-G) with which it was erroneously synonymised by Kohout (1998). However, *P. inusitata* differs from *P. sericeopubescentis* by its smaller size and the form of the sculpturation on the sides of the mesosoma which is reticulate-rugose in the former and distinctly longitudinally striate in *P. sericeopubescentis*. The lateral petiolar teeth in *P. inusitata* are reduced to more-or-less distinct denticles, while they are produced into distinct short teeth in *P. sericeopubescentis*. The gastral pilosity in *P. inusitata* is shorter and more abundant, while it is markedly longer but more sparse in *P. sericeopubescentis*. *Polyrhachis inusitata* is also similar to *P. continua* Emery, 1887, however it differs from that species by its distinctly slender body, reticulate-rugose sculpturation and the abundant short hairs distributed over most of the body. In contrast, the body in *P. continua* is wider and relatively robust, the sculpturation on head and mesosoma more-or-less regularly longitudinally striate and the hairs distinctly longer and much diluted.

Polyrhachis relucens species-group

Polyrhachis andromache Roger, 1863
(Figs 1A, D-E, 8A)

Polyrhachis hector Fr. Smith, 1859: 142. Holotype worker. Type locality: INDONESIA, Aru Is (A.R. Wallace), OXUM

(examined). Junior homonym of *Polyrhachis hector* Fr. Smith, 1857.

Polyrhachis andromache Roger, 1863b: 8, 46. Replacement name.

Polyrhachis connectens var. *australiae* Emery, 1887: 231. Syntype workers, queen. Type locality: AUSTRALIA, Cape York, Somerset (L.M. D'Álbertis), MSNG (examined). Synonymy by Kohout, 1988b: 431.

(For full list of citations see Kohout, 1988b, 1998).

Other material. INDONESIA, Aru I. (no further data) (w); ditto, Wokan, 1873 (O. Beccari) (w). WEST IRIAN, 12 km S of Sorong, 11.iii.1981 (W.L. Brown) (w); nr Kampong Garam, N of Sorong, 14.iii.1981 (W.L. Brown) (w); Nabire, S Geelving Bay, 1-4.ix.1962 (J. Sedláček) (w, ♀); Maffin Bay, 20.vi.1944 (E.S. Ross) (w). NEW GUINEA, Ighibirei, vii-viii.1890 (L. Loria) (w); Dilo vi-vii.1890 (L. Loria). PAPUA NEW GUINEA, Eastern Highlands Prov., Kratke Ra., Mt Piora, 12.vi.1966 (O.R. Wilkes) (w); Morobe Prov., Huon Pen., Finschhafen, iv.1944 (E.S. Ross) (w); Trobriand Is, Kaileuna I., SE of Tauwema, 08°29'S, 150°56'E, 6.& 23-25.vi.1992 (Aniruddh D. Patel) (w, ♀); ditto, Tuma I., 08°22'S, 150°52'E, 10.vi.1992 (Aniruddh D. Patel) (w); Normanby I., Wakaiuna, Sewa Bay, 1-16.xii.1956 (W.W. Brandt) (w, ♀); New Britain Prov., Kimbe Distr., Kavui Subdiv., 13.ii.1981 (W.L. Brown) (w); Northern Prov., Popondetta, 14-15.i.1971 (BBL) (w); Oro Bay, 30 mi S of Popondetta, 14.i.1971 (BBL) (w, ♀); Mt Piora, 2100 m, 12.vi.1966 (O.R. Wilkes) (w); Western Prov., Middle Morehead R., c. 08°50', 141°30'E, viii.1967 (R. Pullen) (w); Oriomo Gov. Stn, 26-28.x.1960 (J.L. Gressitt) (w); Daru I. (w.w. Froggatt #53F) (w); Central Prov., Brown R., 21-25.v.1956 (E.J. Ford Jr.); Kerema, Brown R., 8-11. iii.1955 (E.O. Wilson #574) (w); Laloki R., nr Little Mt Lawes, 8.iii.1958 (E.O. Wilson #526) (w); Bisianumu Stn, NNW of Port Moresby, 29.iv.1960 (C.W. O'Brien) (w); Aroa Estate, W of Redscar Bay, 29.ix.1958 (J.L. Gressitt) (w); Fairfax Harbour (B.F. Hill) (w); Milne Bay, iii-iv.1944 (H.R. Roberts) (w); ditto, xii. (G.H. Bick) (w). AUSTRALIA, QUEENSLAND, Torres Strait, Badu I., 10°07'S, 142°07'E, 18.ii.1984 (J.H. Sedláček) (w); Prince of Wales I., viii.1920 (J.A. Kusche) (w); Thursday I., viii.1949 (N.L.H. Krauss) (w); Cape York, 16.iv.1928 (W.B. Barnard) (w); ditto (Turner); Cape York Pen., Lockerbie Scrub, 10°46'S, 142°29'E, i.1975 (GBM) (w); ditto, xii.1983 (J.H. Sedláček) (w); ditto, 9-11.xii.1986 (J. Gallon) (w, ♀); ditto, 19-23.iii.1987 (RJK accs 87.19, 25, 49, 59, 73) (w, ♀); Bamaga, 10°53'S, 142°23'E, 21.i-12.ii.1984 (J.H. Sedláček) (w); ditto, 18-24.iii.1987 (RJK acc. 87.5) (w); Iron Ra., 12°44'S, 143°14'E, 1-3.vii.1976 (P. Filewood) (w); ditto, 1-17.vii.1978 (S.van Dyck) (w); ditto, 3-10.xii.1985 (GBM & DJC) (w); ditto, 26-31. vii.1981 (RJK accs 81.130, 166, 194, 197, 214, 215) (w, ♀); ditto, 17.iii.1984 (J.H. Sedláček) (w); ditto, 6.xii.1985 (GBM & DJC) (w); ditto, i.1958 (Darlingtons) (w); West Claudie R., 6 km ENE of Mt Tozer, 12°44'S, 143°16'E,

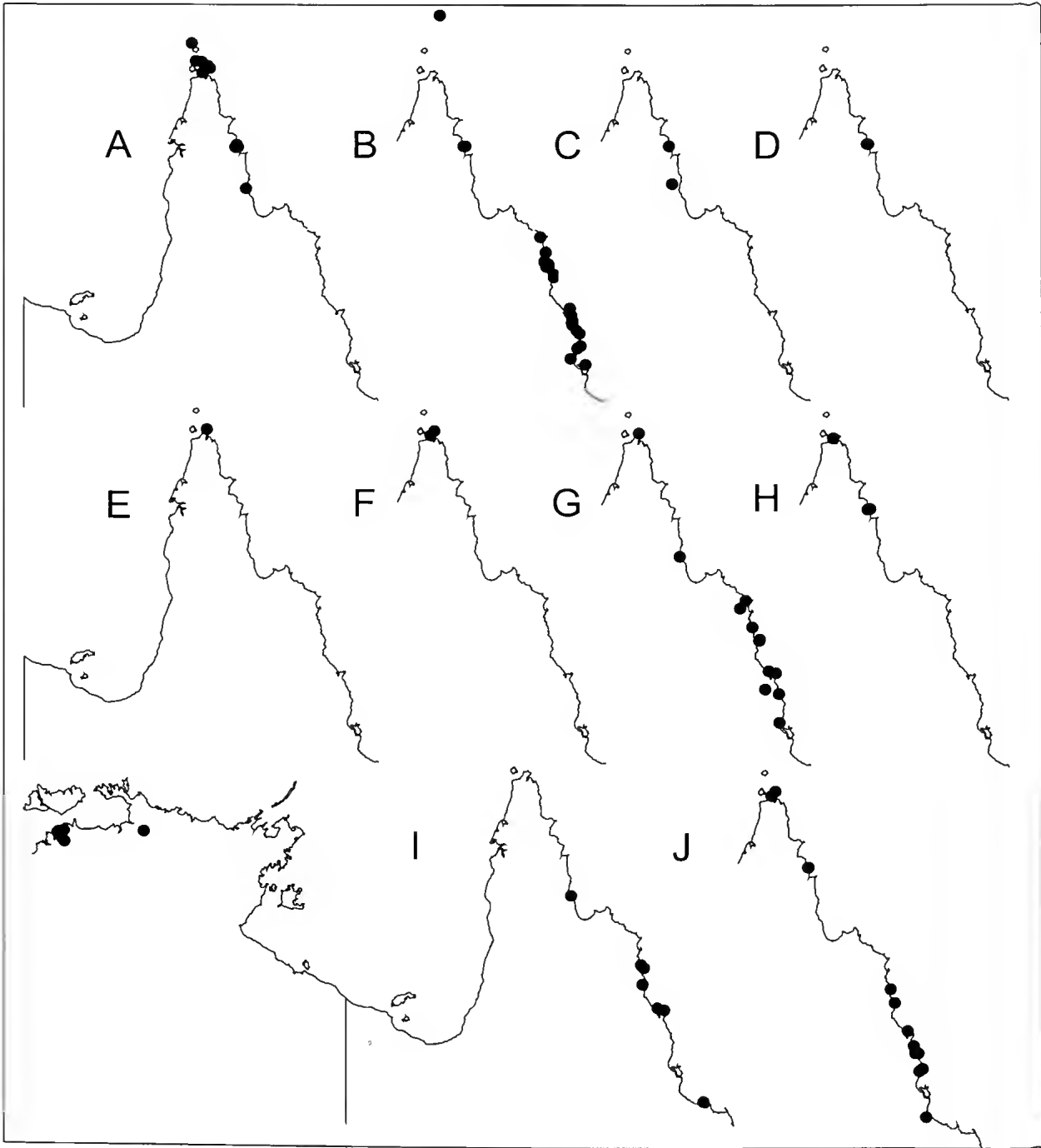


FIG. 8. Australian distributions of *Polyrhachis* species of the subgenera *Myrma* (A-D), *Myrmatopa* (E-G), *Polyrhachis* (H) and *Myrmothrinx* (I-J). A, *P. andromache*; B, *P. foreli*; C, *P. inusitata*; D, *P. rufofemorata*; E, *P. alpha*; F, *P. menozzii*; G, *P. yarrabahensis*; H, *P. bellicosa*; I, *P. delicata*; J, *P. queenslandica*.

3-10.xii.1985 (GBM & DJC) (w); ditto, 30.vi.1986 (T. Weir & A. Calder) (w); Tozer Gap, i.1958 (Darlingtons) (w); Rocky R., NE of Coen, 500 m, 1-2.v.1961 (L. & M. Gressitt) (w); ditto, vi.1958 (P.F. Darlington) (w).

Remarks. In Australia, *P. andromache* is restricted to the lowland rainforests of Cape York Peninsula north of the 14° parallel where it is relatively common. It is characterised by its abundant, distinctly golden or silvery pubescence and yellow or orange-coloured appendages. *Polyrhachis andromache* builds nests of silk and vegetation debris in various tree cavities, but also within the hollow internodes of standing bamboo (Kohout 1988b, 1989, 1999; Robson & Kohout 2007).

Polyrhachis foreli Kohout, 1989
(Figs 1B, F-G, 8B)

Polyrhachis foreli Kohout, 1989: 510, figs 2, 2a, 7, 11. Holotype worker. Type locality: QUEENSLAND, nr Clump Point, NE Tully, 17°52'S, 146°07'E, 30.iv.1969 (R.W. Taylor acc. 69.123), ANIC (examined).

'*Polyrhachis (Myrma) relucens* r. *andromache* var. *andromeda*' Forel, 1915: 110. Workers. Original locality: Queensland, Bellenden Ker (E. Mjöberg), NRMS, MHNG, ANIC (examined). Unavailable name. Material referred to *foreli* by Kohout, 1989: 510; 1998: 521.

'*Polyrhachis relucens* subsp. *decipiens* var. *papuana*' Emery, 1897: 580. Workers, queens. Original localities: New Guinea, Dilo, Bara Bara, Goodenough I. (L. Loria), MHNG, MSNG (examined). Unavailable name. Material referred to *foreli* by Kohout, 1998: 521.

Other material. PAPUA NEW GUINEA, D'Entrecasteaux Is, Goodenough I. (L. Loria) (w); Normanby I., Barara (L. Loria) (w, ♀); Dilo, vi-viii.1890 (L. Loria) (w); Oro Bay, 30 mi S of Popondetta, 14.i.1971 (BBL) (w); Musa R. Valley, Saffa, 5.vi.1972 (RWT) (w); Varirata NP, 5.ii.1981 (W.L. Brown) (w); Eilogo Rd, ESE of Sogeri, 09°25'S, 147°27'E, 500 m, 4.ix.1984 (RJK) (w); Brown R., 23.v.1956 (E.J. Ford jr) (w); 5-6 km W of Brown R., c. 80 m, 3.ii.1981 (W.L. Brown) (w); Laloki R., nr Little Mt Lawes, 8.iii.1955 (E.O. Wilson #531) (w, ♀); Otomata Plant., E of Port Moresby, 2.xi.1960 (J.L. Gressitt) (w); Bisianumu, E of Port Moresby, 500 m, 23.ix.1955 (L.J. Gressitt) (w); Daradae, nr Javarere, Musgrove R., 2.x.1958 (J.L. Gressitt) (w). AUSTRALIA, QUEENSLAND, Torres Strait, Saibai I., 09°22'S, 142°37'E, 27.ii.2001 (K.L. Anderson #71) (♀); Cape York Pen., Iron Ra., 12°44'S, 143°14'E, 1-3.vii.1976 (P. Filewood) (w); ditto, 26-31.vii.1981 (RJK acc. 81.182) (w); 13 km WNW of Lockhard River, W of Claudie R., 12°44'S, 143°13'E, 26.viii.2004 (G.D. Alpert) (w); West Claude R., 6 km ENE of Mt Tozer, 12°44'S,

143°16'E, 3-10.xii.1985 (GBM & DJC) (w); Mt Webb NP, 15°04'S, 145°07'E, 27-30.iv.1981 (J.E. Feehan) (w); Cooktown, 15°28'S, 145°15'E (Staudinger & Bang-Hass) (w); Helenvale, 15°42'S, 145°13'E, 10-20.vii.1976 (P. Filewood) (w); Home Rule Stn, 15°45'S, 145°17'E, 9-11.vi.1996 (RJK et al. acc. 96.43) (w); Mt Hartley, 15°46'S, 145°19'E, 200-500 m, 11.vi.1996 (CJB) (w); Shipton's Flat, 35 km S of Cooktown, 15°48'S, 145°16'E, 22.iv.1982 (GBM) (w); Mt Finnigan, via Helenvale, 15°50'S, 145°16'E, 19-21.iv.1982 (GBM) (w, ♀); Gap Ck, Twelve-mile Scrub, 15°50'S, 145°19'E, 27.xi.1975 (V. Davies & R. Monroe) (w); Emmagen Ck, 16°03'S, 145°27'E, 19-28.ix.1982 (GBM, D. Yeates & G. Thompson); 4.5 km NNW of Cape Tribulation, 16°2'20'S, 145°27'E, 10 m, 28.viii.2004 (G.D. Alpert) (w); Pilgrim Sands, c. 1 km NW of Cape Tribulation, 16°04'S, 145°28'E, 12-15.vi.1996 (RJK et al. acc. 96.47) (w); ditto, 25.viii.1998 (Raven, Churchill & Gallon) (w); Cape Tribulation, 16°04'S, 145°27'E, 29.xii.1983-8.i.1984 (GBM) (w); ditto, 6.xii.1985 (RJK) (w); ditto, 25.ix.1992 (D.G. Furth) (w); Canopy Crane site, nr Cape Tribulation, 16°06'S, 145°27'E, 20-21.ii.2000 (RJK accs 2000.18, 21, 22, 28) (w, ♀); Deeral Landing, nr Cairns, swampy rf., 4.viii.1975 (BBL) (w, ♀); Yarrabah, 16°54'S, 145°51'E, 22, 24.vii.1980 (RJK acc. 80.119) (w); ditto, 25.viii.1996 (SKR #418) (w); Bell Peak Nth, 20 km S of Cairns, 17°05'S, 145°53'E, 16.ix.1981 (GBM & DJC); Bellenden Ker (E. Mjöberg) (w in MHNG, NRMS); Russell R., Bellenden Ker Landing, 17°16'S, 145°54'E, 1-9.xi.1981 (GBM & Earthwatch Exp.) (w); Russell R., 4.viii.1975 (BBL) (w); Babinda, 1920 (J.F. Illingworth) (w); Seymour Ra., Garradunga, c. 7 km N of Innisfail, 17°28'S, 146°01'E, <100 m, 5-6.vi.1996 (RJK et al. acc. 96.29) (w, ♀, ♂); Etty Bay, 17°33'S, 146°05'E, 29.ix.1996 (J. & P. Hasenpush) (♀); NE Tully, nr. Clump Point, 17°52'S, 146°07'E, 30.iv.1969 (RWT acc. 69.123) (w, ♀, ♂); Sth Mission Beach, c. 6 km W, 17°56'S, 146°02'E, 18-19.vii.1980 (RJK acc. 80.60) (w); Kirrama Ra., c. 9 km W of Kennedy, 18°12'S, 145°52'E, 31.xii.1999 (SKR #812) (w); Hinchinbrook I., Gayundah Ck, 18°21'S, 146°14'E, 100-500 m, 8-18.xi.1984 (GBM) (w).

Remarks. The distribution of *P. foreli* consists of two, substantially disjunct populations, Papuan and Australian. Apart from the specimens of the original series of '*relucens decipiens papuana*' from the D'Entrecasteaux Islands, there is a relatively small number of additional specimens from the Papuan population, where the species appears fairly rare. On the other hand, in Australia ('*relucens andromache andromeda*') the species appears relatively common and ranges from Iron Range on Cape York Peninsula, throughout Queensland's Wet Tropics to about

Mission Beach and Hinchinbrook Island in the south. *Polyrhachis foreli* is a rainforest species commonly nesting in rotting logs, tree stumps and epiphytes or in the ground (Kohout 1989, 1998; Robson & Kohout 2005, 2007).

Polyrhachis rufofemorata Fr. Smith, 1859
(Figs 2C, H-I, 8D)

Polyrhachis rufofemoratus Fr. Smith, 1859: 142. Holotype worker. Type locality: INDONESIA, Aru Is (A.R. Wallace), OXUM (examined).

Polyrhachis biroi var. *bidentata* Stitz, 1912: 512. Syntype workers. Type locality: NEW GUINEA, Sattelberg (Lauterbach), MNHU (examined). Synonymy by Kohout, 1998: 523.

(For full list of citations see Kohout, 1998: 523).

Other material. INDONESIA, N.C. SERAM, Manusela N.P., Wae Mual Plain, 25.vii-9.ix.1987, Op. Raleigh (M.J.D. Brendell, B.M.1987-262); ditto, Piroe, 1937 (W.M. Mann, NGS SI Exp.); AMBON I., 1898 (L. Biró); WEST IRIAN, Ifar, Cyclops Mts, 300-500 m, 23-26.vi.1962 (J. Sedláček) (w); Waigiou I. (Bates) (w); 12 km S of Sorong, 11.iii.1981 (W.L. Brown) (w); Maffin Bay, 22.vi.1944 (E.S. Ross) (w). PAPUA NEW GUINEA, West Sepik Prov., Torricelli Mts, Lumi, 400-550 m, 03°28'S, 142°02'E, 4-13.viii.1984 (RJK accs 84.176, 228, 283) (w, ♀); ditto, x.1984 (D. Waisi) (w); Pes Mission, <50 m, c 12 km WSW of Aitape, 03°11'S, 142°15'E, 31.vii-3.viii.1984 (RJK acc 84.176) (w, ♀); Oenake Ra., 3-5 km W of Warimo, 03°40'S, 141°12'E, 200-300 m, 15.viii.1984 (RJK acc. 84.288) (w); Morobe Prov., Huon Pen., Wareo (Wagner) (w); Finschhafen, 7.v.1944 (E.S. Ross) (w); Mongi Watershed, Joangeng, 7-8.iv.1955 (E.O. Wilson) (w); Mongi-Mape Watershed, Boingbongen, 900-1000 m, 5.iv.1955 (E.O. Wilson #730) (w); lower Busu R., 28.iv.1955 (E.O. Wilson #879) (w); Boana, Bunbok Valley, nr Lae, 25.v.1955 (E.O. Wilson #1122, 1123) (w); c. 35 km W of Lae, nr Wampit, 06°45'S, 146°40'E, 24-27.viii.1984 (RJK accs 84.353, 365) (w, ♀); Markham R. Valley, Nadzab, v.1944 (K.V. Krombit) (♀); ditto, 20-22.v.1955 (E.O. Wilson #1086, 1099) (w); Lae, Didiman Ck, 27.iii.1955 (E.O. Wilson #701) (w); Northern Prov., Pongani R., Boikiki Plant., 09°06'S, 148°25'E, c. 500 m, 29-30.viii.1984 (RJK acc. 286) (w); Owen Stanley Ra., Mamba Plant., nr Kokoda, 08°51'S, 147°41'E, 31.viii-1.ix.1984 (RJK accs 84.400, 403); Star Mts, nr Tabubil, 05°15'S, 141°13'E, 16.viii.1989 (Aniruddh D. Patel #291) (w); Bisianumu, nr Sogeri, 500 m, 15-20.iii.1955 (E.O. Wilson #607, 616) (w, ♀); ditto, 500 m, 23-24.ix.1955 (L.J. Gressitt) (w); Otomata Plant., E of Moresby, 2.xi.1960 (L.J. Gressitt) (w); Western Prov., Oriomo Govt. Stn, 26-28.x.1960 (J.L. Gressitt) (w); Milne Bay, 4.iii.1944 (H.R. Roberts) (w). AUSTRALIA, QUEENSLAND, Cape York Pen., Iron Ra., 12°44'S, 143°14'E, 1-3.vii.1976

(P. Filewood) (w); ditto, 26-31.vii.1981 (RJK accs 81.182, 191, 198) (w); West Claudie R., 6 km ENE of Mt Tozer, 12°44'S, 143°16'E, 3-10.xii.1985 (GBM & DJC) (w).

Remarks. The known distribution of *P. rufofemorata* extends from the Moluccas and New Guinea to northern Australia, where it occurs at Iron Range on Cape York Peninsula. As indicated earlier (Kohout 1989, 1998), *P. rufofemorata* appears in two distinct forms that differ primarily in the development of the petiolar node. In the nominal form, including most of its synonyms (*P. merops* Fr. Smith, 1860, *P. biroi* Forel, 1907 and *P. biroi paprika* Forel, 1911), the petiole is simply angulate or at most minutely dentate, while it is clearly spinose in *P. biroi bidentata*. Both forms are relatively common throughout New Guinea and are occasionally sympatric. However, it appears that Indonesian populations of *P. rufofemorata* include only the nominal form, while Australian populations are characterised by the distinctly spinose petiole. Queens of both forms are very similar with only a little variability demonstrated between various populations. *Polyrhachis rufofemorata* is lignicolous, selecting various plant cavities for its nesting sites, with most colonies found occupying hollow internodes of standing dead bamboo.

Subgenus *Myrmatopa* Forel, 1915

Myrmatopa Forel, 1915: 107 (as subgenus of *Polyrhachis* Fr. Smith). Type species: *Polyrhachis schang* Forel by original designation.

Myrmatopa Forel; Emery, 1925: 180 (diagnosis).

Myrmatopa was established by Forel (1915) as a subgenus of *Polyrhachis* Fr. Smith, 1857, with *P. schang* Forel, 1879 from China as the type species. Forel did not define the new subgenus, but he listed the 'Gruppe *Wallacei* Em. and *Schang* For. etc.', established earlier by Emery (1896), as its constituents. However, Emery considered the *P. wallacei*-group to be a part of his 'Manipulus 1 (*P. chlypeata*)', that was later included within the subgenus *Camponyrma* (Wheeler 1911), while he listed *P. schang* as a '*Species incertae sedis*'. Later Emery (1925) delimited *Myrmatopa* and divided it into two species-groups (*P. wallacei*- and *P. schang*-

groups). This arrangement was followed by Dorow (1995), until Kohout (2008a) subdivided the *wallacei*-group further by placing several of its constituents into a newly established *P. flavicornis*-group. Of the three species groups, the *flavicornis*- and *wallacei*-groups are relevant to the Australian fauna.

Diagnosis. *Worker.* Mostly small to medium-sized ants (HL 1.28-2.08) with general characteristics of the genus. Mandibles smooth or very finely, longitudinally striate. Anterior clypeal margin with shallow, central, medially emarginate flange, laterally flanked by teeth or acute angles, or simply truncate. Eyes in most species moderately to strongly convex, clearly exceeding lateral cephalic outline in full face view. Frontal carinae low, separated by rather broad frontal area (as in extralimital *P. wallacei* Emery), moderately raised (as in *P. lombokensis* Emery), or strongly raised as triangular projections (as in extralimital *P. derecynia* Fr. Smith). Mesosoma fully or partly laterally marginate or totally immarginate; humeri armed with acute, triangular teeth or bluntly angular. Lateral mesonotal margins flat or distinctly dorsally raised (as in *P. schaug*-group species). Petiole armed with a pair of acute spines, rarely with intercalary spines or teeth (as in extralimital *P. subtridens* Emery). Sculpturation of head and mesosoma mostly smooth with fine punctation, but may be rather coarsely reticulate-punctate or longitudinally striate. Gaster shagreened or finely reticulate-punctate. All body surfaces usually without abundant pilosity or pubescence, except in some extralimital species (e.g. *P. elii* Emery and *P. chaita* Kohout). Body more-or-less uniformly black or yellowish- to reddish-brown (as in *P. lombokensis*) or distinctly bicoloured with head and body black and gaster and appendages light to medium yellowish- to reddish-brown (as in extralimital *P. alpheia rufiventris* Emery).

Queen. Apart from sexual characters, very similar to worker. Armament of pronotum, propodeum and petiole somewhat reduced, with spines shorter and stronger. In several species (e.g. *P. alpheia*) intercalary petiolar tooth or tubercle is

evident in queen but completely absent in worker. Sculpturation, pilosity and colour very similar to those of worker.

Distribution and biology. Members of the subgenus *Myrmatopa* are distributed throughout south-east Asia, extending south to Indonesia, New Guinea, the Solomons and northern Australia. They are typical arboreal nesters building polydomous nests of silk and vegetation debris between the leaves of rainforest trees and shrubs (Kohout 1999; Robson & Kohout 2005, 2007). Similar to species of the subgenus *Cyrtomyrma* Forel, pupae of all known *Myrmatopa* species are naked, i.e. not enclosed in cocoons.

KEY TO AUSTRALIAN
MYRMATOPA SPECIES
(based on workers)

1. Lateral margins of mesonotum produced into distinct dorsolateral prominences (Fig. 6E) (extralimital) (*P. schaug*-group)
 - Lateral margins of mesonotum rather flat, without distinct dorsolateral prominences (Figs 3E, 3G, 4E) 2.
2. Pronotal humeri produced into distinctly upturned, acute teeth (Fig. 3D); head and body black with gaster and appendages medium to dark reddish-brown (*P. flavicornis*-group) 3.
 - Pronotal humeri obtusely angulate (Fig 3F, H); body and appendages more-or-less uniformly medium reddish-brown, with head usually a shade darker (*P. wallacei*-group) *P. yarrabaliensis* Emery
3. Larger (HL >2.00); antennal scapes relatively short (SI <140); propodeal spines rather long, strongly upturned (Fig. 4E) *P. menozzii* Karavaiev
 - Smaller (HL <1.70); antennal scapes relatively long (SI >160); propodeal spines reduced to short acute teeth (Fig. 3E) . . . *P. alpheia* Fr. Smith

Polyrhachis flavicoruis species-group*Polyrhachis alpheia* Fr. Smith, 1863
(Figs 3A, D-E, 8E)

Polyrhachis alpheus Fr. Smith, 1863: 14. Holotype worker. Type locality: NEW GUINEA, Waigeo I. (A.R. Wallace), OXUM (examined).

Other material. INDONESIA, WEST IRIAN, Bodem, 11 km SE of Oerbefareh, 01°58'S, 138°44'E, 100 m, 7-17.vii.1959 (T.C. Maa) (w). PAPUA NEW GUINEA, Amok, N of Maprik, 03°35'S, 142°57'E, 165 m, 6.i.1960 (T.C. Maa) (w); Western Prov., Oriomo Govt. Str, 08°48'S, 143°05'E, 26-28.x.1960 (J.L. Gressitt); West Sepik Prov., nr Vanimo, 02°40'S, 141°18'E, rf., c. 50 m, 10-11.vii.1972 (R.W. Taylor); Central Prov., Karema, Brown R., 09°12'S, 147°14'E, 8-11.iii.1955, lowland rf. (E.O. Wilson #586) (w, ♀). AUSTRALIA, QUEENSLAND, Cape York Pen., Lockerbie Scrub, 10°46'S, 142°29'E, 19-23.iii.1987, rf., ex nest between leaves (RJK accs 87.29, 61 (w, ♀); ditto, at light (♀).

Worker. Dimensions: TL c. 5.14-6.75; HL 1.34-1.68; HW 1.06-1.31; CI 77-82; SL 1.79-2.18; SI 161-174; PW 0.75-0.94; MTL 1.81-2.25 (12 measured).

Anterior clypeal margin truncate medially; truncate portion widely and shallowly emarginate and flanked by blunt angles. Clypeus with short, median carina, flat in profile, posteriorly rounding into moderately impressed basal margin. Frontal triangle distinct. Frontal carinae sinuate with distinctly raised margins; central area relatively narrow, deeply concave; frontal furrow poorly indicated. Sides of head in front of eyes converging towards mandibular bases in virtually straight line; behind eyes sides rounding into convex occipital margin. Eyes relatively large, strongly convex, in full face view clearly exceeding lateral cephalic outline. Ocelli lacking. Mesosomal dorsum distinctly laterally marginate. Pronotal dorsum flat; humeri with rather short, acute, anterolaterally directed spines; pronotal spines mostly horizontal, but distinctly upturned in some specimens, with lateral edges continuous with weakly rounded pronotal margins. Promesonotal suture distinct. Mesonotum posteriorly with weakly raised lateral margins that converge towards rather shallowly impressed metanotal groove. Propodeal dorsum marginally wider than long,

lateral margins terminating posteriorly in short, transverse ridges that appear as upturned teeth in profile; ridges continued medially for a short distance with propodeal dorsum between them descending into oblique declivity in medially uninterrupted curve. Petiole with anterior face very low, posterior face convex and distinctly higher; dorsum armed with pair of relatively long, more-or-less diverging, dorsoposteriorly directed, acute spines; dorsum between them narrowly rounded or with indication of intercalary teeth or tubercles in some specimens. Anterior face of first gastral segment flat at base, widely rounding onto dorsum.

Mandibles finely longitudinally striate with numerous piliferous pits. Head rather coarsely sculptured, deeply irregularly rugose with superimposed small punctures; sculpture somewhat less intense on clypeus and on vertex near occipital margin. Dorsum of mesosoma and petiole, except spines, coarsely reticulate-punctate with sculpture on pronotum more-or-less longitudinally directed. Gaster finely shagreened, highly polished.

Mandibles with several curved, golden hairs near masticatory borders. Anterior clypeal margin with one longer median seta and fringe of relatively short setae laterally. A pair of longer, erect or semierect hairs near anterior clypeal margin and along frontal carinae; fore coxae with several relatively long, semierect hairs; somewhat shorter, single hairs on venter of trochanters and femora. Gaster with several golden, semierect hairs lining dorsoposterior margins of apical segments; distinctly longer hairs on gastral venter. Appressed, golden or off-white, rather diluted pubescence on dorsum of gaster, virtually absent from other body surfaces.

Colour. Black. Mandibles dark reddish-brown at bases, distinctly lighter apically with dark teeth. Antennal scapes and basal funicular segments dark reddish-brown, subsequent segments progressively lighter; base of scapes and apical antennal segments orange. Legs, including coxae

generally reddish-brown; fore coxae usually darker or almost black in some specimens. Gaster dark reddish-brown, with posterior margins of segments lined with dark brown or black.

Queen. Dimensions: TL c. 8.32-8.87; HL 1.93-2.09; HW 1.50-1.59; CI 75-79; SL 2.43-2.56; SI 158-169; PW 1.65-1.87; MTL 2.65-2.81 (9 measured). Apart from sexual characters, very similar to worker except: distinctly larger; pronotal humeri with somewhat flattened acute teeth. Mesoscutum as long as wide, with lateral margins strongly converging anteriorly, forming distinctly narrowly rounded anterior margin; anterior face of mesoscutum low, with dorsum forming continuous, moderately convex line in lateral view; median line flat anteriorly, weakly raised dorsoposteriorly; parapsides distinct, weakly raised posteriorly. Mesoscutellum not raised above dorsal plane of mesosoma, flat anteriorly, widely rounding posteriorly into deeply impressed metanotal groove. Propodeal dorsum with blunt lateral margins terminating posteriorly in short, upturned, transverse ridges. Petiolar spines virtually identical to those in worker. Sculpturation, pilosity and colour as in worker.

Males unknown. Immature stages (eggs, larvae and pupae) in QM spirit collection.

Remarks. Australian specimens differ slightly from those from New Guinea, notably in the intensity and density of sculpturation. The coarse rugosity of the head is somewhat less pronounced in Australian specimens and confined mostly to the front of the head, with the vertex only reticulate-punctate. The rugosity is also weaker on the sides of the mesosoma and petiole. The petiolar spines in New Guinean specimens, when viewed from the front, form a rather narrow 'U' with the tips of the spines weakly turned inwards. In contrast, the petiolar spines in Australian specimens are straight, more slender and distinctly diverging (Fig. 3D-E). The legs of Australian specimens are generally darker, reddish-brown, while in the holotype and most other New Guinean specimens examined, they

are relatively light, yellowish-brown. However, in spite of these differences, the Australian and New Guinean specimens are very similar and I am reluctant to consider them separate species. Until more New Guinean material, including nest series, becomes available, I consider both forms to represent different populations of a single species.

Polyrhachis alpea appears rather uncommon with a patchy distribution extending across New Guinea and neighbouring islands to the extreme tip of Cape York Peninsula. A single colony, including a dealate queen, and several alate queens collected at light trap represent the only Australian records of *P. alpea*.

Polyrhachis menozzii Karavaiev, 1927
(Figs 4A, D-E, 8F)

Polyrhachis (Myrmatopa) menozzii Karavaiev, 1927: 9. Syntype workers, queen. Type locality: INDONESIA, Aru Is, Wammar, 16.iii.1913 (V. Karavaiev #2596 for w, #2982 for ♀) IZAS, QM (examined).

Other material. INDONESIA, WEST IRIAN, Genjam, 40 km W of Hollandia, 02°46'S, 140°12'E, 100-200 m, 1-10.iii.1960 (T.C. Maa) (w); River To (mouth), 4 km E of Hol Maffin, 02°32'S, 140°42'E, 1.vi.1952, light trap (T.C. Maa) (♀); W. Sentani, SW Cyclop Mts, 02°36'S, 140°37'E, 80 m, 22-27.vi.1959 (T.C. Maa) (♀); Tigi Lake, Wisselmeren, Waghete, 04°00'S, 136°13'E, 1700 m, 15.viii.1955 (J.L. Gressitt) (w). PAPUA NEW GUINEA, West Sepik Prov., Torricelli Mts, Lumi, 03°28'S, 142°02'E, 400-550 m, 4-13.viii.1984 (RJK acc. 84.285) (w); Victor Emanuel Ra., Telefomin, 05°07'S, 141°38'E, 1550 m, 17-19.viii.1984, swamp rf. (RJK acc. 84.331) (w, ♀); Kalalo, 06°04'S, 147°11'E, 750 m, 20-30.viii.1966 (G.A. Samuelson) (w); Northern Prov., Pongani R., Boikiki Plant., 09°06'S, 148°25'E, 500 m, 29-30.viii.1984 (RJK acc. 84.387) (w); Western Prov., Oriomo Govt. Stn, 08°48'S, 143°05'E, 26-28.x.1960 (J.L. Gressitt) (w); Central Prov., Laloki R., 20 km N of Port Moresby, 09°15'S, 147°05'E, 3.xii.1979 (E. Brough) (w); Brown R., 5 m, 23.x.1960 (J.L. Gressitt) (♀). AUSTRALIA, QUEENSLAND, Cape York Pen., Lockerbie Scrub, 10°46'S, 142°29'E, 19-23.iii.1987, rf., at light (RJK acc. 87.61) (♀); Bamaga, 10°53'S, 142°23'E, 24-25.iii.1987, rf. margin, at light (RJK acc. 87.84) (♀).

Worker. Dimensions (syntype cited first): TL c. 8.57, 7.56-8.67; HL 2.18, 2.06-2.25; HW 1.87, 1.75-1.93; CI 86, 85-86; SL 2.50, 2.43-2.53; SI 134,

131-139; PW 1.22, 0.97-1.22; MTL 3.12, 2.96-3.24 (1+4 measured).

Anterior clypeal margin medially with wide, deep, 'V' shaped emargination, delimited laterally by acute teeth. Clypeus with median carina; virtually straight in profile, posteriorly rounding into distinctly impressed basal margin. Frontal triangle distinct. Frontal carinae sinuate with steeply raised margins; central area flat with frontal furrow partly obscured by cephalic sculpturation. Sides of head in front of eyes converging towards mandibular bases in virtually straight line; behind eyes sides rounding into weakly convex occipital margin. Eyes convex, in full face view clearly exceeding lateral cephalic outline. Ocelli lacking. Pronotal dorsum flat; humeri with short, rather blunt, somewhat upturned spines; their lateral edges continuous with posteriorly converging, lateral pronotal margins. Promesonotal suture distinct; mesonotal dorsum flat in profile with weakly raised lateral margins. Metanotal groove distinct; propodeal dorsum with subparallel, somewhat dorsally raised lateral margins, terminating posteriorly in moderately long, strongly oblique, acute spines; propodeal dorsum between spines rounding into weakly concave declivity in medially uninterrupted line. Petiole with anterior face straight, posterior face convex; armed with two, relatively long, widely diverging acute spines; dorsal margin between spines with distinct, acute, intercalary tooth. Anterior face of first gastral segment flat at base, widely rounding onto dorsum.

Mandibles very finely longitudinally striate with numerous piliferous pits. Head and dorsum of mesosoma rather coarsely and deeply reticulate punctate, with rugae on clypeus mostly longitudinally directed. Sides of mesosoma and petiole distinctly less coarsely sculptured. Antennae and legs finely and closely reticulate-punctate. Gaster finely shagreened, polished.

Mandibular masticatory borders with several relatively long, curved, golden hairs. Anterior

clypeal margin with a single long seta and a pair of shorter setae within median emargination and numerous shorter setae lining margin laterally. A few paired, semierect, medium length, yellow hairs near anterior and basal clypeal margins and in central area along frontal carinae. Several relatively long hairs on fore coxae; somewhat shorter hairs on venter of trochanters and femora. Gaster with several hairs lining dorsoposterior margins of apical segments; distinctly longer and more numerous hairs on gastral venter. Appressed, very short, yellowish or off-white, rather diluted pubescence on dorsum of gaster; pubescence virtually absent from other body surfaces.

Colour. Black. Mandibles distinctly lighter, reddish-brown, towards masticatory borders; teeth black. Antennal scapes and basal funicular segments very dark reddish-brown, subsequent segments progressively lighter towards antennal apices. Legs, including coxae, black or very dark reddish-brown. Gaster very dark, virtually black, dorsally; sides and margins of segments on venter a shade lighter with somewhat reddish tint.

Queen. Dimensions: TL c. 9.12-11.69; HL 2.28-2.65; HW 2.06-2.21; CI 82-90; SL 2.46-2.90; SI 119-133; PW 1.96-2.25; MTL 2.93-3.63 (8 measured). Apart from sexual characters, closely resembling worker except: pronotal humeri with rather short, blunt teeth; mesoscutum wider than long, with lateral margins converging anteriorly, forming moderately rounded anterior margin; median line distinct; parapsides flat; anterior face of mesoscutum in lateral view widely rounding onto flat dorsum. Mesoscutellum with flat dorsum, only marginally elevated above dorsal plane of mesosoma. Propodeum armed with obliquely directed spines. Petiole with lateral spines marginally shorter and intercalary tooth stronger and more distinct than in worker. Sculpturation and colour virtually identical to worker.

Males unknown. Immature stages in ANIC spirit collection.

Remarks. The only specimens of *P. menozzii* known from Australia are numerous alate queens from light traps set in lowland rainforest at Lockerbie Scrub and Bamaga. Their identity has been confirmed by comparison with the syntypes of the species and worker-associated queens from a nest series from PNG. The distribution of *P. menozzii* appears to be centred on New Guinea, with the type series specimens collected on the Aru Islands. *Polyrhachis menozzii* builds polydomous nests from silk and vegetation debris upon the leaves of rainforest trees apparently high above ground, with both available nests from PNG collected from the canopy of recently felled rainforest trees.

Polyrhachis wallacei species-group

Polyrhachis yarrabahensis Forel, 1915
(Figs 3B, F-G, 8G)

Polyrhachis (Myrmatopa) lombokensis var. *yarrabahensis* Forel, 1915:115. Syntype worker, queen. Original localities: AUSTRALIA, QUEENSLAND, Yarrabah (for w), Malanda (for ♀) (E. Mjöberg), NRMS (examined).

Polyrhachis yarrabahensis Forel; Kohout & Taylor, 1990: 520. Raised to species.

Polyrhachis lombokensis Emery. Erroneous synonymy by Kohout, 2000: 205.

Other material. INDONESIA, WEST IRIAN, Waris, S of Hollandia, 03°30'S, 140°55'E, 450-500 m, 17.viii.1959 (T.C. Maa) (w). PAPUA NEW GUINEA, Louisiade Archipelago, Misima I., 10°40'S, 152°45'E, (Rev. H.K. Bartlett) (w); Adelbert Mts, Wanuma, 04°36'S, 145°06'E, 800-1000 m, 25.x.1958 (J.L. Gressitt) (w); Kumun, Upper Jimmi Valley, 05°25'S, 144°23'E, 1000 m, 13.vii.1955 (J.L. Gressitt) (w). AUSTRALIA, QUEENSLAND, Cape York Pen., Lockerbie Scrub, 10°46'S, 142°29'E, 19-23.iii.1987, rf., at light (RJK acc. 87.61) (♀); Massy Spur Creek, nr Silver Plains Stn, 13°56'S, 143°29'E, 20.ix.1956 (J.L. Wassell) (w); Mt Webb NP, 15°04'S, 145°07'E, 27-30.iv.1981 (J.E. Feehan) (w); 14 km WbyN of Hope Vale Mission, 15°16'S, 144°59'E, 7-10.v.1981 (J.E. Feehan) (w); Home Rule Stn, 15°45'S, 145°17'E, c. 200 m, rf. margin, 9-11.vi.1996 (RJK & JCB acc. 96.41) (♀); Pilgrim Sands, 16°04'S, 145°28'E, <10 m, 12-15.vi.1996, rf. margin (RJK acc. 96.50) (w); Cape Tribulation, Canopy Crane site, 16°06'S, 145°27'E, 15.x.1999, rf (N. Blüthgen) (w); ditto, 21.ii.2000 (N. Blüthgen #1004) (w, ♂); ditto, 20-21.ii.2000 (RJK acc. 2000.37) (w); Kamerunga, 10 km NW of Cairns, 16°53'S, 145°41'E, 13.vii.1960 (G.W. Saunders) (w); Yarrabah, c. 11 km E

of Cairns, 16°56'S, 145°52'E, 22-24.vii.1980 (RJK accs 80.125, 126, 127, 133, 135, 136, 137, 144, 145, 148) (w, ♀, ♂); Canal Ck, nr Innisfail, 23.v.1993 (L.R. Ring) (w, ♀); Kennedy, 18°12'S, 145°57'E, 4.x.1955 (G. Saunders) (w).

Worker. Dimensions: TL c. 5.44-6.80; HL 1.43-1.68; HW 1.15-1.40; CI 78-83; SL 1.78-2.12; SI 147-159; PW 0.69-0.90; MTL 1.81-2.25 (30 measured).

Anterior clypeal margin with wide median truncation flanked by blunt denticles. Clypeus with poorly defined, blunt, median carina; clypeus in profile straight for most of its length, abruptly rounding into moderately impressed basal margin. Frontal triangle distinct. Frontal carinae sinuate with only moderately raised margins; central area relatively wide; frontal furrow distinct anteriorly, poorly indicated posteriorly. Sides of head in front of eyes converging towards mandibular bases in virtually straight line; behind eyes sides rounding into evenly convex occipital margin. Eyes convex, in full face view clearly breaking lateral cephalic outline. Ocelli lacking. Pronotal humeri obtusely angular, almost rounded in some specimens; lateral pronotal margins rather blunt posteriorly; promesonotal suture strongly impressed. Mesonotum with lateral margins strongly converging posteriorly; metanotal groove distinct. Propodeum with lateral margins blunt, terminating posteriorly in poorly developed, right-angled teeth. Petiole armed with a pair of relatively short, dorsally and weakly posteriorly directed, diverging spines. Anterior face of first gastral segment distinctly higher than full height of petiole, widely rounding onto dorsum.

Mandibles very finely longitudinally striate with numerous piliferous pits. Head distinctly reticulate-punctate, sculpturation more intense towards mandibular bases and sides of head. Dorsum of mesosoma and petiole more finely reticulate-punctate with pronotal sculpture consisting of irregular, mostly longitudinal and laterally curving fine striae. Sides of mesosoma finely, mostly obliquely, reticulate. Antennal scapes finely, closely punctate. Fore coxae and gaster very finely shagreened, highly polished.

Mandibles with a few curved, golden hairs near masticatory borders and numerous short, appressed hairs towards mandibular bases. Anterior clypeal margin with fringe of short setae. Several medium length, paired hairs near anterior and basal clypeal margins and along frontal carinae. A few somewhat longer hairs on fore coxae and single shorter hairs on venter of trochanters and femora. Gaster with several longer hairs lining dorsoposterior margins of apical segments, hairs more numerous on gastral venter.

Colour. Generally medium to dark reddish-brown; head mostly dark reddish-brown to black, with mandibles and anterior portion of clypeus distinctly lighter. Mandibular teeth and anterior clypeal margin narrowly lined with dark brown. Dorsum of mesosoma often blotched dark reddish-brown, almost black in some specimens, with pronotal collar, sutures and sides of mesosoma distinctly lighter. Antennae and legs, including coxae, mostly light to medium reddish-brown. Petiole and gaster reddish-brown; base and venter of gaster a shade lighter; margins of segments lined with dark brown.

Queen. Dimensions: TL c. 8.01-8.87; HL 1.90-1.96; HW 1.47-1.57; CI 77-83; SL 2.28-2.34; SI 149-156; PW 1.62-1.75; MTL 2.43-2.56 (12 measured). Apart from sexual characters, closely resembling worker except: distinctly larger; pronotal humeri bluntly angular; mesoscutum as long as wide, with lateral margins converging anteriorly, forming rather narrowly rounded anterior margin; median line distinct; parapsides flat; anterior margin in side view widely rounding onto flat dorsum. Mesoscutellum convex, elevated above dorsal plane of mesoscutum. Propodeum immarginate; dorsum posteriorly armed with short, upturned teeth. Petiolar spines virtually identical to those in worker. Sculpturation and pilosity as in worker. Generally darker coloured than worker with head and dorsum of mesosoma very dark reddish-brown or black; mandibles, pronotal collar and sides of pronotum, mesopleuron, petiole and

appendages a shade lighter, reddish-brown. Colour of gaster as in worker.

Males and immature stages (eggs, larvae and pupae) in QM spirit collection.

Remarks. Kohout & Taylor (1990: 520) raised *P. lombokensis* var. *yarrabahensis* to species level and noted: 'With some hesitation we consider them to represent separate species. We are hesitant to synonymise the names because of the great distance separating the known ranges of these taxa and because no material is known from areas in between'. However, the discovery of a few additional specimens from Papua New Guinea (Misima I., Rev. H.K. Bartlett) led me to conclude (Kohout 2000: 205) that the slight differences in characters given by Kohout & Taylor (1990) to differentiate the taxa were insignificant and that *P. yarrabahensis* represented an isolated population of *P. lombokensis* (Fig. 3C, H-I).

I have since re-examined the syntypes of both species, including queens, together with a vast number of additional specimens from Cape York Peninsula, north Queensland, and recently discovered specimens from New Guinea (IRIAN JAYA, Waris, 17.viii.1959, T.C. Maa; PNG, Popondetta, 6.xii.1972, P.M. Room; Kokoda, 1.vi.1972, P.M. Room; Wanuma, 25.x.1958, J.L. Gressitt; Upper Jimmi Valley, 13.vii.1955, J.L. Gressitt - ANIC, MCZC and BPBM). As a result, I now consider that both taxa do represent separate species. In addition to trivial differences in the degree of the descending angle of the propodeal declivity, the convexity of the eyes and the outline of pronotal humeri (listed by Kohout & Taylor 1990), the most obvious characters separating them are the intensity of sculpturation, their colour and the development of the propodeal teeth. In *P. yarrabahensis* the sculpturation, notably of the head, is distinctly reticulate-punctate, with the intensity increasing in front of the eyes and towards the sides of the head (see Fig. 3B). The colour of the head is distinctly darker, almost black in some specimens, contrasting with the mostly medium to dark reddish-brown colour of the rest

of the body. In contrast, the sculpturation of the head in *P. loubokensis* is very fine, rather polished (see Fig. 3C) and the body, including the head, is more-or-less uniformly medium reddish-brown. The propodeal teeth in *P. yarrabahensis* are rather poorly developed and more-or-less angular, while they are distinctly upturned and acute in *P. loubokensis*. The differences in the queens of the species are even more distinct. The sculpturation, notably of the head, in *P. loubokensis* is very fine and highly polished, while in the queen of *P. yarrabahensis* it is markedly more distinct than in the worker, consisting of small punctures superimposed upon rather irregular reticulation. In *P. yarrabahensis* the mesoscutum in dorsal view is about as long as wide, with the lateral margins strongly converging anteriorly, forming a rather narrowly rounded anterior margin. In profile, the mesoscutellum is convex and distinctly elevated above dorsal plane of mesosoma. In contrast, the mesoscutum in *P. loubokensis* is distinctly wider than long, with a rather widely rounded anterior margin. The mesoscutellum is only weakly raised above dorsal plane of mesosoma, and is virtually flat before rounding into the propodeal groove. In addition, the mesosomal dorsum of *P. loubokensis* has several medium length, erect hairs that are completely absent in *P. yarrabahensis*.

The known distribution of *P. yarrabahensis* extends from New Guinea south to northern Queensland, where it appears to be most abundant within the Wet Tropics region. It is an arboreal nester, building polydomous nests of silk and vegetation debris upon the leaves of various lowland rainforest trees, shrubs and vines (Kohout 1999; Robson & Kohout 2005, 2007).

Subgenus *Myrmothrinax* Forel, 1915

Myrmothrinax Forel, 1915: 107 (as subgenus of *Polyrhachis* Fr. Smith). Type species: *Polyrhachis thrinax* Roger by original designation.

Myrmothrinax Forel; Emery, 1925: 182 (diagnosis).

The subgenus *Myrmothrinax* was introduced by Forel (1915) as a subgenus of *Polyrhachis* Fr. Smith, 1857, with *Polyrhachis thrinax* Roger, 1863a,

as the type species. Forel did not define the new subgenus but listed *Myrmothrinax* as a direct replacement for the 'Manipulus 3 (*P. thrinax*)' of the earlier classification of Emery (1896). The first description of *Myrmothrinax* was given by Emery (1925), who included 27 species and subspecific forms as its constituents. Both Emery (1925) and Dorow (1995) considered *Myrmothrinax* to be a relatively homogenous subgenus and did not subdivide it into species-group. However, more recently Kohout (2008a) recognised two species-groups (*aequalis*- and *thrinax*-groups), based on the relative length of the petiolar spines. The subgenus is in great need of revision as the discovery of numerous new, mainly south-east Asian species is rapidly increasing, due to the employment of modern collecting methods, notably insecticidal fogging of the rainforest canopy.

Diagnosis. Worker. Small to relatively large (HL 1.35-2.25) ants with characteristics of the genus. Anterior clypeal margin medially truncate or with more-or-less distinct median emargination, laterally flanked by teeth or acute angles. Frontal carinae low or only moderately raised. Eyes in most species relatively large, exceeding lateral cephalic outline in full face view. Ocelli lacking. Mesosomal dorsum relatively slender, laterally marginate; pronotal humeri ranging from rounded or subangular (as in extralimital *P. trispinosa* Fr. Smith) to angular (as in *P. queenslandica* Emery), or distinctly spinose (as in numerous extralimital species). Promesonotal suture and metanotal groove distinct; propodeum terminating posteriorly in acute teeth (as in *P. trispinosa*) or more commonly in variously elevated, acute spines. Dorsum of petiole armed with three spines (except in extralimital *P. uuicuspis* Emery), that are either subequal in length, or with middle spine shorter than lateral pair (*P. aequalis*-group) or with middle spine distinctly elongated (*P. thrinax*-group). Sculpturation of head and mesosoma mostly reticulate-punctate, however, dorsum of mesosoma in many extralimital species with more-or-less distinct, longitudinal reticulate-

striation. Gaster shagreened or finely reticulate-punctate. Pilosity and pubescence rather sparse over most body surfaces, except dorsum of head and mesosoma, where it is virtually lacking. Body uniformly yellowish-brown (as in extralimital *P. dahlia* Forel) or reddish-brown (as in *P. delicata* Crawley) or rarely bicoloured with head and body black and gaster and appendages light to medium reddish-brown (as in extralimital *P. textor brunneogaster* Donisthorpe).

Queen. Apart from sexual characters, very similar to worker except: distinctly larger (HL >1.95); armament of pronotum, propodeum and petiole distinctly reduced, with spines shorter and stronger; petiolar spines in most species more-or-less subequal, even in species of *thrinax*-group (e.g. *P. queenslandica*). Sculpturation, pilosity and colour virtually as in worker.

Distribution and biology. The distribution of the subgenus *Myrmothrinax* is very similar to that of the subgenus *Myrmatopa*, with most species occurring in south-east Asia, including India, Sri Lanka, Myanmar, Malaysia, Indochina, Thailand, Philippines and Vietnam. Both subgenera extend throughout Indonesia, Papua New Guinea, the Bismarck Archipelago and the Solomons to northern Australia. The nesting habits of both subgenera are virtually identical and Australian *Myrmothrinax* and *Myrmatopa* species are often found nesting together at suitable localities in north Queensland. They are all typical arboreal nesters building polydomous nests of silk and vegetation debris between the leaves of rainforest trees and shrubs (Robson & Kohout 2005, 2007). However, in contrast to species of *Myrmatopa*, the pupae of all known species of *Myrmothrinax* are enclosed in cocoons.

KEY TO AUSTRALIAN
MYRMOTHRINAX SPECIES
(Based on workers)

1. Generally reddish-brown; propodeal spines mostly upturned; petiolar node relatively slim, narrowed dorsally; petiolar

dorsum in lateral view forming a single continuous line with dorsoposteriorly elevated median spine (Fig. 4G)
..... *P. delicata* Crawley

- Generally black or very dark reddish-brown; propodeal spines distinctly less elevated, oblique; petiolar node in lateral view distinctly thicker; petiolar dorsum virtually flat with leading edge of median spine more steeply elevated (Figs 4I, 6I)
..... *P. queenslandica* Emery

Polyrhachis thrinax species-group

Polyrhachis delicata Crawley, 1915
(Figs 4B, F-G, 8I)

Polyrhachis delicata Crawley, 1915: 238. Syntype workers. Type locality: AUSTRALIA, NORTHERN TERRITORY, Darwin, 16.iv.1913 (G.F. Hill), BMNH, QM (examined).

Polyrhachis lysistrata Santschi, 1920: 569. Syntype workers. Type locality: AUSTRALIA, QUEENSLAND, Townsville (F.P. Dodd), NHMB, QM (examined). Synonymy by Kohout, 1994: 135.

Other material. AUSTRALIA, NORTHERN TERRITORY, Holmes Jungle, c. 15 km NE of Darwin, 12°25'S, 130°58'E, monsoon rf., 16.xi.1993 (RJK accs 93.39, 40, 44 (w, ♀, ♂); ditto, 2.vi.2002 (RJK accs 02.10, 11) (w); Darwin, 12°27'S, 130°50'E, 16.iv.1913 (G.F. Hill) (w); Darwin, East Pt Reserve, 21.vi.1984 (M.B. Malipatil) (w); Kakadu NP, Ubirr-Manngarre, 12°25'S, 132°57'E, monsoon rf., 4.vi.2002 (RJK acc. 02.15) (w); Berry Springs NP, 12°42'S, 130°59'E, monsoon rf., 10.ii.1994 (RJK acc. 94.3) (w); ditto, 12.iii.1961 (J.L. & M. Gressitt). QUEENSLAND, Cape York Pen., Silver Plains, Station Ck, 13°59'S, 143°33'E, 4.i.1959 (J.L. Wassell) (w, ♀, ♂); Home Rule Stn, 15°45'S, 145°17'E, c.200 m, rf. margin, 9-11.vi.1996 (RJK & CJB acc. 96.42, 43) (w, ♀); Fritz Ck, Mt Finlay S slope, 15°50'S, 145°21'E, 5.xii.1975 (Davies & Monroe) (♀); Daintree, 8.viii.1975, rf. (BBL) (w); Caravonica, 11 km NW of Cairns, 16°51'S, 145°41'E, 19.ii.2000 (RJK & SKR acc. 2000.7) (w, ♀); Yarrabah, c. 9 km E of Cairns, 16°54'S, 145°51'E, 22-24.vii.1980 (RJK accs 80.124, 128, 132, 139, 140, 142, 143) (w, ♀); ?Townsville, 30.iv.1902 (F.P. Dodd) (w).

Worker. Dimensions (syntype cited first): TL c. 6.55, 5.39-6.90; HL 1.62, 1.43-1.72; HW 1.40, 1.22-1.47; CI 84, 82-93; SL 2.06, 1.84-2.15; SI 147, 142-153; PW 0.92, 0.78-0.97; MTL 2.18, 1.84-2.28 (37 measured).

Anterior clypeal margin with wide median truncation flanked by small teeth. Clypeus with

median carina; straight in profile, posteriorly rounding into moderately impressed basal margin. Frontal triangle distinct. Frontal carinae sinuate with margins only weakly raised at midlength; central area almost flat with poorly indicated frontal furrow. Sides of head in front of eyes converging towards mandibular bases in virtually straight line; behind eyes sides widely rounding into convex occipital margin. Eyes convex, in full face view clearly breaking lateral cephalic outline. Ocelli lacking; position of lateral pair indicated by shallow punctures in sculpturation. Pronotal dorsum often with poorly defined median longitudinal depression; pronotal humeri angular with lateral margins converging posteriorly into distinct promesonotal suture. Dorsum of mesosoma with lateral margins converging posteriorly in weakly sinuate line; metanotal groove well defined. Lateral margins of propodeum subparallel, terminating in strongly upturned, weakly diverging, acute spines. Petiole with anterior and posterior faces almost straight, converging dorsally in lateral view; petiolar dorsum a flat, posteriorly rising platform, armed with two widely diverging, short lateral spines and a long, acute, dorsoposteriorly elevated median spine. Anterior face of first gastral segment distinctly higher than full height of petiole, widely rounding onto gastral dorsum.

Mandibles finely longitudinally striate with numerous piliferous pits; sculpture finer and rather polished towards masticatory borders. Clypeus more-or-less longitudinally reticulate-striate. Intensity of sculpturation increasing posteriorly, with vertex, mesosoma and petiole distinctly reticulate-punctate. Gaster very finely shagreened, highly polished.

Mandibular masticatory borders with numerous, semierect, golden hairs and very short, closely appressed hairs towards bases. Clypeus with relatively short setae lining anterior margin and several relatively short, paired hairs near anterior and basal margins. A few slightly longer, semierect hairs along frontal carinae and on vertex, very few erect hairs on front coxae.

Pubescence almost completely absent from mesosoma and petiole. Gastral venter and apical gastral tergites with numerous, relatively long hairs. Dorsum of gaster with very short, closely appressed, much diluted golden pubescence.

Colour. Body mostly medium to dark reddish-brown, often variously blotched light orange or red; head in fully pigmented specimens distinctly darker, usually very dark reddish-brown or black, with mandibles, except masticatory borders, middle portion of clypeus and central area along frontal carinae usually distinctly lighter; appendages mostly light to medium reddish-brown, with distal funicular segments progressively lighter towards antennal apex. Mandibular masticatory borders, anterior clypeal margin and frontal carinae narrowly lined with brown.

Queen. Dimensions: TL c. 8.11-8.67; HL 1.93-1.96; HW 1.61-1.65; CI 83-84; SL 2.28-2.34; SI 139-144; PW 1.59-1.68; MTL 2.43-2.59 (5 measured). Apart from sexual characters, closely resembling worker except: pronotal humeri obtusely angular. Mesoscutum about as wide as long, lateral margins converging anteriorly and forming moderately rounded anterior margin; median line distinct; parapsides flat. In profile, anterior face of mesoscutum widely rounding onto virtually flat dorsum. Mesoscutellum weakly convex, moderately raised above dorsal plane of mesosoma, strongly rounding into distinctly impressed metanotal groove. Propodeal dorsum with lateral margins indistinct; propodeal spines somewhat flattened dorsally, shorter than distance between their bases, oblique to main axis of body; their inner margins continued medially and forming an open 'U' in anterior view. Petiole with anterior and posterior faces converging dorsally; spines shorter and thicker than in worker; median spine only marginally longer than lateral pair with its apex more-or-less emarginated.

Males and immature stages (eggs, larvae and pupae) in QM spirit collection.

Remarks. As indicated earlier (Kohout 1994), the most obvious differences between *P. delicata* and *P. queenslandica* are their colour and the orientation of their propodeal spines. However, due to a high degree of variability, notably within Queensland populations of both species, these characters can be unreliable and, while both species are usually separable, no single character is universally diagnostic. The propodeal spines in *P. delicata* are generally more strongly upturned (Fig. 4G), but the actual angle of elevation varies between specimens, even those of the same nest series. The propodeal spines in *P. queenslandica* are distinctly less elevated with only a small amount of variation between the specimens examined (Figs 4I, 6I). The colour of the body appears to be a more reliable character to separate the species but only in fully pigmented specimens. A mostly red or reddish-brown mesosoma, gaster and appendages, contrasting with a darker head (almost black in some specimens) characterises *P. delicata*, while the body in *P. queenslandica* is mostly uniformly black or very dark reddish-brown. The sculpturation of the head and mesosoma in *P. delicata* is rather distinctly reticulate-punctate and opaque, while it is markedly more finely and closely punctate in *P. queenslandica*. The petiolar node in *P. delicata* is relatively slim and distinctly narrows dorsally in lateral view, with the anterior face smoothly curving onto the petiolar dorsum in an uninterrupted line that incorporates the anterior edge of the dorsoposteriorly elevated median spine. In contrast, the petiolar node in *P. queenslandica* is distinctly thicker in lateral view, with the anterior face curving onto a virtually flat dorsum and the median petiolar spine dorsoposteriorly elevated at a distinctly steeper angle. The latter character does not serve to separate the queens of the two species, however, the median petiolar spine in the queen of *P. queenslandica* is simply pointed, while its apex is clearly emarginated in *P. delicata*.

Both Australian *Myrmotheriuax* species are arboreal nesters, using silk to join the leaves of various lowland rainforest trees and shrubs (Kohout 1999, 2000; Robson & Kohout 2005, 2007).

Polyrhachis delicata is known from two disjunct populations, one in the Northern Territory around Darwin and the other in northern Queensland, ranging from about Coen on Cape York Peninsula south to Cairns. The specimens of the type series of the junior synonym *P. lysistrata* were allegedly collected 'near Townsville' by F.P. Dodd on 30.iv.1902, however, I have seen no other specimens of this species collected that far south.

Polyrhachis queenslandica Emery, 1895
(Figs 4C, H-I, 6C, H-I, 8J)

Polyrhachis queenslandica Emery, 1895: 356. Syntype workers. Type locality: AUSTRALIA, QUEENSLAND, Kamerunga (M. Podenzana), MHNG, MSNG (examined).

Polyrhachis dalili var. *unisculpta* Viehmeier, 1914: 48. Syntype workers. Type locality: NEW GUINEA, Huon Pen., Wareo, MNHU (examined). Synonymy by Kohout, 1998: 510

Other material. PAPUA NEW GUINEA, Kokoda, 08°53'S, 147°45'E, 400 m, 18.xi.1966 (J. Sedláček) (w). AUSTRALIA, QUEENSLAND, Cape York Pen., Lockerbie Scrub, 10°46'S, 142°29'E, 19-23.iii.1987 (RJK accs 87.22, 45, 50, 55, 58, 61) (w, ♀, ♂); Bamaga, 10°53'S, 142°23'E, 18.iii.1987, rf. (RJK acc. 87.12) (♀); West Claudie R., 9 km ENE of Mt Tozer, 12°43'S, 143°17'E, 5-10.vii.1986 (J.C. Cardale) (w); ditto, 3-10.xii.1985, rf. (GBM & DJC) (w); Iron Ra, 12°43'S, 143°18'E, 26-31.vii.1981 (RJK accs 81.131, 135, 154, 155, 157, 158, 171, 186, 188) (w, ♀); Gap Ck, 5 km ESE of Mt Finnigan, 15°50'S, 145°20'E, 13-16.v.1981 (JEF) (w); Cooper Ck, nr Daintree, 16°11'S, 145°26'E, 22.vi.1971 (RWT & JEF) (w); Cairns Botanic Gardens, 16°54'S, 145°45'E, 18.i.1997 (SKR #490) (w); Bellenden Ker, Cableway Base Stn, 17-24.x.1981 (Earthwatch & QM Exp.) (w); Seymour Ra., Garradunga, c. 7 km N of Innisfail, 17°28'S, 146°01'E, <100 m, 5-6.vi.1996 (RJK & CJB acc. 96.31) (w); Canal Ck, nr Innisfail, 23.v.1993 (L.R. Ring) (w, ♀, ♂); N. Mission Beach, nr Tully, 25.vi.1962 (RWT) (w); c. 6 km W of Sth Mission Beach, 17°56'S, 146°02'E, 18-19.vii.1980 (RJK accs 80.68, 71, 72, 73, 74) (w, ergatogyne); Little Crystal Ck, Paluma, 28.viii.1995 (SKR #7) (w).

Worker. Dimensions (syntypes [5] cited first): TL c. 5.95-6.70, 5.09-6.71; HL 1.50-1.65; 1.34-1.65; HW 1.26-1.42, 1.15-1.47; CI 82-88, 82-89; SL 1.90-2.03, 1.72-2.12; SI 141-153, 141-155; PW 0.87-0.97, 0.75-1.00; MTL 2.06-2.28, 1.78-2.40 (74 measured).

Anterior clypeal margin with wide median truncation flanked by small teeth. Clypeus with median carina; straight in profile, posteriorly

rounding into moderately impressed basal margin. Frontal triangle distinct. Frontal carinae sinuate with margins only weakly raised at midlength; central area weakly convex with poorly indicated frontal furrow. Sides of head in front of eyes converging towards mandibular bases in weakly convex line; behind eyes sides widely rounding into convex occipital margin. Eyes convex, in full face view clearly breaking lateral cephalic outline. Ocelli lacking; position of lateral pair indicated in some specimens by shallow punctures in sculpturation. Pronotal dorsum often with poorly defined median longitudinal depression; pronotal humeri angular with lateral margins converging posteriorly into distinct promesonotal suture. Dorsum of mesosoma with lateral margins converging posteriorly into well defined metanotal groove. Lateral margins of propodeum subparallel, terminating in obliquely elevated, subparallel, acute spines. Petiole with anterior face straight, posterior face weakly convex; petiolar dorsum a virtually flat platform, armed with two widely diverging, short lateral spines and a long, acute, dorsoposteriorly elevated median spine. Anterior face of first gastral segment distinctly higher than full height of petiole, widely rounding onto gastral dorsum.

Mandibular bases finely longitudinally striate-rugose, sculpture distinctly finer and polished towards masticatory borders. Head mostly finely reticulate-punctate, feebly polished. Intensity of sculpturation somewhat increasing posteriorly, with mesosoma and petiole more closely and distinctly reticulate-punctate. Gaster very finely shagreened, highly polished.

Mandibular masticatory borders with several, semierect, golden hairs and very short, closely appressed hairs towards bases. Anterior clypeal margin with a fringe of a few, rather short setae; clypeus with pair of relatively short hairs near anterior and basal margins; slightly longer, semierect hairs along frontal carinae, on vertex and front coxae. Pilosity and pubescence almost completely absent from mesosoma and petiole.

Gastral venter and apical gastral tergites with numerous, relatively long hairs. Dorsum of gaster with very short, closely appressed, much diluted golden pubescence.

Colour. Head and body in fully pigmented specimens mostly black or very dark reddish-brown. Mandibles, except masticatory borders, clypeus and central area, legs, including coxae and base of gastral dorsum usually dark reddish-brown; funicular segments progressively lighter, yellowish-brown, towards antennal apex. Mandibular masticatory borders, anterior clypeal margin and frontal carinae narrowly lined with black or very dark brown.

Queen. Dimensions: TL c. 8.11-9.17; HL 1.87-1.96; HW 1.59-1.68; CI 84-87; SL 2.25-2.34; SI 134-144; PW 1.58-1.68; MTL 2.46-2.59 (10 measured). Apart from sexual characters, closely resembling worker except: pronotal humeri obtusely angular. Mesoscutum about as wide as long, lateral margins converging anteriorly and forming moderately rounded anterior margin; median line distinct, bifurcate dorsally; parapsides flat, only marginally raised posteriorly. In profile, anterior face of mesoscutum widely rounding onto weakly convex dorsum. Mesoscutellum raised above dorsal plane of mesosoma, strongly rounding posteriorly into distinctly impressed metanotal groove. Propodeal dorsum with lateral margins indistinct; propodeal spines somewhat flattened dorsally, about as long as distance between their bases, oblique to main axis of body; their inner margins continued medially and forming an open 'U' in anterior view. Petiole with anterior face rounding onto posteriorly elevated dorsum; spines shorter and thicker than in worker; middle spine only marginally longer than lateral pair, acute.

Males and immature stages (eggs, larvae and pupae) in QM spirit collection.

Remarks. *Polyrhachis queenslandica* bears a very close resemblance to *P. delicata*, with differences between them discussed in length under the latter species.

The distribution of *P. queenslandica* is divided between New Guinea and northern Queensland, where it overlaps with *P. delicata*. The syntypes of the synonym *P. dalili unisculpta*, collected at Wareo on Huon Peninsula, and a single worker from Kokoda, are the only known records of the species from New Guinea. In Australia it is relatively common, though somewhat less abundant than *P. delicata*, particularly towards the southern limit of its distribution. The known Australian range extends from the tip of Cape York Peninsula south to about the Paluma Range. Its nesting habits are identical to *P. delicata* (see above).

Subgenus *Polyrhachis* Fr. Smith, 1857

Polyrhachis Fr. Smith; Wheeler, 1911: 859 (as subgenus of *Polyrhachis* Fr. Smith, 1857). Type species: *Formica bilamata* Drury, 1773: 73 by subsequent designation.

Polyrhachis Fr. Smith; Emery, 1925: 181 (as subgenus of *Polyrhachis* Fr. Smith) (diagnosis).

The subgenus *Polyrhachis* was established by Wheeler (1911) to replace the 'cohors' *Polyrhachides hamatae* of Emery's (1896) older generic classification. Wheeler (1911) listed *Polyrhachis bilamata* Drury as the type species but Emery (1925) was the first to define the subgenus. Emery also subdivided *Polyrhachis* into two species-groups; the *lamellidens*-group for species with the mesosoma laterally marginate and the *bilamata*-group for species with an immarginate mesosoma. The subgenus comprises nine species, with only one (*P. bellicosa* Fr. Smith) relevant to the Australian fauna.

Diagnosis. *Worker.* Medium to large-sized ants (HL 1.50-3.00) with characteristics of the genus. Mandibles finely and densely longitudinally striate. Anterior clypeal margin arcuate; clypeus convex in profile with basal margin distinctly impressed (as in *P. bellicosa* Fr. Smith) or virtually straight with basal margin flat (as in extralimital *P. craddocki* Bingham). Sides of head in front of eyes converging towards mandibular bases in more-or-less convex line; rounding behind eyes into convex occipital border. Eyes only moderately convex, in full face view not, or only

marginally exceeding lateral cephalic outline. Median ocellus present in most species (except in *lamellidens*-group), but lateral ocelli mostly obscure or lacking. Pronotum immarginate, armed with anterolaterally projecting, gently downcurved, slender spines (as in *P. bellicosa*), or very stout spines that project outwards, with their tips curved slightly backwards and downwards (as in extralimital *P. ypsilon* Emery); or in contrast, armed with anterolaterally projecting, virtually straight, horizontal spines, with their lateral borders continued towards promesonotal suture and forming laminate pronotal margins (as in *P. craddocki* and *P. lamellidens* Fr. Smith). Mesonotum convex, bearing a pair of pyramidal, dorsoposteriorly projecting spines (as in *bilamata*-group), or with lateral margins distinctly raised dorsally, forming dorsolaterally curved flat spines (as in *lamellidens*-group). Propodeal dorsum weakly marginate, terminating posteriorly in medially directed short ridges (as in *P. bellicosa*), or immarginate, terminating in short spines (as in extralimital *P. olybria* Forel), or fully marginate, terminating in more-or-less horizontal, dorsoventrally flattened, blunt spines (as in *lamellidens*-group species). Petiole columnar, bearing a pair of hook-shaped, subparallel (e.g. *P. bellicosa*), or widely divergent (e.g. *P. ypsilon*) spines. Gaster with basal segment usually covering less than half of dorsum. Body mostly finely reticulate-punctate, gaster very finely shagreened and moderately polished, except in species with abundant gastral pubescence (e.g. *P. ypsilon* or *P. montana* Hung), or head and gaster fairly smooth and polished, with mesosoma and petiole, except tips of spines, distinctly more coarsely sculptured, opaque. Pubescence and pilosity variable between species, ranging from very sparse (as in *P. bellicosa*) to rather abundant (as in *P. ypsilon*). Generally bicoloured; head and gaster mostly black (very dark reddish-black in *lamellidens*-group species), with base of first gastral segment in some species (e.g. *P. olybria*) distinctly lighter, reddish-brown; mesosoma and petiole reddish-brown, ranging from relatively

light (e.g. *P. bellicosa*) to very dark reddish-black (as in *P. craddocki*).

Queen. Very different from the worker and as a result of their dissimilarity, *P. olybria*, originally described from two queens, was not only considered by Forel to be a different species from the associated workers, but was placed in a different subgenus (*Myrnhopla* Forel) (see Kohout 1998).

Queen distinctly larger than worker with usual characters identifying full sexuality. Spines distinctly shorter, with pronotal spines virtually straight and anterolaterally and slightly ventrally directed. Mesonotal spines absent and petiolar spines greatly reduced, short and widely diverging with their tips simply curving backwards (see Kohout 1988, figs 2A-F, 5B, D). Sculpturation similar to that in worker, except in extralimital *P. lamellidens*, where entire body is very smooth and highly polished. Generally black with parts of pronotum, petiole below stigma, dorsum of first gastral segment and appendages, light to medium reddish-brown.

Distribution and biology. The distribution of the subgenus is centered on south-east Asia, extending from Japan and China to the Philippines, Malaysia, Indochina and south throughout Indonesia to New Guinea and northern Australia. Nesting habits of species of *Polyrhachis* range from arboreal to lignicolous and terrestrial, with nests of *P. lamellidens* usually found in rotten logs (Hung 1970).

Polyrhachis bihamata species-group

Polyrhachis bellicosa Fr. Smith, 1859 (Figs 5A, D-E, 8H)

Polyrhachis bellicosus Fr. Smith, 1859: 142. Holotype worker. Type locality: INDONESIA, Aru I. (A.R. Wallace), OXUM (examined).

Polyrhachis bellicosa var. *crudelis* Emery, 1887: 238. Syntype workers. Type locality: INDONESIA, Mortly I. (= Morotai) (Gribodo), MSNG (examined). Synonymy by Hung, 1970: 5.

Polyrhachis (*Polyrhachis*) *bellicosa* Fr. Smith; Hung, 1970: 5 (in part).

Polyrhachis bellicosa Fr. Smith; Kohout, 1988a: 418.

Other material. PHILIPPINES, MINDANAO, Agusan, 10 km SE S. Francisco, 12.xi.1959 (L.W. Quate & C.M. Yoshimoto) (w); NEGROS OR., Dumaguete, 5.i.1922 (J.W. Chapman) (w). MALAYSIA, SELANGOR, Ulu Gombak Research Centre, 18.i.1986 (W.H.O. Dorow #139) (w, ♀); ditto, 8.i.1994 (C. Liefke) (w). BORNEO, BRUNEL, Belait Distr., Melilas (school yard), 20.iv.1993 (RJK acc. 93.31) (w); 1-2 km SE of Melilas Longhouse, 16.vii.1994 (RJK at al. acc. 94.123) (w). INDONESIA, SERAM I. (as Goram I.), Marzo, 1872 (L.M. D'Albertis) (w); ditto, Manusela NP, Wae Mual Plain, 25.vii-9.ix.1987 (M.J.D. Brendell, B.M. 1987-262) (w). AMBON, 11.iii.1965 (A.M.R. Wegner) (w). IRIAN JAYA, 50 km S of Manokwari, Arfak Mts Nat. Reserve, 25 m, 24.ii.1995 (G.D. Alpert) (w); Maffin Bay, 01°57'S, 138°51'E, vi-ix.1944 (E.S. Ross) (w); Nabire, S Geelwing Bay, 10-40 m, 2.x.1962 (H. Holtmann) (w). PAPUA NEW GUINEA, East Sepik Prov., Angoram, 04°04'S, 144°03'E, 10 m, 13.viii.1969 (J.L. Gressitt) (w); Dreikikir, W of Maprik, 03°34'S, 142°44'E, 350-400 m, 23.vi.1961 (J.L. & M. Gressitt) (w); West Sepik Prov., Torricelli Mts, Lumi, 400-550 m, 03°28'S, 142°02'E, 4-13.viii.1984 (RJK accs 84.243, 260, 284) (w, ♀); ditto, x.1984 (D. Waisi) (w, ♀); Pes Mission, 03°11'S, 142°15'E, <50 m, 31.vii-3.viii.1984 (RJK acc. 84.206) (w); Morobe Prov., Finschhafen, 06°34'S, 147°51'E, iv.1944 (E.S. Ross) (w)nr Wampit, 06°45'S, 146°40'E, 24. & 27.viii.1984 (RJK accs 84.345, 365, 377) (w, ♀); Lae, 06°43'S, 147°00'E, <50 m, 17.vi.1972 (RWT acc. 72.371) (w); Chimbu Prov., Keglsugl, 05°44'S, 145°04'E, 2600 m, 13.viii.1969 (J.L. Gressitt) (w); Madang Prov., Wanuma, Albert Mts, 04°36'S, 145°06'E viii.1968 (N.L.H. Kraus) (w); Northern Prov., Owen Stanley Ra., 500 m, Mamba Pltn c. 7 km WNW of Kokoda, 08°51'S, 147°41'E, 31.viii.1984 (RJK acc. 84.403) (w, ♀); Pongani R., Boikiki Pltn, c. 8 km NNE of Afore, c. 09°06'S, 148°25'E, c. 500 m, 29-30.ix.1984 (RJK acc. 84.382) (w); Mt Lamington, 08°50'S, 148°08'E (T.C. McNamara) (w); Tapini, Owen Stanley Ra., 08°21'S, 146°59'E, 1000-1100 m, 18.v.1961 (J.L. & M. Gressitt) (w); Central Prov., 25 km NE of Sogeri, Musgrave R., 09°33'S, 147°38'E, 25.x.1984 (T. Mala) (w), Varirata NP, 760 m, 5.ii.1981 (W.L. Brown) (w); Milne Bay (Province), c.10°22'S, 150°30'E, iii-iv.1944 (H.R. Roberts) (w); New Britain Prov., Gazelle Pen., Maining Mts, nr Gaulim, 04°28'S, 152°07'E, c. 150 m, 13.vii.1984 (RJK accs 84.52, 58, 59) (w); 12 km SW of Vudal Agric. College, 04°25'S, 151°57'E, c. 200 m, 15.vii.1984 (RJK acc. 84.83) (w); Kimbe Distr., Kavui Subdiv., 13.ii.1981, lowland rf. (W.L. Brown) (w); New Ireland Prov., 3 km S of Konos, 03°08'S, 151°43'E <50 m, 22.vii.1984 (RJK 84.112, 117) (w, ♀). AUSTRALIA, QUEENSLAND, Cape York Pen., Bamaga, 10°54'S, 142°23'E, 18-24.iii.1987 (RJK acc. 87.3); Iron Ra., 12°43'S, 143°18'E, 26-31.vii.1981 (RJK accs 81.138, 216) (w); ditto, 1-3.vii.1976 (*P. Filewood*)

(w); West Claudie R., Iron Ra. area, 3-10.xii.1985 (GBM & DJC) (w).

Worker. Dimensions (holotype cited first): TL c. 8.98, 7.30-8.98; HL 2.06, 1.80-2.12; HW 1.75, 1.56-1.96; CI 85, 83-97; SL (antennae missing), 2.27-2.72; SI (missing), 132-154; PW 1.03; 0.86-1.03; MTL 3.65, 3.07-3.68 (57 measured).

Mandibles with 5 teeth reducing in length towards base. Anterior clypeal margin arcuate, entire. Clypeus produced medially into short, blunt carina; convex in profile with basal margin moderately impressed. Frontal triangle distinct. Frontal carinae sinuate with margins distinctly raised at midlength, converging posteriorly; central area flat with clearly indicated frontal furrow. Sides of head in front of eyes very weakly convex; behind eyes sides widely rounding into narrow occipital margin. Eyes only moderately convex, in full face view only marginally breaking lateral cephalic outline. Ocelli present; median ocellus fully developed, lateral ocelli obscure in most specimens. Pronotum with spines long and acute, rising dorsally and turning anterolaterally with their tips gently downcurved; lateral edges of spines continued towards promesonotal suture forming ill-defined lateral pronotal margins. Mesonotum convex, bearing pair of pyramidal, dorsoposteriorly projecting spines with laterally curved tips. Metanotal groove poorly indicated. Propodeal dorsum with weak lateral margins that terminate posteriorly in medially directed, short, transverse ridges, partly separating propodeal dorsum from shallowly concave declivity. Petiolar column, armed with a pair of subparallel, hook-shaped, spines, that occur in two forms; more commonly with spines somewhat flattened and their tips weakly curved outwards, or less commonly (as in holotype), with anterior section of column distinctly swollen and spines more strongly curved posteriorly (see Kohout 1988: 418, figs 1E, F versus 1A, C). Gaster with first segment covering usually less than half of gastral dorsum.

Mandibles finely longitudinally striate with numerous piliferous pits. Head, including clypeus, finely reticulate-punctate, feebly

polished. Mesosoma and petiole generally reticulate-punctate, with pronotal dorsum and apices of spines fairly smooth and polished. Gaster very finely shagreened, moderately polished.

Mandibles with numerous, semierect, golden hairs and very short appressed hairs towards bases. Anterior clypeal margin with several longer setae medially and fringe of short setae lining margin laterally. Clypeus with a pair of longer hairs anteriorly; a few slightly longer hairs on front coxae and subpetiolar process. Gaster with several, relatively long hairs dorsally on apical segments and numerous hairs on gastral venter. Appressed to sub-erect pubescence, yellowish to golden on head and gaster and off-white on mesosoma and petiole, rather abundant over entire body, including appendages, without obscuring underlying sculpturation.

Mandibles, head, antennae, tips of spines, tibiae and tarsi black; mesosoma, petiole, coxae and femora, except their apical portions, light to medium reddish-brown. Gaster mostly black with base and lateral portions of subsequent segments blotched dark reddish-brown.

Queen. Dimensions: TL c. 9.77-10.08; HL 2.12-2.22; HW 1.56-1.66; CI 74-76; SL 2.95-3.02; SI 181-189; PW 1.41-1.51; MTL 3.93-4.03 (12 measured). Queen larger than worker with usual characters identifying full sexuality. Mandibles with 4 teeth, apical tooth almost three times longer than other teeth. Anterior clypeal margin arcuate; clypeus strongly produced medially into short, blunt carina; convex in profile. Sides of head immediately in front of eyes virtually parallel and weakly concave towards mandibular bases. Eyes relatively large, convex, in full face view clearly exceeding lateral cephalic outline. Mesoscutum about as wide as long with flat dorsum; median line distinct; parapsides rather flat anteriorly, weakly raised posteriorly. Mesoscutellum convex, moderately raised above dorsal plane of mesosoma. Pronotal spines distinctly shorter than in worker, virtually straight, anterolaterally

and slightly ventrally directed. Mesonotal spines absent. Propodeal dorsum immarginate with posterior angles terminating in upturned, medially directed transverse ridges, partly separating propodeal dorsum from oblique declivity. Petiolar spines greatly reduced, short and widely diverging with tips simply curving backwards (see Kohout 1988, figs 2A-C). Sculpturation similar to that in worker, except dorsum of mesosoma closely reticulate-punctate, opaque. Whole body black, with only mandibles, pronotal collar, lateral portions of pronotum, petiole below stigma and appendages medium to dark reddish-brown.

Males and immature stages (eggs, larvae and pupae) in JWGU and QM spirit collections.

Remarks. *Polyrhachis bellicosa* is the only member of the nominal subgenus that occurs in Australia. Its distribution extends from south-east Asia to Indonesia, New Guinea and south to Cape York Peninsula in Queensland. It is a relatively rare species towards the northern limits of its distribution (Philippines, Malaysia and Borneo), where the very similar and rather common *P. olybria* Forel is often misidentified as *P. bellicosa* (see Kohout 1998: 508-509). *Polyrhachis bellicosa* is much more common in New Guinea, where it occurs sympatrically with *P. erosispina* Emery. The relationship and differences between both species were discussed in detail by Kohout (1988a: 418-422).

The nesting habits of *P. bellicosa* appear highly diverse with collection records listing terrestrial, lignicolous and arboreal nesting sites. Two nests located at Iron Range on Cape York Peninsula were both situated about 2-4 metres above the ground and attached to tree trunks using lianas and a strong network of tendrils from other climbers for support. The nests consisted of various vegetation debris bound together by a yellowish-brown silk (Kohout 1988a, 1999; Robson & Kohout 2005, 2007).

ACKNOWLEDGEMENTS

This work has been largely supported by an Australian Biological Resources Study Research Grant. The work has also been facilitated by three Ernst Mayr Grants, and I am very grateful to the grant committee at Harvard University for their continued support of my *Polyrhachis* research. My special thanks go to Dr Chris J. Burwell (QM) for his continued support and invaluable help during preparation of this paper. Thanks to Drs Steve O. Shattuck (ANIC), Barry Bolton (BMNH), Dr Stefan P. Cover (MCZC) and Chris O'Toole (OXUM) for unlimited access to the collections in their care. A special thanks to Barry Bolton for making available a copy of his unpublished 'Catalogue of F. Smith type-material from UM, Oxford' which contains a vast amount of information regarding the *Polyrhachis* types lodged in that collection. My sincere thanks are also due to Dr Steve Shattuck for his valuable advice in helping me unravel several nomenclatural problems and for the encouragement received during the preparation of this paper. I would also like to extend my gratitude to the curators and other staff of the museums and other institutions listed in the introduction to this paper for loans of types and other material. My thanks are due to Dr Yoshiaki Hashimoto (MNHA) and Natalie Barnett (ANIC) for producing the digital images used for illustrations, and to Karin Koch and Geoff Thompson for the preparation of the distribution maps. The Environmental Protection Agency and the Department of Natural Resources in Queensland and the Northern Territory respectively, issued the necessary permits to allow collecting in National Parks, Natural Reserves and State Forests.

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Johnsprentia copemani gen. nov., sp. nov. (Haemoproteidae), a parasite of the flying-fox, *Pteropus alecto* (Pteropidae) from Queensland

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Citation: Landau, I., Chavatte, J.-M. & Beveridge, I. 2012 02 17: *Johnsprentia copemani* gen. nov., sp. nov. (Haemoproteidae), a parasite of the flying-fox, *Pteropus alecto* (Pteropidae), from Queensland. *Memoirs of the Queensland Museum – Nature* 56(1): 61-66. Brisbane. ISSN 0079-8835. Accepted: 5 March 2010.

ABSTRACT

Black flying foxes (*Pteropus alecto* Temminck, 1837) captured in Townsville, Queensland, are parasitised by a new species of Haemoproteidae which differs morphologically and in its tissue localisation, having highly distinctive gametocytes and tissue forms in the lungs, which are described here. It cannot be accommodated in any of the genera of the Haemoproteidae known from mammals and is here named *Johnsprentia copemani* gen. nov., sp. nov. □ *Haemoproteidae*, *Pteropus alecto*, *Johnsprentia copemani*, new genus, new species, Queensland.

Knowledge of the haemoproteid parasites of native Australian mammals is limited, with all those known to date being reported by O'Donoghue & Adlard (2000). Studies on flying foxes are particularly limited although one species, *Hepaticystis pteropi* (Breinl 1913), has been reported from a number of species of flying foxes (Mackerras 1959).

We had the opportunity to examine the haemoproteid parasites of several black flying foxes, *Pteropus alecto* Temminck, 1837, over a period of time in captivity. It was apparent that, depending upon the individual, one to three species of haemoproteids were present, at differing levels, in their blood. Histological examination of internal organs using serial sections also revealed three

types of schizonts which differed in their size, their morphology and their localisation.

We describe here the gametocytes and schizonts of one of these haemoproteid species. It cannot be accommodated in any of the known genera. Here we describe and name it as *Johnsprentia* gen. nov. *copemani* sp. nov. after two noted Australian parasitologists, J.F.A. Sprent and D.B. Copeman. The remaining two species will be the subject of a later paper.

MATERIALS AND METHODS

Eleven *Pteropus alecto* Temminck (1837) captured in Townsville using a mist net and exhibiting a parasitaemia with Haemoproteidae, were tran-

sported to the Muséum National d'Histoire Naturelle, Paris, shortly after their capture, arriving on the 15 December 1978 and the 07 June 1979 respectively. Blood samples from each animal were collected by pricking the radial vein and smeared onto a slide, air dried quickly, fixed with absolute methanol and stained by Giemsa stain (8% in buffer phosphate, pH7.4). They were examined over a period of several months. At autopsy, internal organs were fixed in Carnoy's fluid and serial sections of each organ were stained by the giemsa-colophonium method (Bray & Garnham 1962; Garnham 1966) and examined for tissue stages of the parasites. Type material has been deposited in the Queensland Museum, Brisbane (QM) and the Muséum National d'Histoire Naturelle (MNHN), Paris.

SYSTEMATICS

Phylum: Apicomplexa (Sporozoa)

Class: Coccidea

Order: Haemosporida

Family: Haemoproteidae

Johnsprentia gen. nov.

Definition. Haemoproteidae with elongated schizonts, in the lungs of Megachiroptera, not producing colloid, gametocytes in blood films with a nucleus apparently adherent to the margin of the parasite and with peripheral regions denser than the centre.

Type Species. *Johnsprentia copemani* sp. nov.

Etymology. Named after the late Professor John F.A. Sprent, formerly Professor of Parasitology at the University of Queensland.

Johnsprentia copemani sp. nov.

(Figs 1-2)

Material. HOLOTYPE. Histological section of schizont in lung of *Pteropus alecto* no. 409XF autopsied on 29/06/1979 in Paris (origin: Townsville, Queensland, Australia, slide deposited in QM No. G465432, illustrated in Fig. 2B). PARATYPES: a) One microgametocyte marked on a blood smear from the same bat, collected on the same date, deposited in QM No. G465433; b) a blood smear and histological sections of schizonts from the lung of *Pteropus alecto* no. 408XF and 20HD, deposited in MNHN PXX 201-208.

Etymology. Named after our colleague the late Dr. D. Bruce Copeman who helped capture flying foxes in his garden in Townsville.

Description. *Gametocytes.* Young forms or those which have just reached maturity are described from an animal (408XF) parasitised only by *Johnsprentia* (Fig. 1A-1H). This animal, on its arrival in Paris, had only ring-forms and trophozoites. It was examined daily until autopsy 21 days later. The immature parasites developed slowly and on the day of autopsy, several fully-developed gametocytes were observed. More mature gametocytes were found in other animals in which additional species of parasite were present (Fig. 1I-M). The young trophozoites are round or oval with a thin, arcuate nucleus along one side, sometimes with two unequal masses of chromatin. In young trophozoites, there are frequently fine cytoplasmic projections (Fig. 1B-D), which are absent in older forms. The cytoplasm is clear, pale-blue and with numerous poorly-defined vacuoles, some vacuoles being larger and better defined with fine grains of pigment. When the gametocyte reaches two-thirds the volume of the erythrocyte, it is spherical, clear in the centre, denser around the periphery, with the cytoplasm and most of the pigment displaced towards the periphery. The centre has scattered inconspicuous vacuoles and fine,

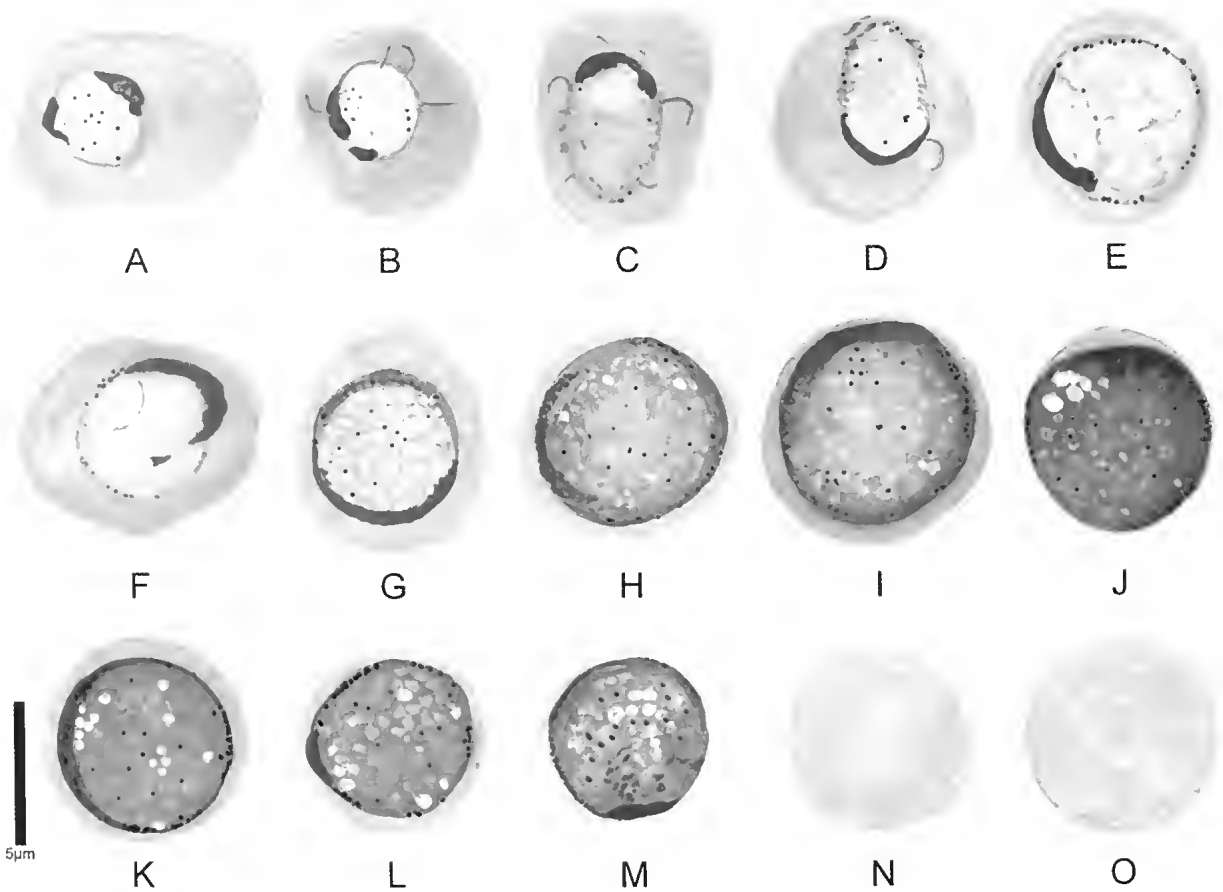


FIG. 1. Drawings of the gametocytes of *Johnsprentia copemani* sp. nov. stained with Giemsa. A, E, F, young gametocytes; B-D, young gametocytes with fine cytoplasmic prolongations; G-I, K, microgametocytes; J, old microgametocyte; L-M, macrogametocytes; N, O, normal red blood cell.

scattered grains of pigment. At this stage, it is difficult to differentiate microgametocytes and macrogametocytes (Fig. 1E-G). The fully developed microgametocytes are highly chromophilic, purple, with a dark, dense periphery (Fig. 1H, I, K). This is not due to overstaining as young forms in the same film do not stain in the same manner. As with the younger forms, small, scarcely visible vacuoles are scattered through the cytoplasm and the fine pigmentation is found mainly around the periphery. Old microgametocytes are often surrounded by a reddish ring. The nucleus is

always peripheral, forming an elongated arc around the border. The macrogametocytes (Fig. 1M, N) are generally clearer than the microgametocytes, with a smaller nucleus. The red globular surrounding layer is of normal size, rarely slightly larger, of usual colour and is always visible around the parasite.

Schizonts. The schizonts are described from bat number 408 XF (Fig. 2). They occurred exclusively in the lungs where they were numerous. They are elongate, between the alveoli, probably in endothelial cells. They are sinuous with a

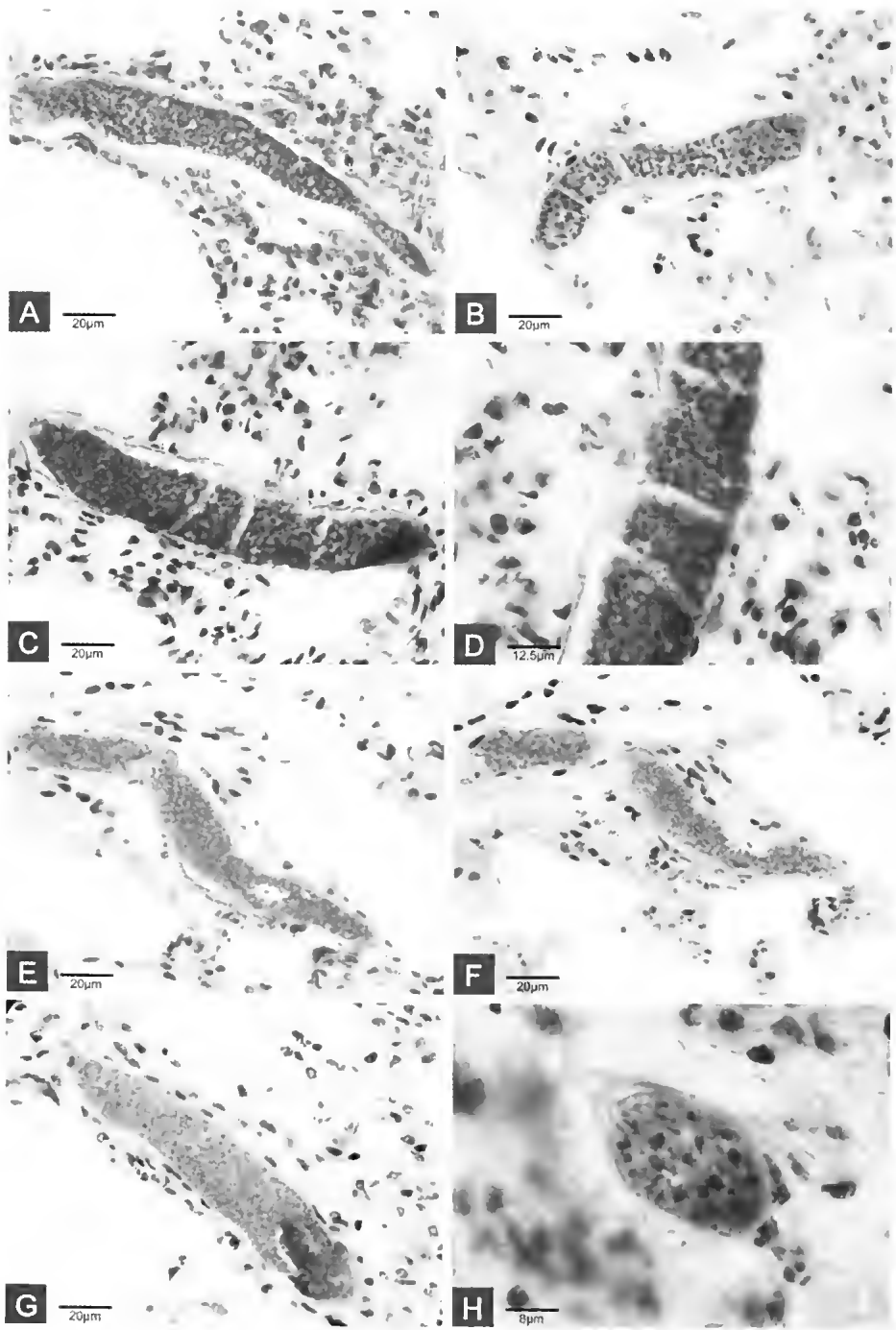


FIG 2. Photomicrographs of schizonts of *Johnsprentia copemani* sp. nov. in the lungs of *Pteropus alecto*. A-C, immature schizonts; D, detail of 'C' showing pseudosepta; E-F, immature schizont in consecutive sections showing the sinuous nature of the schizont; G, almost mature schizont with clear cytoplasm and punctiform nuclei; H, transverse section of young schizont showing large, dense, well defined nuclei.

pink border measuring 1.0-1.5 μm in thickness. Because of their sinuous form it is difficult to determine their precise size. The largest schizont in section (Fig. 2A) measured 160 μm long, 28 μm in maximum width and was seen in 14 sections 5 μm in thickness. Very young schizonts (Fig. 2H) have a dark blue cytoplasm, with large, dense chromatin masses which fragment progressively as the schizont matures. Individual nuclei are initially relatively large with dense chromatin and a well-defined outline (Fig. 2E, F). The centre of the nucleus becomes clear and pink, the chromatin forms aggregations of variable shape around the clear or pink centre. In some schizonts, pseudosepta are seen (Fig. 2B-D). A fully-developed schizont (Fig. 2G) measured 140 μm long and 26 μm wide, the cytoplasm was a clear blue, finely granular with small punctiform, uniformly distributed nuclei. There was no histomacrophagocytic reaction around the parasite. No schizonts were found in hundreds of sections of other organs of this bat (liver, spleen, kidney).

DISCUSSION

In cases of polyparasitism, such as is observed in flying foxes in Queensland, it can be difficult to link the tissue stages with the corresponding gametocytes and it is necessary to connect histological observations on the tissues with those made on the erythrocytes. In the case of the species described here, we were fortunate to be able to study one bat at the commencement of an infection with only one type of gametocyte and schizont. Their morphology was uniform and therefore we are convinced that they belong to a single species.

The distinctive features of this parasite are primarily those of the gametocyte, in which the nucleus is elongated along the periphery of the cell and part of the cytoplasm is also concentrated at the periphery where it forms a dense, chromophilic band. These characteristics

have not been reported in any other species described from *Pteropus* or any other bats, and have not been observed in other haemoproteids from mammals. In addition, the schizonts are exclusively pulmonary, elongated and devoid of colloid.

They are differentiated from the other genera of haemoproteids by the following characters: *Hepatocystis* (Laveran 1899) parasitic in numerous groups of mammals (primates, bats, Sciuridae, hippopotamus, tragulids): the classical merocysts of *Hepatocystis* develop in hepatocytes, are generally very large (can attain 2 mm in diameter in primates), frequently expand into neighbouring tissues and secrete a colloidal substance inside or around the schizont; the schizonts of *Johnsprentia* are localised in the lungs and are much smaller, are compact and elongate and do not secrete colloid.

Nycteria Garnham & Heisch (1953), parasites of micro-bats in which the schizonts localise in hepatocytes and are rounded or lobed, while those of *Johnsprentia* localise in the lungs and are elongate.

Polychromophilus Dionisi (1899), the schizonts are, (as with those of *Johnsprentia*) pulmonary, but by contrast, those of *Polychromophilus* occur equally frequently in other organs such as the kidney, spleen, liver and even the adrenals. The schizonts of *Polychromophilus* are ellipsoidal and surrounded by a thick, brightly pink capsule, their cytoplasm is poorly chromophilic and their nuclei are small, even in young forms. The schizonts of *Johnsprentia* are exclusively pulmonary, are elongated and botuliform, their host cell is poorly visible, their limiting membrane is thin, the cytoplasm of the immature stages stains intensely blue with Giemsa and their nuclei are relatively large.

Bioccala Landau *et al.* (1980), parasites of microbats. The small schizonts of *Bioccala* (Mer & Goldblum 1947; Landau *et al.* 1980) are disseminated throughout the body and do not resemble the current parasite in any way.

Biguetiella Landau *et al.* 1984, again has schizonts that are very small and intra-hepatocytic, bearing no resemblance to the current parasite.

The schizonts of *Rayella* (Dasgupta 1967), form rounded, intrahepatocytic groups, very different from the isolated, elongated pulmonary schizonts of *Johnsprentia*.

Dionisia Landau *et al.* 1980. The schizonts of *Dionisia* are rounded or oval, small in size and localise in the lumen of the hepatic vasculature, in a host cell which is hypertrophic and surrounded by a thick capsule. The schizonts of *Johnsprentia* do not possess any of these characters.

In fact, the most similar schizonts morphologically are those of *Parahaemoproteus* of birds, such as those described from the musculature of *Psittacula roseata* in Thailand, and which are transmitted by *Culicoides* (Miltgen *et al.* 1981). Although larger, as they can attain a size of 900 µm, they are similar to those of *Pteropus* in being elongated, botuliform, highly chromophilic, with pseudosepta, have a thin outer membrane and their host cell is scarcely visible. There is, in neither species, an accumulation of macrophages prior to the rupture of the schizont.

The obvious similarity between the schizonts of *Johnsprentia* and those of *Parahaemoproteus desseri* could indicate a close relationship, one parasitic in mammals, the other in birds. Such a phenomenon is possible since we know that, in the case of the haemosporidians, the ancestral host is an invertebrate, probably *Culicoides* in this case, and not the vertebrate host. However, this hypothesis is unlikely as the morphology of the gametocytes is of greater phylogenetic value than that of the schizonts, which, in this case, suggests that the two taxa are quite different phylogenetically.

ACKNOWLEDGEMENTS

Animals were collected and exported with appropriate State and Federal collection and export permits.

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A summary of Marine Turtle records for Norfolk Island

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Citation: Pendoley, K. & Christian, M. 2012 02 17: A summary of Marine Turtle records for Norfolk Island. *Memoirs of the Queensland Museum – Nature* 56(1): 67-79. Brisbane. ISSN 0079-8835. Accepted: 13 May 2011.

ABSTRACT

Nothing has been published in the modern literature on the status of marine turtles at Norfolk Island although their presence has been recognised since 1793 (Fidlon & Ryan 1980). This study brings together all the available published, anecdotal and field survey data on marine turtles at Norfolk Island so that the status of habitat usage could be established. The results confirm the Norfolk Island group is used for foraging by resident adult and juvenile *Chelonia mydas* (Green) turtles and adult *Eretmochelys imbricata* (Hawksbill) turtles. The natal beaches for these resident animals are thought to be Melanesian and Polynesian islands to the north and the beaches of north eastern Australia. While juvenile hawksbill turtles have not been recorded foraging at Norfolk Island they are the most common species and age class recorded in the island's strandings data. The confirmation of marine turtles at Norfolk means that any future development proposals must include assessment of project impacts on these listed threatened species under Australian Federal legislation and their marine bioregional processes. □ *green, hawksbill, loggerhead, nesting, foraging, stranding, turtle.*

Norfolk Island and its two smaller satellite islands, Nepean and Phillip lie on the Norfolk Ridge which joins New Zealand to New Caledonia (Figure 1). It is 1126 kilometres north west of Auckland (New Zealand) and 1450 kilometres east of Brisbane (Australia). The island group (referred to jointly as Norfolk unless otherwise stated) is located atop a 100 km long plateau and the larger two are the remnants of recent volcanic activity (Jones & McDougall 1973). Nepean is younger, composed entirely of calcarenite and formed when coral reefs were exposed during the last Ice Age. The coastlines of all three are characterised by tall sheer cliffs that drop straight into the ocean and sandy beach development is absent, poorly developed or restricted amongst the group (Fig. 2). Norfolk

Island, the largest and most accessible was selected for the first (European) settlement in 1788 and it is from this period that the first reports of marine turtles were made by Philip Gidley King. Nothing has been published on the status of marine turtles at Norfolk Island since that time.

OCEANOGRAPHY AND CLIMATE

The fine scale oceanography of the Norfolk area is complex and poorly understood. Regionally, the anticlockwise South Equatorial Current (SEC) carries tropical water from the Coral Sea west towards Australia (Fig. 3) before turning into the East Australian Current (EAC). The current generates large ocean eddies up to 200 km across

TABLE 1. Historical record extracts pertaining to marine turtle observations from Norfolk Island, 1788 – 1790, (Hunter 1793, except where noted) *Modern name is Emily Bay.

Observation date	Observation place	Historical record extract
4/3/1788	Anson Bay	Supply Quarter Master drowned attempting to capture a turtle (Clark 1791)
9/3/1788	Turtle Bay*	'Turned 2 on beach, weighed 200 weight each' (this equals about 224 lbs or 89kg), recorded 'a great number of turtle swimming about'
14/3/1788	Turtle Bay	'I turned 3 more turtle brought to settlement. Generally saw 3 lying on the beach at low water, in clear weather but when cloudy they never land.' (Fidlon and Ryan, 1980)
5/4/1788	Turtle Bay	'Several turtle has been seen in the bay but none came onshore.'
6/4/1788	Turtle Bay	'4 turtle seen in bay but none came onshore'
9/4/1788	Turtle Bay	'1 turtle onshore but did not disturb it.'
8/5/1788	Turtle Bay	'Not seen turtles for some time, the cold weather has probably driven then to a warmer climate.'
2/9/1788	Turtle Bay	'A turtle seen on the beach but soon went off without being disturbed.'
3/9/1788	Turtle Bay	'A turtle staid 2 or 3 hours on the beach today'
4/9/1788	Turtle Bay	'A turtle turned today had his (sic) back pierced thro as if done by a peg.'
15/9/1788	Turtle Bay	'3 turtle on beach'
16/9/1788	Turtle Bay	'1 turtle on beach'
16/10/1788	Turtle Bay	'I turned a turtle which weighed 200 lbs'
30/10/1788	Turtle Bay	'Turned a turtle of ~ 160lb'
13/11/1789	Cresswell Bay	'Turtle turned in Cresswell Bay'
24/3/1790		King left Norfolk Island on this date
14/7/1791	Duncombe Bay	'2 marine went to Duncombe Bay fishing and returned with a turtle ~ 200 weight' (Clark 1791)

that rotate anticlockwise as they move eastward. An arm of this eastward flow, the Tasman Front, carries EAC waters past Lord Howe and into the Norfolk Island province (DEWHA 2007b). (It is strongest in summer (peaking in February), reaching speeds of 5 knots, and is weakest in winter. It is confined to the top 500 m of the water column and is 100 km wide. The position and strength of the current is highly variable from season-to-season and year-to-year (Nilson & Cresswell 1981; Ridgeway & Dunn 2003; Williams *et al.* 2006b; Ridgeway & Hill 2009). As a consequence warm currents may approach the island from the north or east for half a year and from the west or south the rest of the year while in other years the flow is from the west or south all year (Cresswell 1989).

The surrounding sea strongly influences temperatures at Norfolk Island. Annual air temperatures range from 18°C to 23°C (BOM 2011). Sea water temperatures vary with the location and direction of the regional currents, ranging from 18°C to 26°C (Darren Bates pers. comm.)

BIOLOGY

The composition of marine flora and fauna at Norfolk is representative of the species found along the eastern coast of Australia and in the tropical seas to the north and east reflecting the sources of the major regional currents that flow past the island group. Marine flora and fauna of Norfolk have been poorly studied and no systematic mapping of habitats has been

Marine Turtle records on Norfolk Island



FIG. 1. Melanesian, Micronesian and Polynesian Island groups located north of Norfolk Island.

conducted. The published studies to date suggest the island supports a diverse mix of tropical and temperate species; a rich marine benthic algae assemblage comprising 236 species (Millar 1999); abundant and locally luxuriant assemblages of hermatypic corals (39 species) both inside the Kingston lagoon and elsewhere around the island group (Brook 1990), 254 coastal tropical and subtropical fish species (Francis 1993) and 60 tropical and temperate echinoderms (Hoggett & Rowe 1988; O'Hara 2008). Local fisherman also report patches of seagrass are present off the north west coast of Norfolk.

Bioregional Planning by the Commonwealth Government includes the Norfolk Island Province in their East Marine Region (EMR) and noted the island was one of a limited number of temperate isolated oceanic islands worldwide, supported some of the most southerly coral reefs in the world and was unique within the EMR in that the demersal assemblages were more closely related to New Caledonia than with eastern Australia. The planning process compiled all available information to describe ecosystems

and ecosystem function for the region. Marine turtles were not identified for the Norfolk Island Province during this process (Brewer *et al.* 2007, DEWHA 2007a; DEWHA 2007b).

Recent marine development proposals for Norfolk Island have triggered the *Environmental Protection and Biodiversity Conservation Act 1999*, which protects among other values, threatened and migratory species such as marine turtles. This study seeks to formally recognise the presence of marine turtles at Norfolk Island and provides a preliminary review of the species present and their distribution around the Norfolk Island region.

METHODS

The information sources consulted during the preparation of this review included: the historical and modern literature; the Norfolk Island Parks and Wildlife marine turtle stranding file notes; local resident wildlife biologist field notes (M. Christian); local divers, fishermen, surfers and cliff top residents. Additional data was collected during an ultra-light aerial survey of near shore

Pendoley & Christian

TABLE 2. Current records of reported marine turtle sightings at Norfolk Island, * aerial survey by ultra-light aircraft.

Observation date	Observation place	Size	Species	Reference/observer	Notes
Regularly	Phillip Island	Adult	? Green	Honey McCoy	Long time resident and natural historian, specialising in Phillip Island
Regularly	All around Norfolk	Adult and juveniles	Green	Jack Marges	Long term resident and dive operator. Believes all turtles he has seen around Norfolk are green turtles. See turtles out to 30m deep (limit of his diving range). Frequently see adult and juvenile (dinner plate) sized animals.
Regularly	Ball Bay	Adult and juvenile	? Green	David Biggs	Mooring master for oil and gas tankers in Ball Bay, has noted turtles every time he moors a ship, this occurs ~ once a month year round.
Regularly	Ball Bay	Adult and juvenile	? Green	Tony Cook	Cliff top resident. Generally sees 4-5 turtles in the south side of the Bay around noon. Not seen as regularly since temporary jetty groynes were constructed, and later removed, from Ball Bay (2005/2006)
Regularly	Simons Water	?	? Green	Arthur Evans	Frequently observes turtles from the cliffs at Simons Water.
Regularly	Kingston	Adult	? Green	Steve Ryves	A keen wind surfer
Regularly	Bumboras	Adult	? Green	Steve Ryves	A keen wind surfer
Regularly	The Cord	Adult	Green	Byron Adams,	K Pendoley observed 3 through binoculars on 21 Oct 2004, confirmed species
26/02/2001	Ball Bay	Adult	Green	Karlene Davies,	Diver, species confirmed from photo by K Pendoley
16/01/2006	Nepean Island	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Cemetery Bay	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Bumboras	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Kingston jetty	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
24/01/2006	Phillip Island	Adult	Green	K Pendoley	Observed through binoculars from top of tall cliff, size and shape indicated green
25/01/2006	Anson Bay	Adult	Green	K Pendoley	Observed through binoculars from top of tall cliff, size and shape indicated green
20/03/2006	Hundred Acres	Adult	Green male	Robert Ryan	This turtle is seen at this location regularly, photographed head
1/07/2007	Duncombe Bay	Adult	Hawksbill	Rob Morely	Diver, the image includes endemic Norfolk Island Big Eye fish
29/09/2008	Phillip Island	?	?	Jarrold Evans	Diver and science teacher
8/10/2008	Duncombe Bay	Adult	Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
8/10/2008	Duncombe Bay	Adult	Green	Jarrold Evans	Diver and science teacher, underwater image
14/01/2009	Duncombe Bay	Adult	Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
26/01/2009	Anson Bay	Adult	? Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
1/02/2009	Nepean Island	Adult	?	Jarrold Evans	Diver and science teacher, underwater image

Marine Turtle records on Norfolk Island

TABLE 2. continued ...

Observation date	Observation place	Size	Species	Reference/observer	Notes
21/07/2009	Cascade Bay	Immature	Green	Kellie Pendoley	turtle comes into jetty with sharks when fish cleaning underway
23/07/2009	Bird / Cathedral Rock area	Adult	Green	Kellie Pendoley	seamen see turtles here regularly
9/01/2010	Anson Point North	Immature	Green	Kellie Pendoley	partial circumnavigation of the island by boat (weather restricted)
9/01/2010	Jacobs Rock	Immature	Green	Kellie Pendoley	partial circumnavigation of the island by boat (weather restricted)
9/04/2010	Kingston Bay	Adult	Green	Jarrod Evans	Diver and science teacher, Swiss Cheese area
9/09/2007	Kingston Bay	Juvenile	?	Arthur Evans Ken Christian	Both described a small (~15cm long) turtle with spines at the joints of the scales along the back, light brown colour.

waters of Norfolk and Nepean Islands (16 January 2006), and two boat based surveys circumnavigating Norfolk Island, Phillip and Nepean Islands (23 July 2009 and 9 January 2010).

RESULTS

Historical records

Prehistory studies of Norfolk Island Polynesian settlements have found scant evidence of marine turtle remains in the Emily Bay sites examined, being restricted to pieces of carapace (Smith *et al.* 2001). Hoare (1999) has suggested early visitors would have found food sources in turtles and turtle eggs, however, there is no supporting evidence from the historical literature to indicate turtles nested (i.e. laid eggs) at Norfolk Island.

The earliest records relating to marine turtle sightings were made by Philip Gidley King (Fidlon & Ryan 1980) during the first attempts to establish a settlement on Norfolk Island (Table 1). King arrived at Norfolk Island on 1 March 1788. His personal journal, which contains detailed records of the amount of fish and turtles collected during his occupation of the island, first reported

turtles at Norfolk Island on 3 March 1788 when a Supply Quarter Master was drowned trying to catch a turtle. Four days later turtles were found basking on the shores of what was named 'Turtle Bay' (the modern name for the bay is Emily Bay).

King immediately recognised the value of the turtles found basking in Turtle Bay and banned anyone from going near the beach and frightening them. Numerous turtles were seen swimming in the bay in March that year and King's journal entry for 14 March 1788 notes that every day at low water they saw "...three or four turtles lying on ye (*sic*) beach asleep in ye (*sic*) sun, but when it is cloudy they never land...", and "...this, together with there being no appearance of any pits where they lay their eggs, leads me to suppose that they do not breed on any part of the island; especially as this is the only place where there is a possibility of them to make their pits." (Fidlon & Ryan 1980).

Between April 9 and 1 September 1788 (austral winter) no records of turtle observations were recorded by King and he comments that this may have been due to the cold weather driving them to a warmer climate. Reference is not made to turtles again until the following spring when turtles were observed between September and November

1788. King remained on Norfolk until 24 March 1790, however, no further mention of turtle was made in his journals.

The final historical record of marine turtles at Norfolk Island was documented by Lt Ralph Clark when two marines fishing at Duncombe Bay captured a turtle. This record was from mid winter, July 1791, suggesting the animal was captured while it was foraging (Fidlon & Ryan 1981).

Sightings

Modern day confirmed sightings of live turtles around Norfolk Island are most commonly of *Chelonia mydas* (green) and *Eretmochelys imbricata* (hawksbill) turtles (Table 2). Green turtle sightings are spread around the entire coast of Norfolk Island and are seen year round. Both adult and juvenile turtles are observed around the island.

The photographic hawksbill records supplied by J. Evans confirm that more than one adult hawksbill is present at Norfolk and that this species is present in both summer and winter (January, July and October).

The description given for the juvenile turtle observed off the Kingston jetty on 9/9/2007 suggests this may have been a very young *Caretta caretta* (loggerhead). The witnesses description of a small (~15 cm long) turtle with spines at the joints of the scales along the back and a alight brown coloration is strongly suggestive of a young loggerhead turtle (Table 2).

Strandings

Table 3 lists the stranding data for Norfolk Island. This data comes from a wide range of sources including the turtle file held by the Norfolk Island National Parks and Wildlife office, The Norfolk Islander newspaper and private individuals holding skeletal, tissue, or photographic material. All sources have been listed in Table 3 and where the species is listed it has been confirmed by Margaret Christian, Dr Bryan Gartrell DVM and/or Dr

Kellie Pendoley. Age class was determined from carapace measurements and or photographs.

Of the 15 strandings records, 7 were green turtles, 6 were hawksbill turtles and 2 were unknown. Only one was a mature animal (NI006), the rest were immature green or hawksbill turtles. The size of the single 'hatchling' record cannot be confirmed due to the loss of the specimen (NI005, Table 3) and it is possible that this specimen was a post-hatchling. Strandings were most frequent in Ball Bay (n=9) followed by Slaughter Bay (n=3).

A juvenile green turtle tagged in a hatchery in Tahiti is the only tagged individual that has been found at Norfolk Island (NI004, Table 3). This turtle was released from Scilly Atoll on 1 October 1993 and found at Norfolk Island, 4480 km south west 17 months later on 4 March 1995. At the time of tagging it measured 44 cm curved carapace length (CCL), at recapture on Norfolk Island it was measured at 60 cm CCL. The tag was supplied by the University of Hawaii, No. P782

DISCUSSION

The basking behaviour of the green turtles described by King has also been documented in the historical literature from New Caledonia, Hawaii and the Galapagos Islands, however, the available literature suggests that Hawaii and Shoalwater Bay in Queensland are the only locations where this behaviour is still observed (Balazs 1980; Balazs & Ellis 2000; Pritchard 1982). Basking green turtles in Hawaii include both male and female animals, year round with a seasonal peak in summer (Balazs 1980; Whittow & Balazs 1982; Balazs & Ellis 2000). The basking turtles in Shoalwater Bay in New South Wales, Australia, are all green turtles that range in size from small immature to adult sized animals and are typically found basking on seagrass beds and intertidal platforms after the tide recedes. The year round presence of these animals suggests they are resident foraging animals (Limpus *et al.* 2005).

Marine Turtle records on Norfolk Island

TABLE 3. Records of marine turtle stranding at Norfolk Island since 1990.

Specimen code	Specimen collection date	Place	Condition	Age class & Species	Measurements (cm)	Notes
NI001	22/11/90	Slaughter Bay	alive	immature Green	55 SCL -	Tangled in net. Animal in good condition, flesh wounds from net.
NI002	16/11/92	Slaughter Bay, inside reef	Alive,	?	43 SCL 42.5 SCW	Exhausted and bleeding from cloaca, deep scoring on carapace
NI003	22/9/93	Ball Bay	Dead	Immature Green	50 SCL -	
NI004	4/3/95	The Cord, Duncombe Bay	Alive	Immature Green	60 SCL -	Tagged turtle. Collected as a hatchling from Scilly Atoll north of Bora Bora and head started in Tahiti. Tagged 1 Oct 1993, U of Hawaii tag, number P782.
NI005	Mid 1990s	Ball Bay	Dead	Hatchling/ Post-hatchling species unknown	- -	Dead and desiccated, washed ashore inside a plastic ice cream container. Specimen eaten by pet dog.
NI006	~1995	Anson Bay	Freshly dead	Mature green	140 SCL over flattened carapace	Turtle was dug up from a terrestrial location, measurements made of the flattened carapace. Species confirmed from skull. Animal found well above the high tide line following a severe storm.
NI007	12/8/03	Ball Bay	Freshly dead	Immature green	78 CCL. 73.5 CCW	No visible damage
NI008	March 2005	Ball Bay		Immature Hawksbill	36.25 CCL 33.75 CCW	Smaller of the two specimens held on Norfolk
NI009	19/4/05	Ball Bay	Decomposing (wet)	Immature hawksbill	- -	Old damage noted on edge of carapace. Buried. Skeletal material held on Norfolk Is.
NI010	June 2005	Ball Bay	Freshly dead	Immature hawksbill	- -	
NI011	November 2005	Ball Bay	Freshly dead	Immature hawksbill	- -	Turtle seen swimming in waves at Ball Bay a few days earlier. Check by Dr Bryan Gartrell DVM indicated the animal was dehydrated and lacked vigour. It was covered in algae. No obvious signs of injury, no entanglements.
NI012	November 2009	Ball Bay	Alive	Immature hawksbill	- -	Found alive, removed 4 small blue crabs from skin folds between carapace and rear flippers, released at Kingston.
NI013	24/8/2009	Point Hunter	Dead and rotting	Adult green	44CCL 45CCW	Washed ashore on rocks, crushed skull
NI014	19/10/2008	Slaughter Bay	Alive	Immature green	- -	Vet treated with antibiotic and vitamin shots, animal gone from beach next day
NI015	19/6/2010	Ball Bay	Dead	Immature hawksbill	- -	Half of head missing

While basking behaviour at Norfolk Island was only observed during the warmer summer months, it was not related to nesting activity. King was familiar with the ecological requirements for turtle nesting (i.e. warm temperatures and adequate sand depth) stating in his journal “We generally saw three [adults] lying on the beach on low water in clear weather, but when cloudy, they never land; this, together with there being no appearance of any pits where they lay their eggs,



FIG. 2. Map of Norfolk Island showing sand beaches, coastal features and names

leads me to suppose that they do not breed on any part of the island, especially as this is the only place where there is a possibility for them to make their pits" (Fidlon & Ryan 1980). The basking turtles documented by King were therefore likely to be from a non breeding resident population, similar to those documented by Balazs (1980) from the French Frigate Shoals in Hawaii.

The historical records further suggest that the basking population was small, with only a few turtles ever observed at one time. This is consistent with the results from prehistoric archaeological surveys at Norfolk Island which found a low abundance of turtle bones from a prehistoric Polynesian settlement on the island (Smith *et al.* 2001). King does not refer to turtles after the first year of occupation and it is possible the basking

turtles that were not killed were driven away by the presence of the humans.

Potential nesting habitat within the group of islands is limited to 6 small (50 m - 350 m long) beaches on Norfolk Island. The most stable deep sand beaches occurring on the cooler, south (Slaughter and Emily Bay) and east (Cemetery Bay), coasts of the island while the sand at Anson Bay and along the Bumboras coast is very shallow (<0.5 m deep) and dynamic.

Preliminary sand temperature studies carried out during February and March 2006 found sand temperatures were not significantly different (t -test $p < 0.05$) between beaches, mean $25.12^{\circ}\text{C} \pm 0.98^{\circ}\text{C}$ (range 21.5°C to 26.5°C). While recognising the limitations on the amount of data, the sand temperatures at Norfolk fall at and below the 26°C - 33°C range required for successful

Marine Turtle records on Norfolk Island

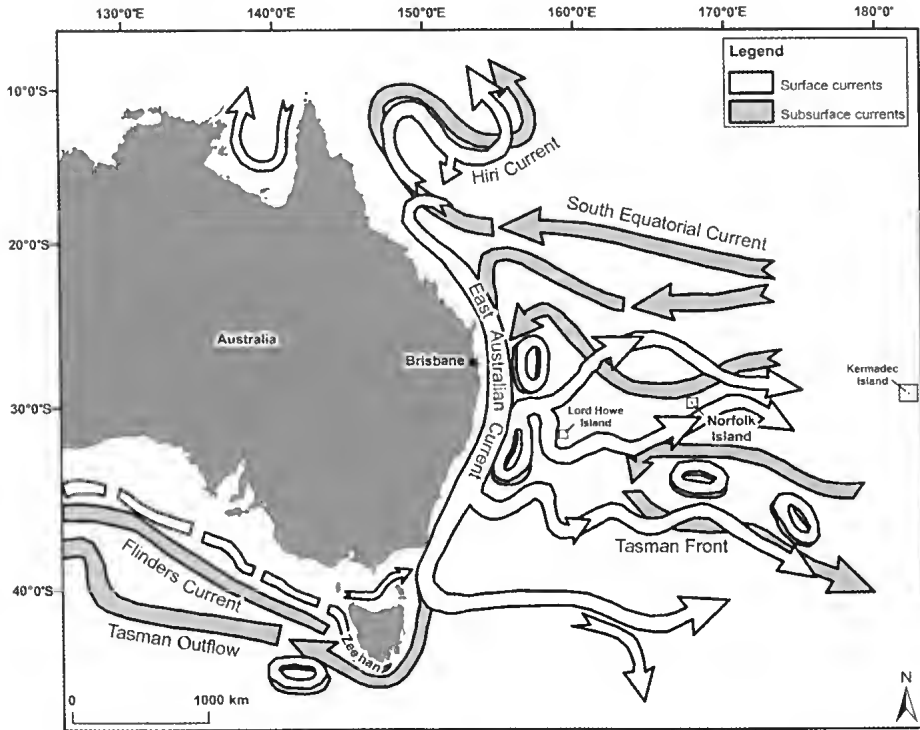


FIG. 3. Schematic of the main ocean currents off eastern Australia (source: Ridgeway & Hill, 2009)

egg incubation (Miller *et al.* 2003; Miller 1982; Miller 1985; Miller & Limpus 1981). Taken together with the lack of any historical or modern day evidence (document or anecdotal) of eggs, nesting attempts or live hatchling recorded at Norfolk it is reasonable to conclude Norfolk is not an active rookery.

The regular observations of live healthy juvenile and adult green turtles and adult hawksbill turtles in Norfolk coastal waters strongly suggests that these species and age classes are resident at the island. The presence of algae (Millar 1999) and coral patch reefs (Francis 1993) provide the necessary (algae) foraging habitat for the resident green turtles (Limpus 1978, Garnett & Murray 1980) and reef species (algae, ascidians, sponges, bryozoans and molluscs) for the hawksbill turtles (Limpus 1978, 1979). To date there have been no confirmed

in-water records of juvenile hawksbill turtles; every record has been of dead, dying or weak animals stranded in Ball Bay. The presence of resident adult hawksbill turtles at Norfolk implies that sub-adults should also be present in the resident population and are likely to be confirmed as the marine fauna of Norfolk are more fully studied.

Regionally Norfolk Island, together with Lord Howe Island, probably represents the southern boundary of foraging range for green and hawksbill turtles. While no published information is available for Lord Howe, Hunter (1793) reported abundant turtles (probably green turtles) at the island; modern tour operators report green and Hawks Bill (sic) turtles at the island (Marine Adventures, Lord Howe Island, 2011). Both species have been recorded from New Zealand as strandings, carried south on seasonally variable flows from the EAC (McCann 1966; Gill 1997).

Hirth (1993) and Pritchard (1982) note that green turtles are seen in the ocean around New Zealand and the Kermadec Islands, however, their resident status (i.e. foraging or single individuals carried there on seasonal currents) was not reported.

Nesting and foraging habitats for both green and hawksbill turtles occur off north Eastern Australia and throughout the islands and waters of the Coral Sea regions encompassing Micronesia, Melanesia and Polynesia (Figure 2) situated in a wide band of ocean to the north of Norfolk Island (Limpus 2008; Trevor 2010). Compiled data on tagged turtle nesting foraging and migration in the regions show that breeding and juvenile green and hawksbill turtles display a general westward movement through the area (Trevor 2010), which is consistent with the direction of the South Equatorial Current (SEC). Depending on the strength and location of the SEC and the EAC and its associated arms, eddies and convergent zones it is reasonable to expect turtles would be carried out of the Coral Sea area to Norfolk Island. The size of the resident foraging population is likely a function of both the probability of animals actually reaching the island and the carrying capacity of the food resources.

The regularity with which juvenile hawksbill turtles strand in Ball Bay is noteworthy. The cause for these strandings is not known and in the absence of systematic marine turtle population data, reliable habitat mapping and local oceanographic modelling it is not possible to determine if these animals are from the resident foraging population or if they have been brought into the island by the spatially and temporally variable oceanic currents.

Both green and hawksbill turtles are protected under the EPBC Act and any proposal that has the potential to cause a significant impact on the populations or their critical developmental habitats must be referred to the Commonwealth Government. The knowledge provided by this study confirms the presence of these animals in Commonwealth waters around Norfolk Island and consequently any future environmental

impact assessments must consider the potential impacts of a proposal on marine turtles as part of the EPBC referral process.

CONCLUSIONS

This study comprises the first published report of resident foraging green and hawksbill turtles within the Norfolk Island group. Confirmed regular sightings of adult and juvenile green turtles and of adult hawksbill turtles at the island, in addition to the published records confirming the presence of food sources that are used by these species, support this conclusion. Until proven otherwise, we conclude that the lack of confirmed foraging records from more southerly waters around New Zealand or the Kermadec Islands suggest that Norfolk Island, along with Lord Howe Island, currently represent the southernmost recognised foraging habitat for green and hawksbill turtles in the south western Pacific region. The study results confirm that green and hawksbill turtles can live year round in waters that fall to a minimum of 18°C.

While the historical records report basking by green turtles at Norfolk, Balazs (1980) has shown that the presence of basking turtles does not automatically imply a beach is a rookery, and from this evidence, together with the restricted nesting sand area, shallow sand depths, cool sand temperatures and the lack of any evidence of eggs or nests either in the historical literature or modern day observations we conclude that Norfolk Island is not now, and has not been, a marine turtle rookery within the recorded history of this area. Furthermore the paucity of turtle remains in the island's Polynesian middens suggests that during the era of Polynesian visitation (>800 years BP) turtles were not a readily available food source. We recognise however that global warming could provide suitably warm enough beaches for turtle nesting to be successful in the future.

The natal rookeries for the resident green and hawksbill turtles have been inferred from large scale regional current movements and are

likely to include rookeries in the north eastern Australia, Melanesia and Polynesia regions. We believe hatchlings arriving at Norfolk Island from these rookeries are carried westward on the SEC before travelling south and east on the EAC and its associated eddies and currents.

The primary implication arising from this study confirming the presence of resident turtles foraging at Norfolk Island will be for future development proposals in Commonwealth waters around the Norfolk Island region. As listed and migratory species, the presence of marine turtles will trigger the EPBC Act and any proposed action must address the potential for impact on these species. Furthermore this information addresses a significant gap in the knowledge on marine turtles within the Commonwealth Government's East Marine Region Bioregional Plan.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable comments and feedback of our reviewers; Dr Kirstin Dobbs, Dr Colin Limpus, one anonymous reviewer and Paul Whittock for his comments and assistance with the figures. On Norfolk Island; Mr Les Q. Brown gave the authors access to his library of historical documents, Dr Bryan Gartrell DMV volunteered his time to do necropsies, and we are grateful to all the island residents who have taken the time and effort to report turtle strandings and sightings over the years.

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Two new genera of myrmecomorph longicorn beetles from Australia and New Caledonia (Insecta: Coleoptera, Cerambycidae)

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Vives, E. 2012 02 17: Two new genera of myrmecomorph longicorn beetles from Australia and New Caledonia (Insecta: Coleoptera: Cerambycidae). *Memoirs of the Queensland Museum – Nature* 56(1): 79-84. Brisbane. ISSN 0079-8835. Accepted: 25 August 2011.

ABSTRACT

Two new genera and species of myrmecomorph Cerambycidae are described. *Myrmeciocephalus monteithi* gen. et sp. nov. (Cerambycinae: Ametrocephalini) comes from mountains of north Queensland, where it apparently associates with the ant, *Myrmecia flavicoma minuscula* Forel, 1915. All members of this tribe are ant mimics. *Myrmeparmena sudrei* gen. et sp. nov., (Lamiinae: Parmenini) is from the Isle of Pines, New Caledonia, and is provisionally placed in the tribe Parmenini. For this species we lack any information relative to the formicids with which it may coexist. □ *Coleoptera, Cerambycidae, Cerambycinae, Myrmeciocephalus gen. nov., monteithi sp. nov., Australia, Myrmeparmena gen. nov. sudrei sp. nov., New Caledonia.*

Ant mimicry (myrmecomorphy) in Australian and New Caledonian cerambycids is not rare. Indeed, this is a characteristic trait of Cerambycidae in the austral fauna, and it is absent in other biogeographical regions or represented in only very few genera. These are *Pseudomyrmecion* Bedel, 1885 in the Palaearctic region, *Myrmecoclytus* Fairmaire, 1895 in the Ethiopian region, *Tinkhamia* Gressitt, 1937, *Iphra* Pascoe, 1866 and *Clytellus* Westwood, 1853 in the Oriental region, *Euderces* LeConte, 1850 in the Nearctic region, and *Arawakia* Villiers, 1981, *Pseudocephalus* Newman, 1842 and *Tillomorpha* Blanchard, 1851 in the Neotropical region.

In this work, two new myrmecomorph genera of Cerambycidae are described. The first comes from the mountainous Carbine Tableland of north Queensland, where it apparently lives together with the large, aggressive ant, *Myrmecia flavicoma minuscula* Forel, 1915. This new genus falls within the subfamily Cerambycinae, among the genera of Ametrocephalini, all of them myrmecophilous. The second new genus is based on

a new species found on the Isle of Pines, in New Caledonia, belonging to the Lamiinae and provisionally to the tribe Parmenini; for this species we lack any information relative to the ants with which it may coexist.

MATERIAL AND METHODS

In 2000 we started to review the Cerambycidae of New Caledonia and some of the most important collections which include Australian and New Caledonian fauna have been studied so far. These include the Australian Museum (Sydney, AMS), the Natural History Museum (London, NHM), the Museum National d'Histoire Naturelle (Paris, MNHN), the Bishop B. Museum (Honolulu, BMH), the Museum of Natural History (Osaka, MNH), the Institute Royal d'Histoire Naturelle (Bruxelles, IRHNB) and the collection at the Centre de Biologie et de Gestion des Populations (Montpellier, CBGP).

We also studied much material loaned by our colleagues Dr Geoff B. Monteith, from the

Queensland Museum, Brisbane (QM), and M. Jérôme Sudre (Faramaz, France), and it is from these sources we identified the two new myrmecomorphic genera and species described below.

SYSTEMATICS

Family Cerambycidae

Subfamily Cerambycinae

Tribe Ametrocephalini Lacordaire, 1869

Ametrocephalides Lacordaire, 1869: 420

Pseudocephalini Aurivillius, 1912: 154

Myrmeciocephalus gen. nov.

Type species. *Myrmeciocephalus monteithi* sp. nov.

Head large, rounded, slightly projecting anteriorly, with arched epistome and trapezoidal labrum with long setae at sides. Mandibles short and thick, with inner margin almost straight and bent apex; external margin arched, with broad flattened and pubescent margin. Maxillary palpi short; fourth segment securiform. Eyes small, globose, finely-faceted, without lateral notch for antennal insertion. Antennal tubercles almost flat, with small inner tooth. Small furrow between base of mandibles and eye margin able to receive antennal scape. Head posteriorly broadly rounded and very convex; temples pubescent, convex and regularly arched; neck narrow, cylindrical, weakly transversely striated. Head above furrowed longitudinally. Antennae long and slender with segments cylindrical, long and parallel-sided, except for scape, slightly arched and broadened apically.

Pronotum narrower than head, clearly longer than wide (8/6.6), with anterior margin forming narrowed pronotal neck articulating with cephalic neck; posterior margin narrowed, transversely furrowed; surface entirely finely rugose with some sparse long brownish setae. Prosternum flattened, decliving towards coxae; prosternal process very narrow and short, slightly widened at margined apex; procoxal cavities open behind.

Procoxae large, conical, strongly protruding. Prothoracic longitudinal axis strongly sinuate as in all *Ametrocephalini*. Mesonotum smooth and shiny, with scutellum short, rounded. Metasternum short, granulose, with coxal cavities open at both sides.

Elytra long, subparallel in anterior half, and strongly widened in apical half as a rounded, globose apical area; humeri rounded, weakly protruding; disc flattened, strongly punctured, with broad oblique, rather smooth, stripe on basal third; hind globose part smooth, shiny, with short yellowish spot at sides on postmedian region, and apex rounded, dehiscent, covered by dense golden pilosity. Hindwings present, but strongly reduced.

First visible segment of abdomen twice as long as wide, waist-narrowed; remaining segments short and wide, covered by short grey tomentum. Legs long and slender, with anterior femora enlarged medially; median and hind femora broad and straight; tibiae long, narrow, straight, covered by sparse long golden setae; tarsi long and thin, with first segment much longer than remaining together.

Myrmeciocephalus monteithi sp. nov.

(Figs.1 B-D)

MATERIAL. HOLOTYPE ♀ : Australia: Pauls Luck, Platypus Creek, 13 km W Mossman, NQ, 1-2 Jan 1990, 1100 m, ANZSES Expedition. In QM, Reg. No. QMT169566.

Size: 16mm long, 2.3 mm wide at posterior half of elytra. Ground colour brownish testaceous, with scape, labrum and mandibles ivory white; anterior half of elytra reddish brown, with glossy oblique stripe on anterior third; posterior half of elytra brown, with yellowish spot at each side behind middle, and a dull triangular area narrowing from suture to epipleura; apex of elytra less shiny, entirely covered by dense golden pubescence with velvety iridescence, as in apical segments of some ants.

Two new genera of myrmecomorph longicorn beetles

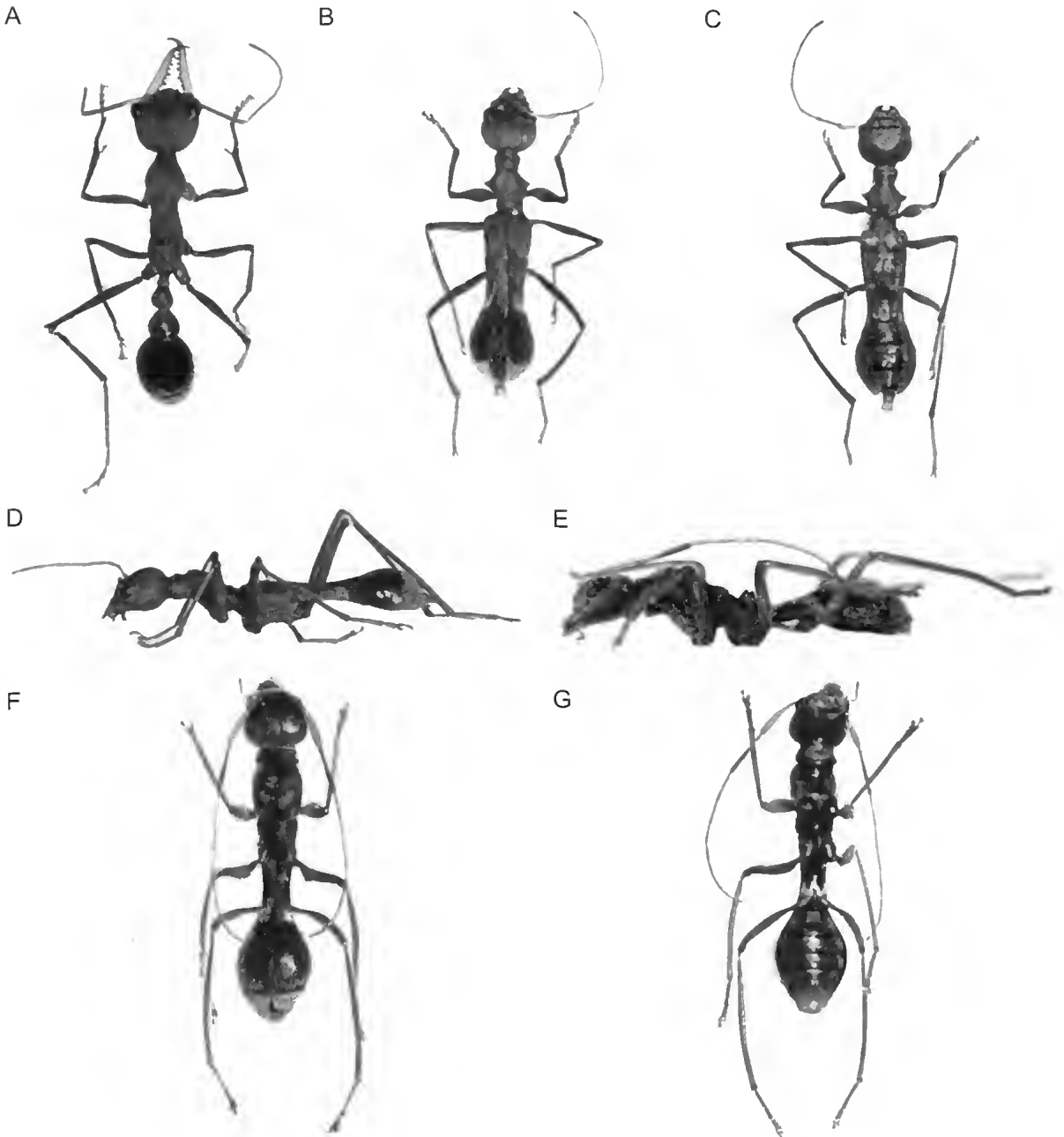


FIG. 1. A, *Myrmecia flavicoma minuscula* Forel (Formicidae), dorsal view, length 17 mm; B-D, *Myrmeciocephalus monteithi* gen. et sp. nov., holotype female, length 16 mm; B, dorsal view; C, ventral view; D, lateral view; E-G, *Myrmeparmena sudrei* gen. et sp. nov., holotype female, length 11 mm; E, lateral view; F, dorsal view; G, ventral view.

Head with sides covered by short silvery tomentum; posterior half with long sparse reddish setae. Antennae with short tomentum and some long setae on first three segments. Pronotum fringed anteriorly by short white setae; surface of pronotum covered by short grey setae, particularly on prosternal area; disc with long brownish setae. Elytra and legs with long sparse brownish setae. Abdominal sternites reddish brown with black posterior margin.

Etymology. We take great pleasure in naming this new species after our dynamic colleague, Dr Geoff B. Monteith (Queensland Museum, Brisbane), who provided us with the studied material, and in recognition of his dedicated contribution to entomological exploration in New Caledonia.

DISCUSSION

Myrmeciocephalus gen. nov. falls perfectly well within the Ametrocephalini as characterised by Lacordaire (1869), based on the globular shape of the head capsule, narrow neck, the sinuate longitudinal axis of pronotum and the very peculiar shape of elytra which are strongly modified due to myrmecomorph mimicry. This elytral shape also occurs in related Australian genera such as *Ametrocephala* Newman, 1851, *Formiconiinus* Aurivillius, 1897 and *Cyclocraniou* Poll, 1892. All species in the Ametrocephalini have their morphology strongly adapted to mimic some of the ants with which they occur.

The unique holotype of *Myrmeciocephalus monteithi* was collected by student collectors on a back-packing expedition by the Australian and New Zealand Schools Exploration Society to the highest parts of the rainforested Carbine Tableland in 1990. This plateau shows extremely high insect endemism and diversity within the Australian Wet Tropics biogeographic zone (Yeates & Monteith 2008). Samples from the expedition were later sorted by G. Monteith at the Queensland Museum and one vial of hand-collected specimens from Paul's Luck

(an old tin-mining area in rainforest at 16° 26'27"S × 145°15'08"E) contained the specimen of the longicorn beetle plus several specimens of the large ant, *Myrmecia flavicomia minuscula* Forel, 1915 (Fig 1A). It can be assumed that all the specimens in the vial were collected in reasonably close proximity. The ant genus *Myrmecia* belongs to the primitive Australian subfamily Myrmeciinae and its members are well known for their large size, aggressive behaviour and formidable defences in the form of large jaws and powerful sting. *Myrmecia f. minuscula* is a daytime-foraging species with dark reddish-brown body and prominent pale mandibles. Its abdominal apex is subglobular, black and furnished apically with silvery hairs. The resemblance of the longicorn (Figs 1B-D) to the ants in size and colour is almost perfect, particularly the abdominal apex which is the same shape and colour and bears the same terminal ornamentation of silvery hairs as in the ant. The long pale, curved, antennal scapes of the longicorn resemble, in size, colour and position, the defensive jaws of the ant. This ant-mimicry by the longicorn most likely benefits it by allowing it to escape the predators which avoid the aggressive ant. This is undoubtedly another case of Wasmannian mimicry, where the mimicking insect lives along with the model, as has been reported for other genera of Australian and New Caledonian longicorn beetles (Hayashi 1961; Vives *et al.* 2011).

Subfamily Lamiinae

Tribe Parmenini Mulsant, 1839

Parmenaires Mulsant, 1839: 118.

Parmenini Breuning, 1950: 29.

Myrmeparmena gen. nov.

Type species. *Myrmeparmena sudrei* sp. nov.

Head large, rounded, very convex dorsally and longitudinally furrowed from occiput to labrum; anteriorly briefly elongated as short rostrum with sides convergent; epistome trapezoidal, glabrous; temples rounded and protruding, covered by

fuzzy grey pilosity; underneath almost smooth, with sparse grey pubescence. Labrum large, with round anterior margin and transversal row of short golden setae. Mandibles very short, weakly protruding, with large golden setae at base of external margin, and inner margin smooth with apical curved and sharp tooth. Palpi rather long; third segment acuminate. Eyes small, feebly protruding, finely faceted, with inner edge strongly emarginate. Antennae short and thin, reaching apical third of elytra; scape long, club-shaped, slightly arched; third segment neatly shorter than scape, longer than fourth segment; segments 3 to 11 cylindrical, long and narrow, with long setae on internal margin of three first segments and remaining segments with very short grey tomentum.

Elytra very long and narrowed, almost cylindrical at anterior half, and very convex and widened at posterior half; almost glabrous with inconspicuous suture; base of each elytron with large carinate tooth, just behind scutellum; surface of elytra rugulose at anterior half, except laterally, smooth, shiny; posterior half very convex, finely punctured but rather glossy between punctures, covered by silvery grey tomentum; golden yellow pubescence on epipleural area; sutural angle strongly dehiscent, making each elytron apically rounded, revealing last abdominal tergite. Hindwings present but strongly reduced, but following shape of elytra, narrowed anteriorly and widened posteriorly. First visible abdominal ventrite trapezoidal; following three ventrites wide and short, rather convex; fifth large, yellow, slightly translucent; abdomen entirely covered by short silvery grey pubescence.

Legs long and slender; profemora strongly widened, meso- and metafemora less so; tibiae long, compressed, slightly arched; protibia feebly grooved at lower part near apex, mesotibiae externally emarginate at apex; tarsi narrow, with first segment twice as long as remaining together; claws divaricate. Tibiae and claw shape are as generally observed in Parmenini.

Myrmeparmena sudrei sp. nov.
(Figs. 1 E-G)

MATERIAL. Holotype ♀: New Caledonia, Île des Pins, 22-X-2008, Arade and Jérôme Sudre. In MNHN, Paris, France. Paratype ♀: same locality, X-2008, Laurent Soldati leg., (E. Vives collection).

Size of holotype/paratype: Length 11/10 mm, width 2.8/2.6 mm at apical third of elytra. Ground colouration black, with some areas glossy and others satin-like; epistome, labrum, mandibles, palpi and two first antennal segments creamy yellow; legs and remaining antennal segments testaceous with short grey tomentum and sparse long golden setae. Head and pronotum black, their surface finely punctured, with slight glossy shine except laterally on anterior half of pronotum, smooth, shiny, indicating a waist-like narrowing; posterior half of pronotum anteriorly with depressed area at both sides surrounded by white pubescence, and apically densely covered by grey tomentum, furrowed transversely by smooth and shiny strip, mimicking the intersection of abdominal segments in some ants.

Etymology. this species is named after our friend M. Jérôme Sudre (Faramaz, France), companion in the research of the beetle fauna of New Caledonia, great expert in the Cerambycidae subfamily Lamiinae.

DISCUSSION

The shape and colouration of this new species mimics perfectly those of some genera of ants, with which it probably coexists. Unfortunately, we were unable to study any of the potential ants serving as model.

The morphology of *Myrmeparmena sudrei* sp. nov. is highly modified to adapt it to an arboreal life-style, presumably living in association with colonies of ants which it mimics. Its derived characters make it difficult to confidently place the new genus among the Lamiinae. Some remarkable characters include the insertion of the cephalic capsule, the pro- and mesotibial furrows

and the peculiar shape of divaricate claws, all of them relating the new genus to Mulsant's (1839) '*Parmenaires*' within the Lamiinae.

Several characters of *Myrmeparmena* gen. nov. are similar to those of *Caledomicrus* Vives et al., 2011, recently described on specimens from New Caledonia. In particular, they are similar in the almost cylindrical shape of pronotum, narrower than head, with sinuate longitudinal axis. However, it can be differentiated from *Caledomicrus* because the latter lacks hindwings, and its antennae are shorter and thicker, as well as by the narrower head and the narrower apical third of elytra. None the less, both myrmecophilous New Caledonian genera share several characters with representatives of Parmenini (*sensu* Breuning, 1950), including the anterior half of elytra narrowed, depressed, with basal spines, the atrophy of hindwings, the elytral apex broadly rounded and convex, and the divaricate claws. Based on these characters we include *Myrmeparmena* gen. nov. among the myrmecomorph Parmenini characteristic of New Caledonia (*Caledomicrus* Vives et al., 2011; *Falsohomaemota* Hayashi, 1961). A deeper analysis of these three atypical myrmecophilous genera may indicate establishing a new supra-generic taxon to include them.

ACKNOWLEDGEMENTS

We thank all colleagues who contributed in one way or another to this work. In particular, we heartily thank Dr Geoff Monteith (Queensland Museum, Brisbane), M. Jérôme Sudre (Faramaz, France) and Laurent Soldati (CIRAD, Montpellier) for their contribution of specimens, expertise and opinions regarding the new taxa. We do not

want to forget all colleagues who hosted our research visits in their respective Institutions, including Dr C.A.M. Reid (Australian Museum, Sydney), Ms S. Shute (Natural History Museum, London), Mme N. Berti (Museum National d'Histoire Naturelle, Paris), G.A. Samuelson and Dr S. Myers (Bishop B. Museum, Honolulu), Dr S. Shiyake (Museum of Natural History, Osaka), Dr A. Drumont (Institut Royal d'Histoire Naturelle, Bruxelles), and Dr H.P. Aberlenc (Centre de Biologie et de Gestion des Populations, Montpellier).

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The genus *Coptoglossus* Chaudoir in eastern Australia (Insecta: Coleoptera: Carabidae: Lebiinae)

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Citation: Baehr, M. 2012 02 17: The genus *Coptoglossus* Chaudoir in eastern Australia (Insecta: Coleoptera: Carabidae: Lebiinae). *Memoirs of the Queensland Museum – Nature* 56(1): 85-98. Brisbane. ISSN 0079-8835. Accepted: 14 August 2009.

ABSTRACT

The Australian lebiine genus *Coptoglossus* Chaudoir is revised. Both recorded species, *Coptoglossus sulcatulus* Chaudoir and *C. carteri* (Sloane), are redescribed and the male and female genitalia examined and figured. *Colpodes porphyriacus* (Sloane) is transferred from Platynini to the lebiine genus *Coptoglossus*, and a new species *Coptoglossus excisicollis* sp. nov. is described. A key for the four species of the genus is provided. □ *Coleoptera, Carabidae, Lebiini, Coptoglossus, new combination, new species, Australia, key to species.*

The lebiine genus *Coptoglossus* Chaudoir, 1869, presently includes two species, namely *C. sulcatulus* Chaudoir, 1869, described from Melbourne, Victoria and so far recorded only from Victoria (Moore *et al.* 1987), and *C. carteri* (Sloane, 1915), described and recorded from Dorrigo in northern New South Wales (Moore *et al.* 1987). Due to the rarity of specimens in collections the genus is not well known and little documented, and even its systematic position in either Lebiini or Platynini was at issue (see Darlington 1956, 1963; Moore *et al.* 1987; Lorenz 1998, 2005; Wikispecies 2009).

For some time I had accumulated, for future work, specimens that apparently belong to this genus, but a recent inquiry about two species by Geoff Monteith of the Queensland Museum, Brisbane, caused me to finally identify the accumulated material and to prepare a key to the species. During this work it turned out that *Colpodes porphyriacus* (Sloane, 1910) belongs to the lebiine genus *Coptoglossus* rather than to the platynine genus *Colpodes* Macleay, 1825, and also that the ranges of the described species are much larger than previously recorded. Moreover, this work gives the opportunity to

describe an additional species from specimens which have been available for some years but remained unidentified. Hence, the genus now includes four quite differently shaped species which range from eastern Victoria along the wet east coast of Australia to southern Queensland, inland at least to the Bunya Mountains.

METHODS

Measurements were taken using a stereo microscope with an ocular micrometer. Length has been measured from apex of labrum to apex of elytra. Body lengths, therefore, may differ slightly from those specified by other authors. Length of the pronotum was measured from the most advanced part of the apex to the most advanced part of the base. Width of the base of pronotum was measured at the position of the posterior lateral seta. Length of elytra was measured from the most advanced part of the humerus to the very apex.

For dissection of the male genitalia, specimens were relaxed for a night in a jar under moist atmosphere, then the genitalia were removed and cleaned for a short while in hot KOH. The

habitus photographs were taken with a digital camera using ProgRes CapturePro 2.6 and AutoMontage and were then edited with Corel Photo Paint 11.

ABBREVIATIONS

AMS Australian Museum, Sydney
 ANIC Australian National Insect
 Collection, Canberra
 BMNH. The Natural History Museum,
 London
 CBM. Working collection M. Baehr in
 Zoologische Staatssammlung, München
 QM. Queensland Museum, Brisbane
 UQIC. University of Queensland Insect
 Collection, Brisbane (now in QM)

Genus *Coptoglossus* Chaudoir, 1869

Coptoglossus Chaudoir, 1869: 124; Darlington 1963: 1; Moore *et al.* 1987: 283; Lorenz 1998: 395.

Type species. *Coptoglossus sulcatulus* Chaudoir, 1869, by monotypy.

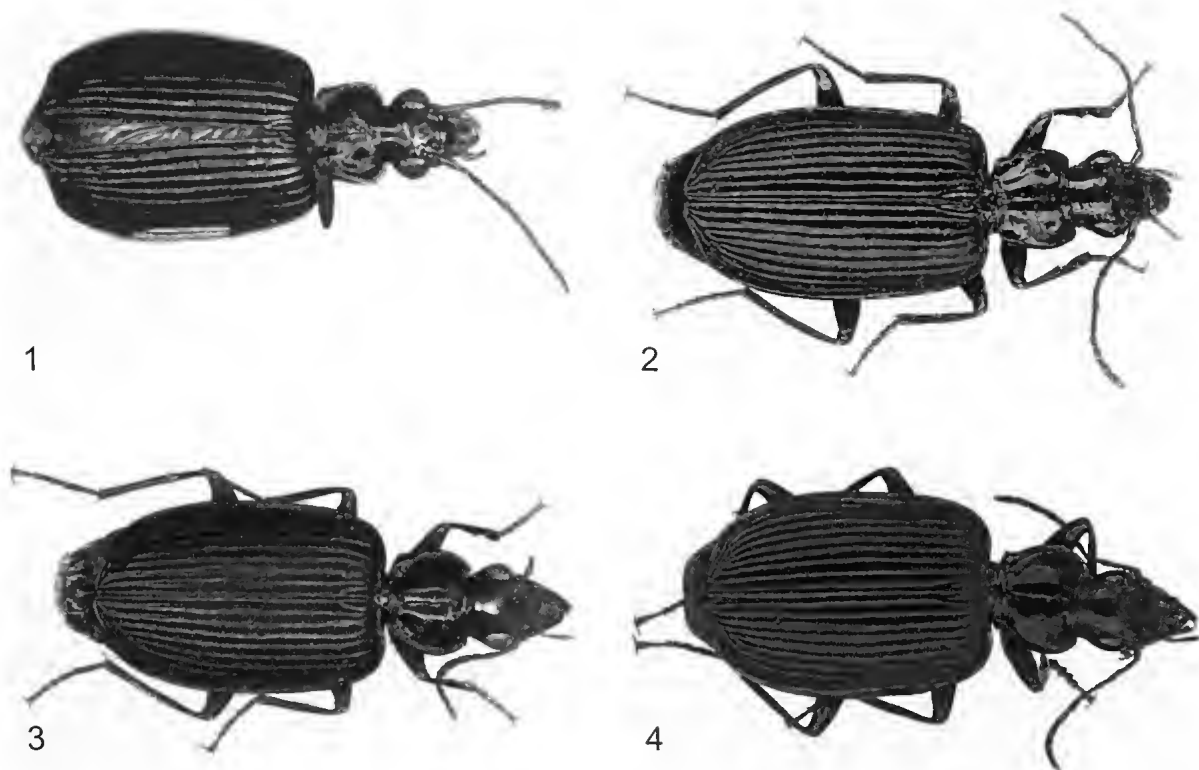
Diagnosis. A genus of the tribe (or subfamily) Lebiini (-inae), characterised by uniformly black or slightly violaceous colour, completely and deeply striate elytra, barely excised apex of the elytra, and tarsal claws not denticulate. The following characters which are common to all species, are not further mentioned in the descriptions: labrum elongate and quadrangular; palpi narrow and elongate, at apex slightly transverse, sparsely but completely pilose; antenna moderately elongate, pilose from mid of antennomere IV; mental tooth triangular, mentum bisetose, submentum bisetose and with two additional setae situated more posteriad; glossa narrow and elongate, bisetose; paraglossae hyaline, far surpassing glossa; lacinia narrow and elongate, with rather few spines on internal margin; elytra completely and deeply striate, intervals convex, striae very finely punctulate; apex of elytra oblique, barely sinuate; 3rd interval with three setiferous punctures; 13-14 setiferous

marginal punctures and 2 apical punctures close to suture present; elytra with distinct, very transverse microreticulation; upper surface of pronotum and elytra with extremely short, slightly declined pilosity which in most species is only visible in lateral view under very high magnification; metathoracic wings fully developed; lower surface with fairly distinct, more or less erect pilosity; terminal abdominal sternum quadrisetose in both sexes; legs of moderate size; 5th tarsomeres with several fairly elongate setae on lower surface; tarsal claws large, not denticulate; 1st - 3rd tarsomeres of male protarsus uniseriately or asymmetrically biseriately squamose with elongate hairs; aedeagus rather compact, suddenly narrowed to basal part which is somewhat curved left, with very large orifice situated almost completely on the left side; internal sac lacking any sclerotised pieces; female gonocoxite 1 large, without any setae at apical rim, gonocoxite 2 variously shaped, with two large ventro-lateral and one slender dorso-median ensiform setae, invariably without subapical nematiform seta.

Because of the barely excised apex of the elytra and the slightly projecting eyes of most species, some species were originally described as platynines, and one species was still regarded as a platynine until this paper (*Coptoglossus porphyriacus*, see Moore *et al.* 1987). The shortened elytra, elongate labrum and shape and structure of the female gonocoxite 2, however, demonstrate that the genus belongs to Lebiini rather than Platynini. The glabrous tarsal claws and the weakly sinuate apex of the elytra, however, suggest a rather basal systematic position within Lebiini. Based on holdings of the large Australian collections, specimens are rarely collected. This may partly explain our poor knowledge of the genus and the uncertainty about its systematic position.

Distribution. Eastern Australia from eastern Victoria to south-eastern Queensland.

Coptoglossus Chaudoir



FIGS 1-4. *Coptoglossus* species, habitus (body lengths in brackets). 1, *C. sulcatulus* Chaudoir (6.5 mm); 2, *C. porphyriacus* (Sloane) (10.6 mm); 3, *C. carteri* (Sloane) (9.3 mm); 4, *C. excisicollis* sp. nov. (12.8 mm).

Coptoglossus sulcatulus Chaudoir, 1869
(Figs 1, 5, 10, 14)

Coptoglossus sulcatulus Chaudoir, 1869: 125; Moore *et al.* 1987: 283; Lorenz 1998: 395.

Material. HOLOTYPE: sex not identified, Melbourne (MHNP). New records: New South Wales, 1♂, Stanwell Park, 1 km W rail sta., xi.2001, C. Reid (AMS); 1♀, Minnamurra Falls, 10 ml W. Kiama 27.xii.1974 H. & A. Howden (CBM); 1♀, Woy Woy 9.08. C. D. (UQIC). Queensland: 1♀, Bunya Mts. (26.50S 151.33E) 3 km from summit on Kingaroy Rd. 6.i.70 Britton, Holloway, Misko (ANIC); 1♀, 27.404°S × 152.801°E Scrub Road, Mt. Nebo SF, 23 Sept 2008 G.B. Monteith (QM); 1♀, 28°04'S, 152°24'E Mt. Mitchell, 1060 m 2 Dec 1991-6 Jan 1992 D.J. Cook

(QM); 1♀, 28°11'S × 153°11'E Lower Coomera 3 Dec 94-9 Jan 1995 G.B. Monteith & H. Janetzki, 350 m (CBM); 1♂, South Emu Creek, Via Emu Vale, S. E. Qld. 22.v.1969 B. Cantrell (UQIC).

Type locality. 'Melbourne', Victoria.

Diagnosis. Easily distinguished from the other species by much smaller size, wide pronotum, and large, laterally well produced eyes.

Partial redescription. *Measurements.* Length: 6.4-6.6 mm; width: 2.7-2.85 mm. Ratios. Width/length of pronotum: 1.46-1.48; width widest diameter/base of pronotum: 1.14-1.17; width of pronotum/width of head: 1.13-1.16; length/width of elytra: 1.43-1.47.

Colour. (Fig. 1) Very dark piceous to black, labrum, mandibles, palpi, and antennae reddish. Legs pale brown, knees slightly lighter. Lower surface reddish in middle, darker laterally, more or less brown.

Head. (Fig. 5) Large and wide (in group), eyes very large, laterally well produced, orbits very small, oblique. Clypeus comparatively short and wide, apical margin of labrum very slightly sinuate. Mandibles moderately elongate, base not markedly depressed. Antennomeres VI and VII c. 1.75 × as long as wide. Posterior supraorbital seta situated well in front of posterior margin of eye. Surface of head with distinct, isodiametric microreticulation, no punctures and no pilosity visible, surface fairly dull.

Pronotum. (Fig. 5) Comparatively wide, though little wider than head, widest at apical fourth or third. Apex gently excised, anterior angles produced but very widely rounded; lateral margin in anterior half convex, posteriad very slightly sinuate. Base in middle straight, laterally oblique-convex, basal angles very obtuse, almost rounded off. Apex not perceptibly margined, base margined. Lateral margin anteriorly rather narrow, widened towards base, margin upturned, marginal channel deep throughout, posteriad deepened. Disc rather depressed, median line and anterior transverse sulcus distinct, the posterior transverse sulcus remarkably deep. Anterior lateral seta inserted at apical fourth, at or slightly in front of widest diameter, seta slightly displaced from margin. Posterior lateral seta inserted at basal angle. Surface with several fine, shallow, slightly irregular, transverse striae, with distinct, slightly transverse microreticulation, and fairly distinct, almost erect pilosity, surface rather dull.

Elytra. (Fig. 1) Comparatively short and wide, slightly widened towards apical third, but not oviform, dorsal surface moderately convex. Humerus very widely rounded, lateral margin slightly but evenly convex, apex oblique, very slightly sinuate, incurved towards suture. Lateral

channel moderately wide, lateral margin slightly upturned. Striae deep, at bottom finely crenulate, intervals convex. Anterior discal puncture located at 3rd stria, both median and posterior punctures in middle of 3rd interval. 13-14 marginal punctures present, series rather interrupted in middle. Setae of different length but some very elongate. Microreticulation on intervals dense and distinct, punctures extremely fine and barely recognisable, pilosity very short but fairly distinct, declined, surface rather dull.

Lower surface. Metepisternum moderately elongate, 1.5-1.6 × as long as wide at apex. Microreticulation fine and slightly superficial, moderately transverse.

Legs. Male protarsus biserially squamose.

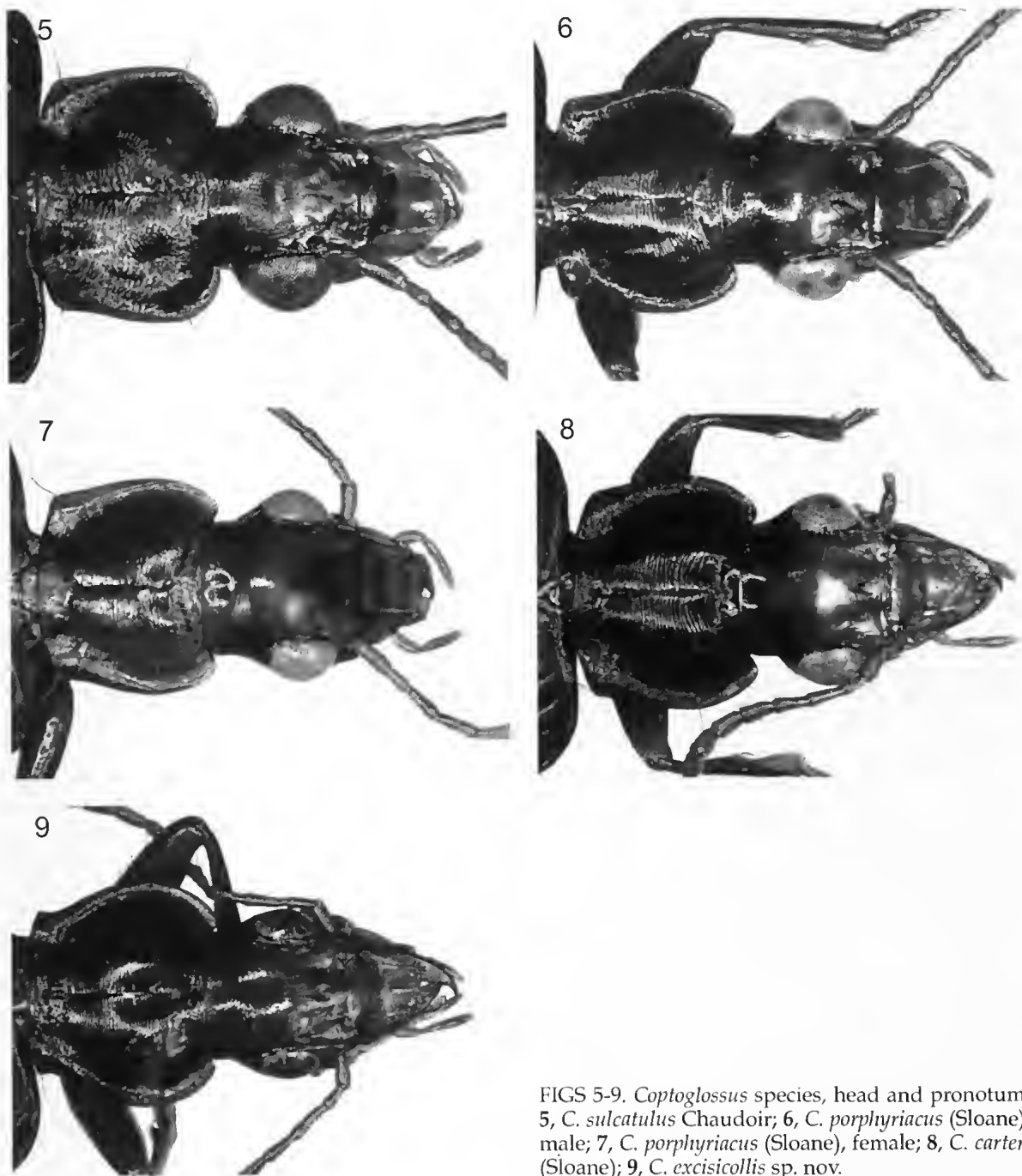
Male genitalia. (Fig. 10) Genital ring moderately wide, almost symmetric, laterally evenly convex, with very convex base and narrow, short, obtusely triangular apex. Aedeagus comparatively small, moderately voluminous, basal part narrow, at tip markedly curved down, lower surface very slightly concave, upper surface convex, with short, fairly stout, triangular-convex apex. Internal sac complexly folded, without any sclerotised pieces, but with some extremely finely denticulate folds. Left paramere large, triangular, with rather narrow, convex apex. Right paramere rather short and wide, basal part curved down.

Female gonocoxites. (Fig. 14) Gonocoxite 1 very large, gonocoxite 2 small, short, markedly curved, with moderately stout ventro-lateral ensiform setae.

Variation. Few differences noted, even between specimens from southern New South Wales and south-eastern Queensland.

Distribution. South-eastern Victoria through eastern New South Wales to south-eastern Queensland, inland to the Bunya Mountains.

Collecting circumstances. One specimen collected in 'Nothofagus forest', others in 'Rainforest, under log', 'RF, bark spray', 'Intercept', 'Intercept Trap'.



FIGS 5-9. *Coptoglossus* species, head and pronotum; 5, *C. sulcatulus* Chaudoir; 6, *C. porphyriacus* (Sloane), male; 7, *C. porphyriacus* (Sloane), female; 8, *C. carteri* (Sloane); 9, *C. excisicollis* sp. nov.

Relationships. On the basis of the relatively large eyes, the moderately elongate mandibles, and the biserially squamose male protarsus, it is most similar to *C. porphyriacus* (Sloane); however, as the mentioned characters are plesiomorphic, the similarity could be due only to the presence of primitive features which do not demonstrate close relationship. As both species rather differ in other character states, e.g. colouration, shape of pronotum and elytra, they may not actually be closely related.

Coptoglossus porphyriacus (Sloane, 1910)
comb. nov.
(Figs 2, 6, 7, 11, 15)

Platynus porphyriacus Sloane, 1910: 455; Sloane 1915: 461.
Colpodes porphyriacus (Sloane); Darlington 1956: 4; Moore *et al.* 1987: 219; Lorenz 1998: 394.

Material. Holotype: almost completely missing from card (ANIC). New records: Victoria: 1♀, Buln Buln, 16 Nov 1958 C.G.L. Gooding (ANIC); 1♀, Wilson's Prom N.P. Lilly Pilly Tr. 15 May 1978 S. & J. Peck (ANIC); 1♂, Club Terr. E.Vic. 30.i.1967. G.B. Monteith (UQIC). New South Wales: 1♀, Dorrigo. W. Heron. B.M.1934-232 (BMNH); 1♂, Lilyvale 17:2:1973 D.A. Doolan / *Coptoglossus* sp. Det. B.P. Moore 1998 (AMS); 1♂, Barrington Tops Via Salisbury, 28-30.xii.1965. B. Cantrell (UQIC). Queensland: 1♂, Mt. Glorious, Tenison Woods, 27.17.30S, 152.45.02E, 757 m, 16.8.2007, leg. M. Baehr (CBM).

Type locality. 'Illawarra', New South Wales.

Note. The specimens very closely match the description of Sloane (1910), I have no doubt that they belong to this species.

Diagnosis. Easily distinguished from all other species by the elongate elytra and their violaceous colour, and by the elongate, spoon-shaped apices of aedeagus and genital ring.

Partial redescription. *Measurements.* Length: 9.1-10.6 mm; width: 3.5-3.95 mm. Ratios. Width/length of pronotum: 1.24-1.25; width widest diameter/base of pronotum: 1.14-1.18; width of pronotum/width of head: 1.11-1.14; length/width of elytra: 1.58-1.61.

Colour. (Fig. 2) Dark brown to almost black, elytra with distinct violaceous lustre; labrum,

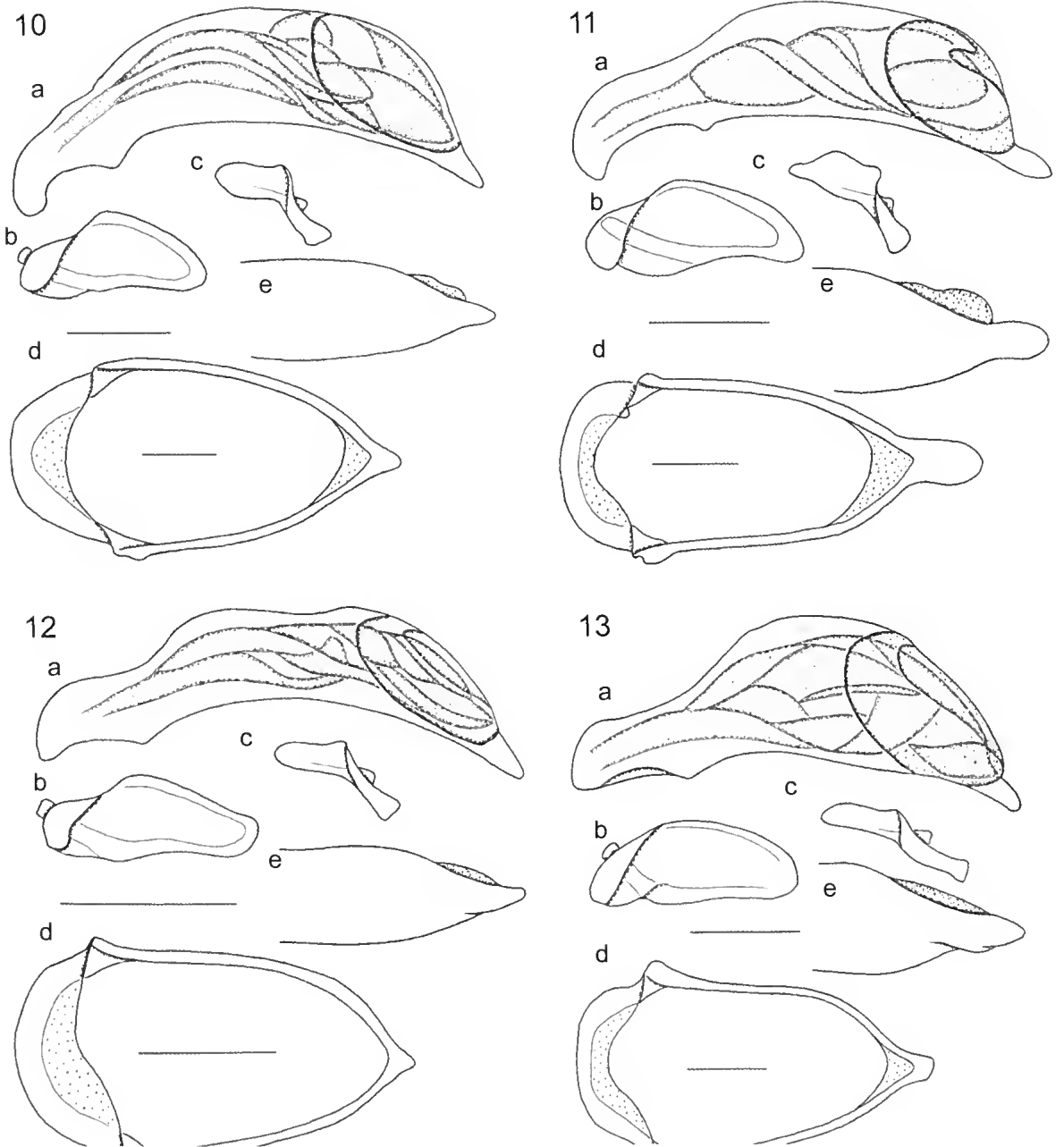
mandibles, palpi, and antennae reddish. Legs dark brown to almost black, knees slightly lighter. Lower surface reddish in middle, darker laterally, more or less dark brown.

Head. (Figs 6, 7) Rather large and wide (in group), eyes in males large, laterally well protruded, orbits small, oblique; eyes in females considerably smaller and far less produced laterally, orbits longer and less oblique. Clypeus comparatively short and wide, apical margin of labrum very slightly sinuate. Mandibles moderately elongate, base not markedly depressed. Antennomeres VI and VII c. 1.75 × as long as wide. Posterior supraorbital seta situated at posterior margin of eye. Surface of head with very fine and superficial, isodiametric microreticulation, very fine punctures but no pilosity visible, surface rather glossy.

Pronotum. (Figs 6, 7) Comparatively narrow, little wider than head, widest at apical third. Apex gently excised, anterior angles produced but widely rounded; lateral margin in anterior half slightly convex, posteriad oblique and straight or very slightly sinuate. Base straight in middle, laterally slightly oblique-convex, basal angles obtuse. Apex not margined, base laterally margined, in middle not or barely margined. Lateral margin anteriorly rather narrow, much widened towards base, margin upturned, marginal channel deep throughout, posteriad deepened. Disc rather depressed, median line and anterior transverse sulcus distinct, the posterior transverse sulcus remarkably deep. Anterior lateral seta inserted at apical third, at or slightly in front of widest diameter, seta slightly displaced from margin. Posterior lateral seta inserted at basal angle. Surface with several fine, shallow, slightly irregular, transverse striae, with very fine and superficial, slightly transverse microreticulation, and extremely short, barely perceptible, almost erect pilosity, surface fairly glossy.

Elytra. (Fig. 2) Comparatively elongate and narrow, very slightly widened towards apical

Coptoglossus Chaudoir



FIGS 10-13. *Coptoglossus* species, male aedeagus and parameres (scale bars in brackets). **10**, *C. sulcatulus* Chaudoir (0.25 mm); **11**, *C. porphyriacus* (Sloane) (0.5 mm); **12**, *C. carteri* (Sloane) (0.25 mm); **13**, *C. excisicollis* sp. nov. (0.5 mm). a, aedeagus left lateral view; b, right paramere; c, left paramere; d, genital ring; e, apex of genital ring, lateral view.

third, dorsal surface rather convex. Humerus very widely rounded, lateral margin very slightly convex, apex oblique, barely sinuate, incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae deep, at bottom finely crenulate, intervals convex. Anterior discal puncture located at 3rd stria, both median and posterior punctures in middle of 3rd interval. 13-14 marginal punctures present, series rather interrupted in middle. Setae of different lengths but some very elongate. Microreticulation on intervals dense and distinct, punctures extremely fine and barely visible, pilosity very short and only visible in lateral view, declined, surface moderately glossy.

Lower surface. Metepisternum elongate, c. 2 × as long as wide at apex. Microreticulation extremely fine and very superficial, moderately transverse.

Legs. Male protarsus biserially squamose.

Male genitalia. (Fig. 11) Genital ring narrow and elongate, rather symmetric, almost parallel-sided, with moderately convex base and elongate, comparatively wide, spoon-shaped apex. Aedeagus large, voluminous, basal part narrow, markedly curved down at tip. Lower surface in middle almost straight, upper surface convex, with large and fairly elongate, slightly spoon-shaped apex. Internal sac complexly folded, without any sclerotised pieces, but with some extremely finely denticulate folds. Left paramere large, rather triangular, with rather narrow, obliquely convex apex. Right paramere wide but small, with narrow, almost acute apex, basal part curved down.

Female gonocoxites. (Fig. 15) Gonocoxite 1 large, gonocoxite 2 small, short, moderately curved, with stout ventro-lateral ensiform setae.

Variation. Little variation noted in most external characters. However, some sexual dimorphism seems to exist, as the available males possess much larger and more laterally produced eyes than the females.

Distribution. Distributed from eastern Victoria through eastern New South Wales to south-eastern Queensland.

Collecting circumstances. Largely unknown, though the specimen from Mt. Glorious was fogged from the bark of the base of a rainforest tree. The localities of the other specimens are probably also in rainforest.

Relationships. See *C. sulcatulus* Chaudoir.

Coptoglossus carteri (Sloane, 1915)
(Figs 3, 8, 12, 16)

Platynus carteri Sloane, 1915: 460.

Coptoglossus carteri (Sloane); Darlington 1963: 1; Moore *et al.* 1987: 283; Lorenz 1998: 395.

Material. Syntype: According to Moore *et al.* (1987) the single specimen that I examined some years ago in the Sloane Collection (ANIC), is a syntype. New records: New South Wales: 1♀, Stanwell Park, 1 km W rail sta., xi.2001, C. Reid (AMS); 1♂, Dorrigo. W. Heron / *Coptoglossus* sp. nov. (AMS); 1♀, Ulong, East Dorrigo W. Heron / *Coptoglossus* det. B.P. Moore 1999 (AMS); 1♀, Lilyvale 11-11-1973 / *Coptoglossus carteri* (Sl.) det. B.P. Moore 1999 (AMS); 1♀, Minnamurra Falls, 10 ml W. Kiama 27.xii.1974 H. & A. Howden (ANIC). Queensland: 2♂♂, 27°22'S, 152°11'E Ravensbourne NP, 740 m 1 Dec 1991-7 Jan 1992 D.J. Cook (CBM, QM); 1♀, 26°43'S, 152°34'E Sunday Ck. Conondale Ra, 900 m 29 Nov 1991-7 Jan 1992 D.J. Cook (QM); 1♀, 26°53'S, 151°36'E Bunya Mts, 1040 m 7 Jan 1992-1 Mar 1992 D.J. Cook (QM); 1♂, 28°06'S, 152°24'E Spicer's Peak summit, 30-31 Dec 1993. 1200 m G.B. Monteith (QM).

Type locality. Dorrigo, New South Wales.

Diagnosis. Distinguished from *C. sulcatulus* Chaudoir and *C. porphyriacus* (Sloane) by the elongate mandibles and the uniseriate squamosity of the male protarsus; from *C. excisicollis* sp. nov. distinguished by smaller size, much wider pronotum with narrower base and lateral margin not excised, and much less stout and voluminous aedeagus.

Partial redescription. *Measurements.* Length: 8.9-10.6 mm; width: 3.8-4.25 mm. Ratios. Width/length of pronotum: 1.28-1.30; width widest diameter/base of pronotum: 1.13-1.20; width

of pronotum/width of head: 1.23-1.28; length/width of elytra: 1.47-1.51.

Colour. (Fig. 3) Dark piceous to black, but head in some specimens more or less reddish; pronotum and elytra with indistinct, very narrow, reddish margin; labrum, mandibles, palpi, and antennae reddish. Legs dark brown to almost black, but tarsi more or less dark reddish. Lower surface reddish in middle, darker laterally, more or less dark brown.

Head. (Fig. 8) Rather elongate (in group), eyes moderately large, moderately produced laterally, orbits fairly elongate, oblique. Clypeus comparatively elongate and triangular, apical margin of labrum very slightly sinuate. Mandibles elongate, almost porrect, base somewhat depressed. Antennomeres VI and VII c. $1.5 \times$ as long as wide. Posterior supraorbital seta situated at posterior margin of eye. Surface of head with only traces of extremely fine and superficial, isodiametric microreticulation; very fine punctures but no pilosity visible, surface glossy.

Pronotum. (Fig. 8) Moderately wide, considerably wider than head, widest at apical third. Apex gently excised, anterior angles produced but widely rounded; lateral margin in anterior half slightly convex, posteriad oblique and straight or very slightly sinuate. Base in middle straight, laterally slightly oblique-convex, basal angles obtuse. Apex not margined, base laterally margined, in middle not or barely margined. Lateral margin rather narrow anteriorly, much widened towards base, margin upturned, marginal channel deep throughout, posteriad deepened. Disc rather depressed, median line and anterior transverse sulcus distinct, the posterior transverse sulcus very deep. Anterior lateral seta inserted at apical third, at or slightly in front of widest diameter, seta slightly removed from margin. Posterior lateral seta inserted at basal angle. Surface with several fine, shallow, slightly irregular, transverse striae, with very fine and superficial, slightly

transverse microreticulation which is barely visible, and extremely short, barely perceptible, almost erect pilosity, surface fairly glossy.

Elytra. (Fig. 3) Rather short and wide, very slightly widened towards apical third, dorsal surface rather depressed. Humerus very widely rounded, lateral margin very slightly convex, apex oblique, barely sinuate, incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae deep, at bottom not or barely crenulate, intervals convex. Anterior discal puncture located at 3rd stria, both median and posterior punctures in middle of 3rd interval. 13-14 marginal punctures present, series rather interrupted in middle. Setae of different lengths but some very elongate. Microreticulation on intervals very fine and dense, markedly transverse, punctures extremely fine and barely visible, pilosity very short and only visible in lateral view, declined, surface moderately dull.

Lower surface. Metepisternum rather elongate, c. $1.8 \times$ as long as wide at apex. Microreticulation extremely fine but distinct, moderately transverse, lower surface dull.

Legs. Male protarsus uniseriately squamose.

Male genitalia. (Fig. 12) Genital ring wide, slightly asymmetric, with convex base and short, triangular apex. Aedeagus moderately large, comparatively slender, basal part fairly stout, not much curved down at tip. Lower surface gently concave throughout, upper surface moderately convex but in middle slightly impressed, with short, fairly stout, triangular apex. Internal sac complexly folded, without any sclerotised pieces, but with some extremely finely denticulate folds. Left paramere large, triangular, with rather narrow, obliquely convex apex. Right paramere rather narrow and elongate, basal part not much curved down.

Female gonocoxites. (Fig. 16) Gonocoxite 1 large, gonocoxite 2 small, short, moderately curved, with very stout ventro-lateral ensiform setae.

Variation. Some variation noted in body size and relative width of pronotum as compared with head and elytra.

Distribution. Distributed from eastern New South Wales south of Sydney to south-eastern Queensland.

Collecting circumstances. Labelled specimens were sampled in 'RF, Intercept' which means that they were collected in a flight intercept trap in rainforest.

Relationships. Most similar to *C. excisicollis* sp. nov. in the eyes being little produced laterally, the mandibles being elongate, almost porrect, and the uniseriately squamose male protarsus. Because the mentioned characters are apomorphic, their similarity most probably indicates close relationship between these species. In *C. carteri*, however, the characters states mentioned are plesiomorphic in comparison with those of *C. excisicollis*.

Coptoglossus excisicollis sp. nov.
(Figs 4, 9, 13, 17)

Material. Holotype: ♂, Tooloom Plateau, via Woodenbong, New South Wales. 30-31.xii.1966. G.B. Monteith (QM T156362). Paratypes: Queensland: 1♀, QLD: 28.188°S × 153.121°E Lamington NP, IBISCA 700A 9 Nov-2 Dec 2008. Malaise RF, G.B. Monteith (QM); 1♀, Queensland. Tallebudgera Valley 12.xi. 2000 D.J. Cook ex log in RF (QM); 1♂, Mt Tamborine NP, Palm Grove, 23.8.2007, leg. M. Baehr (CBM). New South Wales: 1♀, Bundgean 25 km NE Kyogle 22.XI.1986 New South Wales D.J. Scambler / K255273 / *Coptoglossus* Det. B.P. Moore 1999 (AMS).

Etymology. The name refers to both the short but deep prebasal excision and the deep excision of the apex of the pronotum.

Diagnosis. Distinguished from all other species by the large size and the strongly excised lateral margins of the pronotum.

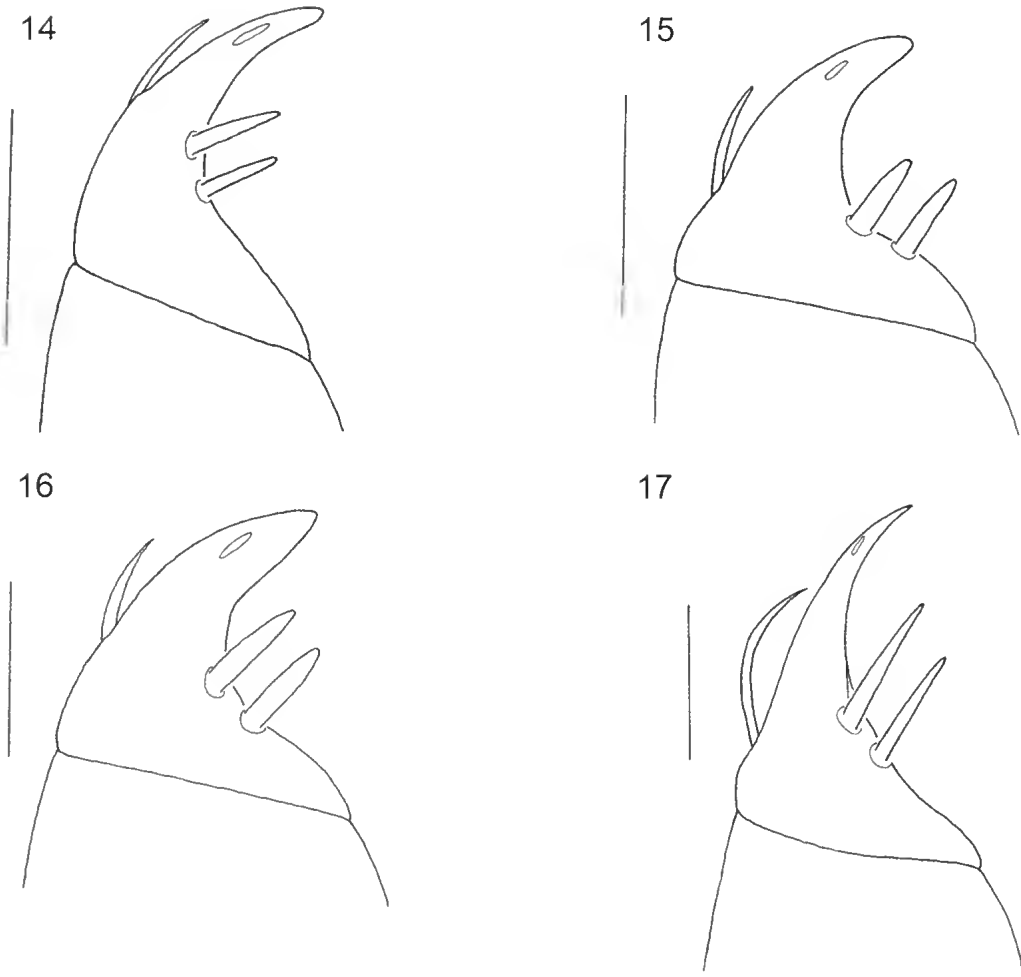
Description. *Measurements.* Length: 12.4-13.9 mm; width: 5.25-5.7 mm. Ratios. Width/length of pronotum: 1.14-1.18; width widest

diameter/base of pronotum: 1.28-1.35; width of pronotum/width of head: 1.25-1.30; length/width of elytra: 1.42-1.43.

Colour. (Fig. 4) Dark piceous to black, head in most specimens more or less reddish; pronotum and elytra with indistinct, very narrow, reddish margin; labrum, mandibles, palpi, and antennae reddish. Legs dark brown to almost black, but knees and tarsi slightly lighter. Lower surface reddish in middle, darker laterally, more or less dark brown.

Head. (Fig. 9) Rather elongate (in group), eyes comparatively small, little protruded laterally, orbits elongate, oblique-convex. Clypeus comparatively elongate and triangular, apical margin of labrum very slightly sinuate. Mandibles very elongate, porrect, base distinctly depressed. Antennomeres VI and VII c. 1.5 × as long as wide. Frontal furrows short but distinct, in anterior-medial part of frons also with a slightly triangular impression. Posterior supraorbital seta situated slightly behind posterior margin of eye. Surface of head with traces of extremely fine and superficial, isodiametric microreticulation; very fine punctures but no pilosity visible, surface glossy.

Pronotum. (Fig. 9) Moderately wide, distinctly wider than head, widest at or slightly in front of middle. Apex deeply excised, anterior angles far produced and only slightly obtuse at tip; lateral margin markedly convex throughout, deeply excised just in front of basal angles. Base in middle straight, laterally very slightly oblique, basal angles rectangular, acute at tip, well produced laterally. Apex not margined, base rather coarsely margined. Lateral margin anteriorly fairly wide, moderately widened towards base, margin upturned, marginal channel deep throughout, posteriad evenly deepened. Disc slightly convex, median line rather deep and almost complete, anterior transverse sulcus shallow, posterior transverse sulcus moderately deep. Anterior lateral seta inserted behind apical third, slightly in front of widest



FIGs 14-17. *Coptoglossus* species, female gonocoxite 2 (scale bars: 0.1 mm). 14, *C. sulcatulus* Chaudoir; 15, *C. porphyriacus* (Sloane); 16, *C. carteri* (Sloane); 17, *C. excisicollis* sp. nov.

diameter, seta slightly displaced from margin. Posterior lateral seta inserted at basal angle. Surface with many very fine, shallow, slightly irregular, transverse strioles, with traces only of extremely fine and superficial, slightly transverse microreticulation which is barely visible, and with very fine punctures and extremely short, almost erect pilosity, barely perceptible even under high magnification, surface fairly glossy.

Elytra. (Fig. 4) Comparatively short and wide, distinctly widened towards apical third, slightly oviform, dorsal surface rather convex. Humerus very widely rounded, lateral margin slightly convex, apex oblique, barely sinuate, incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae deep, at bottom finely crenulate, intervals convex. Anterior discal puncture located at 3rd

stria, both median and posterior punctures in middle of 3rd interval. 13-14 marginal punctures present, series rather interrupted in middle. Setae of different length but some very elongate. Microreticulation on intervals very fine and dense, markedly transverse, punctures extremely fine and barely visible, pilosity extremely short and only visible in lateral view under very high magnification, declined, surface moderately dull.

Lower surface. Metepisternum rather short, c. 1.5 × as long as wide at apex. Microreticulation extremely fine, on thorax rather superficial, on abdomen distinct, moderately transverse, thorax rather glossy, abdomen duller.

Legs. Male protarsus uniseriately squamose.

Male genitalia. (Fig. 13) Genital ring moderately wide, slightly asymmetric, with convex base and narrow, obtuse, rather short apex. Aedeagus large, very voluminous, basal part fairly stout, at tip not much curved down. Lower surface in middle gently convex, upper surface very convex, with short, stout, slightly lancet-shaped apex. Internal sac complexly folded, without any sclerotised pieces, but with some extremely finely denticulate folds. Left paramere large, not triangular, with wide, convex apex. Right paramere rather narrow and elongate, basal part not much curved down.

Female gonocoxites. (Fig. 17) Gonocoxite 1 very large, gonocoxite 2 narrow and elongate, gently curved, with very acute apex, with a narrow, remarkably elongate and markedly curved dorso-median ensiform seta and two narrow and elongate ventro-lateral ensiform setae.

Variation. Little variation noted.

Distribution. Extreme north-eastern New South Wales and adjacent south-eastern Queensland in Lamington and Tamborine National Parks.

Collecting circumstances. One specimen collected in 'Malaise RF' (= rainforest), two other

specimens from logs in rainforest, other specimens most probably also sampled in rainforest.

Relationships. Related to *C. carteri* (Sloane), but in certain characters revealing the apomorphic state as compared with *C. carteri*.

KEY TO SPECIES OF THE GENUS *COPTOGLOSSUS* CHAUDOIR

1. Small species, body length <7 mm; pronotum wide, ratio width/length >1.45; eyes large and strongly projecting laterally (Fig. 5); aedeagus large and stout, with triangular, symmetric apex (Fig. 10). *..sulcatulus* Chaudoir
 - Larger species, body length >8.5 mm; pronotum narrower, ratio width/length <1.3 (Figs 6-9); eyes varied but when large and strongly projecting laterally, elytra with distinct violaceous tinge (Fig. 3); aedeagus either narrower, or with differently shaped, not triangular or asymmetric apex (Figs 11-13) 2
 - Smaller species, body length <10.6 mm; pronotum wider, lateral margin barely excised in front of basal angles, apex less deeply excised and apical angles protruding far less (Figs 6-8); either elytra short and wide but not oval-shaped and more depressed (Fig. 3), or elytra dorsally convex but much longer and narrower and rather parallel-sided (Fig. 2); aedeagus less stout and high, with asymmetrically triangular or spoon-shaped apex (Figs 11, 12); gonocoxite 2 short and stout (Figs 15, 16) 3
2. Very large species, body length >12 mm; pronotum narrow, with short but deep excision in front of basal angles; apex also deeply excised and apical angles markedly protruding (Fig. 9); elytra short, wide and oval-shaped with dorsal surface convex (Fig. 4); aedeagus very stout and high, with somewhat lancet-shaped apex (Fig. 13); gonocoxite 2 very narrow and elongate (Fig. 17) *excisicollis* sp. nov.
3. Elytra black, short, wide and rather depress-

ed, ratio length/width <1.5 (Fig. 3); eyes in both sexes only moderately protruding laterally (Fig. 8); male protarsus uniseriately squamose; aedeagus less stout, with asymmetrically triangular apex (Fig. 12)*carteri* (Sloane)

- Elytra distinctly violaceous, narrow and elongate, dorsally convex, ratio length/width >1.6 (Fig. 2); eyes in males markedly protruding laterally (Fig. 6); male protarsus biseriately squamose; aedeagus stouter, with wide, spoon-shaped apex (Fig. 11)*porphyriacus* (Sloane)

REMARKS

Specimens of *Coptoglossus* are rare in collections and this may be because we have little information about their habits and habitat preferences. Indeed, the (few) recorded collecting circumstances are quite different and include Malaise and intercept traps as well as bark fogging of logs and tree trunks, and collecting from or under logs. But almost all recorded localities seem to be located in rainforest, either subtropical rainforest or temperate and upland *Nothofagus* rainforest. Many localities are lowland and there is a pattern in *C. porphyriacus*, *C. carteri* and *C. sulcatulus* of living close to sea-level in the southern parts of their range, and living on plateaus in the northern parts in southern Queensland. It seems therefore, that the species of this genus mainly inhabit temperate rainforest, and that they probably live on or under the bark of trees and logs.

Based on the structure of the labrum and female gonocoxites, the genus *Coptoglossus* belongs to the lebiine subtribe Pericalina (= Catascopina, = Coptoderina, = Thyreopterina of different authors), but certainly not to the tribe Platynini as in Lorenz (1998, 2005) and, for example, in Wikispecies (2009). Within the subtribe Pericalina, in the structure of the labium, tarsal claws, female gonocoxites, and chaetotaxy of the terminal abdominal sternum,

Coptoglossus is quite similar to the Oriental genus *Peripristus* Chaudoir, 1869 which, however is apomorphic in several aspects of its external morphology. In view of a number of plesiomorphic character states, *Coptoglossus* indeed may represent one of the most basal genera of Pericalina. Hence the original description of two species as belonging to the platynine genus *Platynnus* and the arrangement of the genus within Platynini is understandable, even when the genus originally was described as a lebiine belonging to the 'Thyreopterides' which in Chaudoir's (1869) sense was identical with what today is called Pericalina.

Unfortunately, the phylogenetic relations of the many genera of Pericalina are far from being settled, because the group is numerous in the tropical and subtropical regions of all continents, and usually work has been done only on the fauna of a single continent without any comparisons with the faunas of other regions.

Grouping of species within the genus is difficult, because the species are quite different in character states as well in external morphology and in the male and female genitalia. However, according to the shape of the squamosity on the male protarsus, *C. carteri* and *C. excisicollis* may be related, as they possess uniseriately squamose protarsi which seems to represent a synapomorphic character state, whereas the biseriately squamose male protarsus in *C. sulcatulus* and *C. porphyriacus* is plesiomorphic and hence is not suitable for any phylogenetic reasoning.

Coptoglossus sulcatulus and *C. carteri* possess a much smaller aedeagus than *C. porphyriacus* and *C. excisicollis*, so the distribution of this character state contradicts the above grouping. Within the genus, *C. sulcatulus* is peculiar by its small body size and the wide prothorax; *C. porphyriacus* by its violaceous colouration, the spoon-shaped apex of the aedeagus, and the sexual dimorphism in the size of the eyes; *C.*

carteri by the comparatively slender and low aedeagus; and *C. excisicollis* by the large body size, odd-shaped prothorax, and the slender and elongate female gonocoxite 2. As in many basal groups throughout the animal kingdom, in the genus *Coptoglossus* the morphological differences between species are considerable which probably reflects the rather high age of the genus, as compared with more modern genera within Pericalina.

The occurrence of a genus of Pericalina, basal in terms of its phylogenetic status, in the temperate south-east of Australia is important with respect to biogeographic questions, because the subtropical, but even more so the temperate rainforests of south-eastern Australia, are rather old environments which harbour a number of genera and species which also occupy a basal systematic position within their respective tribes. The genus *Coptoglossus* seems to be one of these old, indigenous inhabitants.

ACKNOWLEDGEMENTS

I am grateful for the kind loan or gift of specimens to Greg Daniels (Brisbane), Geoff Monteith (Brisbane), Conrad Gillett (London), David Britton (Sydney), and Tom Weir (Canberra). The Deutsche Forschungsgemeinschaft (DFG) is thanked for several grants for collecting trips in Australia and visits to certain Australian collections.

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Three peculiar new genera of lebiine carabid beetles from Queensland, Australia (Insecta: Coleoptera: Carabidae: Lebiini)

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Citation: Baehr, M. 2012 02 17: Three peculiar new genera of lebiine carabid beetles from Queensland, Australia (Insecta: Coleoptera: Carabidae: Lebiini). *Memoirs of the Queensland Museum – Nature* 56(1): 99-115. Brisbane. ISSN 0079-8835. Accepted: 29 April 2011.

ABSTRACT

Three new genera and four species of the carabid tribe Lebiini are described from eastern Queensland, Australia: *Anomotariella* gen. nov. with the species *A. hippocrepis* sp. nov.; *Geoffreyella* gen. nov. with the species *G. holoserica* sp. nov. and *G. lamingtonensis* sp. nov.; and *Australovelinda* gen. nov. with the species *A. seriata* sp. nov. The wide, explanate mandibles, presence of a wide mental tooth, denticulate tarsal claws, slightly widened labial palpi, and the narrow, elongate, and parallel-sided gonocoxite 2 place *Anomotariella* in the subtribe Anomotarina (=Calleidina), but in body shape and in the setosity of the female gonocoxite 2 it is quite distinct from all described Oriental-Australian genera of the subtribe. The structure of the ligula, the female gonocoxite 2, and the male aedeagus place the genus *Geoffreyella* in the lebiine subtribe Dromiina, but it is very peculiar within this group because of the atypical, dense, depressed pilosity on the whole body. The setosity of the female gonocoxite 2 is also unusual within the subtribe, although its shape is dromiine-like. Although the female genitalia of *Australovelinda* are not yet known, the body shape, structure of the mouth parts, and structure of the dorsal surface demonstrate that this genus belongs to the small tribe Lichnasthenina which has not previously been recorded from Australia and was known from only southern Africa, Madagascar and India. Their peculiar body shapes and colour patterns make all the new genera easily identified among the Australian lebiines. *Anomotariella* and *Geoffreyella* apparently do not possess close relatives within their respective subtribes.

□ *Coleoptera, Carabidae, Lebiini, Anomotariella, Geoffreyella, Australovelinda, new genera, new species, Australia*

Through the courtesy of Geoffrey Monteith of the Queensland Museum, Brisbane, I was able to accumulate during recent years, a handful of specimens of three peculiar genera of small lebiine carabid beetles. Almost all had been collected by Geoff and his co-workers during his tireless exploration of the forests of Queensland. To study these odd-shaped and conspicuously coloured beetles, and in particular to correctly place them to subtribe, females are usually

needed, because in Lebiini the shape and structure of the female gonocoxites provide the best subtribal characters. Males and females of two of the genera are presently available. Because one species occurs in Lamington National Park in south-east Queensland which is presently the subject of a thorough faunal survey being carried out by staff of Queensland Museum and Griffith University as part of the IBISCA-Queensland Project, it would be useful to describe this

species so that it can be included in the faunal list. Unfortunately, just a single male is available of the third genus, but the species is so striking in its external structures that there is no doubt about its subtribal placement; therefore it is also described, even though the female genitalia are yet unknown.

During the last 20 years the Australian Lebiini have been the main subject of my revisional and descriptive work on Australian carabid beetles. Examination of copious material reveals that the lebiine fauna of Australia apparently consists of four groups of genera not only of different biogeographic origin, but also of different habits and habitats (for citations and for distribution of species see also Moore *et al.* 1987):

1. A group of genera that are widespread in the Oriental region. Those in Australia, occur mainly in closed forest in eastern Queensland, particularly the tropical north-east: the genera *Aristolebia* Bates, *Catascopus* Kirby, *Celaenephes* Schmidt-Goebel, *Coptodera* Dejean, *Dolichoctis* Schmidt-Goebel, *Holcoderus* Chaudoir, *Lachnoderma* Macleay, *Lebia* Latreille, *Miunthodes* Andrewes, *Miscelus* Putzeys, *Mochthierus* Schmidt-Goebel, *Parena* Motschulsky, *Somotrichus* Seidlitz, *Stricklandia* Macleay, and *Syntomus* Schmidt-Goebel. Most of these genera in Australia include only one or a few species and are probably rather recent immigrants from the Oriental and/or Papuan Region into (north) eastern Australia.
2. A few large genera which belong to the famous cortical/subcortical fauna that is characteristic of the Australian sclerophyll forests and woodlands, and which include many species that occur under eucalypt bark: the genera *Agonocheila* Chaudoir, *Cheilagona* Baehr, *Demetrida* White, *Diabaticus* Bates, *Philophloeus* Chaudoir, *Phloeocarabus* Macleay, and *Trigonothops* Macleay. Most of these genera include numerous species and occur throughout Australia including semi-arid regions in the interior and the west. They are indigenous Australian genera, even though species of *Cheilagona*, *Demetrida*, *Trigonothops*, and *Phloeocarabus* occur in New Guinea and some species of *Demetrida* occur in New Zealand.
3. A group of ground-living genera, either of open country (and occurring even in semi-arid regions) or of montane rainforest in north-eastern Australia. These include *Auomotarus* Chaudoir including those of the subgenus *Nototarus* Chaudoir (see Baehr 2009), *Microlestodes* Baehr, *Barrymooreana* Baehr, and *Habutarus* Ball & Hilchie. Probably all genera were originally of Oriental origin or possess close relatives there, but today they are most numerous in Australia. Some species of the anomotarine lineage have even colonised caves.
4. Some genera of peculiar shape and structure whose relationships are therefore not easily recognised. Their biogeographic relations are also uncertain. Most of these genera at present include just a single, very characteristic species and most of them are corticolous: the genera *Brigalowia* Baehr, *Coptoglossus* Chaudoir, *Crassagenia* Baehr, and *Rugitarus* Baehr. The three new genera described in the present paper belong to this enigmatic group of genera which most probably are not related *inter se*, because some are apparently plesiomorphic in many respects (e.g. *Coptoglossus*); others are very specialised, odd-shaped beetles.

MATERIAL AND METHODS

All specimens of *Geoffreyella*, the single specimen of *Australovelinda*, and most specimens of *Anomotariella* were collected by Geoff Monteith and his co-workers of the Queensland Museum, Brisbane, and thus the holotypes and most

paratypes are located at the Queensland Museum, Brisbane (QM). Single specimens of *Anomotariella* were borrowed from the Australian National Insect Collection, Canberra (ANIC) and the Deutsches Entomologisches Institut, Müncheberg (DEI). Paratypes of some species are located in the working collection of the author (CBM) in the Zoologische Staatssammlung München.

Measurements were taken using a stereo microscope with an ocular micrometer. Body length was measured from apex of labrum to apex of elytra, length of pronotum from the most anterior part of apex to the most posterior part of base, width of base of pronotum at the position of the posterior lateral seta, length of elytra from the most advanced part of humerus to the very apex.

For dissection of the genitalia, specimens of both sexes were relaxed for a night in a jar under moist atmosphere. The genitalia were then removed and cleaned for a short while in hot KOH. The habitus photographs were taken with a digital camera using ProgRes CapturePro 2.6 and AutoMontage and then edited with Corel Photo Paint 11.

Genus *Auomotariella* gen. nov.

Type species. *Anomotariella hippocrepis* sp. nov., by original designation.

Etymology. The name refers to the putative relationships of this genus with the anomotarine lineage.

Diagnosis. A genus of the tribe (or subfamily) Lebiini (-inae) and the subtribe Anomotarina (=Calleidina), characterised by the following features which are not fully repeated in the description of the single species: eyes large, orbits cheek-like, forming almost a right angle with the neck; labrum short and transverse, 6-setose; mandibles short and wide, depressed, with wide scrobe; both palpi sparsely pilose, the maxillary palp cylindrical, the labial palp in both sexes distinctly widened apicad; mentum with unidentate tooth, bisetose; glossa wide, bisetose, paraglossae hyaline, barely surpassing the glossa; lacinia large, with sparse

but very elongate spines; antenna short; basal antennomeres sparsely pilose, more densely pilose from 4th antennomere; pronotum cordiform, bisetose, base in middle markedly produced; elytra depressed; apex oblique-convex, not sinuate; disc with two setiferous punctures in 3rd interval; microreticulation dense and distinct, isodiametric to slightly transverse, pilosity moderately dense but extremely short, erect; metathoracic wings fully developed; terminal abdominal sternum in males bisetose, in females quadrisetose; 4th tarsomeres not widened nor excised; lower surface of 5th tarsomeres setose; tarsal claws denticulate; 1st to 3rd tarsomeres of male protarsus slightly widened and biserially squamose; aedeagus small, narrow and elongate; apex elongate, straight, obtuse at tip; orifice very short, situated at left side; internal sac simply folded, with a narrow, rather sclerotised rod in middle; gonocoxite 1 asetose at apical rim; gonocoxite 2 narrow, elongate, almost parallel-sided, with a dense fringe of moderately elongate nematiform setae at apex.

Distribution. Windsor, Carbine and Atherton Tablelands, north-eastern Queensland.

Relationships. The wide mandibles, the apically widened labial palp, and shape and pilosity of the female gonocoxite 2 suggest that this genus belongs to the subtribe Anomotarina (=Calleidina). Within the Australian and Oriental genera of the subtribe, however, the relationships of *Anomotariella* are obscure and no close relatives are recorded so far.

Anomotariella hippocrepis sp. nov. (Figs 1, 5, 8, 11, 15)

Material. HOLOTYPE: ♂, Windsor Tableland, N.Qld. 9 Jan 1989, 1270 m E. Schmidt & ANZSES Site 4, pyrethrum (QMT156373). PARATYPES: 1♂, 3♀♀, same data (CBM, QM); 1♂, NEQ: 16°14'Sx145°00'E Windsor Tblnd, 5.7 km past barracks 1260 m 8 Feb 1998, G.B. Monteith 1827 pyrethr, R/F, tree bases & logs (QM); 2♂♂, 1♀, QLD: 16°35'Sx145°16'E Leichhardt Creek, upper 28 May 2003. G.B. Monteith Pyrethrum on Bunya Pine trunks. 11311 (CBM, QM); 1♀, NEQ: 16°35'Sx145°16'E Upper Leichhardt Creek 18

Nov. 1997. 840 m G.B. Monteith 1627 Pyreth on Bunya Pines (QM); 1♀, Tully R. Xing. 10 km S. Koombooloomba Dam, N.Qld 4-5 Jan 1990. 750 m G.B. & S. R. Monteith (QM); 1♀. Herberton Rng. QLD. 7-10 km NW Herberton. 17- 18 Dec. 1982 J. T. Doyen / ex shaggy bark *Eucalyptus* (ANIC); 1♀, Kuranda 4/05 (DEI).

Etymology. The species name reflects the horseshoe-shaped elytral pattern.

Diagnosis. As for the genus, easily recognised by the horseshoe-shaped, dark elytral pattern and the cordiform pronotum which bears a markedly protruded basis.

Description. *Measurements.* Length: 3.25-3.6 mm; width: 1.35-1.6 mm. Ratios. Width/length of pronotum: 1.29-1.34; width base/apex of pronotum: 1.04-1.09; width of pronotum/width of head: 1.18-1.22; length/width of elytra: 1.37-1.42.

Colour. (Figs 1, 5) Head black or almost so, clypeus, labrum, and mandibles brown, palpi and antenna dark yellow. Pronotum more or less light brown, lateral margins widely yellow translucent. Elytra dirty yellow, with an approximately horseshoe-shaped, dark piceous spot that covers the lateral part of the apical two thirds but leaves the narrow lateral margin and the central three or four intervals yellow. At the very apex only the sutural interval is light coloured. Lower surface of head and thorax piceous, but the proepipleura, the central basal part of the metasternum, and the epipleura of the elytra rather contrastingly yellow. The abdomen dirty yellow, laterally slightly darkened. Legs yellow.

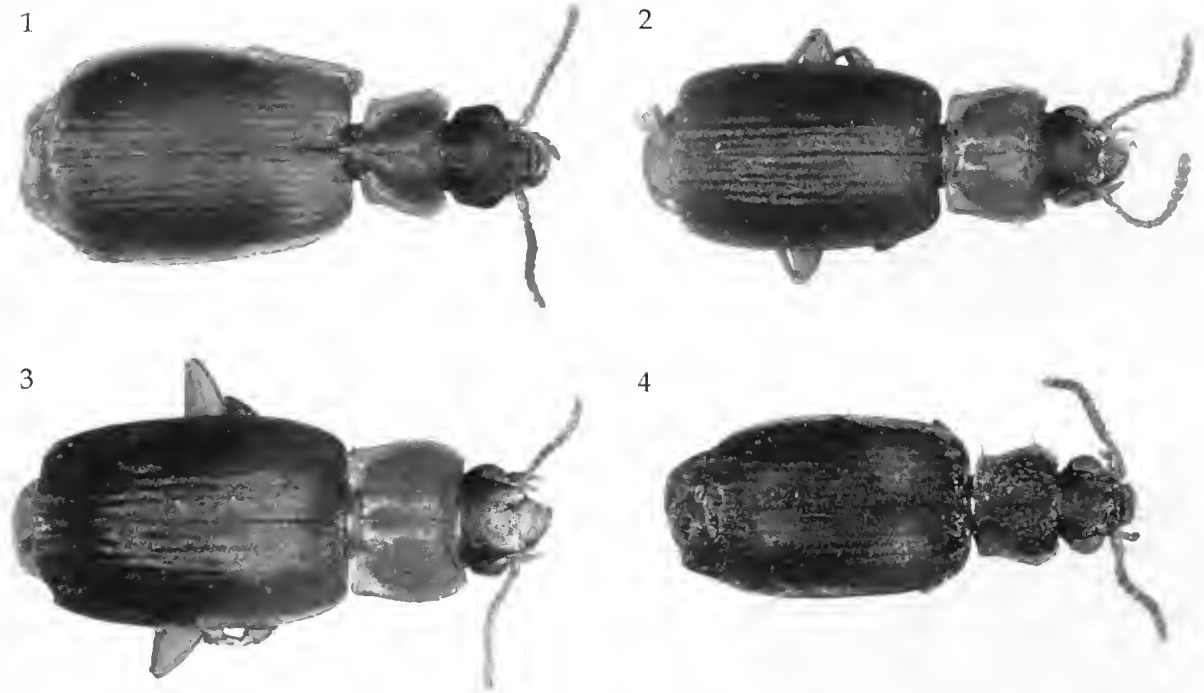
Head. (Figs 1, 5, 8) Rather large and wide but definitely narrower than the pronotum. Eyes large, laterally fairly produced, slightly more than twice as long as orbits, these cheek-like, forming almost a right angle with the neck. Clypeus transverse, well separated from frons, labrum short and transverse, anteriorly almost straight, laterally rounded and pilose. Mandibles short and wide, depressed, with wide scrobe, largely concealed by the labrum. Maxillary palp cylindrical,

narrowed apicad, the labial palp in both sexes distinctly widened apicad. Mentum with large, unidentate, obtuse tooth at apex, bisetose. Submentum bisetose, setae very elongate. Glossa wide, straight at apex. Lacinia large, apex markedly incurved, with sparse but very elongate spines. Antenna short, just surpassing base of pronotum, 6th and 7th antennomeres c. 1.25 x as long as wide. Posterior supraorbital seta situated at posterior margin of eye. Frons without any impressions or wrinkles, but orbits laterally rather rugose. Surface of head with very dense and distinct, isodiametric microreticulation, with rather dense, but very short, erect pilosity, but no punctures visible within the dense microreticulation; surface dull.

Pronotum. (Fig. 1, 5) Rather wide, markedly cordiform, widest at apical fifth. Apex excised, anterior angles produced but very widely rounded; lateral margin in anterior half convex, posterior with distinct, elongate excision, basal angles rectangular, slightly produced laterad. Base in middle markedly produced, convex, laterally transverse but slightly convex laterad. Apex and base not margined. Lateral margin wide and explanate throughout, evenly widened towards base, margin slightly up-turned, marginal channel shallow, deepened posteriorly. Disc depressed, median line deep and elongate, though not attaining apex or base. Anterior transverse sulcus very shallow to almost invisible, the posterior transverse sulcus well impressed. Anterior lateral seta inserted at apical fifth, at the widest diameter, posterior lateral seta inserted at basal angle, both setae elongate. Surface with many fine, shallow, barely perceptible, transverse striae, with distinct, slightly superficial microreticulation on disc that consists of slightly transverse meshes, and with rather dense, very short, almost erect pilosity, surface moderately dull.

Elytra. (Fig. 1) Fairly short and wide, slightly widened towards apical third, but not oviform, dorsal surface depressed. Humerus very widely rounded, lateral margin slightly but evenly

New genera of lebiine carabid beetles



FIGS 1-4. Habitus (body lengths in brackets). 1, *Anomotariella hippocrepis* sp. nov. (3.4 mm); 2, *Geoffreyella holoserica* sp. nov. (3.3 mm); 3, *Geoffreyella lamingtonensis* sp. nov. (4.3 mm); 4, *Australovelinda seriata* sp. nov. (2.55 mm).

convex, apex oblique-convex, not sinuate, not incurved towards suture. Lateral channel moderately wide, lateral margin slightly up-turned. Striae complete, shallow, extremely finely crenulate at bottom, intervals slightly convex. Disc with two setiferous punctures on 3rd interval which are barely perceptible when the setae are broken. The anterior puncture located at or slightly behind middle, the posterior puncture at apical fourth, setae very short. 12-13 marginal punctures present, series interrupted in middle. Setae of different length but some very elongate. Microreticulation on intervals dense and distinct, isodiametric to slightly transverse, punctures indistinct within the microreticulation, pilosity moderately dense but extremely short, erect, surface moderately dull but slightly iridescent.

Metathoracic wings. Fully developed.

Lower surface. Metepisternum rather short, <1.5 x as long as wide at apex. Microreticulation generally very fine and highly superficial, transverse, surface glossy. Whole lower surface with sparse, on abdomen denser, extremely short, erect pilosity which is difficult to detect. Setae of terminal abdominal sternum elongate.

Legs. Fairly slender and elongate. 4th tarsomeres not widened nor excised. 5th tarsomeres with a few setae on the lower surface near apex. Tarsal claws large, distinctly denticulate.

Male genitalia. (Fig. 11) Genital ring moderately wide, triangular, slightly asymmetric, laterally evenly convex, with narrow, convex base and moderately wide, short, obtuse apex. Aedeagus comparatively small, narrow and elongate,



FIGS 5-7. Head and pronotum. 5, *Anomotariella hippocrepis* sp. nov.; 6, *Geoffreyella lamingtonensis* sp. nov.; 7, *Australovelinda seriata* sp. nov.

lower surface very slightly convex. Apex elongate, straight, very slightly triangular, obtuse at tip. Orifice very short, situated at left side. Internal sac rather simply folded, with a narrow, moderately sclerotised rod in middle, otherwise without any sclerotised pieces. Left paramere large, with slightly oblique apex. Right paramere short, convex at apex.

Female gonocoxites. (Fig. 15) Gonocoxite 1 elongate, without any setae at apical rim; gonocoxite 2 narrow, elongate, almost parallel-sided, with wide apex which bears a dense fringe of moderately elongate nematiform setae. Lateral plate asetose.

Variation. Very little variation noted.

Distribution. Atherton, Carbine and Windsor Tablelands in north-eastern Queensland.

Collecting circumstances. Most specimens sampled by pyrethrum fogging of tree trunks and logs, some from Bunya Pine (*Araucaria bidwilli*), one specimen collected from *Eucalyptus* bark. All but one specimen at rather high altitude (750-1200 m). The specimen from Kuranda (ca. 350 m) does not fit the high altitude pattern and may require confirmation as this locality name was often used for wider collecting localities in north Queensland in earlier times.

Genus *Geoffreyella* gen. nov.

Type species. *Geoffreyella holoserica* sp. nov., by present designation.

Etymology. The name is a patronym in honour of the collector of almost all specimens of this genus, Geoffrey Monteith, and his technical assistant, Geoffrey Thompson, who co-sampled single specimens.

Diagnosis. A genus of the tribe (or subfamily) Lebiini (-inae) and the subtribe Dromiina, characterised by the following features which are not fully repeated in the species descriptions: Eyes large but laterally little produced, orbits short, oblique-convex; labrum short, anteriorly straight, 6-setose; mandibles narrow, rather short; both palpi sparsely pilose, cylindrical; mentum with unidentate tooth, asetose; glossa narrow, obtusely triangular at apex, bisetose, paraglossae hyaline, barely surpassing the glossa; lacinia with dense, moderately elongate spines; antenna short, sparsely pilose; surface of head with very coarse, isodiametric microreticulation and extremely short, erect pilosity, very dull; pronotum rather rectangular, weakly cordiform, bisetose; surface of pronotum with very distinct isodiametric microreticulation and with moderately short, irregularly declined pilosity; elytra rather rectangular, gently convex; apex very slightly sinuate; disc with three setiferous punctures near 3rd stria; microreticulation dense and distinct, isodiametric, punctation very dense; pilosity very dense, declined; surface dull; metathoracic wings fully developed; terminal abdominal sternum in both sexes quadrisetose; 4th tarsomeres not widened nor excised; lower surface of 5th tarsomeres asetose or very sparsely setose; tarsal claws very elongate, not denticulate; 1st - 3rd tarsomeres of male protarsus widened, somewhat cordiform, biserially squamose; aedeagus narrow and elongate; apex elongate and acute; folding of internal sac composed of several parallel folds, without sclerotised pieces, but in one species with small spines at apex; gonocoxite 1 elongate, asetose at apical rim; gonocoxite 2 short, laminate, with widely rounded apex; at apex with a few indistinct dentations; with a moderately

elongate dorso-median ensiform seta and two large ventro-lateral ensiform setae.

Distribution. The two known species occur in south-eastern and north-eastern Queensland, respectively.

Relationships. It is mainly the shape of the female gonocoxite 2 which suggests affiliation of the genus to the subtribe Dromiina. Within the Australian and Oriental genera of the subtribe, however, the relationships of *Geoffreyella* are obscure and no close relatives are recorded so far.

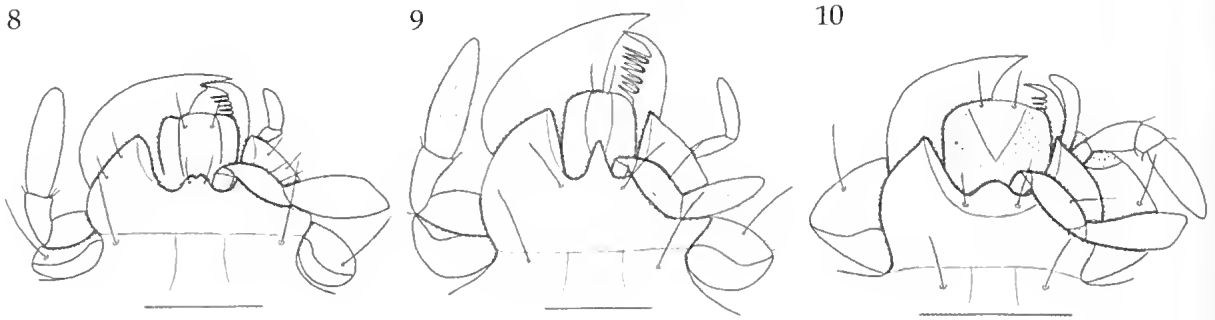
Geoffreyella holoserica sp. nov.
(Figs 2, 9, 12, 16)

Material. Holotype: ♂, NEQ: 17°33'Sx145°33'E Mt Fisher, ½ km NW 8 Feb 1999. 1280 m. R/F. GB Monteith. pyrethrum-trees&logs. 2178; (QMT156375). Paratypes: 2♂♂, 1♀, same data (CBM, QM); 1♂, NEQ: 17°41'Sx145°32'E Vine Ck Rd. 1100 m 24 Nov 1994 G.B. Monteith Pyrethrum, trees&logs (QM); 1♂, 1♀, Lamb Range, 19 km SE Mareeba, N. Qld. 3 Dec 1988, 1200 m Monteith & Thompson Pyrethrum/Logs & Trees (CBM, QM); 1♀, Boonjje, 13 km ESE of Malanda, N. Qld. 8 Dec 1988, 700 m Monteith & Thompson Pyrethrum/Logs & Trees (QM); 1♀, NEQ: 17°03'Sx145°41'E Upper Isley Ck., 750 m 29 Nov 1993 Monteith & Janetzki Pyrethrum/trees&logs (QM); 1♀, NEQ: 17°27'Sx145°29'E Tower nr. The Crater NP 25 Nov 1994, 1230 m G.B. Monteith Pyrethrum, trees & logs (QM).

Etymology. The name refers to the dense pilosity of the whole upper surface of this species.

Diagnosis. As for genus. Distinguished from the southern *G. lamingtonensis* sp. nov. by its less average size, less extended pale colour at the base of the elytra, and presence, in apical half, of narrow reddish suture and lateral margins, slightly narrower prothorax with comparatively narrower base, perceptibly punctate and less rugose pronotum, smaller and slenderer aedeagus bearing a number of fine spines at the apex of the inverted internal sac, and stouter ventro-lateral ensiform setae at the female gonocoxite 2.

Description. *Measurements.* Length: 3.1-3.7 mm; width: 1.25-1.55 mm. Ratios. Width/length



FIGS 8-10. Lower surface of head (scale bars: 0.5 mm). 8, *Anomotariella hippocrepis* sp. nov.; 9, *Geoffreyella holoserica* sp. nov.; 10, *Australovelinda seriata* sp. nov.

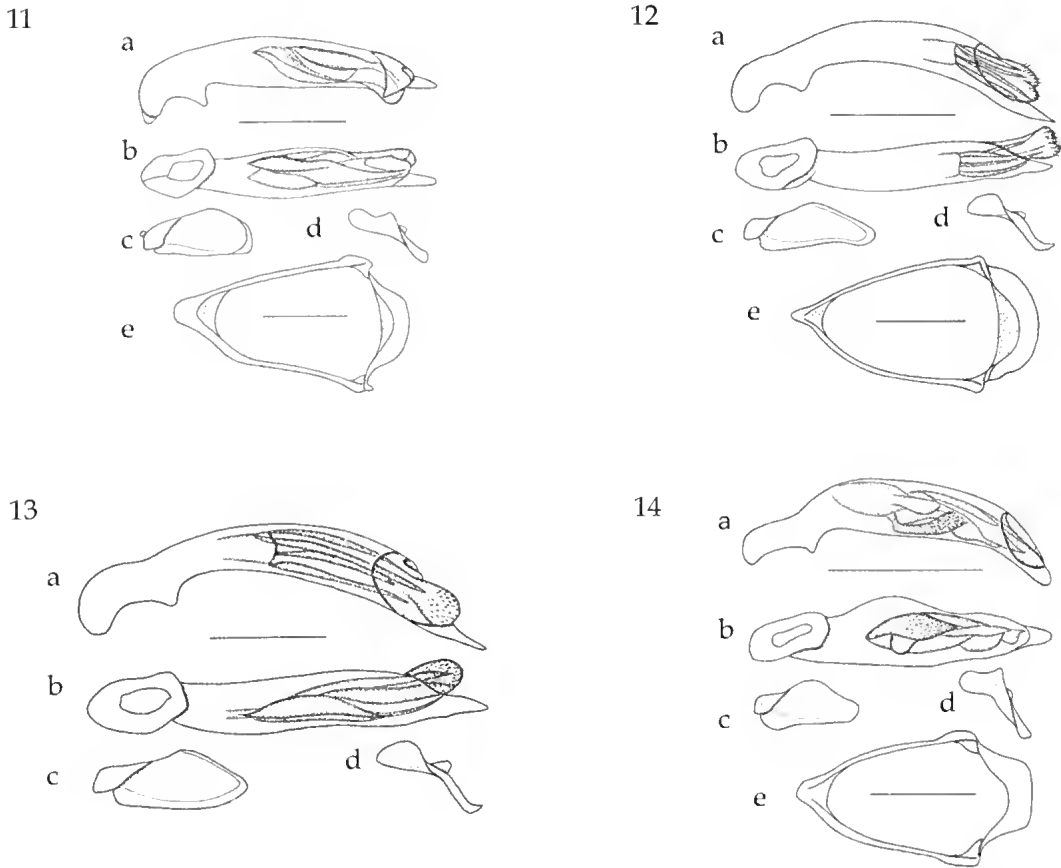
of pronotum: 1.27-1.33; width base/apex of pronotum: 1.06-1.11; width of pronotum/width of head: 1.25-1.34; length/width of elytra: 1.41-1.46.

Colour. (Fig. 2) Head dark piceous to almost black, clypeus, labrum, mandibles, and palpi reddish, antenna light reddish to dark yellow. Pronotum pale reddish-brown, elytra largely dark piceous, but base more or less widely, sutural area and lateral margins narrowly pale reddish-brown. Lower surface dark yellow to pale reddish-brown, epipleura of prothorax and elytra even paler. Legs dirty yellow.

Head. (Figs 2, 9) Fairly large but definitely narrower than the pronotum. Eyes large but laterally little produced, orbits short, oblique-convex. Clypeus transverse, well separated from frons, labrum rather short, moderately wide, anteriorly almost straight, laterally rounded and pilose. Mandibles medium-sized, rather straight, incurved at apex. Mentum with moderately elongate, wide, obtusely triangular tooth. Submentum bisetose, setae very elongate. Lacinia large, apex markedly incurved. Antenna short, not attaining base of pronotum, antennomeres globular, from 5th antennomere wider than long, antenna distinctly widened apicad. Basal antennomeres very sparsely pilose, more densely pilose from 4th antennomere. Posterior supraorbital seta

situated at or slightly in front of posterior margin of eye. Frons without any impressions or wrinkles. Surface including clypeus with dense and very coarse, rugose, isodiametric microreticulation, with dense, fairly coarse punctures which, however, are quite difficult to detect within the rugose microreticulation, and with fairly dense, extremely short, erect pilosity; surface very dull. On labrum microreticulation much more superficial, hence surface quite glossy.

Pronotum. (Fig. 2) Large, rather rectangular, weakly cordiform, with wide base, widest at or slightly behind apical fourth. Apex more or less deeply excised, anterior angles produced but obtuse; lateral margin in anterior half convex, posteriad with shallow, elongate excision, basal angles about 100°, obtuse at tip. Base almost straight, only towards basal angles slightly oblique. Apex not margined, base coarsely margined. Lateral margin in anterior two thirds narrow, posteriad much widened and explanate, margin slightly upturned, marginal channel shallow. Disc gently convex, median line deeply impressed, elongate, almost attaining apex and base. Anterior transverse sulcus very shallow to almost invisible, the posterior transverse sulcus well impressed. Anterior lateral seta inserted at widest diameter, posterior lateral seta inserted at basal angle, both



FIGS 11-14. Male aedeagus and parameres (scale bars: 0.25 mm). **11**, *Anomotariella hippocrepis* sp. nov.; **12**, *Geoffreyella holoserica* sp. nov.; **13**, *Geoffreyella lamingtonensis* sp. nov.; **14**, *Australovelinda seriata* sp. nov. a aedeagus left lateral view; b, aedeagus ventral view; c, left paramere; d, right paramere; e, genital ring.

setae fairly elongate. Surface with dense, distinct, even rather rugose, isodiametric microreticulation which is more rugose on the apical field, with rather dense, coarse, very indistinct punctures within the microreticulation, and with dense, moderately short, irregularly declined pilosity, surface dull.

Elytra. (Fig. 2) Rather short and wide, rectangular, very slightly widened towards apical third, dorsal surface gently convex, but depressed in middle. Humerus very widely rounded, lateral margin very slightly, evenly convex, apical

angles widely rounded, apex oblique, faintly sinuate, slightly incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae complete, shallow, intervals slightly convex, more distinctly so in apical half. Disc with three setiferous punctures near 3rd stria which are very indistinct, as the setae are very short. The anterior puncture located at basal quarter, the posterior punctures at about middle and at apical fifth. 12-13 marginal punctures present, series rather interrupted in middle. Marginal setae of different length but some very elongate. Microreticulation on

intervals dense and distinct, isodiametric, punctation very dense, but punctures indistinct within the dense and rather rugose microreticulation; pilosity very dense, fairly elongate, declined and directed apicad; surface dull.

Metathoracic wings. Fully developed.

Lower surface. Metepisternum fairly short, c.1.5 x as long as wide at apex. Microreticulation dense and fine, rather superficial, more or less transverse, surface glossy. Whole lower surface with moderately dense pilosity, short and erect on thorax, denser, slightly longer, and more declined on abdomen. Setae on terminal abdominal sternum very elongate.

Legs. Comparatively short and stout. 5th tarsomeres usually with a single pair of setae on the lower surface near apex.

Male genitalia. (Fig. 12) Genital ring moderately wide, almost symmetric, laterally evenly convex, with convex base and narrow, short, obtusely triangular apex. Aedeagus comparatively small, narrow and elongate, lower surface slightly concave, perceptibly convex near apex. Apex elongate, triangular, depressed, acute at tip. Orifice elongate, situated at left side. Internal sac composed of several straight folds in parallel arrangement, without any sclerotised pieces, but with several fine spines when inverted at apex. Left paramere narrow and elongate, with triangular apex. Right paramere short, convexly triangular, basal part curved down.

Female gonocoxites. (Fig. 16) Gonocoxite 1 narrow and elongate, without any setae at apical rim; gonocoxite 2 short, oval-shaped, laminate, with widely rounded apex; with a few indistinct dentations at apex; with a moderately elongate dorso-median ensiform seta arising slightly below middle on dorsal surface, and two very large and stout, slightly curved ventro-lateral ensiform setae. Lateral plate with very few setae at apical rim.

Variation. Little variation noted apart from some differences in body size.

Distribution. Higher mountains around the margin of the Atherton Tableland, North-east Queensland.

Collecting circumstances. All specimens sampled by pyrethrum spraying on trees and logs in upland rainforest at altitudes from 700 to 1280 m. 'Trees' actually means the basal 2-3 meters of standing, probably moss-covered trees.

Geoffreyella lamingtonensis sp. nov.
(Figs 3, 6, 13, 17)

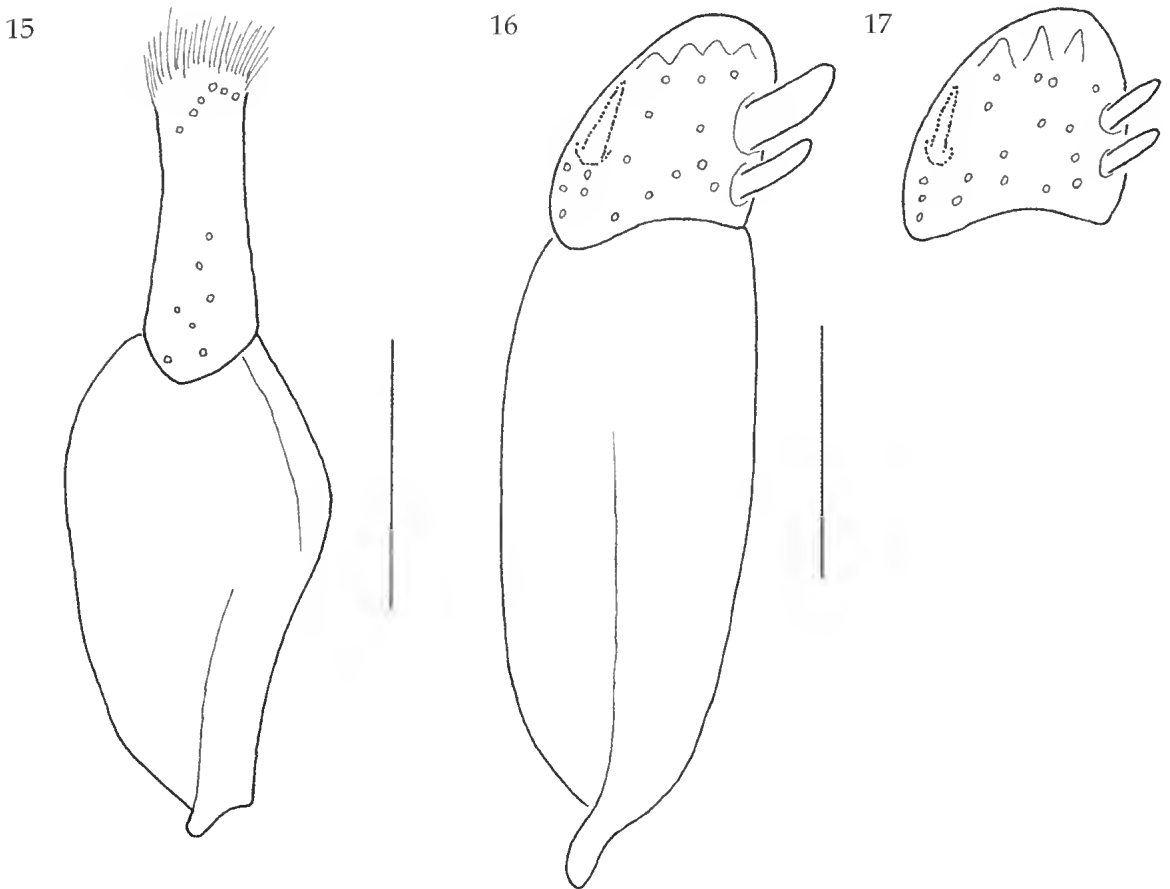
Material. Holotype: ♂, QLD: 28.193°S x 153.128°E Lamington NP. IBISCA 700c, 29 Oct 2008. F. Turco RF, Bark-spray, trees&logs (QMT156376). Paratypes: 2 ♀♀, QLD: 28.188°Sx153.121°E Lamington NP. IBISCA Qld Plot IQ-700-A, 746 m 25 Jul 2007. G.B. Monteith pyrethrum, logs. 31368 (CBM, QM).

Etymology. The name refers to the range of this species at Lamington Plateau and National Park.

Diagnosis. As for genus. Distinguished from the northern *G. holoserica* sp. nov. by larger average size, more extended pale colour at the base of the elytra, and absence, in apical half, of narrow reddish suture and lateral margin; slightly wider prothorax with comparatively wider base, barely punctate and even more rugose pronotum, larger and stouter aedeagus lacking the spines at the apex of the inverted internal sac, and smaller ventro-lateral ensiform setae on the female gonocoxite 2.

Description. *Measurements.* Length: 3.65-4.3 mm; width: 1.5-1.8 mm. Ratios. Width/length of pronotum: 1.35-1.40; width base/apex of pronotum: 1.14-1.19; width of pronotum/width of head: 1.36-1.44; length/width of elytra: 1.47-1.50.

Colour. (Figs 3, 6) Head dark piceous to almost black, clypeus, labrum, mandibles, and palpi reddish, antenna light reddish to dark yellow. Pronotum pale reddish-brown, elytra largely dark piceous, but base widely pale reddish,



FIGS 15-17. Female gonocoxites (scale bars: 0.1 mm). 15, *Anomotariella hippocrepis* sp. nov.; 16, *Geoffreyella holoserica* sp. nov.; 17, *Geoffreyella lamingtonensis* sp. nov.

sutural area and lateral margins of apical part unicolourous dark. Lower surface dark yellow to pale reddish-brown, epipleura of prothorax and elytra even paler. Legs dirty yellow.

Head. (Figs 3, 6) Fairly large but definitely narrower than the pronotum. Eyes large but laterally little produced, orbits short, oblique-convex. Clypeus transverse, well separated from frons, labrum rather short, moderately wide, anteriorly almost straight, laterally rounded and pilose. Mandibles medium-sized, straight, incurved at apex. Mentum with fairly

elongate, obtusely triangular tooth. Submentum bisetose, setae very elongate. Lacinia large, apex markedly incurved. Antenna short, not attaining base of pronotum, antennomeres globular, from 5th antennomere wider than long, antenna distinctly widened apicad. Basal antennomeres very sparsely pilose, more densely pilose from 4th antennomere. Posterior supraorbital seta situated at or slightly in front of posterior margin of eye. Frons with some very faint longitudinal wrinkles near the eyes. Surface including clypeus with dense and very coarse, rugose, isodiametric microreticulation,

with dense, fairly coarse punctures which, however, are very indistinct within the rugose microreticulation, and with fairly dense, extremely short, erect pilosity; surface extremely dull. On labrum microreticulation much more superficial, hence surface quite glossy.

Pronotum. (Figs 3, 6) Large, rather rectangular, weakly cordiform, with wide base, widest at or slightly behind apical fourth. Apex comparatively deeply excised, anterior angles produced but obtuse; lateral margin in anterior half convex, posteriad with shallow, elongate excision, basal angles almost rectangular, slightly obtuse at tip. Base almost straight, slightly oblique towards basal angles. Apex not margined, base coarsely margined. Lateral margin in anterior two thirds narrow, posteriad much widened and explanate, margin very slightly upturned, marginal channel shallow. Disc gently convex, median line deeply impressed, elongate, almost attaining apex and base. Anterior transverse sulcus very shallow to almost invisible, posterior transverse sulcus distinctly impressed. Anterior lateral seta inserted at widest diameter, posterior lateral seta inserted at basal angle, both setae fairly elongate. Surface with dense, very rugose, isodiametric microreticulation which is even more rugose on the apical field, with rather dense, coarse punctures which are extremely indistinct within the microreticulation, and with dense, moderately short, irregularly declined pilosity, surface very dull.

Elytra. (Fig. 3) Fairly short and wide, rectangular, very slightly widened towards apical third, dorsal surface gently convex but depressed in middle. Humerus very widely rounded, lateral margin very slightly, evenly convex, apical angles widely rounded, apex oblique, faintly sinuate, slightly incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae complete, shallow, intervals slightly convex, more distinctly so in apical half. Disc with three setiferous punctures near 3rd stria which are extremely

difficult to detect, as the setae are very short. The anterior puncture located at basal quarter, the posterior punctures about at middle and at apical fifth. 12-13 marginal punctures present, series slightly interrupted in middle. Setae of different length but some very elongate. Microreticulation on intervals dense and distinct, isodiametric, punctation very dense, but punctures indistinct within the dense and rugose microreticulation; pilosity very dense, fairly elongate, declined and directed apicad; surface dull.

Metathoracic wings. Fully developed.

Lower surface. Metepisternum fairly short, c.1.5 x as long as wide at apex. Microreticulation dense and fine, rather superficial, more or less transverse, surface glossy. Whole lower surface with moderately dense pilosity, short and erect on thorax, denser, slightly longer, and more declined on abdomen. Setae on terminal abdominal sternum very elongate.

Legs. Comparatively short and stout. 5th tarsomeres apparently aetose on the lower surface.

Male genitalia. (Fig. 13) Genital ring moderately wide, almost symmetric, laterally evenly convex, with convex base and narrow, short, obtusely triangular apex. Aedeagus moderately large, narrow and elongate, lower surface slightly concave, near apex slightly convex. Apex elongate, triangular, depressed, acute at tip. Orifice elongate, situated at left side. Internal sac composed of several straight folds in parallel arrangement, without any sclerotised pieces and apparently without any spines at apex. Left paramere narrow and elongate, with triangular apex. Right paramere short, convexly triangular, basal part curved down.

Female gonocoxites. (Fig. 17) Gonocoxite 1 narrow and elongate, without any setae at apical rim; gonocoxite 2 short, oval-shaped, laminate, with widely rounded apex, at apex with a few rather distinct dentations; a moderately elongate dorso-median ensiform

seta arising slightly below middle on dorsal surface, and two moderately large, almost straight ventro-lateral ensiform setae. Lateral plate with very few setae at apical rim.

Variation. Apart from some differences in body size little variation noted.

Distribution. Lamington Plateau and National Park, south-east Queensland, at the Queensland/New South Wales border.

Collecting circumstances. All specimens sampled by pyrethrum spraying on trees and logs in upland rainforest at about 700 m.

**KEY TO THE SPECIES OF
GEOFFREYELLA BAEHR**

1. On average smaller species, body length 3.1-3.7 mm; pale colour of base of elytra less extended; in apical half of elytra, suture and lateral margins narrowly reddish; pronotum narrower, ratio width/length 1.27-1.33, with narrower base, ratio width of base/width of apex 1.06-1.11; disc of pronotum with distinct punctures, surface less rugose; aedeagus smaller, with several small spines at apex of the inverted internal sac (Fig.12). North-east Queensland *holoserica* sp. nov.
- On average larger species, body length 3.65-4.3 mm; pale colour of base of elytra more extended; in apical half of elytra, suture and lateral margins dark; pronotum wider, ratio width/length 1.35-1.40, with wider base, ratio width of base/width of apex 1.14-1.19; disc of pronotum with indistinct punctures, surface more rugose; aedeagus larger, without perceptible spines at apex of the inverted internal sac (Fig.13). South-east Queensland. *lamingtonensis* sp. nov.

Genus *Australovelinda* gen. nov.

Type species. *Australovelinda seriata* sp. nov., by original designation.

Etymology. The name is composed of the generic name *Velinda* Andrewes and the stem of the word Australia.

Diagnosis. A genus of the tribe (or subfamily) Lebiini (-inae) and the subtribe Lichnasthenina, characterised by the following features which are not fully repeated in the description of the single species: eyes very large and laterally far produced, orbits very short; clypeus with median carina; labrum short, anteriorly straight, 6-setose; mandibles short; both palpi impilose, the maxillary palp slightly widened apicad and obliquely cut at apex, the labial palp more distinctly widened, rather globose; mentum with apically slightly incised tooth, bisetose; glossa at apex transverse, bisetose, paraglossae hyaline, fused to and not surpassing glossa; lacinia with moderately dense, moderately elongate spines; antenna short, very sparsely pilose, three basal antennomeres impilose, antennomeres from 4th with a number of fine, longitudinal carinae; surface of head with very coarse, isodiametric microreticulation, very dull; pronotum cordiform, bisetose; surface with dense, very rugose, isodiametric microreticulation, with rather elongate, hirsute pilosity which is declined and directed posteriad, surface very dull; elytra weakly widened apicad, gently convex; apex very slightly sinuate; intervals slightly carinate, striae slightly canaliculated; disc apparently with a single setiferous puncture near apex; microreticulation dense and distinct, isodiametric, intervals with a single row of punctures and declined hirsute hairs; metathoracic wings fully developed; terminal abdominal sternum in male quadrisetose; 4th tarsomeres not widened nor excised; lower surface of 5th tarsomeres sparsely setose; tarsal claws minutely denticulate; 1st - 3rd tarsomeres of male protarsus slightly widened, sparsely biserially squamose; genital ring with quadrangular base, markedly excised towards lateral angles; aedeagus small, asymmetric, with short, obtuse apex; internal sac with a minutely denticulate fold in middle; female genitalia unknown.

Distribution. The single species is recorded from eastern central Queensland.

Relationships. Even though the female genitalia of the single species are unknown, this species can be placed in the small subtribe Lichnasthenina on the basis of structure of the mouth parts, surface structure, and colour pattern of the elytra.

Australoveliuda seriata sp. nov.

(Figs 4, 7, 10, 14)

Material. Holotype: ♂, MEQ: 22°02'Sx148°03'E Moranbah, 3 km S. Bendee 25 Mar 2000. G.B. Monteith. Pyrethrum, bendee scrub. 9264 (QMT156374).

Etymology. The species name reflects the uniseriate setosity of the elytral intervals.

Diagnosis. As for genus. Easily distinguished from all recorded Australian lebiine species by the extremely rugose surface, regularly uniseriate setosity of the elytral intervals, and the colour pattern of the elytra.

Description. *Measurements.* Length: 2.55 mm; width: 1.15 mm. Ratios. Width/length of pronotum: 1.36; width base/apex of pronotum: 1.23; width of pronotum/width of head: 1.22; length/width of elytra: 1.48.

Colour. (Figs 4, 7) Head almost black, clypeus, labrum, and mandibles brown, palpi and antenna dark yellow. Pronotum and elytra very dark piceous, lateral margins of pronotum and basal field in middle yellow translucent. Elytra with lateral margins narrowly yellow, disc with inconspicuous, indistinctly limited reddish spots: a large, irregularly triangular humeral spot in anterior half of either elytron that extends from 2nd to 7th intervals, and a common, slightly heart-shaped preapical spot that extends laterad to 4th interval. Lower surface of head almost black, of thorax and abdomen dark piceous with middle of base of abdomen reddish; proepipleura and eplipleura of the elytra dirty yellow to pale brown. Legs dirty yellow, but basal two thirds of femora slightly darker.

Head. (Figs 4, 7, 10) Medium-sized, definitely narrower than the pronotum. Eyes very large and laterally markedly produced, orbits very short, very oblique, almost perpendicular, forming a distinct angle with the neck. Clypeus transverse, well separated from frons, in basal part slightly transversely raised, thus clypeal suture deep, clypeus in middle with a faint carina which extends to the anterior part of frons. Labrum rather short, wide, anteriorly almost straight, weakly rounded laterally, impilose. Mandibles short, almost regularly rounded. Mentum with medium-sized tooth, slightly incised at apex. Submentum apparently bisetose. Antenna short, barely attaining base of pronotum, antennomeres little longer than wide. Three basal antennomeres impilose, from 4th antennomere remarkably sparsely pilose. Posterior supraorbital seta situated well in front of posterior margin of eye, both supraorbital setae located very close to the margin of the eye. Frons medially of the eye with an indistinct, somewhat irregular sulcus and carina. Surface with dense and extremely coarse, highly rugose, isodiametric microreticulation; no punctation recognisable, surface impilose, very dull. Microreticulation on clypeus and labrum much more superficial, hence surface quite glossy.

Pronotum. (Figs 4, 7) Fairly large, decidedly cordiform, widest at apical fourth, dorsal surface gently convex, but impressed on disc. Apex with shallow excision, anterior angles produced but rounded; lateral margin in anterior half convex, posterior with fairly deep, elongate excision, basal angles almost rectangular but obtusely rounded at tip. Base in middle straight, laterally oblique and slightly excised. Apex indistinctly margined, base not margined. Lateral margin moderately wide in anterior two thirds, posterior much widened and explanate, margin slightly upturned, marginal channel moderately deep. Disc gently convex, median line deeply impressed, even somewhat sulcate, elongate, but not attaining apex or base. Anterior transverse sulcus very shallow, situated close to apex, posterior transverse

sulcus not perceptible. Anterior lateral seta inserted at widest diameter, posterior lateral seta inserted at basal angle, both setae elongate. Surface with dense, very rugose, isodiametric microreticulation, punctures virtually invisible within the coarse microreticulation, and with moderately dense, rather elongate and somewhat hirsute pilosity which is declined and mostly directed posteriad, but at apical margin the pilosity is more erect and directed mediad; surface very dull.

Elytra. (Fig. 4) Medium-sized, rather rectangular, slightly widened towards apical third, dorsal surface gently convex, but depressed in middle. Humerus very widely rounded, lateral margin slightly convex, apical angles widely rounded, apex oblique, very slightly sinuate, slightly incurved towards suture. Lateral channel moderately wide, lateral margin slightly upturned. Striae complete, rather deep, even slightly canaliculated, because the intervals are somewhat carinate. Number of setiferous punctures on disc uncertain, because in the holotype only one seta is visible, situated on 3rd interval close to apex. Marginal punctures extremely difficult to recognise as most seta are broken, apparently 12-13 punctures present, series apparently slightly interrupted in middle. Setae when present very elongate. Microreticulation distinct, coarse, isodiametric, slightly superficial, intervals with a row of moderately coarse, indistinct punctures, and with a uniseriate row of mostly rather declined hairs which are directed apicad; however, some of these hairs erect; surface moderately dull.

Metathoracic wings. Fully developed.

Lower surface. Metepisternum moderately elongate, slightly >1.5 x as long as wide at apex. Microreticulation dense and rather coarse, more or less transverse, surface moderately glossy. Lower surface apparently impilose. Terminal abdominal sternum in male quadrisetose, the

lateral pair of setae very elongate and longer than the median pair.

Legs. Fairly slender and elongate. 5th tarsomeres with two rather strong setae on the lower surface; teeth on tarsal claws indistinct; squamosity on male protarsus elongate.

Male genitalia. (Fig. 14) Genital ring moderately wide, almost symmetric, laterally evenly convex, with elongate, rather quadrangular base, markedly produced lateral angles, and short, obtuse apex. Aedeagus small, elongate, at middle of left side suddenly widened, lower surface very gently convex, bent down towards apex. Apex rather short, moderately wide, obtuse at tip. Orifice short, situated at left side. Internal sac with fairly complex folding, with a minutely denticulate fold at left side in middle, otherwise without any sclerotised pieces. Left paramere rather short, with obtusely triangular apex. Right paramere short, stout, apex convex.

Female gonocoxites. Unknown.

Variation. Unknown.

Distribution. Eastern central Queensland. Known only from type locality near Moranbah.

Collecting circumstances. Holotype collected by pyrethrum spraying of tree trunks in 'bendee scrub' (*Acacia catenulata*). This *Acacia* species has prominent grooves and folds in the trunk surface offering retreats for insects living on the trunk surface.

REMARKS

All the newly described genera and species are rather odd-shaped beetles which, in shape and structure, widely deviate from other genera and species of lebiine carabid beetles so far recorded from Australia.

On the basis of the shape and structure of their female gonocoxites, *Anomotariella* can be allocated to the subtribe Anomotarina (= Calleidina) and *Geoffreyella* to the subtribe

Dromiina, respectively, but within their subtribes the systematic position of both genera seems to be quite isolated and not easily determined.

The female gonocoxites of *Auomotariella hippocrepis* differ from those of all recorded anomotarine genera of the Australian region and seem to be plesiomorphic in their dense apical setosity. They most resemble the gonocoxites of the New Caledonian genus *Do* Baehr (Baehr 2009), but are differently shaped, and the lateral plate is aetose. The apparent arboricolous habit of *Auomotariella* is likewise specialised, because most Australian Anomotarina, and also the New Caledonian *D. holotrichius* Baehr, are ground-living beetles. Only the single species of the genus *Rugitarus* Baehr (*R. puellarum* Baehr) is arboricolous, but the various subspecies of this species occur in open forest to semiarid woodland (Baehr 2009), whereas the single species of *Auomotariella* inhabits montane rain forest.

The female gonocoxites of the genus *Geoffreyella* undoubtedly place it in the Dromiina, but it differs very much in shape and surface structures from 'normal' dromiines. Dromiina are barely represented in Australia with only three genera occurring: *Barrymooreana* Baehr with a single species, *Microlestodes* Baehr with 13 Australian species, and *Brigalowia* Baehr. *Microlestodes* and *Barrymooreana* are typical Dromiina, but the systematic position of *Brigalowia* is still somewhat uncertain, and in shape and structure the unique species much deviates from the 'normal' dromiine habitus. *Brigalowia setifera* Baehr is also arboricolous and occurs in deep fissures in the bark of acacias in semiarid areas (Baehr 2006). Both species of *Geoffreyella*, however, were collected from tree trunks and logs in montane subtropical or tropical rainforest, and certainly the genus is not related to *Brigalowia*.

The occurrence of two slightly different species of *Geoffreyella* on rainforest tablelands of south-eastern, and north-eastern Queensland, respectively, confirms a distribution pattern

that is very common in carabid beetles and many other rainforest inhabiting creatures. It seems that the Atherton, Carbine and Windsor Tablelands in North Queensland, and the Lamington Plateau in southern Queensland, respectively, are the main areas where a rich and diverse montane tropical-subtropical rainforest fauna has survived the various climatic changes during Glacial Periods. Hence, the occurrence of closely related but separate species in both regions is not surprising, even in view of the great distance (1300 km) between both areas.

Australoveliuda seriata represents the first Australian member of the peculiar, very small subtribe Lichnasthenina which so far has been known from only six genera containing a handful of described species that mostly occur in southern Africa and Madagascar, with a single genus and species recorded from India (*Veliuda lirata* Andrewes) (Lorenz 2005). It seems that this subtribe represents another example of a carabid group having an (southern) Afrotropical-Oriental-Australian range which may reflect old Gondwanan relationships. Other examples within Carabidae that possess this sort of range are the zuphiine tribe (or subtribe) Leleupidiini (-ina) and the pseudomorphine genus *Cryptocephalomorpha* Ritsema. In both groups a single known Australian species occurs in north-eastern Queensland (Baehr 1987, 1997).

All species mentioned in the present paper have been sampled by pyrethrum spraying of tree trunks and logs, from either moss-covered rainforest trees or from rough-barked trees in open forest and woodland. Again it must be stressed that this method, at least in the diverse forests and woodlands of Australia, is one of the most promising techniques for sampling carabid species which are not easily collected using other sampling methods (see e.g. Baehr 1995, 2006, 2008, 2009). Actually, the systematic use of this technique during the previous 20 years, in particular carried out by G.B. Monteith and co-workers in Australia, has brought to

light many very peculiar arboricolous carabid species.

ACKNOWLEDGEMENTS

First of all, my thanks are due to Geoff Monteith (Brisbane) who kindly loaned the bulk of the available material. I am also grateful to Tom Weir (Canberra) and Lothar Zerche (Müncheberg) for the loan of specimens. The Deutsche Forschungsgemeinschaft (DFG) is thanked for several grants for visits at certain Australian Collections where I was able to sort through unidentified material.

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Emendation of the specific name of the frog *Neobatrachus sudelli* (Lamb, 1911) (Anura: Myobatrachidae).

Memoirs of the Queensland Museum 56(1): 116-117. 2012:- Lamb (1911) described three species of frog, *Heleioporus sudelli*, *Hyla vinosa* and *Limnodynastes marmoratus*. All three species were rapidly synonymised with previously known species (*Heleioporus pictus* (Peters 1863), *Hyla lesueuri* Duméril & Bibron, 1841 and *Limnodynastes fletcheri* Boulenger, 1888, respectively) by Fry (1912). The latter two species have subsequently remained in synonymy. *Heleioporus sudelli* has had a more tortuous taxonomic history. Loveridge (1935) synonymised both *H. sudelli* and *H. pictus* with *H. eyrei* (Gray 1845), but later in the same account states that *pictus* is 'a full species'. Parker (1940), without examining the type material, separated the three again, treating *H. sudelli* as a distinct species, but expressed the opinion that it might be a species of *Limnodynastes*. Parker also suggested that *Heleioporus* might be divisible into two genera, with *Neobatrachus* representing the *pictus* group. Main (1957) and Main *et al.* (1958) formalised the latter suggestion, but did not treat *sudelli* as a distinct species. Similarly, Hosmer (1958) and Moore (1961), based on examination of type specimens in the Queensland Museum and the Australian Museum, continued to treat *H. sudelli* as a synonym of *Neobatrachus pictus*. However, Roberts (1978) resurrected *Neobatrachus sudelli*, based on differences in calls and the morphology of the skin in the groin. Subsequently, Mahony & Robinson (1980) reported that the two species differed karyologically, with *N. sudelli* being tetraploid and *N. pictus* diploid. Subsequent work (Mahony & Roberts 1986) determined that *N. centralis* (Parker 1940), *N. kuwapalari* Mahony & Roberts, 1986 and *N. aquilonius* Tyler *et al.*, 1981 were also tetraploid. The relationship between these four tetraploid species has been the subject of much recent attention, with analyses of genetics and call structure concluding that *N. sudelli*, *N. centralis* and central Australian populations previously ascribed to *N. aquilonius* belong to a single lineage (Mahony *et al.* 1996; Roberts 1997a,b; Mable & Roberts 1997). While these studies concurred in suggesting that *N. sudelli* and *N. centralis* might be synonymous, they did not formally synonymise the two species; Roberts (1997a) stated 'the status of *N. aquilonius* and *N. centralis* as possible synonyms of *N. sudelli* was not resolved'. However, in the absence of differentiation in call structure, allozymes or mitochondrial DNA sequence data, and with few morphological characters purported to distinguish the two species (Hosmer 1958; Cogger 2000; Anstis 2002), Roberts (2010) formally synonymised *N. centralis* with *N. sudelli*, and hence *N. sudelli* now has a distribution extending into all mainland states and territories.

Despite the previous attention to the species, no author appears to have noticed that Lamb (1911) clearly stated that the species was named after Miss J. Sudell of Warwick, Queensland, the collector of the types. A search of the

online Queensland Births Deaths and Marriages website reveals that only a single person with surname Sudell was born in Queensland between 1870 and 1911: Jane Ann Sudell, born in 1880 at Warwick to Henry Sudell and Emma Jane Lamb, who had married in 1879. Emma Jane Lamb (née Harrison) was the widow of Joseph Spurr Lamb (d. 1878), and the mother of Joseph Lamb (b. 1869), describer of *Neobatrachus sudelli*. Hence, Jane Ann Sudell was Joseph Lamb's younger half-sister.

As the species was named after a woman, the species name, a noun in the genitive case that is not of Latin origin, must have a feminine termination (Article 31.1.2, ICZN, 2000), and as there is, in the original publication, without recourse to external sources of information, evidence of an inadvertent error in the formation of the species name (Article 32.5.1) I formally emend *Neobatrachus sudelli* to *Neobatrachus sudellae*.

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The pachyrhizodontid teleosts from the marine Lower Cretaceous (latest mid to late-albian) sediments of the Eromanga Basin, Queensland, Australia

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Citation: Bartholomai, A. 2012 02 17: The pachyrhizodontid teleosts from the marine Lower Cretaceous (latest mid to late Albian) sediments of the Eromanga Basin, Queensland, Australia. *Memoirs of the Queensland Museum-Nature* 56(1): 119-148. Brisbane. ISSN 0079-8835. Accepted: 11 March 2010.

ABSTRACT

Two species of the fossil pachyrhizodontid teleost, *Pachyrhizodus*, are present in the marine Lower Cretaceous (mid to late Albian) Toolebuc and Allaru Formations of the Eromanga Basin in Queensland, Australia. New morphological data on *P. marathonensis* (Etheridge Jnr., 1905) is provided as part of a revision of the species. The smaller and much less common *P. grawi* sp. nov. is described and is shown to co-exist with *P. marathonensis* but has a more restricted distribution. *Pachyrhizodus grawi* is more gracile than the larger species, with a shorter premaxilla and with its jaw articulation positioned more anteriorly, below and just behind the back of the orbit. □ *Pachyrhizodontidae*, *Pachyrhizodus*, *P. marathonensis*, *P. grawi* sp. nov., Toolebuc Formation, Allaru Formation, Lower Cretaceous, Albian, Eromanga Basin, Queensland, Australia.

As part of a general review of Queensland's Lower Cretaceous fossil marine fishes, recently collected specimens added to the Queensland Museum collections expand representation of material referable to the Family Pachyrhizodontidae.

This material was largely collected from poorly exposed surface exposures of both the Toolebuc and Allaru Formations, that occur as an arc around the northern and western edge of the Eromanga Basin (part of the Great Artesian Basin) and that were deposited within the epeiric sea of that time.

For over a century, fossil teleosts that were originally described by Etheridge Jnr. (1905) as *Ichthyodectes marathonensis* appeared to represent the only pachyrhizodontid present in the Australian Cretaceous sediments. Bardack (1962) suggested that this species should have been referred to *Pachyrhizodus* but considered the age of the deposits from which it was

derived to be Upper Cretaceous. Bartholomai (1969) agreed with Bardack's (1962) suggestion regarding the taxonomic position of the species, provided a more complete description of its skeletal morphology, and corrected the age of the deposits from which it was derived to Lower Cretaceous (Albian). Forey (1977) has subsequently added further comments on the morphology of *P. marathonensis*, based on a specimen, P 55858, in the collections of the British Museum (Natural History).

The thin, widespread and organic-rich Toolebuc Formation (and the contemporaneous but considerably thicker Allaru Formation) is now dated as latest mid to late Albian, the *Pseudoceratium ludbrookiae* dinoflagellate zone/upper *Coptospora paradoxa*-*Phimopollenites paunosus* spore-pollen zone (Moore *et al.* 1986; McMinn & Burger 1986). Henderson (2004, Fig.1) has provided a map of the Great Artesian Basin and its subdivisions that also illustrates the surface

expression of the Toolebuc Formation. He has suggested the age should be refined further to late Albian on the basis of ammonite and nannofossil biostratigraphy. However, the author prefers to retain the more conservative age determination for the purposes of the current study. Material referred in the study to a new, more gracile species has come from localities close to Richmond, CNQ, close to the oceanic inflow area over the basement Eureka Ridge between the Eromanga and Carpentaria Basins. Distribution of the larger species, *P. marathoniensis* is wider, extending from near the Eureka Ridge area to the western margin of the Eromanga Basin, near Boulia, CWQ, east of the Northern Territory border.

Nearly all pachyrhizodontid material studied is neurocranial and only rarely are more than anterior parts of the body present. This reflects the fact that the bulk of specimens have come from the poorly layered coquinite that represents the majority of the rare surface exposures of the Toolebuc Formation. Little material has been collected from the Allaru Formation. Many preserved specimens form the nucleus of calcilutite concretions that are developed within the coquinites and that are released and exposed on the surface by weathering and erosion of the containing sediment. Excavation of exposed coquinites by the Kronosaurus Korner, Richmond, NCQ, has recently provided almost complete specimens of several of the early teleosts, including an almost complete skeleton and body outline identified by the author as *S. achyridodus* sp. and a large specimen of the ichthyodectid, *Cooyoo australis* (Smith Woodward, 1894). Similar excavations have been undertaken below surface finds by the Stonehouse Museum, Boulia, CWQ but, to date, success there has mostly been in regard to articulated remains of marine reptiles and cranial remains of fishes. Recently exposed fish remains are often of higher quality compared to those that have remained on the surface for longer periods. Much of the material in the Queensland Museum has been prepared using

acetic acid but that held externally on loan is often either unprepared or has been cleared manually of supporting matrix.

ABBREVIATIONS

Material examined listed with prefix 'F' refers to fossils in the palaeontological collection at the Queensland Museum at Hendra Brisbane.

Ang.	angular
Ao.	antorbital
Atfc.	anterior opening jugular canal
Asp.	autosphenotic
Bhtp	basihyal tooth plate
Boc	basioccipital
Bsp	basisphenoid
Cb.	ceratobranchial (1-4)
Cea	anterior ceratohyal
Cl	cleithrum
De.	dermethmoid
Den.	dentary
df	dilatator fossa
Dsp.	dermosphenotic
Eb.	epibranchial (1-3)
Ect.	ectopterygoid
Enpt	endopterygoid
Epo.	epiotic
Exo	exoccipital
fm	foramen magnum
fmcv	foramen for middle cerebral vein
focc	foramen for occipital nerve
fVIIot	foramen for otic branch of VII
Fr	frontal
H.	hypural
Hm	hyomandibular
Ic.	intercalar
Io.	infraorbital (1-5)
Le	lateral ethmoid
Me.	mesethmoid
Mpt.	metapterygoid

Pachyrhizodontid teleosts from the marine Lower Cretaceous

Mx	maxilla
Op	operculum
Ors	orbitosphenoid
Pa	parietal
Pal	palatine
Par	parasphenoid
Ph	parhypural
Pmx	premaxilla
Pop	preoperculum
Pro	prootic
Psp	pterosphenoid
Pto	pteric
Pu	preural centrum (1-2)
Qu	quadrate
Rart	retroarticular
Smx	supramaxilla
So	supraorbital
Soc	supraoccipital
Sop	suboperculum
Sosc	supraorbital sensory canal
Spl	clerotic plate
Un	uroneural (1-2)
I	foramen for olfactory tract
II	optic nerve opening
III	foramen for oculomotor
V	foramen for trigeminal

Cohort Elopomorpha incertae sedis

Suborder Pachyrhizodontoidei Forey, 1977

Family Pachyrhizodontidae Cope, 1872

Genus Pachyrhizodus Dixon, 1850

Type species. *Pachyrhizodus basalis* Dixon, 1850

Generic Diagnosis. An emended generic diagnosis is provided in Forey (1977).

The Queensland material essentially conforms with that diagnosis but possesses the

following features: Dermethmoid broad, laterally with muted posteroventral processes, lacking definitive bone-enclosed ethmoid commissure. Exoccipitals meet above and below foramen magnum. Endochondral elements of posterior of otic region meet loosely without interdigitating sutures. Dilator fossa present, sometimes emphasised anteriorly by a large fenestra between autosphenotic and pterotic below excavated frontal margin behind autosphenotic 'crest'; pterotic roof of dilator diminishes posteriorly to virtually disappear. Fenestration of anterior ceratohyal variably present. Preoperculum varies from minimally expanded ventrally to significantly expanded posteroventrally, with preopercular sensory canal moderately branched across preopercular base.

Discussion. Forey (1977) undertook a complete redescription of the osteology of a number of Cretaceous teleosts referred to the genera *Notelops* Smith Woodward, 1901, *Rhacolepis* Agassiz, 1841 and *Pachyrhizodus* Dixon, 1850 (including its junior synonym, *Thrissopater* Günther 1872) and provided comments on *Elopopsis* Heckel, 1856. He provided emended generic diagnoses and erected a new suborder, the Pachyrhizodontoidei for *Notelops*, *Rhacolepis*, *Pachyrhizodus* and *Elopopsis*. This was proposed on the assumption that *Pachyrhizodus*, *Rhacolepis* and *Notelops* form a monophyletic group suggested by the common possession of patterns of derived character states in the circumorbitals and the caudal skeleton. He separated *Notelops* within a new family, the Notelopidae, regarding it as a plesiomorphic sister group of the Pachyrhizodontidae Cope, 1872, to which he referred the other genera. A full discussion of the earlier history of the pachyrhizodontoids was included in Forey (1977).

Taverne (1987) concluded that *Pachyrhizodus* is the plesiomorphic sister group of *Rhacolepis*, indicating that some species of the former genus still possess a primitive mesethmoid, with well ossified supraethmoid and hypoethmoid, while *Rhacolepis* has an evolved small and carti-

laginous mesethmoid. The taxonomic positions of *Rhacolepis* and *Pachyrhizodus* were also reviewed by Maisey (1991a), who suggested that these genera are clearly elopocephalans (*sensu* Patterson & Rosen 1977) with some evidence supporting an elopomorph relationship. However, Maisey observed that much of the morphological basis for this had been shown by Forey (1977) to represent primitive character states. In reviewing the taxonomy and morphology of the early South American albuloid, *Paraelops*, Maisey (1991b) showed that the principal characters used by Forey (1977) to establish pachyrhizodontoid monophyly also occurred in this genus. He suggested that this introduced doubt that the pachyrhizodontoids are monophyletic. As a consequence, he treated notelopids as being referable to the Cohort Elopomorpha *incertae sedis*.

While detailed descriptions of the osteology of *N. brama*, *R. buccalis* and *P. megalops* were provided by Forey (1977), no exhaustive revision of all of the described species was undertaken. Only minimal discussion of the Australian and North American species of *Pachyrhizodus* was undertaken. Nonetheless, his descriptions of those species studied in detail and his comments on other described pachyrhizodontoid taxa, provide an invaluable basis for further work, in the current instance on the morphology and evolutionary radiation of pachyrhizodontids in the Australian region.

The genus *Pachyrhizodus* is represented by numerous fossil species from marine Cretaceous deposits of England, France, Italy, North America, New Zealand and Australia. Forey (1977) concluded that six species of *Pachyrhizodus* range in age from the Albian to the possible Santonian in England. Subsequent work by Wenz and Fricot (1985) records one of these species from the Albian of France, while Sorbini (1976) records two of the English species and an additional taxon from the Turonian/Cenomanian deposits of northern Italy. Applegate (1970) recognised three different species of *Pachyrhizodus* in North American Turonian to Campanian sediments. A

single species, identified as conspecific with one of the North American species, *P. caninus* Cope, has been recorded from the Late Cretaceous of New Zealand by Wiffen (1983). Until the current study, only *P. marathoneensis* (Etheridge Jr. 1905) was described from Australia (Bardack 1962; Bartholomai 1969).

A prepared specimen in the collections of the British Museum (Natural History), numbered BM(NH) P 55858, from the marine Cretaceous (Albian) of Queensland, was illustrated and referred by Forey (1977, Fig. 33) to *P. marathoneensis*. He listed the features he regarded as 'typical' for *Pachyrhizodus* but added that the specimen possessed a large basibranchial tooth plate and a spine-like anterior tip of the preoperculum, features seen in *Rhacolepis*. He also observed the fenestrated anterior ceratohyal in the specimen, noting it was 'the only species (of *Pachyrhizodus*) in which a fenestrated anterior ceratohyal is recorded'. He illustrated a clearly defined antorbital in the specimen but ascribed it to part of the supraorbital.

Forey (1977) concluded that although the pachyrhizodontoids as a group possess a compliment of derived character states comparable with proto-canthopterygian euteleosts, they should be left as Teleostei *incertae sedis*, in keeping with Nelson's (1973) earlier conclusion to this effect, based upon a comparative study of lower jaws. Maisey (1991a) noted that *Pachyrhizodus* and *Rhacolepis* share several specialised features and that a number of other characters unite these genera with *Notelops*. He added that the principal characters applied by Forey (1977) to establish pachyrhizodontoid monophyly are also found in the early albuloid, *Paraelops*, concluding that it is no longer clear that pachyrhizodontoids are monophyletic, leading to their treatment as *incertae sedis* elopomorphs. Maisey (1991a) also concluded that separation of *Pachyrhizodus* and *Rhacolepis* is not as straightforward as that between *Rhacolepis* and *Notelops*. Indeed, where preserved, most of the character states considered diagnostic for *Rhacolepis* by Maisey (1991a) are

shared by one or both of the Australian species of *Pachyrhizodus* recognised below.

Pachyrhizodus marathouensis
(Etheridge Jnr., 1905)
(Figs 1- 7)

- 1905 *Ichthyodectes marathouensis* Etheridge Jnr., 5
1962 *Pachyrhizodus marathouensis* (Etheridge Jnr.); Bardack, 387
1969 *Pachyrhizodus marathouensis* (Etheridge Jnr.); Bartholomai, 250
1977 *Pachyrhizodus marathouensis* (Etheridge Jnr.); Forey, 178

Material examined. L 504 (Australian Museum, Sydney), cast of holotype, partial skull with 10 attached vertebrae, original apparently lost, Flinders River, nr. 'Marathon' Station, nr. Richmond, NCQ. F 355, skull, Flinders River, nr. Hughenden, NCQ., figd. Bartholomai (1969, pl. 15). F 3349, skull and anterior of body, 14 miles N of 'Springvale' Station, SE of Boulia, CWQ., figd. in part Bartholomai (1969, figs. 47-8). F 5687, skull and anterior of body, 'Boree Park' Station, nr. Richmond, at MR 622415 Richmond 1: 250 000 sheet, NCQ., figd. Bartholomai (1969, pl. 14). F 5688, incomplete posterior of skull and anterior of body, 'Boree Park' Station, nr. Richmond, at MR 627413 Richmond 1: 250 000 sheet, NCQ. F 5690, incomplete anterior of skull, 'Boree Park' Station, nr. Richmond, NCQ. F 5691, very distorted partial neurocranium, 'Sylvania' Station, nr. Hughenden, NCQ. F 5692, fragments of skull and skeleton, 'Dinga Ding' Station, nr. McKinlay, at MR 404304 McKinlay 1:250 000 sheet, CWQ., figd. in part Bartholomai (1969, fig. 49). F 5705, partial vertebral column and isolated fin, 'Boree Park' Station, at MR 627413 Richmond 1:250 000 sheet, NCQ. F 10111, partial skull, locality unknown. F 13713, partial anterior of body, 'Dunraven' Station, unnamed tributary of Stewart Creek, N of Hughenden, NCQ. F 13725, partial skull, locality as for F 13713. F 14422, skull and anterior of body, 'Canary' Station, nr. Boulia, CWQ. F 14423, skull and anterior of body, 'Canary' Station, nr. Boulia, CWQ. Uni.Qd. F 10210, skull, 'Boree Park' Station, NCQ. F 15212, partial neurocranium, 'Marathon' Station, N of homestead along anabranch of Flinders River, at MR 123396 Richmond 1:250 000 map (E of Richmond), NCQ. F 18919, base of neurocranium, 'Boree Park' Station, NW of Richmond, NCQ. F 48771, incomplete base of neurocranium, QML 754, 'Marathon' Station about 1.5- 3 kms. from homestead, upstream along Flinders River (E of Richmond), NCQ. F 49152, partial skull and anterior of body, 'Warra' Station, nr. Boulia, CWQ. F 49170, very weathered partial skull, Elizabeth Springs, S of extremity of Toolebuc adjacent to spring (W of spring) nr. Boulia, CWQ. F 49172, skull, anterior of body and abdominal scales,

'Lorna Downs' Station, nr. Boulia, CWQ. F 49173, Partial skull, 'Slashers Creek' Station, approx. 1 km. W of homestead, just N of Gidgee Gully, nr. Boulia, CWQ. F 49175, partial skull, 'Slashers Creek' Station, nr. Boulia, CWQ. F 49201, partial skull, 'Elizabeth Springs' Station, nr. Boulia, CWQ. F 54815, partial skull, Richmond, NCQ.

Formations and age. All specimens have been derived from the marine Toolebuc and Allaru Formations of the Great Artesian Basin in Queensland, Australia but most have come from Toolebuc sediments. They are all of Lower Cretaceous (latest middle to late Albian) age.

Emended diagnosis. Relatively large, fusiform species of *Pachyrhizodus*, exceeding ca. 80 cm. total length with body depth of ca.17.5 cm. Skull roof width at autosphenotics slightly narrower than across otic region; orbit length about 26% of neurocranial length; large, separate antorbital present; supraorbital large, ornamented, sutured to dermosphenotic; posterior infraorbitals separate, elongated; supraoccipital often with foramina leading to post-temporal fossa on each side of solid, posteriorly directed process; vomer with at least one, large, recurved, internal tooth; complex external expression of mesethmoid present at posterolateral margin of olfactory capsule; dilator fossa roofed but with roof reduced posteriorly; large foramen penetrates dilator fossa anteriorly between autosphenotic and pterotic; hyomandibular with very slightly anteriorly curved shaft and with prominent, thin, anteriorly directed crest supporting posterodorsal margin of metapterygoid; inner wing of metapterygoid strongly flexed, reduced and rounded; ectopterygoid carries numerous, fine, recurved teeth; endopterygoid large, narrowing anteriorly; palatine slightly expanded anteriorly; lateral ethmoid large, ossified, meeting posterior of vomer and anterior of parasphenoid; autosphenotic spine more crest-like, added to ventrally by prootic; anterior and lateral surfaces of prootic separated by sharply angled, anterolateral flange; premaxilla with strong dorsal wing; marginal premaxillary and maxillary teeth similar with largest up to 5.1 mm long; six

incurved marginal premaxillary teeth and up to three mesially angled internal teeth present, with central one largest (ca. 8 mm long); maxilla with ca. 22 marginal teeth; dentary with fewer but larger, incurved marginal teeth in a single row (ca. <11 present, up to 9.0 mm long), with anterior teeth slightly backwardly inclined; dentary with deep, slightly inflected, ventral flange; retroarticular separate, expanded medially and with angular and articular also unfused posteriorly; dorsally, articular facet with a thin sliver of articular overlying angular, excluding contribution by angular at least to upper part of facet; anterior ceratohyal with large dorsal fenestra; preoperculum not greatly expanded posteroventrally, acutely pointed anteroventrally; supratemporals large, not meeting along mid-line, each with radiating grooves leading from area of anterior supratemporal commissure; post-temporal with elongate, stout, epiotic limb and extended, thin, intercalary limb; pectoral fin large with up to 18 fin rays and with the outer fin ray very robust.

Descriptive remarks. Although a detailed description of the cranial osteology of this relatively large species was provided in Bartholomai (1969) and additional morphological comments were published in Forey (1977), an expanded description is provided because of the additional details/information now available. The skull showing external and internal bony elements is shown in Figs. 1 and 2 respectively and was also illustrated by Bartholomai (1969, Pls. 14 and 15).

Neurocranium. The incomplete cranial roof in F 13725 (Fig. 3) is only slightly distorted. Similar to that figured by Forey (1977) for *P. megalops* (Smith Woodward) from the Cenomanian Lower Chalk of Sussex, England, it has lateral emargination, exaggerated in some specimens, originating from just anterior to the autosphenotic 'spines'. *Pachyrhizodus megalops* has frontals that are relatively more elongated anterior to the emargination. Greatest depth of the braincase

is about 43% of total neurocranial length and occurs above the upward flexure of the parasphenoid. Length of the orbit, at 26% of neurocranial length, is less than recorded for English species in Forey (1977), viz. 50% in *P. megalops*; 30% in *P. magnus* and *P. subulidensis* but is about the same as in *P. salmonius*. The skull roof has a shallow median frontal depression, often accentuated where lateral compression occurred during fossilisation, a character not present in *Rhacolepis*, as redefined by Maisey (1991a). The skull roof is somewhat convex across the otic region and is also slightly arched dorsally above the posterior of the orbits. The gape is elongate and set at an angle of about 35° to the horizontal.

The dermethmoid is solid, medially dished and anteriorly bluntly pointed and is overlain posteriorly by the frontals (Fig. 4A, B). Laterally it is notched above the olfactory capsule and is extended into muted posteroventrally projecting arms on each side, around the anteroventral base of the margin of the olfactory capsule, similar to those depicted by Forey (1977) for *Notelops* and *Rhacolepis*. This feature is lacking in *P. megalops* and consequently was applied by Maisey (1991a) in his emended generic diagnosis for *Rhacolepis*. The bone broadens posteriorly and, like *P. megalops*, is marked by fine lateral ridges and grooves radiating from the mid-dorsal surface over raised 'humps' and that appear to represent the crests of anterodorsally angled, fused plates that extend onto the ventrolateral arms; a number of fine pores are present within the grooves and it is possible that this structure includes an enclosed ethmoid commissure. However, a bone encased commissure is generally lacking in *Rhacolepis* and *Pachyrhizodus* as noted by both Forey (1977) and Maisey (1991a). Posterolaterally, the dorsal surface has small, overlapping, posteriorly directed, ossified sheets. Anterolateral facets are present for ligamentary attachment of the dorsal processes of the premaxillae and, as in *P. megalops*, there is a deep, spongy ossification interpreted as part of the mesethmoid.

The posterior of the olfactory capsule cups a complex, more compact lateral part of the possible mesethmoid (Figs. 4A, B). Anteromedially this lines the capsule and posterolaterally extends beyond the margin of the dermethmoid, separated by a short process that masks a laterally directed small pore. A larger, associated part floors the posterolateral part of the capsule. Dorsally, this carries a deep, thin flange with a small, lateral pore that meets the base of the short process mentioned above. Basally, it bears two, elongated ridges with the dorsal one curving ventrally to the front of the antorbital (see below) and with the ventral one extending to meet the supraorbital. Each has a small pore towards the external edge, at its extremity.

No nasal has been found in any of the referred specimens of *P. marathoniensis* and Forey (1977) states that no nasal has been located in any *Pachyrhizodus* available to him. However, Taverne (1987) records an element identified as a nasal in *P. subulidensis* from Italy.

The frontal represents the major component of the neurocranial roof (Fig. 3 and Bartholomai 1969, Fig. 48). It is deeply emarginated just posterior to the autosphenotic spine and the skull roof is shallowly depressed medially. Laterally, the emarginated area joins with a minimal contribution from the pterotic to provide a roof for the anterior of the dilator fossa. The interfrontal suture is dentate. Ornamentation of the frontal, apart from the longitudinal ridge associated with the supraorbital sensory canal, is variably developed from one individual to another. The supraorbital sensory canal opens just posterior to the dermethmoid junction (see Figs. 4A, B) and well-defined, short, posterior and medial processes terminating in elevated pores are present close to the centre of ossification in F 14422. Ornamentation in most individuals is, however, usually weak anteriorly, radiating from the centre of ossification anterolaterally and laterally, with intervening bone with very fine tubercles in the anterior moiety. Ridges curving

gently posterolaterally from the centre of ossification in F 14422 are sometimes stronger, while those across the medial suture are even coarser. A well developed pore is sometimes present near the lateral margin of the parietal suggesting that the supraorbital sensory canal extends into this element. No lateral branch opening above the autosphenotic spine has been observed.

Continuation of the posterolateral ridges from the frontal occurs onto the dorsal surface of the pterotic. This element provides the bulk of the posterolateral cranial roof. The pterotic roofs the bulk of the dilator fossa but is progressively reduced posteriorly. The posterior of the dilator fossa itself narrows and diminishes to almost disappear posteriorly. Laterally, the bone carries the posterior one-half of the hyomandibular facet and contributes to the lateral and anterodorsal sides of the post-temporal fossa. No pterotic spine is present. However, the detail of the extent of the pterotic on the lateral cranial surface is usually masked by the hyomandibular or upper circumorbitals.

The parietal is small, wider than long and, as shown by Bartholomai (1969, Fig. 48), is widely separated from its counterpart by a dorsal wedge of the supraoccipital. It is ornamented by muted ridges and, as mentioned above, appears to carry an extension of the supraorbital sensory canal.

The supraoccipital is relatively small and separates the parietals dorsally. It carries a short, posteriorly directed but variable supraoccipital process that usually appears thinner dorsally than in *P. megalops* and is generally less developed and shorter than in *Rhacolepis* or *Notelops*, as figured by Forey (1977). Foramina leading to the post-temporal fossa are variably present on each side of the upper part of the process but are said to occur in other pachyrhizodontid genera (Forey 1977). The posterior junctions of the supraoccipital with the epiotic and exoccipital are loose and often open and apparently cartillagenous (see Bartholomai 1969, fig. 47).

The epiotic is a slightly larger element than the supraoccipital. Posteriorly, it is sometimes quite dishd. Its lateral margin contributes most of the medial rim of the post-temporal fossa but this can be somewhat reduced by dorsal expansion of a narrow arm of the intercalar. The epiotic process is present dorsomedially but is not strongly developed. Contact between the epiotic and exoccipital is often loose.

The exoccipital meets its counterpart both above and below the foramen magnum, differing from those in *P. megalops* and *Rhacolepis* but similar to that recorded by Forey (1977) in *Notelops*, with the dorsal abutment with the basioccipital loose and sloping anteroventrally at an angle of about 40° to the vertical. The posterior surface of the bone is angled anteromedially, with the outer margin more posterior than the inner edge. The junction below the foramen magnum with the basioccipital is solidly pedestal-like and is basally flared and fluted posterolaterally in F 14222. A very small foramen is present beside and very close to the foramen magnum for the passage of the occipital nerve. The posterior and lateral surfaces of the exoccipital meet along an acute ventrolateral flange close to the base of the bone and laterally this is penetrated near its base by a large foramen for the vagus nerve. However, that for the glossopharyngeal nerve is masked by other elements, as is the ventrolateral base of much of the braincase.

The basioccipital appears to have formed the occipital condyle through incorporation of a fused, partial, vertebral centrum. Dorsally it bears a well-defined pit on each side of the midline, posteroventral to the foramen magnum, for insertion of a divided neural arch. Laterally, the bone appears reduced and is loosely overlapped by the posterior arms of the parasphenoid. The hyomandibular masks the posterolateral view of much of the braincase in all individuals found to date.

The intercalar is small but frequently has a vertical arm that extends further up the medial

rim of the post-temporal fossa in most individuals than was shown for F 3349 by Bartholomai (1969, Fig. 47).

The autosphenotic is large, posterolaterally forming much of the anterior of the dilatator fossa and the anterior one-half of the hyomandibular facet. It bears a well-defined, sharp, autosphenotic crest rather than a 'spine'. This crest curves ventrolaterally from below the frontal emargination. Anteriorly, the bone forms much of the posterodorsal margin of the orbit. A foramen for the otic branch of the facial nerve penetrates the anterior face of the autosphenotic. The autosphenotic flares ventrolaterally to roof the sharply inclined anterior moiety of the hyomandibular facet. Posterior to the autosphenotic crest, a broad groove leads dorsally into the large fenestra within the dilatator fossa between the autosphenotic and the pterotic, with the bone forming its anterior wall and floor. Only the anterior tip of the pterotic is involved in the fenestra, contributing its posterior wall. As observed by Forey (1977) in *Notelops* and some specimens of *Tarpon* Jordan and Evermann, the large fenestra appears to provide a link between the dilatator fossa and the post-temporal fossa. The fenestra is not stated to be present in *Rhacolepis* or *P. megalops* and was apparently not present in the British Museum (Natural History) specimen, BM(NH) P 55858, that he illustrated and referred to *P. marathoniensis*.

The lateral face of the prootic is largely covered by the hyomandibular. It is separated from its anterior face by a prominent, sharp, narrow, anterolaterally directed flange. The anterior face is partially visible in F 14422. It is relatively narrow, deep and cupped and is angled posteroventrally, but this may have been emphasised by lateral crushing around a posteriorly sloping, dorsoventral axis. It is penetrated by separate openings for the anterior jugular canal and a smaller foramen for the trigeminal nerve, both close to the strongly concave, acute lateral margin of the prootic. The foramen for the profundus

ciliaris is close to that for the trigeminal nerve and slightly dorsomesial to it. The large foramen for the oculomotor nerve is situated slightly dorsomesial to the trigeminal foramen and ventral to it, adjacent to an obliquely angled suture between the prootic and one of the upper arms of the basisphenoid.

The pterosphenoid is relatively small and appears to make only a short contribution to the margin of the optic foramen. Even allowing for distortion, it appears to be angled more anteriorly than shown for *P. megalops* by Forey (1977). The inner margin is notched for passage of the trochlea nerve but this is very close to the junction with the prootic. A relatively large foramen is present well posterodorsal to this notch, presumably for the middle cerebral vein. The suture with the orbitosphenoid is deeply interdigitated but the interdigitated suture with the autosphenotic is not raised to form a groove in that element.

The orbitosphenoid is also small but in F 14422, as is usual, it appears to have extended ventrally to form the dorsal margin of the optic foramen. Dorsally it unites with ventral flanges of the frontal. Any penetration of the bone for the passage of the olfactory nerve has been masked.

The basisphenoid in F 14422 has detached from its contact with the prootic. It is similar in depth or even relatively deeper than that in *P. megalops* described by Forey (1977) but has a broader pedicel that remains attached to the parasphenoid and that has the basal margin of the optic foramen smoothly 'U'-shaped, rather than more sharply 'V'-shaped.

The parasphenoid is elongate, with the posterior extending slightly beyond the articulating surface of the basioccipital. The posterior part is flexed upwards from just behind the level of the weakly developed ascending wings and covers much of the lateral surface of the basioccipital and lateral base of the exoccipital (and, presumably, that of the prootic). In F 14422, the anterior of the bone curves slightly convexly in lateral view and is

triangular in mid-section, with its base slightly dished transversely close to the ascending wings and also close to the vomer. There is a short, shallow, longitudinal groove along the lateral margin anterior to the ascending wings, while just below the dorsal margin in F 14423 there is a longitudinal groove to accommodate the dorsal margin of a thin, anteriorly deepening, lateral splint of the vomer from beneath the orbit. The parasphenoid deepens anteriorly to also overlie a ventral splint of bone from the vomer. No parasphenoid teeth have been observed.

The vomer in F 14423 appears only partially ossified and is anteriorly largely associated with perichondral bone. It bears at least one conical but recurved tooth, similar in size to the smaller teeth of the dentary, immediately anterior to the parasphenoid. That in F 5690 has two vomerine teeth present posteromedially. Maisey (1991a) includes a vomer with two recurved teeth as one character state diagnostic for *Rhacolepis*.

The lateral ethmoid is also composed of perichondral bone. It is a very robust element minimally contacting the frontal dorsally and appears to meet the mesethmoid anteriorly. The posterior border is broad and smoothly concave, forming the anterior margin of the orbit. Ventrally, it meets the anterodorsal surface of the parasphenoid and the vomer. Its margin, especially dorsolaterally, is acute and presents numerous, large tubercles and a short lateral process. As in *P. megalops*, it lacks a foramen in the orbital wall. A dorsal gap is present below a groove in the longitudinal, ventral ridge strengthening the frontal from the olfactory capsule. This was presumably for the passage of the olfactory nerve and the nasal artery.

Strong, broad, sclerotic plates are present.

Hyopalatine series. The hyopalatine series is not fully exposed in any specimen (Fig. 2; and Bartholomai 1969, pl.15).

The hyomandibular is a large, hatchet-shaped bone set almost vertically. It has an expanded,

dorsal articulating surface, divided into an elongate, posterior part that is gently curved dorsally to lie within the hyomandibular facet and a crescent-shaped anterior articulation to the back of the autosphenotic. Two, angular ridges descend from the posterodorsal corner of the expanded articulation, with the inner ridge produced into a short, relatively deep and robust opercular process. The two ridges are separated by a deep, 'U'-shaped valley that disappears ventrally and that is penetrated by a large hyomandibular foramen at the base of the opercular process. Both ridges contribute to the robustness of the posterior of the hyomandibular shaft. The anterodorsally inclined head of the bone is supported by a robust, posteroventral ridge that becomes confluent with the outer ridge of the shaft. This is broadened and cupped anteriorly, continuing the line of curvature of the back of the orbit from the autosphenotic. This continues beneath the metapterygoid as an extensive, thin flange that comprises the base of the 'head' of the hatchet. A strong, sharply crenulated ridge that meets the edge of the metapterygoid is angled and diminishes posteroventrally, parallel to the posterior shaft. A cup-shaped depression is present immediately below the dorsal articulating head of the hyomandibular.

The symplectic has not been exposed.

The metapterygoid is a large bone that is slightly dished dorsoventrally in its larger lateral part. This part is ventrally broad, narrowing anterodorsally and closely adpressed to the upper part of the anterior flange of the hyomandibular, immediately anterior to the sharp, crenulated ridge on the bone. The anterior margin of this portion of the metapterygoid descends broadly sinuously from an upper crenulated edge into a diminishing ridge that separates the lateral, vertical part of the bone from a dorsomedially orientated, much smaller, inner 'wing' of the bone. This has a broadly curved anterior margin.

The quadrate is a smaller, subtriangular bone, thickened posteriorly and vertically grooved

and thinned to a flange near the anteroventral margin of the preoperculum. It is also deeply notched posterodorsally for the symplectic. The articulatory head is rounded and ventrolaterally sharp and is notched above posteriorly, presumably to accommodate the sharp anteroventral process of the preoperculum. The articulation is ventromedially broadened and rounded.

The endopterygoid is poorly exposed, except in F 355. It is seen in dorsal view in F 48771 but is strongly distorted. It is elongated, anteriorly flexing and narrowing as it becomes more horizontal. The bone appears to have supported a mass of perichondral bone above in F 14423. The dorsal surface is bulbous and marked by fine ridges radiating laterally. Posteriorly, it meets the ectopterygoid along its lateral margin and is overlain by the edge of the metapterygoid; anteriorly it meets the palatine and medially, it abutts the parasphenoid.

The ectopterygoid, also seen from above in F 48771, is elongated, thin and shallow, with a rounded ventrolateral margin. Internally, it carries numerous, small, recurved, multiserial teeth. A single row of ectopterygoid teeth was identified as diagnostic for *Rhacolepis* by Maisey (1991a). The posteroventral margin is only very slightly downturned to meet the quadrate, while the posterodorsal corner lacks the dorsal process present in *Rhacolepis* (Forey 1977) and minimally overlies the metapterygoid.

The palatine is relatively short and laterally shallow and thin. It flexes anteromedially in front of the endopterygoid into a more expanded flange. It is not known whether the element carried teeth. It has expanded, anterodorsal processes that bear articulatory surfaces that were probably the sites for attachment to anterior cranial elements.

Dermal upper jaw. The upper jaw is elongate, extending well behind the level of the back of the orbit (see Figs. 1, 9). A single supramaxilla is present, in addition to a premaxilla and maxilla.

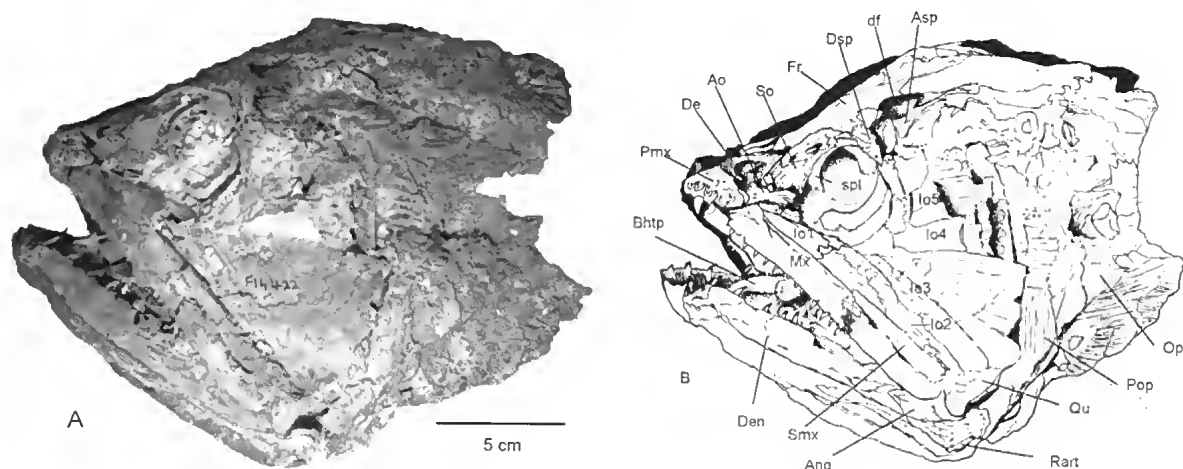


FIG. 1. *Pachyrhizodus marathionensis*, F 14422, A, photograph of nearly complete skull, left lateral view (slightly crushed laterally and minimally rotated); B, drawing.

The supramaxilla is slender and unornamented and laterally shelves over the posterior of the upper margin of the maxilla from below the mid-orbital area, more like that in *Notelops* and *Rhacolepis* than that depicted for *P. megalops* by Forey (1977).

The premaxilla is small, comprising about 20% of the total upper jaw length. Laterally, it is slightly convex, becoming slightly more rounded anteriorly towards its symphysis with its counterpart from the other side. Posteriorly, it closely overlies an anteromedially directed process of the maxilla (Fig. 4A, B). Its dorsomedial margin is elevated into an elongate, triangular process best seen in F 49152. This has a gently sloping posterior edge leading to a notch that appears to be associated with the front of the antorbital. Anterodorsally, the process is bent medially into a broad flange that posteriorly has an elevated articulation surface for contact with the anteroventral margin of the dermethmoid. The bone carries 5-6 conical, marginal teeth (see Fig. 4A, B), with alveoli for up to four additional teeth. Internally, At least two and possibly three larger, conical teeth are present although the most posterior

of these is known only from its socket. The internal teeth are angled posteromedially and, although the second is larger than the marginal teeth, the anterior one is very small. General morphology of these elements is similar to those described for *P. megalops* in Forey (1977). Table 1 compares marginal teeth of the dermal upper jaw in *P. marathionensis* with those recorded by Forey (1977) for the English species of *Pachyrhizodus*.

The maxilla is elongate, moderately stout and very slightly arched laterally; the dental margin is somewhat sigmoidal. The bone is relatively more slender in smaller individuals like F 48771. The dorsal margin is slightly convex dorsoventrally, more so anteriorly than posteriorly. A small facet for articulation with the palatine is present in F 18919, close to the anterior of the anterior process, above the overlap with the premaxilla. A curved, anterodorsal ridge is present laterally, ending in a low, sharp crest immediately behind the articulation with the premaxilla, interpreted by Forey (1977) as a possible point of insertion for a palatamaxillary ligament. Above this is a very low ridge and groove, just below the upper margin of the

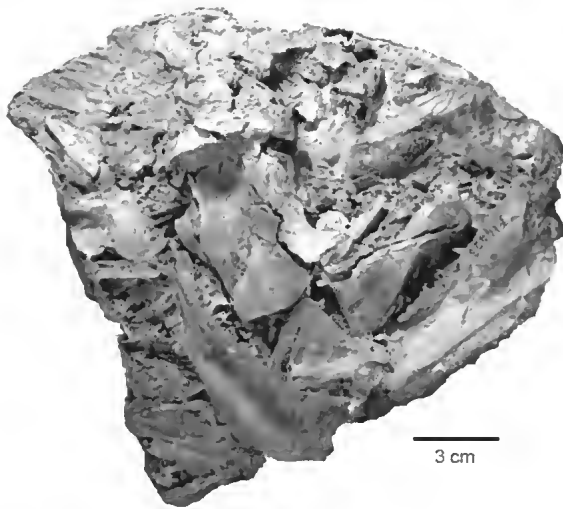


FIG. 2. *Pachyrhizodus marathionensis*, F 14423, photograph of partial skull, internal elements from right lateral view.

bone and into which the base of the first circumorbital lies.

Fewer maxillary teeth are apparently present in *P. marathionensis* than in the English species of *Pachyrhizodus* (Table 1). The maxilla has up to 22 conical, functional, marginal teeth, all ankylosed within shallow sockets on an alveolar shelf, above and within a low, external

TABLE 1. Comparison of upper marginal teeth in *P. marathionensis* with those recorded for English species of *Pachyrhizodus* by Forey (1977)

Species	Premaxillary Number of teeth	Maxillary Number of teeth
<i>P. marathionensis</i>	5–6	22
<i>P. megalops</i>	9–11	35
<i>P. salmoncus</i>	10	40
<i>P. magnus</i>	14	40
<i>P. subulidens</i>	10	-
<i>P. basalis</i>	9	-
<i>P. dibleyi</i>	-	-

flange which is shaped to accommodate the external base of each tooth. Bases of teeth are usually more ovate, being compressed anteroposteriorly and set at an obtuse angle to the lateral flange. Small tips of unankylosed, developing teeth are sometimes present between functional teeth within alveoli that often alternate with functional teeth. The marginal teeth are slightly incurved and are generally only slightly smaller than those on the premaxilla. Largest maxillary teeth vary in length from 5.1 mm in F 13725 to 3.6 mm in F 18919. The ventrolateral surface of the bone, especially anteriorly, is ornamented with very fine tubercles in some individuals.

Lower jaw. The lower jaw is robust, slightly longer than the upper jaw and relatively deep. It has only a weakly developed coronoid process. In lateral view, the angular represents only about 25 % of the lower jaw length and is overlapped by the much larger dentary.

The dentary has its lower margin deeply flanged and slightly inflected (see Figs 1, 5). Its very shallow symphysis, best seen in F 5690, is slightly incurved and rugose. The oral border ascends rapidly behind the symphysis before becoming subparallel to the ventral border over much of its length. The lateral surface is solidly convex longitudinally, above a well-defined groove penetrated by a series of fenestra associated with the mandibular sensory canal, along the upper margin of the ventral flange. An alveolar shelf is present medially below a thin, shallow, dorsolateral flange to the oral border. Ornamentation is limited to very small tubercles towards the dental margin. Marginal teeth in a single series are ankylosed within shallow sockets along the alveolar shelf and are partially masked basally in lateral view by the lateral flange. These are much fewer in number than those on the maxilla but are similarly conical in shape; however, they are often angled slightly posteriorly, as well as being medially curved at the tips. Up to 11 functional teeth are present in most individuals. The largest are

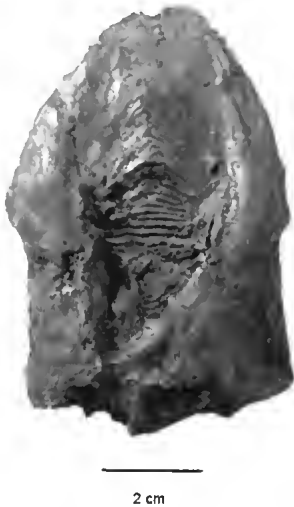


FIG. 3. *Pachyrhizodus marathoniensis*, F 13725, photograph of neurocranial roof (excluding dermethmoid and posterior), dorsal view, length of specimen 11.5 cm.

generally about twice as large as maxillary teeth, reaching 9.0 mm in length in F 14423. Towards the anterior of the tooth row, larger teeth are sometimes more inclined posteriorly. As in the maxilla, functional teeth are often alternating with alveoli, sometimes with developing teeth.

The angular is anteriorly fused with the articular but the bones are joined but separate posteriorly, meeting along a simple but close suture about one-third the distance from the top of the postarticular process. A thin sliver of the articular overlies the angular at the outer edge of the articular facet, excluding a contribution of the angular from the facet. Its upper relationship with the dentary has not been well exposed but no reverse overlap on the lateral surface, recorded by Forey (1977) in *Rhacolepis* and *Notelops*, is present in F 355 of *P. marathoniensis* (see Bartholomai 1969, Pl. 15). The posteromedial aspect of the mandible is partially visible in F. 14422. In this region, there is some similarity with that in the North American Upper Cretaceous *P. caninus*, illustrated in Nelson (1973, Fig. 2C).

The postarticular process is less flared in *P. marathoniensis* while the inner development of the retroarticular is much more elevated. However, the retroarticular is posteriorly unfused and does not appear to contribute to the articular facet. The posterior opening of the mandibular sensory canal is more medial than in *P. caninus*.

No gular plate is present.

Hyoid bar, branchiostegal rays and gill arches.

The ceratohyal exists as two elements, the anterior and posterior ceratohyals (Fig. 2 and Bartholomai 1969, Pl. 15). These are separated by a short gap that would have been filled with cartilage to connect them during life. The anterior ceratohyal is stout and is penetrated by a large fenestra separated from the dorsal margin by a thin splinter of bone and a number of smaller fenestrae immediately anterior and posterior to the large fenestra, within a deep, longitudinal groove. Maisey (1991a) considered a fenestrated anterior ceratohyal as one of the diagnostic characters for *Rhacolepis*. Anterior and posterior margins of the element slope posteroventrally at about 25° to the vertical. The posterior ceratohyal is subtriangular in lateral view, with a slightly upturned, blunt, posterior point for articulation with a very short, rod-like interhyal. Laterally, the posterior ceratohyal lacks a groove but a deep pit is present posteriorly, presumably for insertion of the hyoidean-mandibular ligament.

Two ossified hypohyals are present (Fig. 2), with the dorsal element slightly smaller than the ventral. The upper hypohyal has a very prominent, dorsomedially and bluntly pointed process. The lower bone has a solid, anteromedially directed process bearing a large, ovate, articulating surface. Separation of the two bones is near planar.

A broad, elongate, tooth plate is present anterior to the hypohyals. This is interpreted as the tooth plate on the basihyal. It is bilaterally symmetrical, anteriorly drawn into a short, central point and set on a very thin, bony plate. Its dorsal surface is covered with numerous,

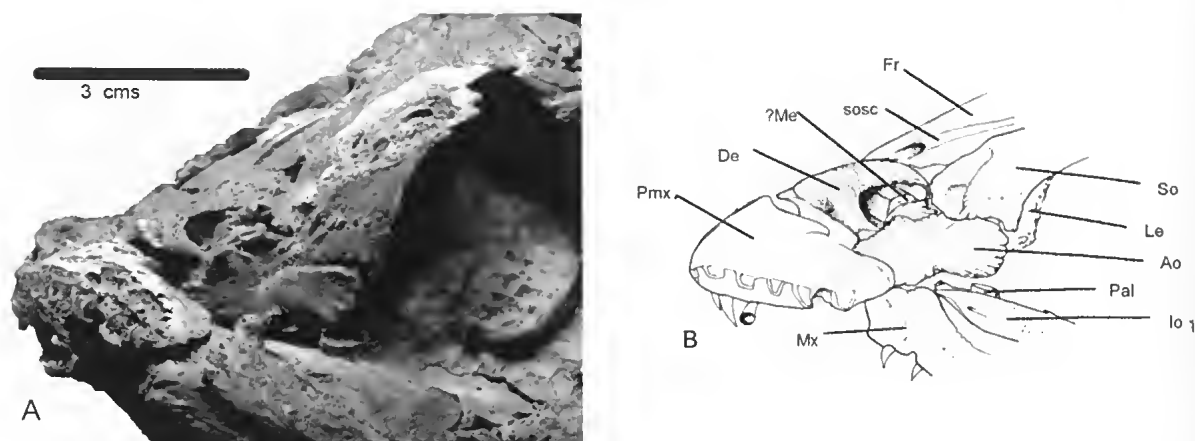


FIG. 4. *Pachyrhizodus marathonsensis*, F 14422; A, photograph of anterior of skull in lateral view, showing dermethmoid, olfactory capsule, part of mesethmoid, premaxilla (slightly rotated), supraorbital, antorbital, anteriors of maxilla and infraorbital 1; B, drawing of above.

small, irregularly positioned, recurved and pointed teeth. A small, ossified, rod-like basihyal element is present beneath the posterior of the tooth plate in F 355, figured in Bartholomai (1969, Pl. 15). No trace of a urohyal exists.

Other elements of the gill arches are exposed in F 14423 as well as in F 355. Anteriors of the hypobranchials exist close to the dorsal margin of the anterior ceratohyal and all bear a strong process close to the anterior margin. Five ceratobranchials have been observed. Cb1 and 2 are long, 'C'-shaped in section and are equipped with solid, short gill rakers, at least posteriorly. Fine rakers are also present on Cb2. Four epibranchials are present. The anterior ones are more solid than the ceratobranchials and are widely 'U'-shaped in section. Eb1-3 have anteromedial processes, with that on Eb3 most distinct. Eb4 expands distally but is covered anteriorly by the supracleithrum.

Branchiostegal rays are best seen in F 5687, illustrated by Bartholomai (1969, Pl. 14) and in F 48771 (Fig. 5). Anterior rays are separated and slender, with more posterior rays becoming progressively more spathiform. Attachment of these to the ceratohyal bones is masked in all specimens. At least 20 are present on each side.

Circumorbital series. The circumorbital ring is complete. However, it differs markedly from *P. megalops*, described by Forey (1977), where an antorbital is not present. The series is best seen in F 14422 (Fig. 1) but posterior infraorbitals are well preserved in F 14423 and F 5687 (see Bartholomai 1969, Pl. 14).

The supraorbital is large, at the anterodorsal edge of the orbit. The frontal margin supports the bone medially while the perichondral bone of the lateral ethmoid and the mesethmoid support it anteriorly. It expands anteroventrally to overlap the antorbital and posteriorly, it is sutured to the dermosphenotic. It is ornamented with a large, dorsally directed, sinuous crest from the centre of its ventral border and by a short, lesser crest at a right angle to this. It also has a series of tubercles across its ventrolateral surface, above its overlap with the antorbital and very small tubercles, especially anterodorsally. Minor ridges are associated with plications in the anteroventral margin. Internally, it is penetrated by a number of tracts of the supraorbital sensory system and of the circumorbital sensory canal from the dermosphenotic through a foramen in the posterior margin. It has a small pore anterodorsally, close to those associated

with the posterior processes of the mesethmoid and another behind the smaller crest. A further foramen opens from the anteroventral corner, immediately above another in the posterodorsal corner of the antorbital (Fig. 4A, B).

The antorbital is well displayed in F 14422 (Fig. 4A, B). No separate antorbital is present in those pachyrhizodontoids revised by Forey (1977) although it appears to have been present in BM (NH) P 55858, identified and illustrated by him as *P. marathionensis* but suggested to be part of the supraorbital. The antorbital is a reasonably large, 'bow-tie'-shaped element lying anterior to the base of the orbit and contributing the anteroventral orbital margin. Its dorsolateral surface is shallowly excavated by a broad 'V'-shaped depression that posterodorsally becomes a shelf that supports the ventral margin of the supraorbital. A small pore is present centrally, below the basal point of the 'V' of the depression. Anterior and posterior margins are plicated and are associated with low, curved ridges sweeping centrally. Two small pores are present anterodorsally and anteroventrally along the anterior margin. The anterodorsal edge of the bone is supported by a flange of the mesethmoid.

The first infraorbital is elongate, extending from below the middle of the antorbital to above the anterior moiety of the quadrate. Anteriorly, it is spike-like, closely fitting behind the longitudinal ridge towards the dorsal margin of the maxilla (Fig. 4A, B) and posteriorly, it is shallower than below the orbit and lies along a shallow dorsal groove in the supramaxilla. It provides the ventral margin for the anterior moiety of the orbit. The infraorbital sensory canal is enclosed towards the centre of the bone, with a second enclosed canal close to the dorsal margin. A single, low ridge leading to a single pore is present close to the anteroventral margin (Fig. 4A, B). The bone is ornamented with very small tubercles.

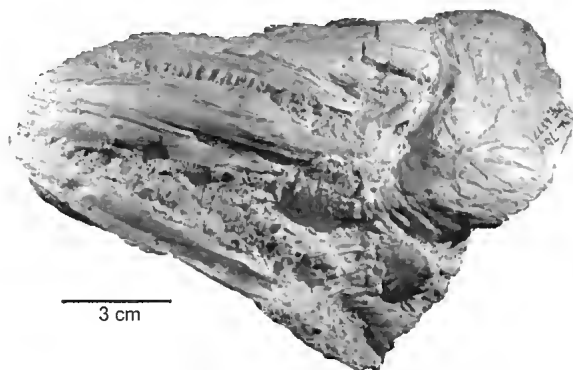


FIG. 5. *Pachyrhizodus marathionensis*, F 48771, photograph of ventral view of partial neurocranium showing partial inflected base of dentary and branchiostegal rays.

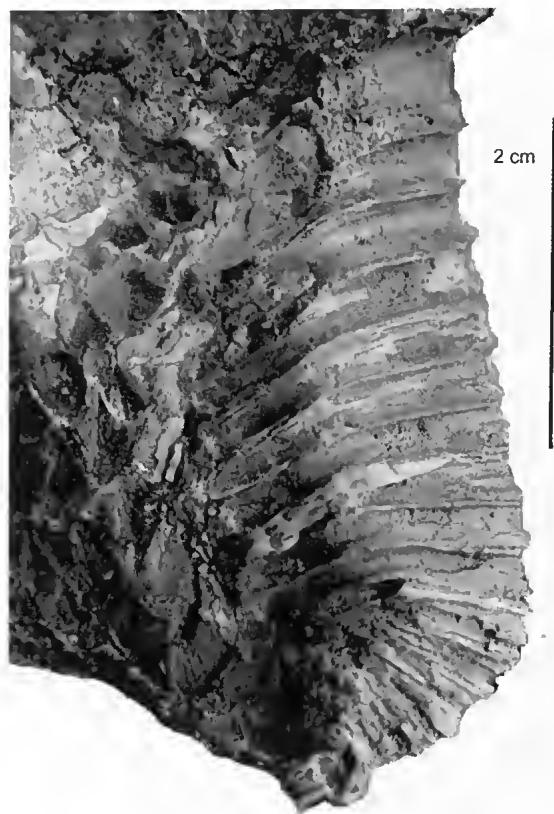


FIG. 6. *Pachyrhizodus marathionensis*, F 49172, photograph of natural mould of base of partial right pectoral fin.



FIG. 7. *Pachyrhizodus marathonsensis*, F 49172, natural mould of ventral body scales, each scale ca. 0.5 cm across.

The second infraorbital is well preserved in F 5687 (see Bartholomai 1969, Pl. 14) and F 13725. It is a separate element making only a limited contribution to the posteroventral corner of the orbit where its dorsal margin is somewhat elevated. The bone is generally shallow and much shorter than the first infraorbital but extends slightly more posteriorly. It has several small pores anteriorly and has similar ornamentation to Io1, especially near its posterior edge.

Unlike other pachyrhizodontids redescribed by Forey (1977), the posterior infraorbitals are all separate. Io3-5 are all large, deep, elongate and thin elements. They form the posterior and posterodorsal orbital margins and extend to cover the upper half of the preoperculum and front of the operculum. At the orbital margin, they have an anteroventral process, posteriorly closely followed by an inverted 'V' gap, then by a sweeping overlap by the underlying bone. In Io3, the inverted 'V' underlies a normal 'V' in the previous element, apparently marking the zone occupied by the infraorbital sensory canal (Fig. 1). Small pores are present especially on Io3 above the expected position of the infraorbital canal. However, by Io4 and Io5

the ventral margin of the infraorbital overlies the upper margin of Io3 and Io4 respectively. Openings are difficult to locate in other infraorbitals. The surface of each infraorbital, especially posteriorly, is ornamented by a series of shallow, parallel grooves that often bifurcate posteriorly. The surface is flat between the grooves, terminating in rounded or pointed margins that give the series a posteriorly frilled appearance. The anterolateral surface of Io4 and almost all of Io5 is ornamented with very fine tubercles in F 14423.

The dermosphenotic progressively becomes less elongate dorsally than Io5 but has similar anteroventral structure to that in lower elements. Laterally, it covers the majority of the dilatator fossa and hyomandibular facet and most of the autosphenotic spine. It has a deeply sutured junction with the supraorbital anteriorly and forms the posterodorsal margin of the orbit. The orbital margin is slightly dentate in F 14422. The infraorbital sensory canal runs close to the anterior of the bone but, unlike *P. megalops*, it has an anterior opening to the supraorbital as well as external openings. A posterior branch also opens to the surface. Its surface is ornamented with fine tubercles but the longitudinal grooves are less well-developed anteriorly becoming better defined posteriorly.

Opercular series. This is shown in Bartholomai (1969, Fig. 46 and Pl. 14), and is also based on those in F 5687, F 5688 and F13725. In general, the series is relatively short and deep and the bones are thin.

The preoperculum is moderately short. Its anterior margin is almost vertical except for the anteroventral corner which is curved gently forwards and medially, the latter presumably to enable the postarticular process of the mandible to clear the bone during opening of the mouth. An acutely pointed spine is present anteroventrally (c.f. *Rhacolepis* diagnosis, Maisey 1991a), below the edge that is inserted into the vertical groove in the back of the quadrate. This feature was also

reported by Forey (1977) and illustrated in the British Museum specimen of *P. marathonsensis*. The ventral margin of the bone is not greatly expanded posteriorly and curves gently to the posterior margin which is subparallel to the anterior margin over much of its depth, except for the upper one-quarter where it narrows progressively. Posterodorsally, the bone is reasonably broad and the back margin turns anteroventrally at about 25° to the horizontal. The preopercular sensory canal runs down the front of the bone, close to the margin and usually leads to numerous, sweeping branches in the lower 25% of the bone. Those in F 5688 are fewer in number and are contained within sweeping, flattened ridges. Internally, the preoperculum in F 13725 is composed of a closely adpressed series of curved, flattened plates that separate into sharp spikes dorsally.

The operculum is anteriorly overlain by the preoperculum. It is short and narrows markedly dorsally. Its ventral margin is obliquely angled posterodorsally and is deeply indented (as also seen in *Rhacolepis*). The surface has weak ornamentation of very fine, irregular grooves that radiate from above the articulation with the hyomandibular. F 5688 has several radiating, flat ridges in its upper area, similar in form to the posterior margins of the infraorbitals and its posterodorsal margin is finely crenulated.

The interoperculum is reasonably well developed, situated below the lower margin of the preoperculum. It is much more elongated than deep.

The suboperculum is obliquely positioned posteroventrally and is a large bone, overlain by the operculum, the preoperculum and, anteriorly by the interoperculum. It overlies the anterior of the top of the cleithrum and the ventral part of the supracleithrum.

Pectoral girdle and fin. The supratemporal is best seen in F 5687 (Bartholomai 1969, Pl. 14). It is relatively large and semicircular, with an angled anterior margin. It does not meet its counterpart

along the mid-line. The outer surface is marked by five deep grooves that radiate posteriorly from an anterodorsal groove. A supratemporal commissure probably ran along this groove with branches into the radiating grooves.

The post-temporal in F 14423 is elongate, narrow anteriorly and broadens posteriorly into an indented, rounded margin. The dorsal epiotic limb is strengthened internally by an elongate ridge, while the ventral limb comprises an elongated, round, anteroventral prop to the intercalar.

The supracleithrum is deep and moderately long and carries a continuation of the lateral line obliquely across its surface. This can be seen best in F 5687 (see Bartholomai 1969, pl. 14). The bone extends ventrally to overlie the top of the cleithrum.

The cleithrum is broadly expanded posteriorly below its junction with the supracleithrum and has its dorsal limb extended along much of the inner margin of the supracleithrum as reported for *P. megalops* by Forey (1977). The posteroventral margin is excavated for insertion of the pectoral fin, exposing parts of the internal bones of the girdle. The concave, inner margin of the cleithrum is very deep, adding strength to the bone. A large interosseus foramen is present anteromedially, above the keel-like coracoid and below the anteriorly pointed end of the cleithrum. Neither the scapula nor the mesocoracoid are exposed in any specimen and postcleithra, although present are difficult to differentiate.

The bases of anterior rays of the pectoral fin are present in a number of specimens. These show the fin to have been set downwards at a low angle to the horizontal and to have been very strong, with the first ray being widest. Up to 13 rays are present in F 5687, while F 3349 presents the bases of 15 rays. F 49172 has the bases of 18 fin rays represented (Fig. 6). Forey (1977) illustrates a partial fin for BM(NH) P 55858 that suggests the pectoral fin was relatively elongated.

Squamation. Cycloid scales are present over the body and extend to between the back of the lower jaws and between the posterior of the supratemporals. They are thin and circular (Fig. 7) and there are many evenly spaced circuli that are ornamented externally with fine tubercles.

Other elements of the skeleton of *P. marathonsensis* have not been preserved in any of the museum specimens available.

Pachyrhizodus grawi sp. nov.
(Figs 8 - 11)

Material examined. Holotype, F 48770, almost complete skull from QML 37, Pub Paddock, 'Boree Park' Station, about 16 kms. NW of Richmond, nr. MR 627413 Richmond 1: 250 000 sheet, NCQ.

F 12709, incomplete neurocranium, Mountain Creek, 'Arrara' Station, S of Hughenden, NCQ. F 48769, partial skull, from QML 37, Pub Paddock, 'Boree Park' Station, about 16 kms. NW of Richmond, nr. MR 627413 Richmond 1:250000 sheet, NCQ. F 15585, ventral aspect of lower jaws, 'Dunluce' Station, W of Hughenden, NCQ. F 41517, very incomplete skull, 'Boree Park' Station, about 16 kms. NW of Richmond, NCQ.

Formations and age. Derived from the marine Toolebuc and Allaru Formations of the Great Artesian Basin, Queensland Australia, of Lower Cretaceous (latest mid to late Albian) age.

Etymology. Named for the late Mr B.H. 'Beno' Graw, Manager of 'Boree Park' Station, near Richmond, NCQ, who collected and donated many fossil fish specimens to the Queensland Museum.

Specific diagnosis. A moderately sized, gracile species of *Pachyrhizodus*, estimated to be about 45 cm in total length and with a body depth of about 10 cm. The neurocranium is comparatively narrow, shallow and elongated. Articulation with quadrate is just behind level of back of orbit; gape moderately angled upwards; marginal teeth on maxilla relatively robust with swollen bases, variably represented (up to 18 on maxilla); dentary relatively short, gently shallowing anteriorly; shallow lower margin strongly inflected below squared,

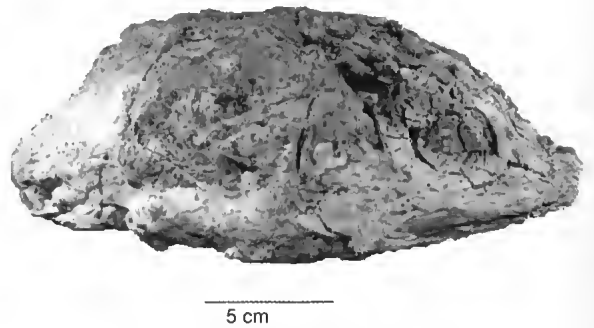


FIG. 8. *Pachyrhizodus grawi* sp. nov., Photograph of Holotype, F 48770, almost complete neurocranium and anterior of body, right lateral view.

swollen, ventrolateral base; coronoid process low; post-articular process reduced, low; separate, prominent, unfused retroarticular present; maxilla shallow, relatively short (ca. 45% of neurocranial length), variably but convexly bowed laterally; anterior ceratohyal blade-like without dorsal fenestra; preoperculum expanded posterovertrally, with strong, sharply pointed anteroventral spine; operculum relatively large and elongated, with obliquely angled but only slightly indented lower margin; suboperculum very large, angled obliquely.

Descriptive remarks. The holotype shows characteristics common in many teleost specimens from the Albian marine sediments of the Great Artesian Basin. The side of the neurocranium lying downwards during fossilisation has most of the external bony elements minimally disrupted, while the upper side has lost covering bones by low impact water movements and consequently now presents some of the internal cranial morphology. F 12709 is less crushed than the holotype but has its gape slightly more inclined, possibly as a result of slight dislocation of maxilla. This specimen also has the bases of its dentary teeth exposed, giving the impression of abnormally large teeth on the lower jaw. The shaft of its hyomandibular is

also straighter than that in the holotype but the differences noted are not considered sufficient to justify taxonomic separation.

Neurocranium. The holotype is illustrated in Fig. 8. The roof of the skull has been crushed laterally and slightly distorted in all specimens. It appears to have been relatively much narrower than in *P. marathonsensis* and posteriorly was more convex transversely. In lateral view, the skull is gracile, being relatively elongated and shallow. The orbit is comparatively larger than in *P. marathonsensis*, being 40% of neurocranial length and the articulation between the quadrate and angular is positioned much more anteriorly, below and just behind the back of the orbit. The lateral elements of the holotype are compared with those in *P. marathonsensis* in Fig. 9, illustrating the relative differences that contribute to the separation of the two species.

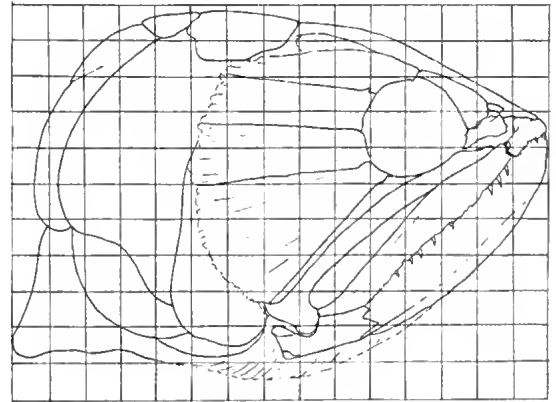
The dermethmoid has not been sufficiently well preserved to allow it to be described and, as is usual in *Pachyrhizodus*, no nasal is present.

The frontals have limited ornamentation and are elongated but have been laterally crushed in all specimens. A mid-dorsal depression is present. The lateral margin behind the auto-sphenotic spine does not appear as deeply indented as in *P. marathonsensis*.

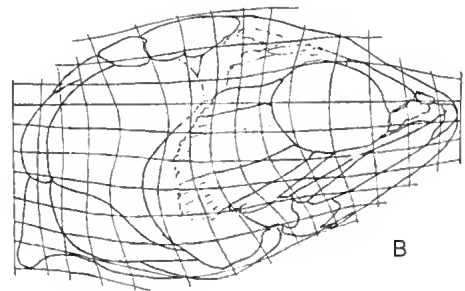
Small, unornamented parietals are present posteriorly, separated medially by a dorsal wedge of the supraoccipital.

The posterior of the braincase is best seen in F 12709 (Fig. 11A). The supraoccipital makes a significant contribution to the posterodorsal limit of the braincase, similar to that in *P. marathonsensis* but has a relatively more elongated posteriorly directed crest. Foramina interpreted as leading into the post-temporal fossa occur close to the dorsal extent of the crest. Dorsolaterally, the margin of the bone swells to support the inner margin of the epiotic process.

The pterotic forms the bulk of the posterolateral corner of the braincase. Its upper surface



A



B

FIG. 9. Comparison of neurocrania of *Pachyrhizodus marathonsensis* and *P. grawi* sp. nov., to show more gracile form of the latter (not to same scale).

is subtriangular and is angled ventrolaterally. Its lateral margin contributes to a narrow roof for the dilatator fossa but, like *P. marathonsensis*, this diminishes and may be absent posteriorly. The narrow, anterodorsal end of the bone is sutured to the frontal behind the autosphenotic 'spine', while the posterodorsal margin meets the parietal and the epiotic. It contributes to the dorsolateral and lateral margins of the post-temporal fossa. Its lateral surface is slightly dished within the dilatator fossa and ventrally provides a roof for the posterior of the deep hyomandibular facet, which itself is angled anteroventrally and

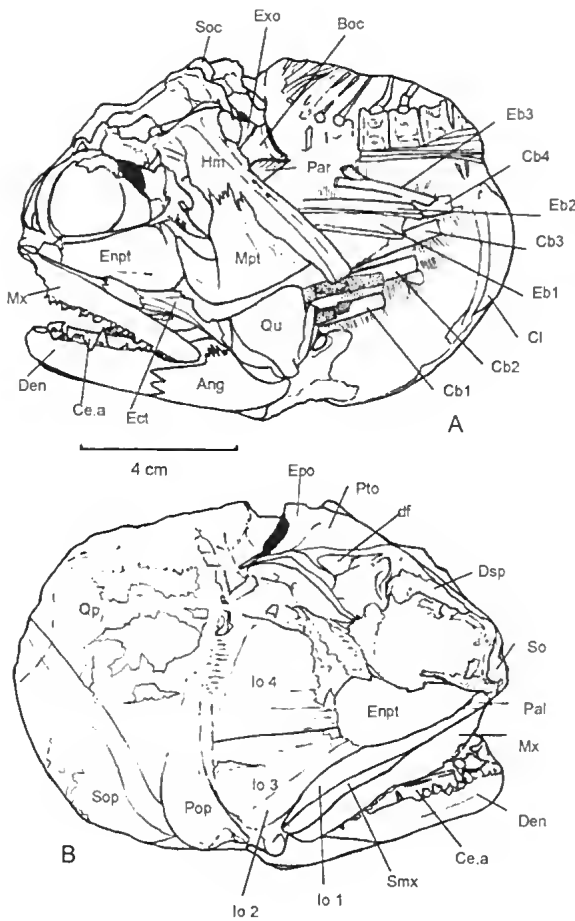


FIG. 10. *Pachyrhizodus grawi* sp. nov., F 12709, drawings of partial neurocranium; A, from left side; B, from right side.

then continues with a lesser contribution from the autosphenotic. The dilatator fossa above the near-vertical junction of the pterotic and autosphenotic is deeply excavated; however, the large fenestra, apparently medially directed into the post-temporal fossa in *P. marathouensis*, is lacking.

The epiotic is relatively large and is slightly angled ventrolaterally. The epiotic process is prominent. The bone provides the dorsomedial margin of the narrow but relatively deep post-temporal fossa. The posterior opening of the

fossa is angled ventrolaterally and the fossa extends anteriorly to above the autosphenotic 'spine' but does not meet its counterpart.

The exoccipital is relatively larger than that in *P. marathouensis*. As in that species, it meets its counterpart both above and below the foramen magnum, with the lower junction gently angled anterodorsally. Surrounding of the foramen magnum by the exoccipital is similar to that in *Notelops* but unlike those in *Rhacolepis* and *P. megalops*, as noted by Forey (1977). The foramen for the vagus nerve lies posterolaterally, just above the suture with the basioccipital and just anterior to a posteriorly directed foramen above the posterolateral exoccipital flange, also present in *P. megalops* and identified by Forey (1977) as the foramen for the occipital nerve. Another foramen is immediately adjacent to the lateral margin of the foramen magnum, also possibly for an occipital nerve. Much of the lateral face of the exoccipital is masked by the hyomandibular in all available specimens.

The intercalar caps the base of the post-temporal fossa and has a vertical arm that provides much of the medial margin of the fossa, excluding any contribution of the exoccipital, similar to that in *P. megalops* (Forey 1977, Fig. 27).

The basioccipital is relatively small, forming the occipital condyle and posteroventral base of the neurocranium. The dorsal surface posterior to the foramen magnum is marked by two pits, presumably to accommodate the bases of neural arches, in keeping with a vertebral centrum having been incorporated into the basioccipital. The articulating surface is penetrated by a remnant of the notochord. The ventrolateral faces of the bone are angled into a 'V'-surface to accommodate the separated posterior wings of the parasphenoid; a small process carrying a small foramen extends posteriorly from the base of the articulating surface.

The autosphenotic is relatively small and has a reduced lateral 'spine' that is curved ventrally into a sharp, posteriorly inclined crest, like that

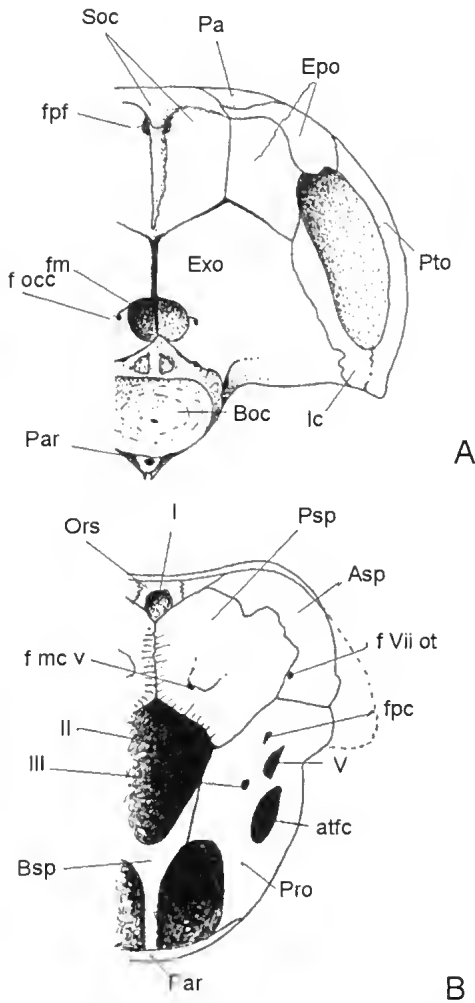


FIG. 11. *Pachyrhizodus grawi* sp. nov., F 12709; A, drawing of posterior of braincase; B, orbital view of the postorbital part of the braincase.

in *P. marathionensis*, supported below by the narrow dorsal crest of the prootic (Fig. 11B). Laterally, the bone forms the major, anterior part of the dilatator fossa. It also forms the anterior 25% of the hyomandibular facet. Unlike *P. megalops*, the orbital face of the autosphenotic is pierced more medially, on the suture with the pterosphenoid by the foramen for the otic branch of the facial nerve. The lateral suture between the autosphenotic and

pterothoracic is much more like that in *Rhacolepis* than in *P. megalops*. Posterolaterally, the bone meets the pterotic, contributing to the anterior of the dilatator fossa but there is no large fenestra developed into the anterior of the post-temporal fossa.

The prootic is best seen in F 12709, where the anterior face and part of the lateral face are visible. However, the posterior of the lateral face of the prootic is masked by the hyomandibular in all available specimens. Some lateral crushing has occurred and Fig. 11B shows a partially reconstructed anterior face. Little resemblance exists with any of the pachyrhizodontids illustrated by Forey (1977). The most obvious difference relates to the narrowness of the neurocranium in *P. grawi*. However, like *P. megalops*, the foramina for the trigeminal nerve and that for the anterior opening of the jugular canal are separate, while the foramen for the oculomotor nerve lies medial to that for nerve V and the foramen for the profundus ciliaris is above nerve V. The lateral and anterior faces are separated by a well developed, slightly anteriorly orientated crest, that is lobate dorsally just before the junction with the autosphenotic. The foramen for the hyomandibular branch of the facial nerve lies just posterior to the crest opening into the jugular canal, above a small, hooded foramen for the orbital artery. This is again like that for *P. megalops* and *P. magnus*, part of the structure termed a prootic cup by Forey (1977). Suture lines between the prootic, autosphenotic, pterosphenoid and basisphenoid are not zigzag in shape, a feature of *P. megalops*.

The pterosphenoid is an ovate element whose anteroventral margin forms the dorsolateral part of the optic foramen. A small foramen exists on the lateral surface for the middle cerebral vein, anteroventral to a small tubercle. The bone is firmly united with the autosphenotic and dorsally with the back of the orbitosphenoid (Fig. 11B). Medially it meets its counterpart along a vertical suture, excluding the orbitosphenoid from the margin of the optic foramen. It has

the dorsolateral surface raised and coarsely, complexly ridged. Its anteromedial margins are finely, radially ridged.

The orbitosphenoid is very small but is poorly preserved and appears to carry a space for the passage of the olfactory nerve.

The basisphenoid is poorly preserved but appears to contribute the 'Y'-shaped base of the optic foramen. A thin, shallow but relatively elongated pedicel links this to the parasphenoid.

The anterior of the parasphenoid is poorly exposed. In that area, it appears sub-parallel to the vertebral column, while the posterior is flexed dorsally, posterior to the more broadly expanded area of the ascending wings, as in the larger species. The posterior is partially keeled, divided and opening into the posterior myodome; it is loosely attached to the base of the prootic and basioccipital. It extends slightly beyond the posterior of the articulating surface of the basioccipital.

Little is known of the vomer.

The lateral ethmoid is small and ossified, curving anteroventrally and broadening towards the vomer and forming the anterior rim of the orbit.

Sclerotic plates are present.

Hyoid bar, branchiostegal rays and gill arches. The hyoid bar is incompletely preserved.

The ceratohyal is divided. The anterior ceratohyal is very slender, blade-like posteriorly and, in F 12709, is elongated, being 4.3 cm long. It lacks a dorsal fenestra. The dorsal margin is anteromedially inflected but this feature reduces and is lacking posteriorly. Anterior and posterior margins are near vertical and contact with the posterior ceratohyal was apparently cartilagenous. A displaced posterior ceratohyal is present. The bone appears similar to that in *P. marathomensis* appearing to have been subtriangular in shape. A short, rod-like interhyal is present apparently associated with a small bony

disc that fits a depression on the posteromedial surface of the posterior ceratohyal.

The hypohyal is represented by both upper and lower elements but preservation is too poor for their description.

Branchiostegal rays are preserved as natural moulds in F 15585 and, as in *P. marathomensis*, at least 20 are present on each side, with the rays becoming more spatulate towards the posterior of the series.

The posteriors of the gill arches in F 12709 (Fig. 10A) are moderately well exposed. Most of the endochondral elements are ossified and membrane elements are generally separate from these. No basihyal elements are exposed and the anterior base of what is interpreted as a basibranchial tooth plate is present above the hypohyals within the mouth. Similarly, only the posterior of one of the hypobranchials is visible above the ceratohyal in lateral view. Four ceratobranchials are present and, because the ventral gill arches are relatively undisturbed, it is likely that the most obvious elements are Cb1-4. Ceratobranchials are lunate in section, with Cb1-4 each carrying numerous, fine, short, gill rakers from the concave surface. Ceratobranchial 1 is narrower and deeper in section than Cb2-4. All larger, preserved ceratobranchials carry loose, curved, finely dentate tooth plates. If Cb5 is present it remains covered by other elements. Three and possibly four epibranchials are present. Eb1-3 are elongate, with a more deeply lunate section than in the ceratobranchials and all carry minutely dentate tooth plates and numerous, short, fine, gill rakers. Eb3 has a prominent, offset, proximal process. Eb4, if correctly identified, is very small and thin and carries small gill rakers but lacks a tooth plate.

Hyopalatine series. The hyopalatine series in F 12709, shown in Fig. 10A, is only slightly incomplete.

The hyomandibular is large and slightly angled posteriorly even allowing for post-mortem

movement, whereas that in *P. marathionensis* is near vertical. The shaft is very slightly convex posteriorly, with a strong, dorsoventral, lateral ridge extending ventrally from below the dorsal articulation, about 30% of the way from the posterior corner. The posterior edge is extended into a short, relatively deep but thin opercular process, about one-fifth of the distance down from the dorsal extremity. A strong groove separates these two ridges of the shaft, penetrated by two, large foramina, below the opercular process. The head articulates with the hyomandibular facet. The anterodorsally directed component of the head appears to have been present but is not angled markedly from the major part of the articulation surface. A thin but large anterior flange is present, narrowing ventrally to disappear some distance above the ventral end of the shaft. An anteriorly directed, strong, plicated, lunate ridge descends from below the dorsal head, about one-third of its length from the anterior corner to disappear near the anteroventral corner of the anterior flange. A broad ridge runs from below the anterodorsal extremity of the bone to below the middle of the plicated ridge and continues to the shaft, opposite the opercular process. A shallow, ventrally expanding cup exists between the broad ridge and the centre of the face of the bone, below the dorsal head. Medially, the area between the articulating surface and the base of the opercular process is expanded and rugose.

The metapterygoid is moderately large, with its deeply saw-toothed dorsal margin closely adpressed to the middle of the hyomandibular flange, below and behind its plicated ridge. That in *P. marathionensis* is strongly developed anterior to the plicated ridge. The metapterygoid is slightly cupped medially, allowing its expanded ventral edge to separate from the base of the hyomandibular flange. This edge is slightly convex ventrally and thins anteroventrally. A small, narrow, very pointed part of the metapterygoid is slightly flexed medially, at about 45° to the lateral part of the bone, with a posterior margin that curves posteroventrally to

just behind the lower margin of the anterolateral part of the bone. This differs from the larger species where the medial flange is rounded, relatively much larger and less elevated.

The quadrate is smaller than the metapterygoid and is subtriangular with a deep, posterior notch at the back of its sinuous dorsal margin, for insertion of the symplectic. The posterior is shallowly grooved dorsoventrally to accommodate the anterior of the base of the preoperculum. The anterior margin is gently concave, while the lateral surface is shallowly dishd, deepening slightly towards the articulatory head. This is rounded posteroventrally, with a relatively deep notch posteriorly above it. The head is also notched along the articulation in posterior view.

The ectopterygoid is small, deepening and gently turned down posteriorly. It is dorsally thin but has a strengthening posteroventral ridge that curves across the outer face to a low, elongate, dorsal process anteriorly. A muted posterodorsal process was probably present as well. A very thin dorsal flange is present above a lateral groove, beside the base of the ventral edge. The ectopterygoid appears to be edentulous, unlike that in *P. marathionensis*.

The endopterygoid is a much larger, subtriangular element, shallowly cupped laterally and carrying fine, recurved teeth anteriorly. The posterior margin is deep and rounded while the dorsal margin is slightly concave, abutting the parasphenoid. Ventrally, the margin is almost straight, fitting within the dorsal groove of the ectopterygoid. Upper and lower margins converge anteriorly to meet the back of the palatine.

The palatine has thin, shallow, inner and outer arms that partially surround the anterior of the ectopterygoid. These converge anteriorly into a dorsomedially directed plate that carries numerous, small, multiserial, recurved teeth, some of which are present on the anterior of the inner arm as well. The anterodorsal curved edge of the expanded plate is raised into two,

short but prominent processes, the posterior of which is the more strongly developed. Separation of autopalatine and dermopalatine components has not been possible.

Dermal upper jaw. The upper jaw is composed of three bones, the premaxilla, the maxilla and a single supramaxilla. The gape is elongate and is inclined at an angle of about 45° to the horizontal.

The premaxilla is not preserved in the holotype nor is it present in other referred specimens.

The maxilla is elongate and relatively shallow, extending posteriorly to just behind the level of the back of the orbit. Its curvature is less sigmoid in lateral view than in *P. marathonsensis* and, in ventral view, it is moderately convex laterally. The anterior process that would have fitted behind the back of the premaxilla is not well preserved in the holotype but appears to have been elongate, tapered, positioned dorsally and curved anteromedially. Laterally, the maxilla has a thin flange of bone masking the bases of the single series of marginal teeth and providing lateral support for them. The teeth are relatively short (largest being about 1.4 mm long) robust, conical with slightly bulbous bases but they have often had their tips broken e.g. in QMF 12709. Eighteen teeth are present in the holotype. Teeth are ankylosed in shallow sockets along an inner shelf, with functional teeth usually interspersed with spaces previously occupied by functional teeth or containing developing teeth.

The supramaxilla is a very shallow splint of bone, lying along the top of the maxilla from near its posterior margin and thinning anteriorly to below the middle of the orbit, similar to that in *P. marathonsensis*.

Lower jaw. The lower jaw is best known from its lateral and ventral aspects. It is relatively short and shallow.

The dentary comprises the major bone of the lower jaw, occupying some 70% of its estimated total length. The symphysis has not been preserv-

ed. The oral margin is straight or slightly dished, and posteriorly diverges slightly from its ventral margin; the anterior is gently shallowed, not abruptly so as in *P. marathonsensis*. In ventral view, the dentary has greater lateral curvature along its dorsolateral edge than along its ventrolateral edge. Its ventral flange is shallow and is strongly inflected medially, giving the ventrolateral aspect of the bone a squared, solid appearance. Laterally, the dentary posteriorly overlies the angular, except immediately below the low coronoid process where reverse overlap with the angular occurs. As with the maxilla, there is a thin, dorsolateral flange of bone present supporting the lateral edges of the marginal teeth. Teeth are ankylosed in shallow sockets along an interior shelf of the dentary. The teeth vary in number but are fewer than in the maxilla with 13 present in F 15585. The bases preserved in F 12709 suggest the dentary teeth in that specimen were larger than would have been expected. Unfortunately, dentary teeth are not visible in the holotype.

The angular occupies about 30% of the length of the lower jaw. Dorsolaterally, it underlies a thin, anteriorly fused but posteriorly unfused part of the articular that provides the surface of the mandibular articulation. The post-articular process is poorly developed and not greatly elevated.

The tip of the post-articular process is contributed by the unfused but firmly united part of the articular.

The retroarticular is present as an unfused, posteroventral nugget of bone, sometimes separated dorsally from the main body of the post-articular process by a shallow notch. Its internal extent is not well exposed.

There is no gular plate.

Circumorbital series. The circumorbital series is incompletely preserved in the holotype and is imperfectly preserved in other specimens. Ornamentation is of longitudinal grooves

separating broad, flat surfaces, terminated distally by pointed or rounded margins.

The supraorbital is well developed in the holotype, curving anteriorly from above the centre of the orbit to above the anteroventral orbital limit. It is relatively broad, increasingly so anteriorly. In F 48769, the supraorbital posteriorly meets the dermosphenotic.

The antorbital is poorly preserved but is relatively small, lying anteroventral to the supraorbital and anterodorsal to the front of the first infraorbital. It contributes to the basal margin of the olfactory capsule and the anterior margin of the orbit.

The first infraorbital is expanded anteriorly, providing the anteroventral margin of the orbit. It extends posteriorly as a thin sliver of bone tapering below the middle of the orbit and extending posteriorly above the dorsal margin of the surmaxilla. As in *P. marathouensis*, the second infraorbital wedges above the back of the first and contributes the posteroventral orbital margin. It deepens slightly posteriorly and extends to about the middle of the external surface of the quadrate and is slightly longer in F 48769. However, both Io1 and Io2 in the holotype differ from those in *P. marathouensis* where they are both more elongate reaching across the bottom of the cheek area further to near the back moiety of the quadrate. The third, fourth and fifth infraorbitals cover the bulk of the cheek region and provide most of the posterior margin of the orbit. They extend in F 48769 over the anterior of the preoperculum and in F 48770, those of Io5 reach well onto the operculum. The bones deepen posteriorly and are ornamented by longitudinal grooves. The fifth infraorbital dorsally reaches the base of the dilatator fossa.

The dermosphenotic wraps over the auto-sphenotic spine from its anterior junction with the supraorbital and covers at least the anterior of the dilatator fossa, tapering posteroventrally.

Opercular series. The opercular series is best preserved in the holotype and this together with other referred specimens enables most of the series to be described, showing it to be relatively more elongated and shallower than in *P. marathouensis*. Fig. 9 shows the relative differences in shape of the series to that in *P. marathouensis*.

The preoperculum is relatively large, being posteriorly expanded in the ventral moiety, more so than in *P. marathouensis*. It is reasonably strongly curved anteromedially over its lower one-third and is pointed dorsally. The bone is produced into a solid, sharply pointed spine that follows the line of the quadrate and is inturned ventrally. Further minor spikes are rarely present posterior to the major spine. A large opening for the preopercular sensory canal is present above the anteroventral spine, while lesser pores are associated with variable sweeping but very muted ridges in the ventral expansion of the preoperculum. The anterior margin of the preoperculum is thickened and is multilayered, with the layers ventrally rotated and broadened, overlying and adhering to one another but thinning posteriorly.

The interoperculum is incompletely preserved along the ventral margin of the preoperculum.

The operculum is relatively large and relatively more elongated than that in *P. marathouensis*, with a posterodorsally angled lower margin that is indented to a lesser degree.

The suboperculum is also reasonably large and elongated, angled posterodorsally with a curved lower margin.

The supratemporal and post-temporal is too crushed in the holotype to be described.

Pectoral girdle and fin. These elements are not well represented, with only the dorsal part of the cleithrum present. This has an anterodorsal, solid margin that would have extended well above the ventral margin of the supracleithrum. The posteroventral margin is excavated for insertion

of the pectoral fin. The posterior margin is expanded and rounded, possibly by expansion of the ventral postcleithral element. The eroded base of the first fin ray in the holotype shows it to have been a very solid element.

Vertebral column. Vertebrae are amphicoelous and slightly spool-shaped in lateral view. Only anterior abdominal centra are known. These are somewhat shorter than deep and, in posterior view, are slightly flattened dorsally and rounded ventrally with a small opening for the notochord. The dorsal surface is deeply pocketed to accommodate the divided and separate neural arch components, while lateral walls are ornamented by anastomosing, slender ridges and grooves and rare foramina.

Other osteological elements are either not preserved or are too poorly preserved to be described.

Discussion. The features that distinguish *P. grawi* sp. nov. from *P. marathouensis*, as well as the detail of the skeletal anatomy of the two species, have been noted in the above descriptions. *Pachyrhizodus grawi* is by far the smaller of the two species, attaining approximately 55–60% the total length of the larger species. The more gracile nature of the neurocranium of *P. grawi* is illustrated in Figs. 8 and 9. Its cranial depth compared with its length is ca. 55%, while that in *P. marathouensis* is ca. 70%. The orbit in *P. grawi* is relatively larger (ca. 17.5% of cranial length) compared with ca. 14.5% in *P. marathouensis*. The lower flange of the dentary is much more strongly inflected in *P. grawi* while its lower jaw articulation with the quadrate is just below the back of the orbit, not well posterior as in *P. marathouensis*. The maxilla is relatively shallower in *P. grawi* (4.5% of neurocranial length c.f. 5.6% in the larger species) and is much more laterally convex. *P. marathouensis* has a large fenestra developed in the anterior of the dilatator fossa into the front of the post-temporal fossa, a feature not seen in the available sample of *P. grawi*. The post-

temporal fossa is much narrower and laterally inclined in the latter species (Fig. 11A). The hyomandibular shaft in *P. grawi* is inclined and posteriorly curved in *P. grawi*, while the lateral ethmoid is much less developed in the smaller species. The anteromedial wing of the metapterygoid in *P. grawi* is pronounced and pointed, compared with the more flattened and rounded wing in *P. marathouensis*. The pterospheneoids exclude the orbitospheneoid from the dorsal margin of the opening for the optic nerves. In keeping with its more elongated neurocranium, the opercular bones are more elongated in *P. grawi*.

It is not considered unusual for two species within the genus *Pachyrhizodus* to co-exist in the same area at the same time in the relatively shallow-water, environments that developed in the Queensland Lower Cretaceous (latest middle to late Albian) marine transgression into the Eromanga Basin portion of the Great Artesian Basin. Co-existing species of *Pachyrhizodus* are preserved in both English (and European) and North American Cretaceous marine sediments. Sexual dimorphism is not considered likely to explain the differences in the Queensland material. Both overall body form and apparent differences in numbers of individuals within the preserved samples confirm this view. Because the Queensland material is derived from a relatively isolated zoogeographical situation and is generally somewhat older than the North American species, although broadly comparable in age with some of the European taxa, it would be anticipated that more primitive character states might be more evident in both species now recognised.

Forey (1977), in his consideration of pachyrhizodontoids, based his analysis on 45 character states of the genera *Notelops*, *Rhacolepis* and *Pachyrhizodus* that he believed useful in adding to the interpretation of the evolution of this early teleost group. Particular emphasis was given to the circumorbital series and the caudal fin anatomy in his conclusion that

the group of genera is monophyletic. The presence of an antorbital in both Queensland species of *Pachyrhizodus* is at variance with Forey's (1977) statement that this element is lacking in pachyrhizodontoids. A separate antorbital is shown in the illustrations for *P. marathouensis* (Fig. 4A, B) and is here believed to represent retention of an additional primitive character state in the Queensland material. Similarly, separation of the second and third infraorbitals in both Queensland species is considered another retained primitive state that varies from Forey's statement that these are fused in pachyrhizodontoids. Indeed, the close association of the antorbital with the supraorbital in the Queensland taxa suggests that absence of the antorbital in other species of *Pachyrhizodus* may have resulted from its fusion with that element rather than with any other of the neurocranial elements or from actual loss.

It is unfortunate that no *P. marathouensis* or *P. grawi* specimens with associated post-cranial (especially caudal elements) are present in the Queensland Museum collections. However, a disassociated partial caudal specimen, QML 754, with morphological characters compatible with described pachyrhizodontoids is available and is illustrated in Fig. 12, while a second disassociated caudal fin (F 49171) is present in the part of the collection held in the Stonehouse Museum in Boulia, CWQ. An almost complete *Pachyrhizodus* specimen, probably of *P. grawi*, showing nearly all elements of the post-cranial skeleton as well as the body outline, has been collected and prepared by the Kronosaurus Korner in Richmond, NCQ. A photograph of this specimen, numbered RFM 500 in that collection, was provided to the author (P. Stumkat pers. comm.). This has been used to confirm reference of QML 754 and F 49171 to *Pachyrhizodus* sp.

The skeleton of the Queensland pachyrhizodontoid caudal fin retains similarities with those seen in *Notelops* (Forey 1977, Figs. 10). It also shares some character states with those in the Italian examples of *Pachyrhizodus* sp.

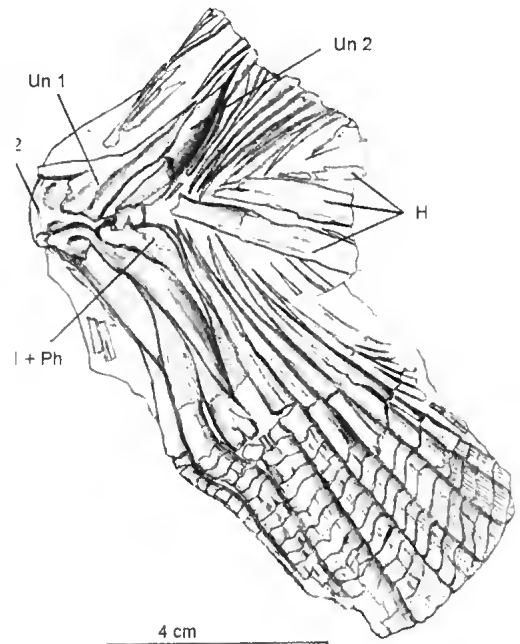


FIG. 12. *Pachyrhizodus* sp. F 55459, partial caudal fin, drawing in left lateral aspect.

(Taverne 1987, Figs. 4-5) and *P. caninus* Cope, from the Upper Cretaceous of North America (Forey 1977, Fig. 36; Nelson 1973, Fig. 8A). In general and where represented, those skeletal caudal fin characters in pachyrhizodontoids that are considered by Forey (1977) to represent a more advanced situation than in the elopoids, at least appear present in *Pachyrhizodus* sp. The parhypural bears a small hypurapophysis, similar to that shown by Taverne (1987, Fig. 5) in *Pachyrhizodus* sp. and is fused with the first preural centrum. This is also seen in the caudal fin of *P. caninus* (Forey 1977, Fig. 36). Unfortunately, the proximal end of the lower hypurals is not visible in QML 754 but is visible in F 49171, showing its fusion with the first ural centrum. All hypurals in QML 754 are imperfectly preserved and are present as 'strap'-like remnants. Those in F 49171 are fused to one another, similar to that illustrated by Forey (1977) for *P. caninus* and by Taverne

(1987, Fig. 5) as *Pachyrhizodus* sp. However, as noted by Forey (1977), hypural fusion patterns vary and may even be an ontogenetic phenomenon. As in *P. caninus*, there are two uroneurals present, the first of which is strongly forked proximally, a feature of *Pachyrhizodus* noted by Forey (1977) and interpreted as possibly present to strengthen the skeleton. A quite strong anterior expansion of the base of Un 1 extends anteriorly along the dorsal moiety of the third preural centrum but probably not to the extent of that figured by Taverne (1987, Fig. 4) in *Pachyrhizodus* sp. The second uroneural is elongated and, although broken proximally, would have extended over the lateral face of the first preural centrum. There is no evidence to support the presence of a neural spine on the second preural centrum.

The lack of complete fusion of the articular and angular in the posterior lower jaw elements and the unfused retroarticular in both Queensland species of *Pachyrhizodus* (as in *Notelops*) were considered to be a primitive teleostean state by Forey (1977). The contribution of the separate articular with exclusion of the angular, at least to the dorsal part of the articulatory facet in the Queensland material (unlike *Notelops* where both separate parts of the angular and articular form the facet, with the articular excluded from the dorsolateral margin) is also at variance with the recorded observations of Nelson (1973) for *P. caninus*, where *Notelops* was stated to be more primitive than most 'lower teleosts'. Apparently, the American species of *Pachyrhizodus*, *Rhacolepis*, the euteleosts, the clupeomorphs and possibly the elopomorphs, have fusion of the angular and articular contributions to the facet and a separate retroarticular (Forey 1977).

It appears likely that the two species of *Pachyrhizodus* recorded from Queensland were both fast swimming, predatory carnivores of the Lower Cretaceous epeiric sea of the Eromanga Basin, particularly in the area close to the inflow over the basement Euroka Ridge. *Pachyrhizodus marathonsensis*, in particular, is preserved more

widely in the coquinas of the Toolebuc Formation, deposited especially along the shallow margins as far west as the Boullia area. This suggests that distance from the major inflow area into the Basin may represent a factor influencing their distributions. It is interesting that, although globally widespread and successful, unlike some of the contemporaneous but no more significant fishes of that time, *Pachyrhizodus* (and the group as a whole) did not apparently survive beyond the Cretaceous.

ACKNOWLEDGEMENTS

The author expresses his appreciation to Mr R. Ievers, Manager and Curator, Mr P. Stumkat, both of the Kronosaurus Korner, Richmond and to Mr R. Suter, Curator of the Queensland Museum's distributed fossil collection in the Stonehouse Museum, Boullia, for providing invaluable assistance and allowing access to the material displayed and held in their care.

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A review of *Macrophthalmus sensu lato* (Crustacea: Decapoda: Macrophthalmidae) from Australia, including two new species and new records

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Citation: Davie, P.J.F. 2012 02 17. A review of *Macrophthalmus sensu lato* (Crustacea: Decapoda: Macrophthalmidae) from Australia, including two new species and new records. *Memoirs of the Queensland Museum – Nature* 56(1): 149–219. Brisbane. ISSN 0079–8835. Accepted 30 August 2011.

ABSTRACT

Nineteen species of *Macrophthalmus sensu lato* from Australia and its Territories are reviewed, diagnosed and illustrated. One new species *M. gagudju* is described from the Northern Territory. It differs from its nearest allies by carapace shape, armature and granulation, thick setae on the inner face of the palm of the male cheliped, and the lack of a tooth on the fixed finger of the male claw. Five species are newly recorded for the Australian fauna, *Macrophthalmus (Paramareotis) erato* De Man, 1888, from the vicinity of Darwin, and in Kakadu National Park; *M. (Macrophthalmus) dentatus* Stimpson, 1858, from Moreton Bay; *M. (M.) ceratophorus* Sakai, 1969, from the Great Barrier Reef; *M. (M.) serenei* Takeda & Komai, 1991, from the Great Barrier Reef and Cocos-Keeling Is.; and *M. (M.) graeffei* A. Milne-Edwards, 1873, from coastal waters off eastern Cape York. The record of *M. (M.) graeffei* is the first from the Western Pacific since the original type description; a neotype is designated. It is demonstrated that specimens recorded from the Indian Ocean under this name are not conspecific with *M. (M.) graeffei*, and a new species name, *M. (M.) indicus* is provided. The geographic range of *Macrophthalmus (Mareotis) abercrombiei* has been extended westwards from the Gulf of Carpentaria to Kakadu National Park, on the western edge of Arnhem Land; *M. (Mareotis) darwinensis* is now known from northeastern Australia and New Caledonia. *Chaenostoma* and *Tasmanoplax*, previously considered subgenera of *Macrophthalmus*, are formally treated as full genera. *Tasmanoplax latifrons* is recorded from the Hunter River, central New South Wales, considerably extending northwards its known distribution. The typically subtropical species *Chaenostoma punctulatus* is newly recorded from Port Augusta, South Australia, and it is speculated that this has been a recent introduction. Keys to the genera and species of Australian Macrophthalminae are presented. □ Crustacea, Decapoda, Brachyura, Ocypodidae, Macrophthalmus, Australia, Northern Territory, Queensland, New South Wales, new species, intertidal.

Davie (2009), in erecting a new Australian macrophthalmine genus, *Lutogenma*, followed Ng *et al.* (2008) in recognizing the family Macrophthalmidae, containing the nominal subfamily, along with the Ilyograpsinae Števc̆ić,

2005, and the Tritodynamiinae Števc̆ić, 2005. Barnes (2010) has given an excellent review of the broader family Macrophthalmidae including a key to the subfamilies and keys to all genera and species. The Macrophthalminae *sensu stricto*

now contains seven genera: *Macrophthalmus* Desmarest, 1823, *Chaenostoma* Stimpson, 1858, and four endemic Australian monotypic genera, viz., *Australoplax* Barnes, 1966 (with *A. tridentata* (A. Milne-Edwards, 1873)), and *Enigmaplax* Davie, 1993 (with *E. littoralis* Davie, 1993); *Lutogemma* (with *L. sandybrucei* Davie, 2009); and *Tasmanoplax* Barnes, 1967 (including *Macrophthalmus latifrons* Haswell, 1881), and the endemic New Zealand genus *Hemiplax* Heller, 1865 (including *Hemiplax hirtipes* (Hombron & Jacquinot, 1846)), although there is strong evidence that this last genus should be removed to the Varunidae (see Kitaura *et al.* 2010).

The Australian species of *Macrophthalmus sensu lato* were revised by Barnes (1967). This was one of the earliest papers of what was to become a series revising the genus throughout the Indo-West Pacific (Barnes 1966, 1967, 1970, 1971, 1973, 1976, 1977). Barnes (1967) introduced four new subgenera, making a total of six subgenera under *Macrophthalmus* (subsequently increased to eight, see Ng *et al.* 2009)). These subgenera have been a basis for ongoing interest and study of the phylogenetic relationships within this diverse genus (see Kitaura *et al.* 2006, 2010; Mendoza & Ng 2007; Davie 2009; McLay *et al.* 2010). Davie (2009) and McLay *et al.* (2010) have indicated that *Chaenostoma* Stimpson, 1858 (= *Macrophthalmus (Mopsocarcinus)* Barnes, 1967), *Hemiplax* Heller, 1865, and *Tasmanoplax* Barnes, 1967, should be recognised as distinct genera in their own right (see also Kitaura *et al.* 2010). Davie (2009) argued that the 'broad-fronted' forms, *Chaenostoma*, *Hemiplax* and *Tasmanoplax* form a separate lineage that is more akin to *Australoplax*, and seem quite separate from the other typically narrow-fronted *Macrophthalmus* subgenera. Kitaura *et al.* (2010) present strong genetic evidence that the monotypic New Zealand genus *Hemiplax* (*H. hirtipes*) is in fact not a macrphthalmid at all, but should be transferred to the Varunidae. In my opinion it is very likely that many of the macrphthalmid subgenera will prove to need generic status, but this should await more genetic

analyses including a greater range of species and genera, and involving more genes than just 16s rRNA. Mendoza & Ng (2007) and Barnes (2010) have discussed some of the complex aspects of the subgenera and provided a key to identify them.

There have been some important recent nomenclatural changes. Barnes (1967) erected the subgenus, *Macrophthalmus (Mopsocarcinus)* (type species *Macrophthalmus boscii* Audouin, 1826), unaware that there was an earlier name, *Chaenostoma* Stimpson, 1858 (type species *C. orientale* Stimpson, 1858). Since *Chaenostoma orientale* Stimpson, 1858, is now regarded as a junior synonym of *Macrophthalmus boscii* Audouin, 1826, the name *Chaenostoma* Stimpson, 1858, must have priority as the subgeneric name (see Stimpson 1858; Ng *et al.* 2001). *Euplax* H. Milne Edwards, 1852, was synonymised under *Macrophthalmus (Venitus)* Barnes, 1967, by Barnes (1977) (see also Barnes 1966), but was regarded as a good subgenus by Mendoza & Ng (2007). In any case, if *Euplax* and *Venitus* are regarded as synonyms, *Euplax* has priority, as first pointed out by Karasawa & Matsuoka (1992), and see also Ng *et al.* (2008). McLay *et al.* (2010) stated that Ng *et al.* (2008) had suggested that '*Euplax* H. Milne Edwards, 1852, and *Venitus* Barnes, 1967, could be treated as good genera', and tentatively recognised generic status for both genera following those earlier authors despite the fact that their molecular phylogeny included *M. (Venitus) latreillei* within their *Macrophthalmus* clade as we currently understand it. In fact Ng *et al.* (2008) did not suggest generic status for either subgenus, and as no new evidence has been presented, I here continue to treat *Euplax* and *Venitus* as subgenera following Davie (2009) and Barnes (2010). Barnes (2010) has provided diagnoses for genera and subgenera within the Macrophthalmidae, so these have been not repeated here except for *Chaenostoma* and *Tasmanoplax* which are treated in the present work as full genera.

The present paper is based on collections I have made from northern Australia over many years, supplemented by specimens made as part of environmental studies by Dr Russell Hanley, and Ms Melanie Burke, of the Northern Territory Museum of Arts and Sciences, and the Queensland Museum and Western Australian Museum collections. Several species could not be identified using the key to Australian species in Barnes (1967), and closer scrutiny led to the identification of four species new to the Australian fauna, and two species new to science from the Northern Territory and Western Australia. One of these, *M. (Mareotis) pistrosinus* Barnes & Davie, 2008, has been described separately.

The following is a list of currently recognised *Macrophthalmus* (*sensu lato*) species occurring in Australia (* = new Australian record):

- M. (Macrophthalmus) ceratophorus* Sakai, 1969*
- M. (M.) convexus* Stimpson, 1858
- M. (M.) crassipes* H. Milne Edwards, 1852
- M. (M.) dentatus* Stimpson, 1858*
- M. (M.) graeffei* A. Milne-Edwards, 1873*
- M. (M.) milloti* Crosnier, 1965
- M. (M.) serenei* Takeda & Komai, 1991*
- M. (M.) telescopicus* Owen, 1839
- M. (Mareotis) abercrombiei* Barnes, 1966
- M. (M.) durwinensis* Barnes, 1971
- M. (M.) gagudju* sp. nov.
- M. (M.) pacificus* Dana, 1851
- M. (M.) pistrosinus* Barnes & Davie, 2008
- M. (M.) setosus* H. Milne Edwards, 1852
- M. (Paramareotis) erato* De Man, 1888*
- M. (Venitus) latreillei* (Desmarest, 1822)
- Chaenostoma boscii* Audouin, 1826
- Chaenostoma puuctulatus* Miers, 1884
- Tasmanoplax latifrons* Haswell, 1882

Macrophthalmus (Mareotis) definitus Adams & White, 1848, is sometimes cited as being recorded from Queensland (e.g. Barnes 2010:

36), but this seems to be an error. Barnes included this species in his 1967 paper on the 'Macrophthalminae of Australasia'. However, the only specimens that he examined in that paper were from the Solomon Islands, and I can find no subsequent confirmed record of this species from the Australian region.

Abbreviations used in the text are: NHM, The Natural History Museum, London; NTM, Northern Territory Museum; QM, Queensland Museum; WAM, Western Australian Museum; G1, male first gonopod. Measurements given in the text are of the carapace breadth (measured at the widest point) followed by length, and are in millimetres (mm).

MACROPHTHALMIDAE DANA, 1851

Macrophthalminae Dana, 1851

Diagnosis. Carapace usually markedly broader than long, quadrilateral, more or less flattened; dorsal, surface with regions usually well defined; anterolateral margins either straight or slightly arched, usually armed with one to several teeth, but may be entire. Front variable but never very broad. Interantennular septum very narrow. Antennules folding transversely or slightly obliquely; flagellum well developed. Eyestalks usually elongate, often remarkably long. Third maxilliped typically more-or-less closing buccal cavern, but may be widely gaping (*Lutogeumma*); exopod visible, moderately broad, flagellum well developed. Chelipeds subequal, chelae usually distinctly larger in males; dactylus of males often with subproximal tooth; chelae of females weaker, more slender. No brush of long setae edging pouch at base of pereopods. Thoracic sternum broad posteriorly. Male genital openings sternal. Free-living, intertidal to shallow subtidal, usually in estuaries or mangroves but may extend into sandier coastal waters; mostly inhabiting burrows (Davie 2009).

**KEY TO GENERA OF
MACROPHTHALMINAE**

(The endemic New Zealand monotypic genus *Hemiplax* is now considered to belong to the Varunidae following the recent work of Kitaura *et al.* (2010), and is not included in this key)

1. Third maxillipeds broadly gaping, ischium narrow with inner margin deeply excavated, palp with long setae reaching to sternum; legs subcylindrical . . . *Lutogenium* [Monotypic; restricted to north Australia; *L. sandybrucei* Davie, 2009, inhabits inshore soft sediments in shallow subtidal seagrass meadows].
 - Third maxillipeds largely closing bucal cavity, ischium subrectangular, inner border not excavated, palp normal, without very long setae; legs flattened 2
2. Front very narrow or moderately narrow, lateral margins not markedly diverging, strongly to slightly constricted between bases of ocular peduncles. Merus of third maxilliped markedly smaller than ischium. *Macrophthalmus*
 - Front broad, lateral margins moderately to markedly divergent, without constriction between bases of ocular peduncles. Merus of third maxilliped subequal or only slightly smaller than ischium 3
3. Male abdomen broad; sixth somite markedly elongated, c. 1.5 times wider than long, lateral margins markedly convergent distally towards telson; distal margin of fifth somite markedly concave. Third maxilliped with transverse row of setae above base; adult male chela with fingers broadly gaping, but gape obscured by thick matt of long setae extending along most of the length of both fingers *Australoplax* [Monotypic; east coast of Australia; *A. tridentata* (A. Milne Edwards, 1873) inhabits intertidal muds typically around mangroves].
 - Male abdomen relatively narrow, sixth somite not markedly elongated; sutures between somites relatively straight. Third maxillipeds and male chelae otherwise. . . 4

4. Carapace subquadrate, c. 1.1–1.2 times wider than long; ocular peduncles relatively short and stout 5
 - Carapace broader, breadth equal to c. 1.5 x length; ocular peduncles relatively slender and elongated *Tasmanoplax*
5. Frontal width c. 0.4 times fronto-orbital width; merus of third maxilliped slightly smaller than ischium; fingers of male chela pointed. *Euigmaplax* [Monotypic, *E. littoralis* Davie, 1993; east coast of Australia; in intertidal and shallow subtidal seagrass meadows, in algal mats, and under rocks].
 - Frontal width c. 0.25–0.3 times fronto-orbital width; merus of third maxilliped subequal to ischium; fingers of male chela spooned *Chaenostoma*

**KEY TO AUSTRALIAN
MACROPHTHALMUS**
(modified after Barnes 2010;
based on adult males)

1. Short horny ridge present on inner surface near inner margin of merus of cheliped; lower orbital border with small number of large triangular protuberances occupying at least one fifth of the margin [inner surface of palm of chela with large spine near articulation with carpus]. *M. (Paramareotis) erato*
 - No horny ridge on merus of cheliped; lower orbital border regularly serrated by granules or smooth, but without any large triangular protuberances. 2
2. Ocular peduncles with a long, thin, segmented filament (style) projecting distally beyond the tip of the cornea; upper margins of palm and dactylus of chela with strong spines *M. (Macrophthalmus) ceratophorus*
 - Ocular peduncles without an obvious long style 3
3. Ocular peduncle extended beyond lateral carapace margin by at least half length of cornea (may be extremely elongate). . . . 4

Macrophthalmus of Australia

- Ocular peduncle not extended beyond lateral carapace margin by half length of cornea, if at all. 7
- 4. Cornea projecting beyond tip of exorbital tooth for only half its length.
 *M. (Macrophthalmus) graeffei*
- Ocular peduncle projecting beyond lateral carapace margin for at least 25% of its length, so that cornea located beyond lateral carapace margin for more than its own length 5
- 5. Ocular peduncles extend beyond tip of exorbital tooth for < 36% of their length and for less than a distance equal to twice length of cornea. *M. (Macrophthalmus) niilloti*
- Ocular peduncles extend beyond tip of exorbital tooth for > 36% of their length and for more than a distance to twice the length of the cornea. 6
- 6. Exorbital tooth triangular, sharp, not projecting beyond second anterolateral tooth. Poorly differentiated tooth on cutting margin of dactyl of chela; lower margin of index concave; may attain a carapace breadth of > 35 mm.
 *M. (Macrophthalmus) telescopicus*
- Exorbital tooth spiniform, projecting beyond second anterolateral tooth. Prominently differentiated teeth on cutting margins of both fingers of chelae; lower margin of fixed finger straight; carapace breadth < 25 mm *M. (Macrophthalmus) serenei*
- 7. Carapace with four or five anterolateral teeth, exorbital tooth largest and marking position of greatest carapace breadth; carapace surface generally smooth and shiny. *M. (Macrophthalmus) dentatus*
- Carapace with two to four anterolateral teeth; if fourth present then carapace surface heavily granular and greatest breadth behind the exorbital angle 8
- 8. Central region of epistome with a protuberance 9
- Central region of epistome straight or excavated. 10
- 9. Inner surface of palm of chela with one or more spines near articulation with carpus; exorbital angle narrower than second lateral tooth and projecting about the same distance *M. (Macrophthalmus) crassipes*
- Inner surface of palm of chela without spines; exorbital angle larger than, and projecting beyond, second lateral tooth
 *M. (Macrophthalmus) convexus*
- 10. Inner surface of palm of chela without mats of setae [no longitudinal rows of granules on branchial regions; carapace markedly narrowed anteriorly].
 *M. (Mareotis) abercrombiei*
- Inner surface of palm of chela with mat of setae concealing at least part of surface. . . 11
- 11. Greatest carapace breadth across exorbital angles; outer surface of palm and index of chela with longitudinal ridge near lower margin; index deflexed
 *M. (Mareotis) setosus*
- Carapace with greatest breadth situated posterior to exorbital angles; if longitudinal ridge present on outer surface of palm and index of chela, then index undeflexed. . . 12
- 12. Inner surface of palm of chela with longitudinal band of setae along upper half; index of chela deflexed.
 *M. (Mareotis) pistrosinus*
- Setae on inner surface of palm of chela not as described above; index of chela scarcely or not at all deflexed. 13
- 13. Cutting margin of index of chela of adult males with a differentiated tooth; carapace breadth less than 40 mm [carapace surface not coarsely granular, with thick lateral setae, and with longitudinal rows of setae on branchial regions
 *M. (Mareotis) darwinensis*
- Cutting margin of index of chela of adult males without a differentiated tooth (except in specimens of more than 45 mm carapace breadth). 14
- 14. Carapace surface smooth; inner surface of palm of chela without dense setae
 *M. (Mareotis) pacificus*

- Carapace surface granular; inner surface of palm of chela with dense setae 15
- 15. Carapace surface with relatively small granules; third anterolateral teeth inconspicuous or absent [medium sized species reaching < 20 mm c.b.].
. *M. (Mareotis) gagudju* sp. nov.
- Carapace surface heavily granular; third anterolateral teeth prominent and projecting [anterolateral teeth all projecting and acute; large species reaching 60 mm c.b.].
. *M. (Venitus) latreillei*

TAXONOMY

Macrophthalmus (Macrophthalmus)

ceratophorus Sakai, 1969

(Figs 1, 2)

Macrophthalmus (Macrophthalmus) ceratophorus Sakai, 1969: 280, pl. 2, figs 3a–d; 1976: 611–613, text-figs 335a–d; Barnes 1976: 140–143, fig. 5; 1977: 276, 279; Fransen 1997: 341–345, figs 1–3; Ng & Davie 2002: 378, 382–383; Ng, Guinot & Davie 2008: 237.

Macrophthalmus ceratophorus – Wada 1978: 20; Nagai 1990: 117; Takeda & Komai 1991: 166; Ho 1995: 21–24; Ng *et al.* 2001: 38.

Material examined. QM-W27081, ♂ (39.9 × 24.4 mm); 2 ♀ (47.7 × 28.8, 42.2 × 26.6 mm), Magnetic Passage, North of Helix Reef, East of Slashers complex, off Townsville, Qld, 18°27'S, 147°16'E, 07.07.1980. QM-W27080, ♂ (35.5 × 21.04 mm); ♀ (33.3 × 25.5 mm), north of Ile Desnoeuvs, Amirante Is., 6°08'S, 53°02'E, 54 m, soft bottom amongst sponges & seagrass, Dutch Oceanic Reefs' Expedition, 2.01.1993.

Diagnosis. Carapace smooth and punctate centrally, pitted, scattered large rounded granules present laterally, particularly on branchial regions; front deflexed, markedly constricted between bases of ocular peduncles, with smooth margins, clearly bilobed distally, median furrow narrow. Lateral margins granulate, slightly convergent posteriorly, exorbital angle moderately prominent, followed by two poorly defined antero-lateral teeth. Ocular peduncles long and narrow, cornea extending well (about half length of eyestalk) beyond tip of exorbital angle, a slender, terminal segmented filament present beyond cornea. Central region of epistome pointed.

Merus of third maxilliped noticeably smaller than ischium. Palm of adult male cheliped elongate, outer face with medium-sized, scattered, rounded or pointed granules, inner face with rounded or pointed granules medioventrally, with distinct and discrete thick patch of setae near base of dactylus; fixed finger straight or slightly deflexed, cutting edge lined with pointed granules but without differentiated tooth; cutting edge of dactylus proximally with a large, quadrangular, crenulated tooth, distally with a row of pointed granules; dorsal margin of dactylus with about four prominent spines. Meri of ambulatory legs with pointed granules on both margins, and a row of setae along upper margin; carpi of P2–4 with two longitudinal rows of spinules, that extend less prominently onto proximal end of propodi.

Colour. Porcelain white speckled with fine red dots on pereopods. Red dots largest and most conspicuous on carpus and distal part of merus in male specimens. Elongate patch of dense setae in centre of proximal surface of dactylus usually dark brown to black. (Fransen 1997).

Remarks. These specimens agree closely with the description and figures of Sakai (1969) and Barnes (1976), as well as those of Fransen (1998), and they have been directly compared with specimens studied by Fransen from the Amirante Islands, and donated to the Queensland Museum. This large species of sublittoral *Macrophthalmus* is remarkable because of the long segmented filament at the tip of the eyestalk. Originally described from Japan, it is now reported from a number of localities through to the western Indian Ocean.

Habitat. Appears to prefer offshore soft substrates in depths of 20–50 m; has been found on bottoms amongst seagrass roots, sponges, and foraminiferan and bryozoan rubble.

Distribution. New record for Australia. Range: Japan—Gokasho Bay, Mie Prefecture, and Shimogusui, Kii Province (Sakai 1976); Taiwan (Ho 1995); South China Sea (Chen 1998); western Thailand (Ng & Davie 2002); Amirante Is.,

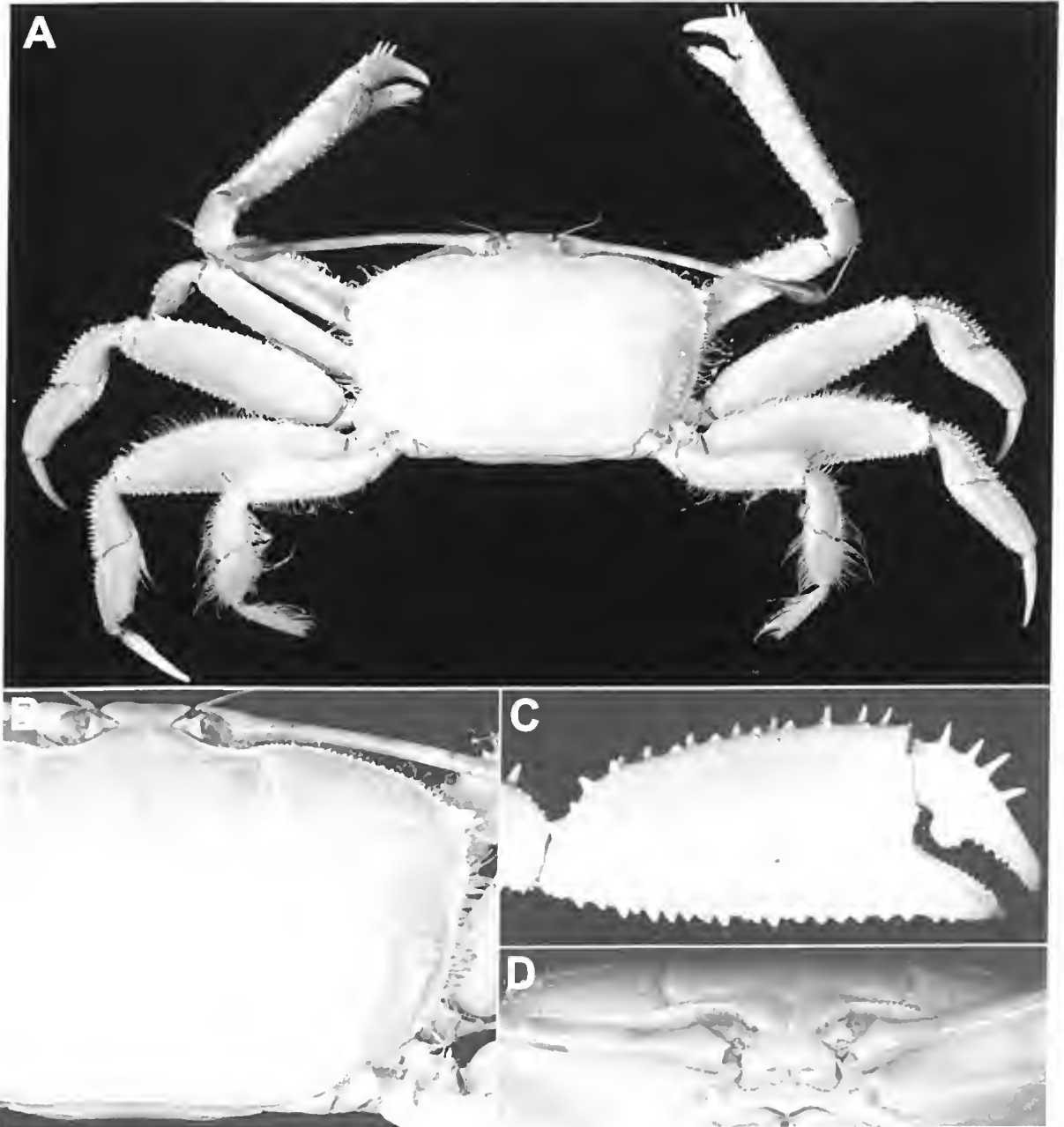
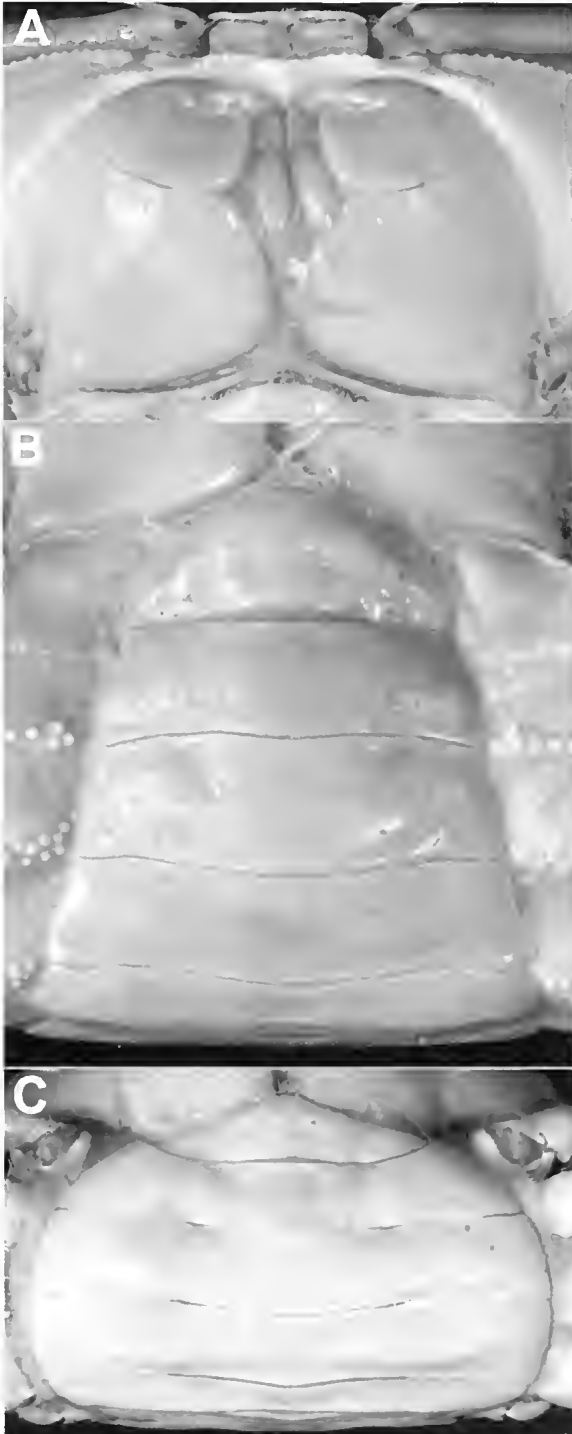


FIG. 1. *Macrophthalmus* (*M.*) *ceratophorus* Sakai, 1969. QM-W27081, ♂ (39.9 × 24.4 mm), Magnetic Passage, off Townsville, Qld. **A**, Dorsal view; **B**, enlarged view of carapace; **C**, frontal view of chela; **D**, frontal margin and orbits.



Seychelles (Fransen 1997); and now from Magnetic Passage off Townsville, Qld.

Macroththalmus (Macroththalmus) convexus
Stimpson, 1858
(Figs 3, 4)

Macroththalmus convexus Stimpson, 1858; 97; Miers 1880b: 307; Haswell 1882a: 89; de Man 1888b: 354, pl. 15, fig. 4; 1902: 493, pl. 19, figs. 6, 6a; Ortmann 1894a: 745; 1897: 343; Alcock 1900b: 378; Stimpson 1907: 97, pl. 13, fig. 2; Rathbun 1910a: 323, pl. 2, fig. 3; Tesch 1915: 154 (key), 175 (part), pl. 7, fig. 8; 1918: 59; Kemp 1919: 389, pl. 24, fig. 2; Balss 1922: 145; Maki & Tsuchiya 1923; Boone 1934: 210, pls. 104–106; Shen 1936: fig. 3g–i; Shen & Dai 1964: 113; Chopra & Das 1937: 427; Tweedie 1937: 163; Sakai 1939: 625, fig. 97; Lin 1949: 27; Barnard 1954a: 98; Barnes 1977: 277 (key); Takeda 1982: 210; Davie 1992: 348 (key); Ng *et al.* 2001: 38.

Macroththalmus inermis A. Milne-Edwards, 1867: 286; 1873: 277, pl. 12, fig. 5; Rathbun 1906: 834.

Macroththalmus (Macroththalmus) convexus – Barnes 1967: 211, fig. 3, pl. 1c; 1970: 222; 1971: 9; Lundoer 1974: 8 (list); Sakai 1976: 613, fig. 336; Takeda 1981: 71; Miyake 1983: 167, pl. 56, fig. 4; Tai & Song 1984: 81 (key); Dai *et al.* 1986: 431, pl. 59 (8), fig. 240 (1); Dai & Yang 1991: 472, fig. 240 (1), pl. 59 (8); Huang *et al.* 1992: 147, fig. 6, pl. 1F; Komai *et al.* 1995: 110, figs. 3–4; Wada 1995: 416, pl. 118, fig. 1; Shokita *et al.* 1998: 66 (list); 2000: 658 (list); Ng *et al.* 2008: 237 (list).

Not *Macroththalmus (Macroththalmus) convexus* – Tesch 1915: 175 (part) [= *M. graeffi* A. Milne-Edwards, 1873].

Material examined. QM-W21292, ♀ (8.6 × 5.3 mm), Sandy I., Cape Talbot, Kimberley Coast, 13°45'S, 126°48'E, intertidal muddy sand flat, 28.11.1995, P. Davie & J. Short. QM-W29104, 6 ♂ (13.3 × 6.3 – 24.0 × 11.9 mm), 4 ♀ (15.7 × 8.7 – 24.3 × 12.7 mm), Portland Roads, Cape York, NE Qld, sandflat, P. Davie, 12.11.1982. QM-W8196, 2 ♀ (27.7 × 15.4, 26.6 × 14.3 mm), ♂ (29.9 × 14.3 mm), Murray River, NQ, 18°1'S, 145°53'E, estuarine, littoral, shallow pools, open mud bank, 21.05.1978, P. Davie. QM-W1251, 2 ♀ (22.2 × 10.1, 23.4 × 11.2 mm), 5 ♂ (26.6 × 13.3, 24.4 × 10.1, 19.9 × 9.9, 19.8 × 9.9, 22.2 × 10.1 mm), Cockle Bay,

FIG. 2. *Macroththalmus (M.) ceratophorus* Sakai, 1969. QM-W27081, ♂ (39.9 × 24.4 mm); ♀ (47.7 × 28.8 mm), Magnetic Passage, off Townsville, Qld. A, third maxillipeds; B, male abdomen; C, female abdomen.

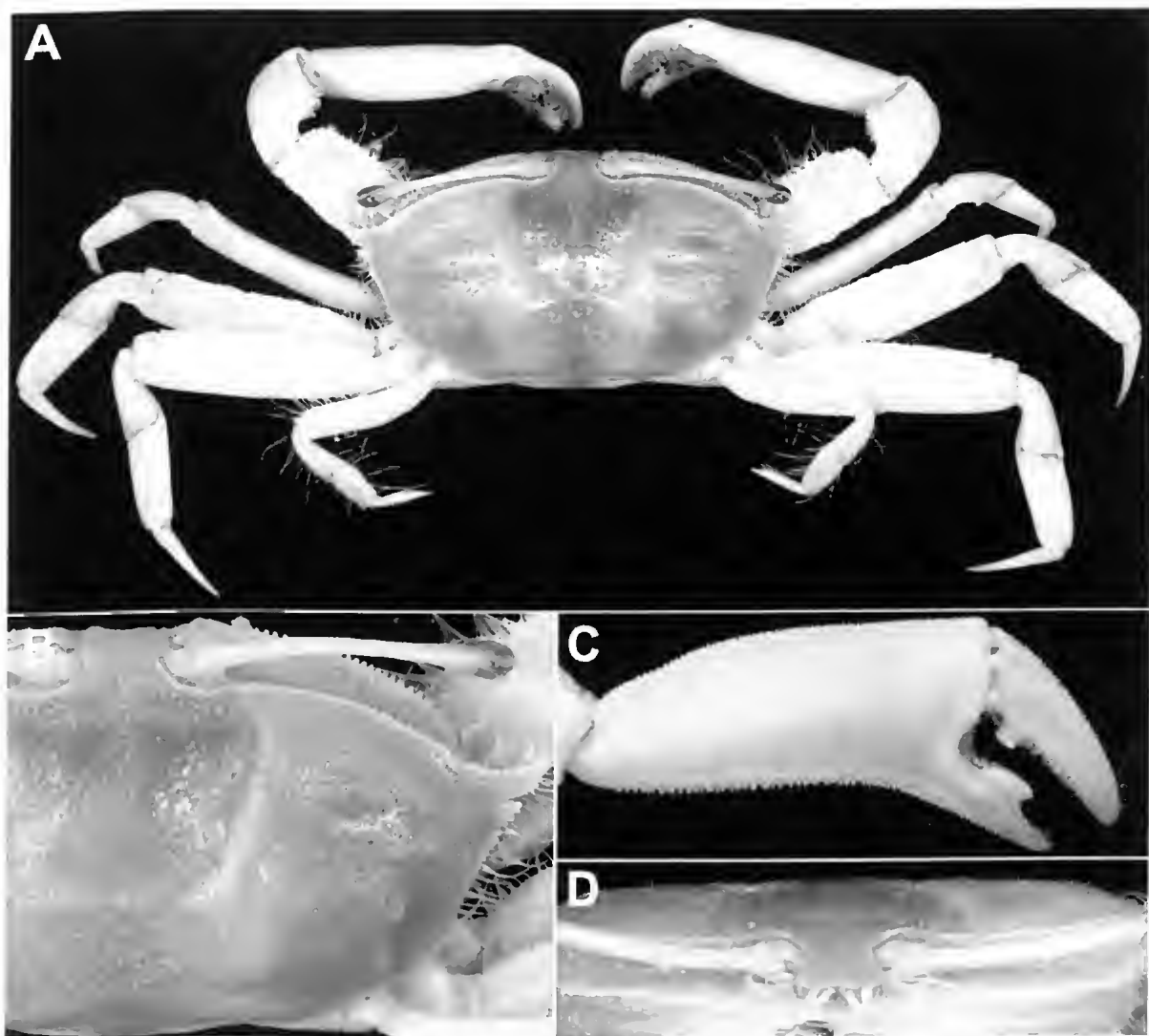
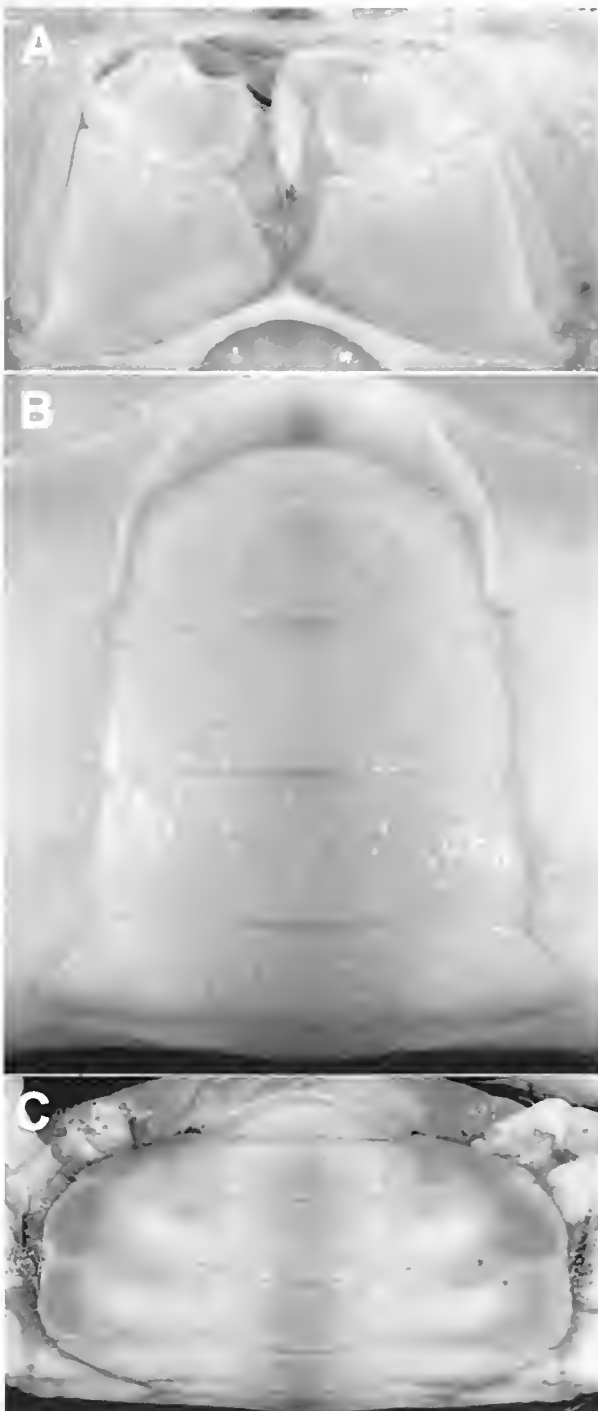


FIG. 3. *Macrophthalmus* (*M.*) *convexus* Stimpson, 1858. QM-W8196, ♂ (29.9 × 14.3 mm), Murray River, NQ. A, Dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

19°11'S, 146°49'E, 19.03.1998, R. Barnes. QM-W10469, ♂ (25.5 × 10.1 mm), Ross R., Townsville, 19°22'S, 146°44'E, estuarine, sandy mud flat, lower estuary, July 1983, P. Davie. QM-W11921, ♀ (17.3 × 9.2 mm), Shoal Water Bay, ME Qld, 22°23'S, 150°31'E, Nov. 1982. QM-W11920, ♂ (12.9 × 7.3 mm), Triangular I., Shoal Water Bay, ME Qld, 22°23'S, 150°31'E, Nov. 1982.

Diagnosis. Carapace smooth except for raised clumps of granules on branchial regions; front

deflexed, constricted between bases of ocular peduncles, with smooth margins, slightly bilobed distally, median furrow distinct; greatest breadth across exorbital regions; lateral margins posteriorly convergent, 3 anterolateral teeth, first two well defined, third poorly defined. Ocular peduncles long and narrow, cornea extending to tip of exorbital angle and sometimes slightly



overreaching it. Central region of epistome with a protuberance. Merus of third maxilliped markedly smaller than ischium. Palm of male cheliped elongate, outer face smooth above longitudinal ridge, granular below, inner face finely granular, no spine near carpus articulation; fixed finger markedly deflexed in adults, cutting edge with a long, low, crenulate tooth; cutting edge of dactylus proximally with a small quadrangular tooth near base and granules distally. Meri of ambulatory with some fine setae on upper margins.

Habitat. Occurs at low tide levels, burrowing in wet muddy, and sandy mud, substrates, often amongst mangroves.

Distribution. Widely distributed throughout the Indo-West Pacific Ocean from Mauritius, the west coast of Thailand, through Indonesia, and further east to Japan, Hawaii and French Polynesia. Within Australia *M. convexus* is found along the north-west coast of Western Australia, the Northern Territory, and extending south along the eastern coast of Queensland to about Shoalwater Bay. Previous Australian records include: Torres Straits (Barnes 1970); unspecified localities (Miers 1880b; Boone 1934), Roebuck Bay, north-western WA, and from Cooktown to Port Curtis (Barnes 1967), Low Isles, Great Barrier Reef (Barnes 1970).

Macrophthalmus (Macrophthalmus) crassipes
H. Milne Edwards, 1852

(Figs 5, 6)

Macrophthalmus crassipes Milne Edwards, H., 1852: 157, pls. 3, 4; Hess 1865: 142; Haswell 1882a: 89; de Man 1890: 76, pl. 4, Fig. 7; Ortmann 1894a: 744; 1897: 345; Rathbun 1910a: 323; Tesch 1915: 174, pl. 7; Rathbun 1924: 12; Tweedie 1937: 164; Dai & Yang 1991: 474, figs 241(1-3), pl. 60(2); Tai & Song 1984, 78-79, figs 1b, 2b, 3e, f; Poore 2004: 495, fig. 156g; Davie 2011: 242, colour picture.

FIG. 4. *Macrophthalmus (Macrophthalmus) convexus* Stimpson, 1858. QM-W8196, ♂ (29.9 × 14.3 mm), ♀ (27.7 × 15.4 mm), Murray River, N. Qld. A, third maxillipeds; B, male abdomen; C, female abdomen.

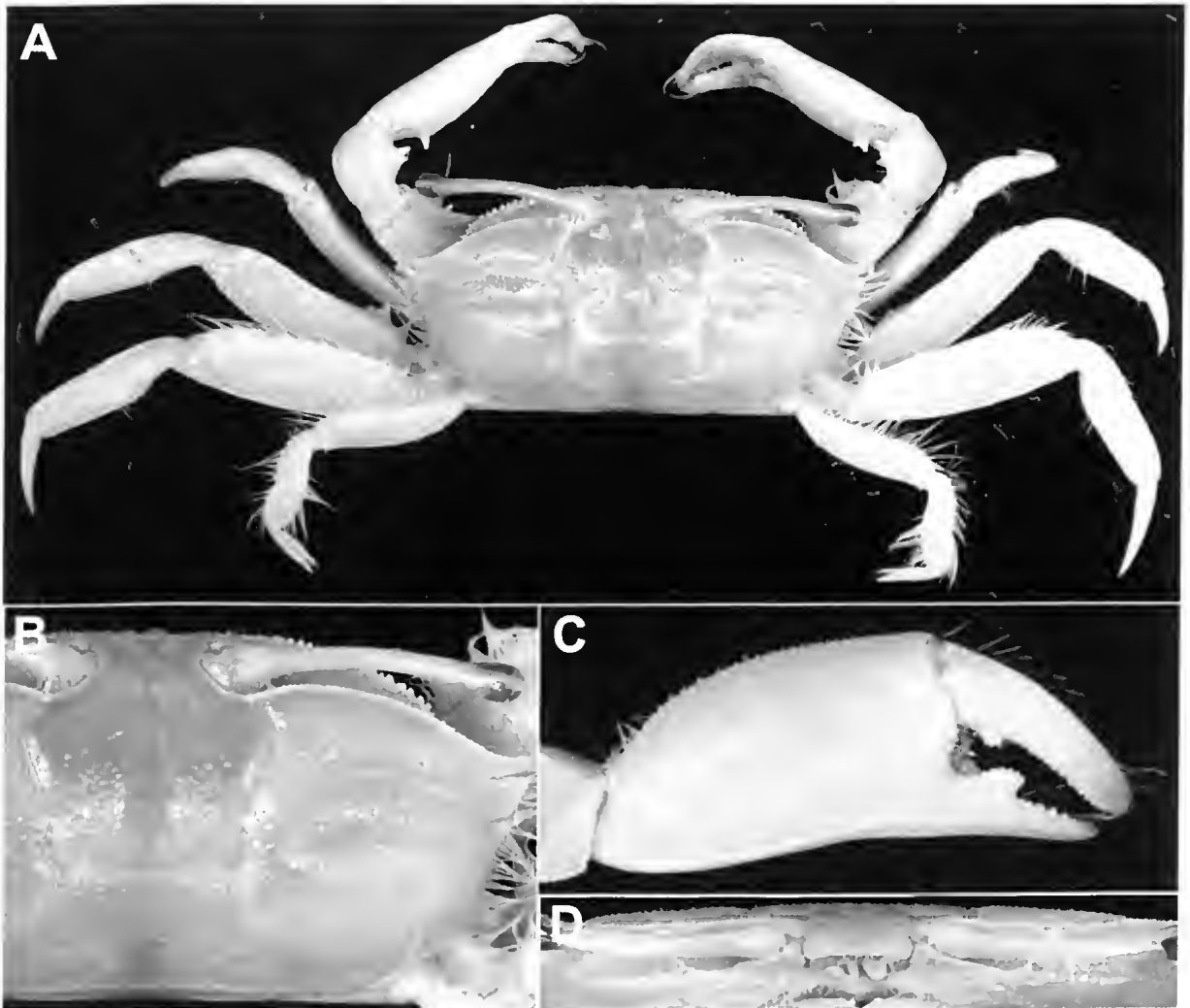


FIG. 5. *Macrocephalus (Macrocephalus) crassipes* H. Milne Edwards, 1852. QM-W3842, ♂ (28.8 × 13.3 mm), Dunwich, North Stradbroke Island, SE Qld. A, Dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

Macrocephalus carinimanus — Haswell 1882a: 88; McNeill 1962: 41, pl. 2, fig. 2 [not *Macrocephalus carinimanus* H. Milne Edwards, 1837: 65].

? *Macrocephalus sundakani* — Rathbun 1924: 12, Pl. 1, Fig. 3.

Macrocephalus (Macrocephalus) crassipes — Barnes 1967: 208–211, pl. 1(b), figs. 2; Morgan 1990: 60; Davie 2002: 352; Ng *et al.* 2008: 237 (list).

Material examined. WAM-C22609, ♂ (13.4 × 7.2 mm), Exmouth Gulf, NE coast of Tent Point, WA, 22

00.0°S, 114 30.5°E, stn 3, M. Hewitt, 18.08.1995. QM-W21034, 2 ♂ (21.7 × 9.6, 12.7 × 5.7 mm), ♀ (12.2 × 6.7 mm), Turtle Bay and Unnamed Bay to S. Lacrosse I., Cambridge Gulf, WA, 14°45'S, 128°18'E, marine, littoral, mud flat near mangroves, 20.11.1995, P. Davie & J. Short. QM-W18170, ♀ (12.1 × 6.6 mm), 2 ♂ (22.5 × 11.9, 17.8 × 9.8 mm), Starke River, FN Qld, 14°47'S, 145°1'E, marine, littoral, upper mud flat, in burrows salinity 35 ppt, 11.11.1992, P. Davie & J. Short. QM-W20245, 2 ♀ (14.7 × 6.8, 11.8 × 5.8 mm),



FIG. 6. *Macrophthalmus (M.) crassipes* H. Milne Edwards, 1852. QM-W3842, ♂ (28.8 × 13.3 mm), Dunwich, North Stradbroke I., SE Qld; QM-W15330, ♀ (25.4 × 10.1 mm), Brisbane R. mouth, SE Qld. A, third maxillipeds; B, male abdomen; C, female abdomen.

Gregory I., Kimberley Coast, WA, 16°8.'S, 123°18.'E, intertidal flat, 19.11.1994, J. Short. QM-W20269, ♀ (18.4 × 8.2 mm), Bedford I., Kimberley Coast, WA, 16°08'S, 123°18'E, intertidal flat, 19.11.1994, J. Short. QM-W20251, ♂ (9.7 × 5.4 mm), Gregory I., Kimberley Coast, WA, 19°19'S, 123°19'E, mud flat near mangroves, *Sonneratia*, 19.11.1994, J. Short. QM-W19186, 6 ♀ (15.5 × 7.7, 10.0 × 5.4, 11.1 × 5.5, 10.0 × 5.5, 10.0 × 5.4, 10.0 × 5.5 mm); 2 ovig. ♀ (15.4 × 6.6, 15.5 × 6.8 mm); 5 ♂ (17.7 × 7.7, 5.6 × 3.3, 12.2 × 5.5, 8.3 × 4.3, 12.1 × 5.5 mm), Lee Point, Darwin, NT, 12°27'S, 130°50'E, sand flat, 27.06.1982, P. Davie. QM-W15171, ♂ (18.3 × 9.8 mm), 8km north of Old Doomadgee, Gulf of Carpentaria, NW Qld, 16°50'S, 138°50'E, 11.04.1988, J. Covacevich & P. Couper. QM-W20696, 2 ♂ (19.6 × 8.7, 14.80 × 6.1 mm), Karumba Point, NW Qld, 17°28'S, 140°49'E, mud flat, 23.06.1995, P. Davie & J. Short. QM-W10468, ♂ (19.9 × 9.7 mm), Ross River, Townsville, 19°22'S, 146°44'E, sandy mud flat, lower estuary, July 1983, P. Davie. QM-W11925, ♀ (13.1 × 5.5 mm), Triangular Bay, ME Qld, 22°23'S, 150°31'E, Nov. 1982, B. Campbell. QM-W4817, ♀ (13.4 × 6.4 mm), Round Hill, North of Bundaberg, 24°9'S, 151°53'E, 25.04–26.04.1975, P. Davie. QM-W5396, 2 ♂ (21.9 × 10.0, 21.2 × 9.9 mm), Hervey Bay Harbour, SE Qld, 25°18'S, 152°55'E, muddy shore, 23.07.1975, P. Davie. QM-W15330, ♀ (25.4 × 10.1 mm), Brisbane River mouth, SE Qld, 27°22'S, 153°10'E, mudflats in burrows, 07.07.1988, P. Lawless & J. Short. QM-W5139, ♂ (17.5 × 7.9 mm), Serpentine Creek, Cribb I. 27°24'S, 153°7'E, August 1972, B. Campbell *et al.* QM-W5293, 2 ♀ (18.1 × 8.3, 15.8 × 7.5 mm), Juno Point, Cribb I., SE Qld, 27°24'S, 153°0'E, B. Campbell. QM-W1077, ♀ (21.7 × 10.4 mm), Green I., Moreton Bay, SE Qld, 27°26'S, 153°14'E, surface of sand, 07.06.1940. QM-W21739, ♂ (25.8 × 11.9 mm), Myora Springs, Stradbroke I., 27°29'S, 153°25'E, marine, littoral, mud flat, 08.03.1996, A. Humpherys. QM-W3842, 4 ♂ (28.8 × 13.3, 25.5 × 11.9, 26.3 × 12.1, 24.5 × 11.5 mm), Dunwich, North Stradbroke I., 27°30'S, 153°24'E, 04.05.1973; S. Cook. QM-W21461, ♂ (31.6 × 14.5 mm), Dunwich, North Stradbroke I., 27°30'S, 153°24'E, marine, littoral, mud flat, 16.06.1996, P. Davie. QM-W24987, 3 ♂ (24.4 × 11.2, 20.7 × 9.9, 22.5 × 10.5 mm), Dunwich, North Stradbroke I., SE Qld, 27°30'S, 153°24'E, marine, littoral, flats, 09.03.1998, P. Davie *et al.* QM-W2368, ♀ (19.5 × 9.2 mm), Victoria Point, SE Qld, 27°35'S, 153°19'E, 11.10.1962, R. Barnes. QM-W3188, ♀ (25.9 × 11.7 mm), ♂ (21.1 × 11.4 mm), Victoria Point, SE Qld, 27°35'S, 153°19'E, adjacent to *Zostera* in burrows to 10–15 cms, 26.03.1968, B. Campbell.

Diagnosis. Front deflexed, bilobed; markedly constricted between bases of ocular peduncles;

upper orbital border strongly curved and markedly sloping. Exorbital angle narrow, elongate, bluntly pointed, separated from second lateral tooth by deep, narrow incision; third lateral tooth small or almost obsolete. Carapace covered in small to medium sized granules; distinct clumps of granules on branchial regions. Lateral margins markedly convergent posteriorly. Ocular peduncles long and narrow; cornea not protruding beyond tip of exorbital angle. Third maxilliped with merus markedly smaller than ischium. Male cheliped with inner surface of carpus with large spine and tubercular granules dorsally. Palm elongate, strongly marked longitudinal ridge near lower margin extending onto fixed finger; inner surface heavily hairy granular; setae densely concealing most or all of surface; with large spine or spines antero-proximally, directed towards carpus. Fixed finger moderately deflexed; cutting margin with large, crenulated, quadrangular or hemispherical tooth. Dactylus cutting margin with small quadrangular tooth near base. Pereiopod meri with setae along upper margins concealing subterminal spines.

Colour. Large males with distal half of cheliped fingers reddish brown, and reddish brown pterygostome and ventral surface. Spines on carpus and inner upper proximal face of palm of male cheliped are bright orange.

Remarks. Adult males are easily identified in the field by the bright orange spines on the carpus and inner upper proximal face of the palm of the cheliped. Interestingly, there are a lack of reports of this species south of Singapore, and through the Indonesian region. This apparent disjunct distribution between the Australian and Asian populations warrants further investigation as to whether the Asian representatives of this species are truly conspecific.

Habitat. Common; burrows, mostly on open soft sandy-mud to muddy flats, and low on river and creek banks, but also around fringes of mangroves (Davie 2011).

Distribution. Type locality: Australia (as 'Nouvelle-Hollande'). Appears to have a central

Indo-West Pacific distribution: Malaysia (Tweedie 1937), Gulf of Thailand (Rathbun 1910), China (Dai & Yang 1991), and the Caroline Islands (de Man 1890). In Australia it is common across northern Australia, and extending to the southern coast of New South Wales.

Macrophthalmus (Macrophthalmus) dentatus
Stimpson, 1858
(Fig. 7)

Macrophthalmus dentatus Stimpson, 1858: 97, 1907: 96; Rathbun 1910a: 22; Tesch 1915: 184; Barnes 1971: 9–13, fig. 2; 2010: 40; Dai & Yang 1991: 471–472, pl. 59 (7); fig. 239 (2–6).

Macrophthalmus (Macrophthalmus) dentatus – Barnes 1966: 203 (in list).

Material Examined. QM-W3252, ♀ (8.0 × 4.6 mm), 500 m off SE rocks, Moreton Bay, 27°30'S, 153°21'E, mud, 5.5 m, March 1970, grab, B. Campbell.

Diagnosis. Carapace surface smooth, except for short granular rows on branchial regions; 1.7 to 1.9 times broader than long. Front narrow, markedly constricted; upper orbital border curved, backwardly sloping; exorbital spine prominent, followed by four smaller lateral teeth, last tooth close to poterolateral margin and may be inconspicuous. Lateral margins moderately convergent. Ocular peduncles long, cornea extending to middle of exorbital angle. Third maxilliped merus smaller than ischium; proximal part of external margin with distinct lateral convexity; central region of epistome with broad, low protruberance. Male cheliped with merus markedly elongate; carpus elongate Palm elongate, without setae except on anterior margin between bases of fingers; outer surface smooth except for very fine granules near upper and lower margins, without longitudinal ridge near lower margin; inner surface with some very fine granules near upper and lower margins, especially proximally, without spine near joint with carpus; fixed finger short, slightly deflexed, cutting margin with large, central triangular tooth, slightly crenulated or smooth at tip, proximal slope much the longer, with 1–2 smaller lobular

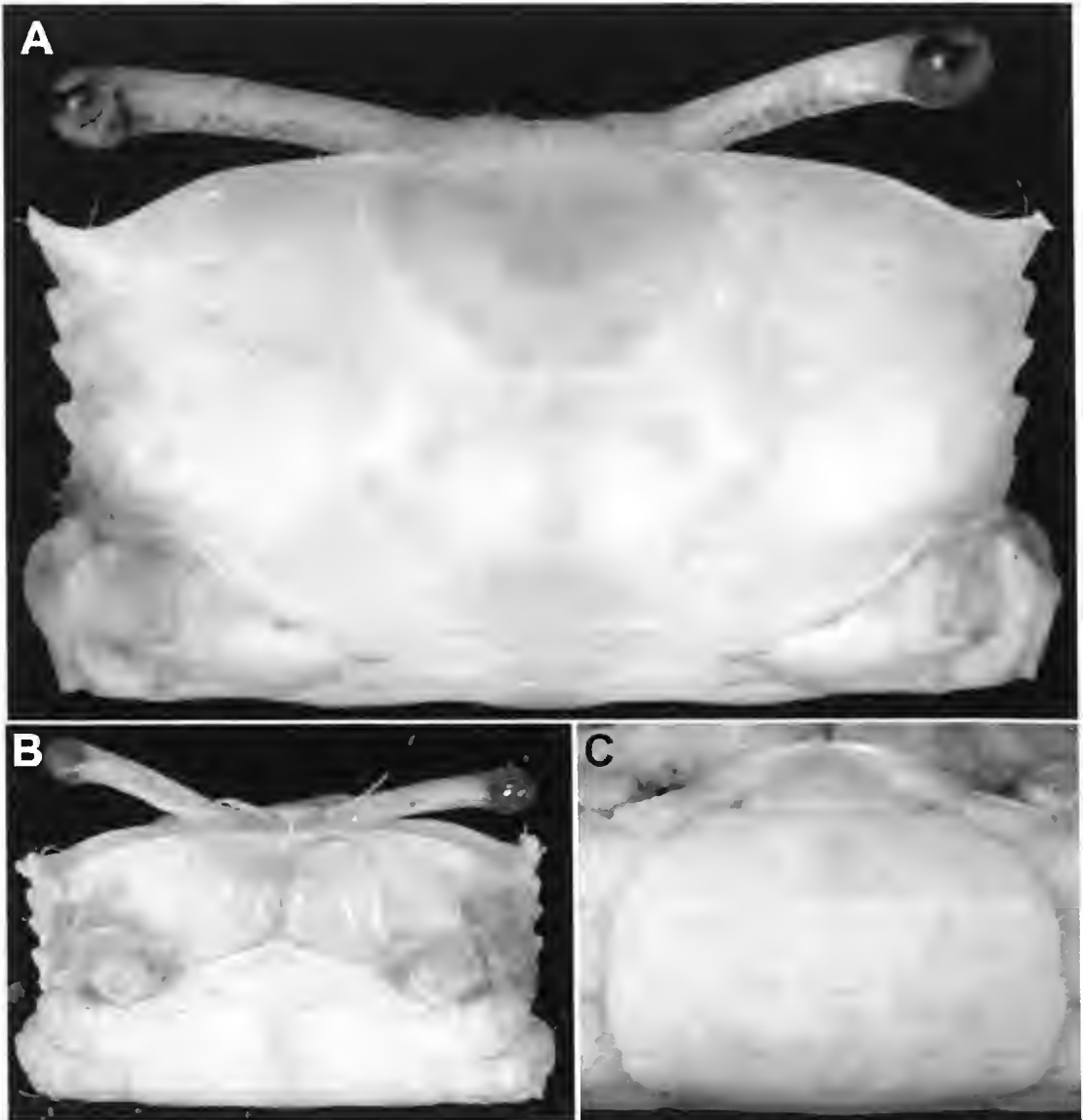


FIG. 7. *Macrophthalmus (M.) dentatus* Stimpson, 1858. QM-W3252, ♀ (8.0 × 4.6mm), Moreton Bay, SE Qld. A, dorsal view of carapace; B, third maxillipeds, lower orbital margins, and pterygostome; C, abdomen.

protuberances distad; dactylus strongly curved, cutting margin with small, flat tipped, quadrangular tooth near base. Walking legs elongate, especially meri; meri with rows of small, pointed granules along upper margin, curved subterminal spine.

Remarks. There is still very little material of this species known. It was redescribed in detail by Barnes (1971). The lateral dentition of the carapace (four small teeth occupying nearly all the lateral border behind the exorbital angle) is the most obvious characteristic of this peculiar

sublittoral species. However it is also atypical among *Macrophthalmus* by having a markedly broad convex lobe over the proximal half of the outer margin of the merus of the third maxilliped. Only one other species of *Macrophthalmus* (*Macrophthalmus*) is known to have five lateral teeth (including the exorbital tooth), and that is *M. pentaodon* Mendoza & Naruse, 2009, from the Philippines. That species is known from only a single female, but the relative sizes and disposition of the lateral teeth are different to *M. dentatus*, the supraorbital margins are significantly more obliquely sloping backwards, and the shape of the female abdomen has the telson more deeply sunken into somite 6. However, *M. pentaodon* seems likely to be closely related, and is also apparently a sublittoral species, as it was collected by a vacuum suction device working in depths of 4–12 m, in muddy to silty sediment.

The discovery of this small female in Moreton Bay marks a significant range extension; and indicates that this species should prove to be more widespread in Australia. The present specimen has relatively short exorbital teeth compared with the long acute teeth of a larger male figured by Barnes (1971: fig. 1a), although the tips of both teeth are slightly damaged; however the presence of 4 teeth on the lateral margin preclude it being any other described species. Unfortunately the present specimen is a small female, and lacks claws. It seems quite possible that the length of the exorbital tooth may be variable according to sex and size, but more specimens will be required before this can be adequately assessed. It is possible that the Moreton Bay specimen represents a related new species, but without further material, and particularly a mature male specimen, this decision must be deferred.

Habitat. Muddy sand bottoms on shallow coastal waters 8–20 m deep. The present specimens, like those of Rathbun (1910), were collected using a benthic grab.

Distribution. Type locality: Hong Kong. New Australian record and major southerly range

extension. Previously known from Guangdong, China; Timor; and the Gulf of Thailand. Within Australia only known from Moreton Bay, south-east Queensland.

Macrophthalmus (*Macrophthalmus*) *graeffe*

A. Milne-Edwards, 1873

(Figs 8, 9, 10A–C, 11D, 12B)

Macrophthalmus graeffei A. Milne-Edwards, 1873: 257, pl. 2, fig. 5.

Not *Macrophthalmus graeffei* – Guinot 1967: 283 (in list); Titgen 1982: 253 (in list); Naderloo, Turkey & Apel 2011: 19–23, figs 11 a–e, 12a–d, 17a, b. [= *Macrophthalmus indicus* sp. nov.]

Not *Macrophthalmus* (*Macrophthalmus*) *graeffe* – Barnes 1970: 225; 1971: 13, 36 (in key), fig. 3; 1977: 276 (in key), 279 (in list); 2010: 34 (in key), 39; Apel 2001: 108; Ng, Guinot & Davie 2008: 237 (list). [= *Macrophthalmus indicus* sp. nov.]

Material Examined. NEOTYPE: QM-W29105, ♂ (19.1 × 10.6 mm), off Princess Charlotte Bay, Cape York, 13°32'42"S, 144°04'30"E, Great Barrier Reef Seabed Biodiversity Study, Spp. code SBD2009274, 23 m depth, sandy-mud sparse coverage of algae/*Halimeda* and seagrass, 18.01.2005. QM-W29106, 2 ♂ (14.6 × 8.4; 15.4 × 8.9 mm), same data as neotype. QM-W29107, ♀ (7.5 × 4.4 mm), NE of Townsville, Qld, 18°57'18"S, 146°53'42"E, Great Barrier Reef Seabed Biodiversity Study, Spp. code SBD2000306, 24 m depth, sandy-mud bottom covered with algae/*Halimeda*, 18.09.2003.

Diagnosis. Carapace c. 1.8 times wider than long; small patch of rounded granules on epibranchial region; regions relatively well defined, furrows delimiting gastric region deep. Front deflexed, narrow, constricted medially, lateral angles pointed. Lateral margin with two distinct teeth behind exorbital tooth; exorbital tooth slender, most protruding, separated from second tooth by very deep, narrow, V-shaped notch, directed laterally or slightly posteriorly; second tooth broad, equilateral triangular, directed laterally, base at top and bottom of tooth vertically aligned; third tooth smallest; lateral margins slightly convergent. Ocular peduncle narrow, long, extending slightly less than half of cornea beyond exorbital angle, no apical 'style', but at most a very low, blunt, prominence; cornea

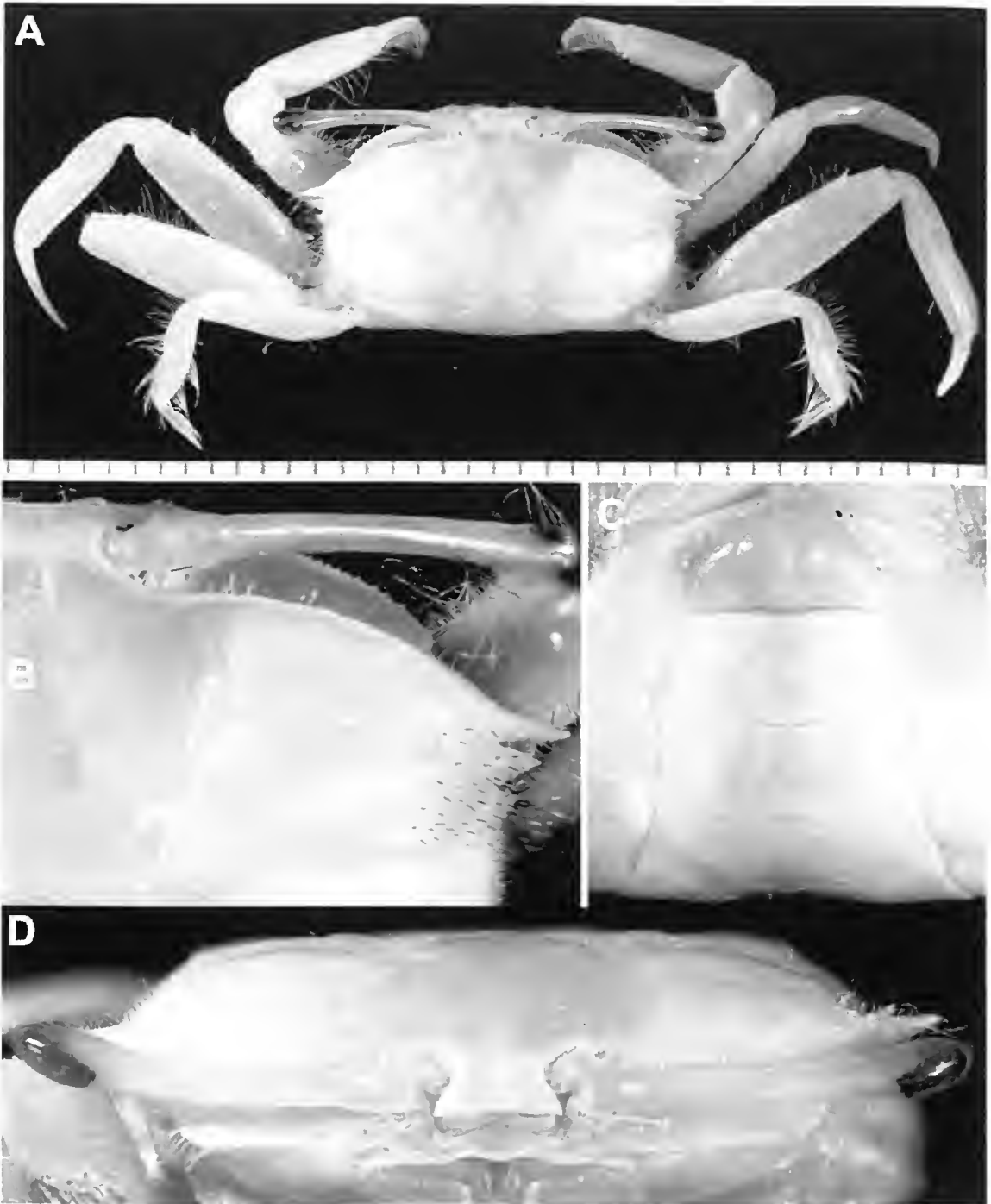


FIG. 8. *Macrophthalmus (Macrophthalmus) graeffei* A. Milne-Edwards, 1873. QM-W29105, neotype ♂ (19.1 × 10.6 mm), off Princess Charlotte Bay, Cape York. A, Dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

relatively bulbous; upper orbital margin strongly convex, markedly sloping laterally. Third maxilliped large, ischium about twice as long as merus; merus subquadrate, wide, about 1.7 times as wide as long. Chelipeds subequal. Merus with outer margin bearing large denticles along entire length, denticles slightly larger medially. Palm relatively long, about 1.6 times as long as high in distal portion; longitudinal ridge parallel to lower margin, continuing along most of fixed finger; inner surface without patch of setae. Dactylus relatively long, curved strongly inward, upper margin with large denticles along proximal two thirds, larger distally, small granules proximally; cutting edge with small differentiated tooth subproximally. Fixed finger short, cutting edge elevated medially. Walking legs medium length, relatively narrow; merus of third walking leg about 3.4 times as long as wide; merus of second, third with large subdistal tooth; anterior, posterior margins finely serrated; margins of carpus, dactylus smooth; dactylus of third walking leg shorter than propodus. Posteromedian margin of epistome moderately convex. Male abdomen with segments 5, 6 of same length; lateral margin of segment 6 noticeably swollen proximally, weakly converging distally; telson semicircular, about as long as segment 6. Male G1 relatively long, narrow, slightly curved; apical chitinous process short, narrow, turned 90° to stem, projecting directly laterally with upper margin flat; subdistal dorsal palp weakly developed, not forming prominent lobe in lateral view.

Remarks. Barnes (1971) redescribed and partially illustrated what he believed to be *Macrophthalmus graeffei* based on two males collected in the eastern Indian Ocean off West Timor, in southern Indonesia. In his synonymy he also cited the earlier record of Stephensen (1945) based on one male and one juvenile from the east coast of Kharg I., off Iran in the Persian Gulf, which Stephensen had originally tentatively identified as '*Macrophthalmus (convexus) Stimpson?*'. Apel (2001) examined the Kharg I. specimen and agreed that it was identical with

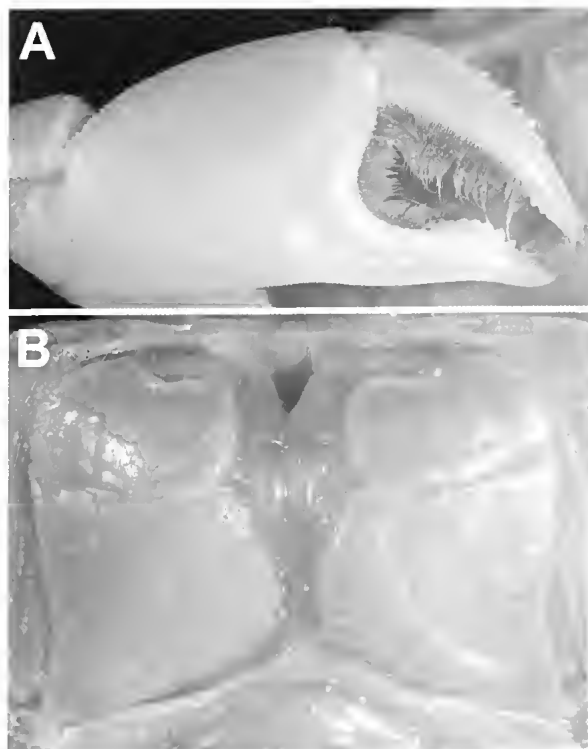


FIG. 9. *Macrophthalmus (M.) graeffei* A. Milne-Edwards, 1873. QM-W29105, neotype ♂ (19.1 × 10.6 mm), off Princess Charlotte Bay, Cape York. A, frontal view of chela; B, third maxillipeds.

M. graeffei sensu Barnes. This same material has also formed the basis for the thorough redescription by Naderloo *et al.* (2011), although they also examined three other females from the Red Sea. While our modern conception of *M. graeffei* has followed that of Barnes (1971), unfortunately the type specimens of *M. graeffei* originally from Samoa have not been critically reexamined and therefore, the identity of the true Pacific Ocean *M. graeffei* has never been positively established.

The type specimen (or specimens) of *M. graeffei* was originally deposited in the Godeffroy Museum, Hamburg (1861–1885), Germany, however in 1885, the zoological collections were sold to various other European museums, and there is now no information as to the

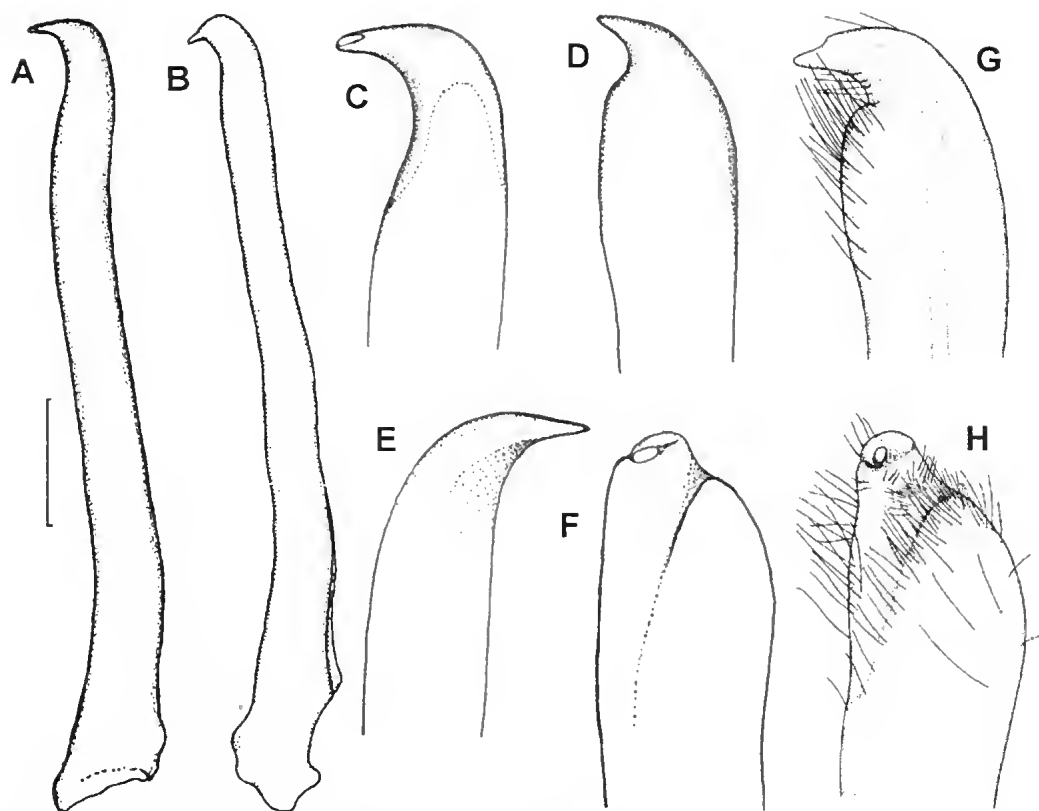


FIG. 10. *Macrophthalmus* (*Macrophthalmus*) *graeffei* A. Milne-Edwards, 1873. QM-W29105, neotype ♂ (19.1 × 10.6 mm), off Princess Charlotte Bay, Cape York. A, C–F, male G1; B, G, H, *Macrophthalmus* (*Macrophthalmus*) *indicus* sp. nov., after Naderloo *et al.* (2011: fig. 12a, c, d; original figure reversed for easier comparison with present figure of opposite G1). Scale line = 1mm.

whereabouts of any *M. graeffei* types. It is likely that they have been lost. It is unclear how many specimens of *M. graeffei* were in the original type series. The caption for the original Fig. 5 states it is of a male, but Fig 5e is clearly that of an immature female. The main figure of the complete crab also appears to be of a female based on the small undeveloped claws, which do not look like they could be the same as the left and right male claws shown in Figs 5b, c, which look like a typical adult male. It must therefore be assumed that there were at least two syntypes, one male and one female, even though measurements for only one specimen were given.

The present specimens from the Great Barrier Reef region off north Queensland, are the first Pacific Ocean samples to have been found since the original specimens from Samoa. The very good descriptions and figures of crabs identified as *M. graeffei* from the Indian Ocean (Barnes 1971; Naderloo *et al.* 2011) have made it possible to clearly identify the present neotype of *M. graeffei* (here designated) as belonging to a distinct species, thus requiring a new name for the Indian Ocean crabs that have been treated under this name.

The west Pacific *M. graeffei* differs from the Indian Ocean *M. indicus* sp. nov. by the following characters:

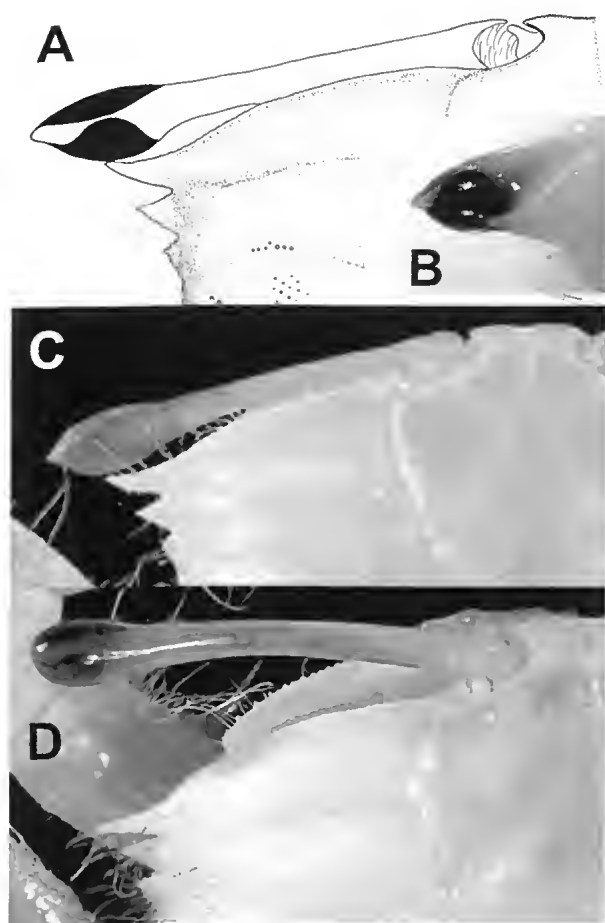


FIG. 11. Comparison views of superior orbital margins and ocular peduncles of: A, B, C, *Macrophthalmus (M.) indicus* sp. nov. (A, C after Naderloo *et al.*, 2011: fig. 11a, 17a – B, from Pancucci-Papadopoulou *et al.* 2010: fig. 3). D, *Macrophthalmus (M.) graeffei* A. Milne-Edwards, 1873, QM-W29105, neotype ♂.

1) The present specimens lack development of a style at the end of the cornea (Fig. 11A–C) as described by Laurie (1915: 471) and Barnes (1971: 14), and illustrated by Pancucci-Papadopoulou *et al.* (2010: figs 2, 3), and Naderloo *et al.* (2011: fig. 11a). This style was neither figured nor described as part of the original description and figures (A. Milne-Edwards (1873: 257, pl. 2, fig. 5), and as the original specimen measured 12 × 7 mm, it should have been apparent on a

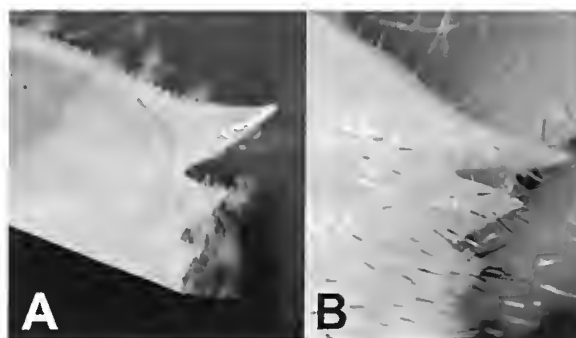


FIG. 12. Detail view of exorbital tooth and lateral teeth of A, *Macrophthalmus (M.) indicus* sp. nov. (from Pancucci-Papadopoulou *et al.* 2010: fig. 4). B, *Macrophthalmus (M.) graeffei* A. Milne-Edwards, 1873, QM-W29105, neotype ♂.

crab that size as it is already clearly evident the 11 mm carapace breadth Mediterranean specimen photographed by Pancucci-Papadopoulou *et al.* (2010: fig. 3).

2) The shape of the supraorbital margin differs between the two species. In *M. graeffei* (Fig 11D) the supraorbital margin is markedly more convex and more backwardly sloping laterally than in *M. indicus* (Fig 11A, C) which is comparatively flatter. The original figure of *M. graeffei* by A. Milne-Edwards (1873: pl. 2 fig. 5), clearly shows the strongly convex supraorbital margin that is characteristic of the neotype.

3) The shape of the lateral teeth, and in particular the exorbital tooth, differs between the two species (compare Fig. 12A & B). In *M. graeffei* (Fig 12B) the exorbital tooth is very narrow and slender, directed laterally, and separated from the first lateral tooth by a deep narrow v-shaped sulcus; in *M. indicus* (Fig 12A), by contrast, the exorbital tooth is noticeably broader at its base, somewhat forwardly directed, and separated from the first lateral tooth by a widely open v-shaped sulcus. The shape of the narrow fissure between the first two teeth, such that the first lateral tooth appears to closely abut the exorbital angle agrees exactly with the original figure by A. Milne-Edwards (1973) of the syntype from

Samoa. Also, in *M. graeffei* the second tooth forms a broad, equilateral triangular, is directed laterally, and the base at the top and bottom of the tooth is vertically aligned; however in *M. indicus* though the tooth is still broadly, triangular, the posterior margin is longer than the anterior margin, it is directed slightly more anteriorly, and there is a tendency for the base of the tooth to slightly recede (cf. figs 11A, C & 11D).

4) The male G1 is different: in *M. graeffei* (Fig. 10A–C), the tip is a little more slender and bent at a right-angle to the stem; however in *M. indicus* (Fig 10D–F), the apical part is more convexly rounded and the tip more deflexed downwards, to give more of a 'birds-head' appearance. Also the subdistal dorsal palp is much more strongly developed and prominent in lateral view in *M. indicus* (Fig. 10F).

5) The Indian Ocean material has now been discovered from a number of localities across a wide geographic range, even to the extent of becoming established in the Mediterranean. So far the largest specimen recorded is a male specimen (14.8 × 8.4 mm) from the Persian Gulf. The present neotype specimen of *M. graeffei* is significantly larger (19.1 mm carapace breadth), and this suggests that the Pacific *M. graeffei* probably obtains a larger size than the Indian Ocean *M. indicus* sp. nov.

Habitat. Present material came from sandy-mud bottoms with coverage of algae/*Halimeda* and seagrass. To at least 24 m depth.

Distribution. Indo-West Pacific: Upolu (Samoa) (original type locality); Cape York, eastern Qld (present record).

Macrophthalmus (Macrophthalmus) indicus
sp. nov.

(Figs 10D–F, 11A–C, 12A)

Macrophthalmus (Macrophthalmus) graeffei – Barnes 1970: 225; 1971: 13, 36 (in key), fig. 3; 1977: 276 (in key), 279 (in list); 2010: 34 (in key), 39; Apel 2001: 108; Naderloo *et al.*, 2011: 19–23, figs 11 a–e, 12a–d, 17a, b [not *M. graeffei* A. Milne-Edwards, 1873].

Macrophthalmus graeffei – Laurie 1915: 470–472, fig. 5; Guinot 1967: 283 (in list); Pancucci-Papadopoulou *et al.* 2010: 195–200.

Macrophthalmus (convexus) Stimpson? – Stephensen 1945: 191 [not *M. convexus* Stimpson, 1858].

Macrophthalmus convexus – Guinot 1967: 282 (in list; in part) [not *M. convexus* Stimpson, 1858].

Material. HOLOTYPE: ZMUC-CRU-1782, ♂ (CL = 14.8, CB = 8.4 mm), DSII St. 26, Kharg I., Iran, Persian Gulf, sand and shells, 18 m deep, 15.03.1937, G. Thorson, identified as *Macrophthalmus (convexus) Stimpson?* by Stephensen (1945). PARATYPE: ♂ (juv.) (ZMUC-CRU-1782), data as for holotype. [Not examined here, but these are the specimens upon which Naderloo *et al.* (2011) based their description and figures].

Diagnosis. Carapace c. 1.8 times wider than long; small patch of rounded granules on epi-branchial region; regions relatively well defined, furrows delimiting gastric region remarkably deep. Front deflexed, narrow, constricted medially, lateral angles pointed. Lateral margin with two distinct teeth behind exorbital tooth; exorbital tooth slender, most protruding, separated from second tooth by deep V-shaped notch, directed laterally and slightly anteriorly; second tooth broad, triangular but posterior margin longer than anterior margin, directed slightly posteriorly, bottom of tooth receding backwards and base not vertically aligned with base of top of tooth; third tooth smallest; lateral margins slightly convergent. Ocular peduncle narrow, long, extending slightly less than half of cornea beyond exorbital angle, continued apically as a small but distinct 'style'; cornea relatively narrow and elongated; upper orbital margin moderately convex, weakly sloping laterally. Third maxilliped large, ischium about twice as long as merus; merus subquadrate, wide, about 1.7 times as wide as long. Chelipeds subequal. Merus with outer margin bearing large denticles along entire length, denticles slightly larger medially. Palm relatively long, about 1.6 times as long as high in distal portion; longitudinal ridge parallel to lower margin, continuing along most of fixed finger; inner surface without patch of setae. Dactylus relatively long, curved strongly inward, upper

margin with large denticles along proximal two thirds, larger distally, small granules proximally; cutting edge with small differentiated tooth subproximally. Fixed finger short, cutting edge elevated medially. Walking legs medium length, relatively narrow; merus of third walking leg about 3.4 times as long as wide; merus of second, third with large subdistal tooth; anterior, posterior margins serrated; margins of carpus, dactylus smooth; dactylus of third walking leg about as long as propodus. Postero-medial margin of epistome moderately convex. Male abdomen with segments 5, 6 of same length; lateral margin of segment 6 noticeably swollen proximally, weakly converging distally; telson semicircular, about as long as segment 6. Male G1 relatively long, narrow, slightly curved; convexly rounded apically, chitinous process short, narrow, turned 90° to stem, tip slightly deflexed downwards, to give 'birds-head' appearance; subdistal dorsal palp strongly developed and forming prominent lobe in lateral view. (After Naderloo *et al.* 2011).

Remarks. This species has been recently fully described and illustrated by Naderloo *et al.* (2011) under the name *Macrophthalmus (Macrophthalmus) graeffei* A. Milne-Edwards, 1873. It differs from *M. (M.) graeffei* by the characters already listed and discussed under that species.

I follow Barnes (2010) in considering both *M. graeffei* and *M. indicus* sp. nov. to be most closely related to the *M. telescopicus* species-group. This group typically has long eyestalks with the cornea extending beyond the exorbital tooth; the carapace is moderately narrow and broad, with three lateral teeth; the male cheliped carpus lacks spines on the distal margin, the fingers are short, and the fixed finger is not deflexed. Most species of this group are sublittoral.

Habitat. Substrates of sand and shell, mud, and fine sandy mud. Subtidal; 5-74 m depth (Stephensen 1945; Galil *et al.* 2002; Naderloo *et al.* 2011).

Distribution. Indian Ocean – Red Sea, Gulf of Oman, Persian Gulf, Indonesia (West Timor). *Macrophthalmus indicus* (as *M. graeffei*) is the

only species of the genus that has spread into the eastern Mediterranean through the Suez Canal. It is known from southern Turkey (Enzenross & Enzenross 1995); Haifa Bay, Israel (Ksiunin & Galil 2004; Galil 2007), Lebanon (Lakkis & Novel-Lakkis 2005), Gökova Bay, the Aegean coast of Turkey (Ateş *et al.* 2007), the Bay of Iskenderun, SE Turkey (Galil *et al.* 2002/2009) and from off Rhodes Island, Greece (Pancucci-Papadopoulou *et al.* 2010).

Macrophthalmus (Macrophthalmus) milloti
Crosnier, 1965
(Figs 13–15)

Macrophthalmus milloti Crosnier, 1965: 112, figs. 217–220, 222–223, 228, pl. 11, fig. 4; 1975: 737; Barnes 1977: 276 (key); Takeda & Komai 1991: 166, fig. 1.

Macrophthalmus (Macrophthalmus) milloti – Barnes 1967: 203 (list); Serène 1973: 112, pl. 4, figs. A–C; Harnoll 1975: 309 (list); Barnes 1976: 135, fig. 3; Takeda & Nunomura 1976: 81; Morgan 1990: 60; Komai *et al.*, 1995: 116, fig. 6. Davie 2002: 352–353; Nagai *et al.* 2006: 8, figs. g, H, 13 (key); Ng *et al.* 2008: 237 (list).

? *Macrophthalmus (Macrophthalmus) telescopicus* – Barnes 1967: 205 (part), pl. 1, fig. a; 1970: 219.

? *Macrophthalmus podophthalmus* – Lanchester 1900: 760. [not *M. podophthalmus* Souleyet, 1841].

Macrophthalmus telescopicus – Kemp 1919: 387 (part), pl. 24, fig. 11 (not pl. 24, fig. 10). [not *M. telescopicus* Owen, 1839].

Macrophthalmus cf. telescopicus – Tweedie 1937: 164; 1950, 128 (part).

Material examined. WAM-C14615, 2 ♀ (18.2 × 11.3; 18.6 × 11.6 mm), 3 ♂ (14.4 × 8.8; 15.8 × 9.2; 15.2 × 9.0 mm), Tanimbah I., Timor Laut, Indonesia, Mariel King Memorial Expedition, Stn T34, V. Semenuik, 26.06.1970.

Morgan (1990) recorded the following material as being present in the Western Australian Museum, but it was not re-examined as part of the present study: WAM-108-89, ♂ (damaged), Descartes I., NW Western Australia, intertidal, 20.07.1988. WAM-25-89, ♂ (8.7 × 15.8 mm), Shirley I., NW Western Australia, intertidal sand, 26.07.1988.

Diagnosis. Carapace almost smooth, but with feeble clumps of granules on branchial regions; front deflexed, constricted between bases of



FIG. 13. *Macrophthalmus (M.) milloti* Crosnier, 1965. WAM-C14615, ♂ (15.8 × 9.2 mm), Tanimbah I., Timor Laut, Indonesia. A, dorsal view; B, frontal view of frontal margin and orbits.

ocular peduncles, bilobed distally, shallow median furrow; 3 well defined anterolateral teeth, greatest carapace with between exorbital teeth. Ocular peduncles long and narrow, cornea extending beyond tip of exorbital angle for less than twice its length. Central region of epistome with a pointed protuberance. Merus of third maxilliped smaller than ischium. Length of merus of male cheliped less than carapace length; palm stout, outer face mostly

smooth, except for row of minute granules along inferior margin, inner face with a mat of setae at base of fixed finger; fixed finger straight, not deflexed, cutting margin with a strong, subacute tooth at about half its length; cutting edge of dactylus proximally with a large, quadrangular tooth. Meri of walking legs with granular margins, and finely granular surfaces, a row of setae along upper margin. Male G1 with a short terminal process.

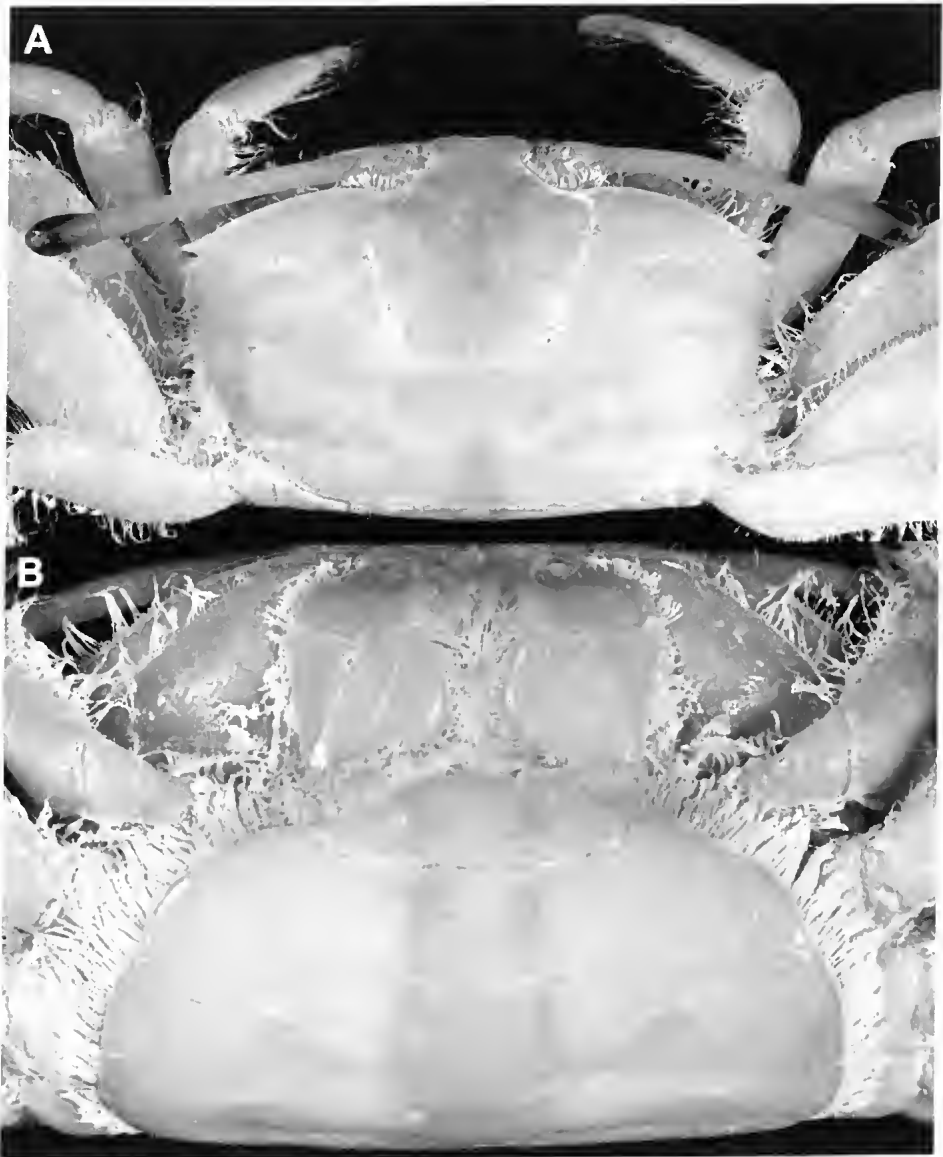
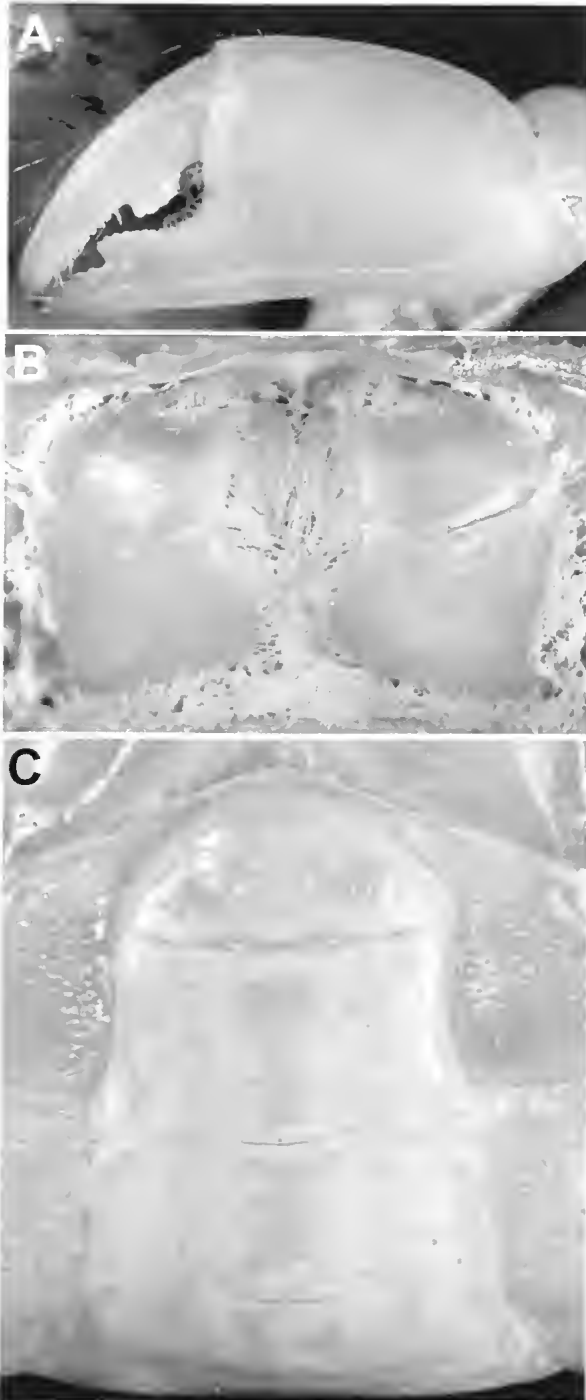


FIG. 14. *Macrophthalmus (M.) millofi* Crosnier, 1965. WAM-C14615, ♀ (18.6 × 11.6 mm), Tanimbah I., Timor Laut, Indonesia. A, dorsal view; B, ventral view showing female abdomen.

Remarks. Serène (1973) suggested that both *M. millofi* and the similar *M. telescopicus* (Owen) would be found in Australia. This prediction was confirmed by the records of Morgan (1990) from north-western Australia. *M. millofi* differs

from the other species with extremely long eyes (*M. telescopicus*, *M. serenei* Takeda & Komai, 1991 and *M. microfylacas* Nagai, Watanabe & Naruse, 2006) by possessing numerous sharp spines on the mesial face of the cheliped palm,



and by the characteristic shape of the apex of the male G1 (see Crosnier 1965: text-fig. 228).

Habitat. Low intertidal shallow pools on sheltered sand and sandy-mud flats; fully marine.

Distribution. From eastern Madagascar to the Andaman Islands; Indonesia; Singapore; north-western Australia. Type locality: NW coast of Anorotsanga, Madagascar.

Macroplthalmus (Macroplthalmus) serenei
Takeda & Komai, 1991

(Figs 16, 17)

Macroplthalmus serenei Takeda & Komai, 1991: 168, fig. 3 [replacement name for *M. kemp* Serène, 1981]; Ng *et al.* 2001: 38.

Macroplthalmus kemp Serène, 1981: 1140 (not Gravely, 1927) [type-locality: Red Sea].

Macroplthalmus verreauxi – ? De Man 1880: 184–87; Alcock 1900: 237; ? Borradaile 1903: 433; Nobili 1906a: 317; Rathbun 1910a: 332, fig. 6; Laurie 1915: 472, fig. 5; Yamaguchi *et al.* 1987: 38, pl. 18, fig. 5 (not *M. verreauxi* H. Milne Edwards, 1848 = *M. telescopicus*).

Macroplthalmus telescopicus – Tesch 1915: 161, pl. 5, fig. 2 (in part); 1918: 58 (in part); Kemp 1919: 387 (in part), pl. 24, fig. 10; Crosnier 1965: 126 (in part), fig. 227.

Macroplthalmus cf. *telescopicus* – Tweedie 1950: 128.

Macroplthalmus (Macroplthalmus) telescopicus – Barnes 1967: 205 (part), fig. 1 (? in part); Barnes 1970: 219.

Macroplthalmus (Macroplthalmus) verreauxi – Serène 1973: 107, text-figs. 2a, d, pl. 3, figs. C, D; Lundoer 1974: 8 (list); Barnes 1976: 135, fig. 2; Vannini & Valmori 1981: 217, fig. 9C; Takeda 1981: 70; Dai *et al.* 1986: 433, pl. 60(3), fig. 242(1) (7 in part); Dai & Yang 1991: 475, pl. 60(3), fig. 242(1) (7 in part); Davie 2002: 353.

Macroplthalmus (Macroplthalmus) cf. verreauxi – Hartnoll 1975: 309 (list).

Macroplthalmus (Macroplthalmus) serenei – Komai, Goshima & Murai 1995: 122–125, fig. 9.

Material Examined. QM-W29108, 2 ♂ (15.9 × 9.4; 12.1 × 7.2 mm), juv. ♀ (8.9 × 5.5 mm), ♀ (18.9 × 11.3 mm), 2 ovig. ♀ (21.8 × 12.3; 19.2 × 11.5 mm), sandy

FIG. 15. *Macroplthalmus (M.) milloti* Crosnier, 1965. WAM-C14615, ♂ (15.8 × 9.2 mm), Tanimbah I., Timor Laut, Indonesia. A, male chela; B, third maxillipeds; C, male abdomen.

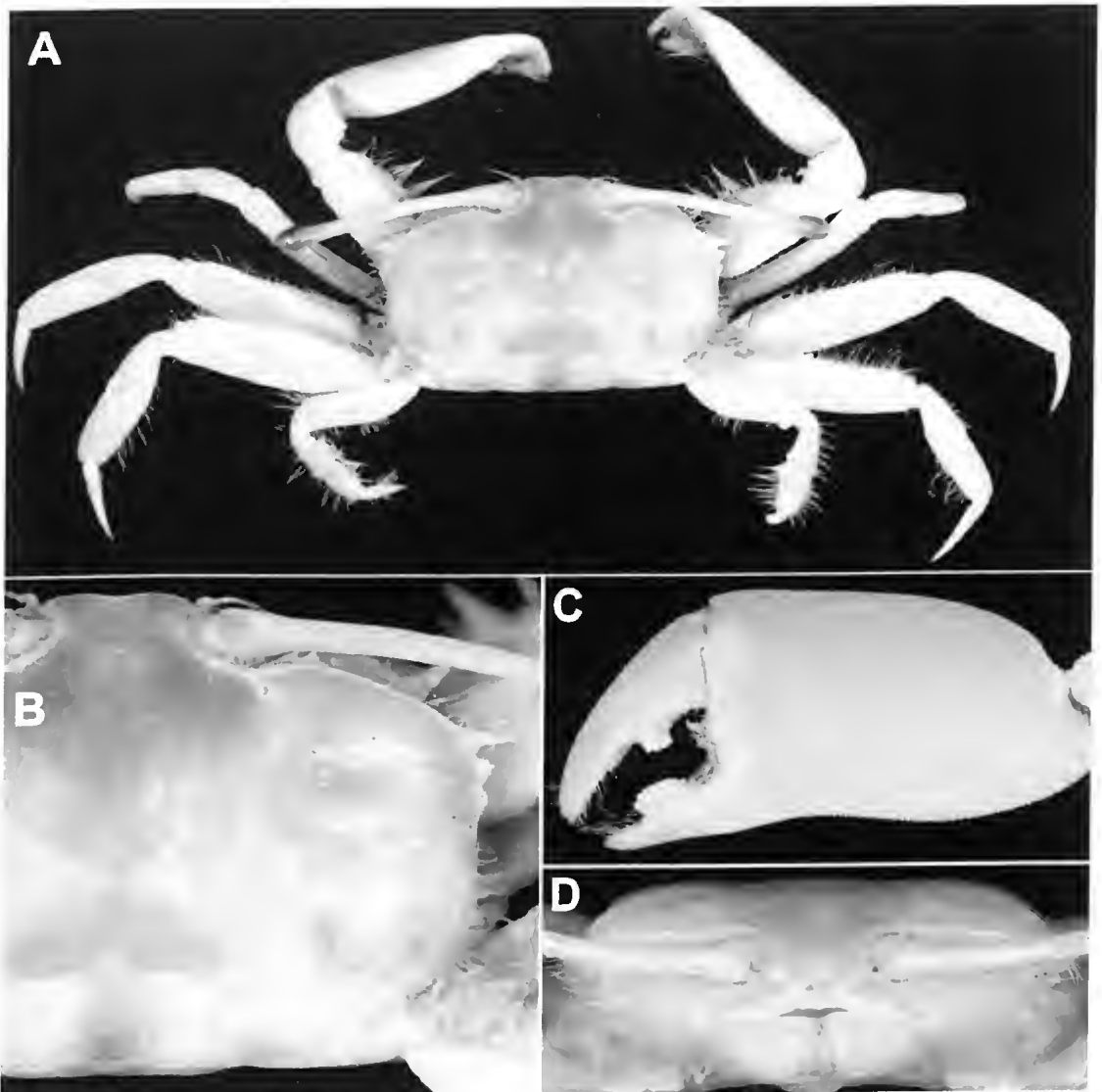


FIG. 16. *Macrophthalmus (M.) serenei* Takeda & Komai, 1991. QM-W7448, ♂ (18.5 × 11.3 mm), Low Isle, NE Qld. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

mud flat in lagoon, West I., Cocos-Keeling Is., Stn CK3, P. Davie & P. Ng, March 2011. WAM-C19783, West I., Cocos-Keeling Is., G.J. Morgan, 6.02.1989. QM-W7448, ♂ (18.5 × 11.3 mm), Low Isle, NE Qld, 16°23'S, 145°34'E, east of main drainage channel, 27.07.1973, B. Campbell.

Diagnosis. Carapace greatest width across exorbital teeth, c. 1.6–1.7 times wider than long; surface lacking setae; branchial region covered in small granules on lateral half, lacking distinct ridge or clumps of granules except for

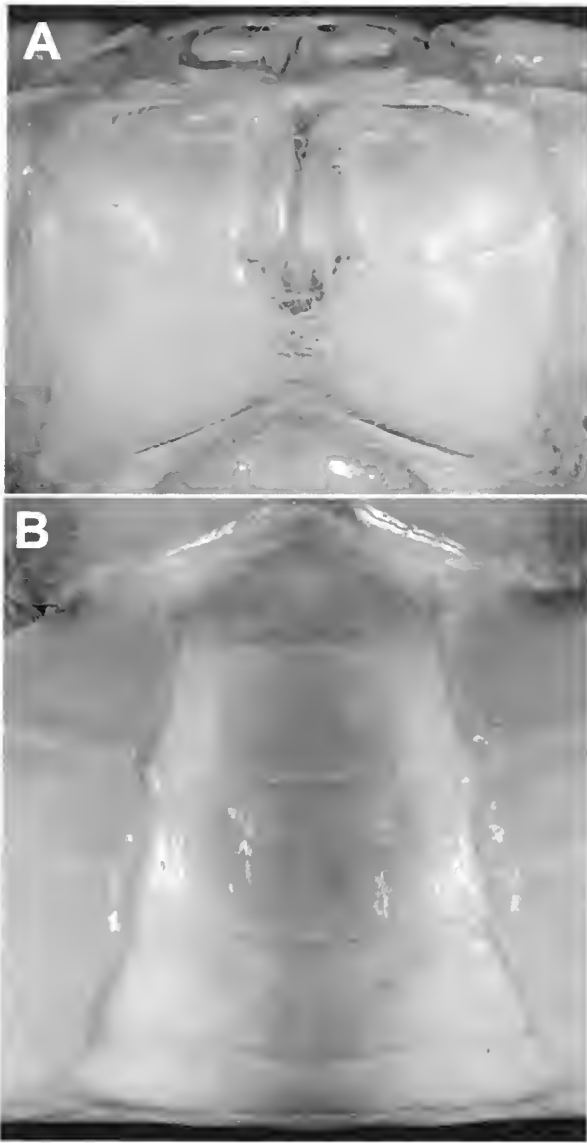


FIG. 17. *Macrophthalmus* (*M.*) *serenei* Takeda & Komai, 1991. QM-W7448, ♂ (18.5 × 11.3 mm), Low Isle, NE Qld. A, third maxillipeds; B, male abdomen.

short posterolateral ridge; intestinal ridge absent. Postero-median margin of epistome convex. Front moderately broad, markedly constricted between bases of ocular peduncles; median groove obvious. Ocular peduncle

narrow, very long, about 1.1–1.2 times as long as carapace, projecting beyond exorbital tooth by 1/3 to 2/5 of its length. Upper orbital border strongly sinuous, obliquely receding backwards. Lateral margins slightly convergent posteriorly; exorbital tooth very narrow, spine-like, wider than second anterolateral tooth, and separated by broad V-shaped sulcus; second tooth broadly triangular; third tooth small, but distinct, blunt. Chelipeds stout, elongated; palm of male about 1.6 times longer than high, finely granular on ventral and dorsal faces; fixed finger weakly deflexed, with high broad crenulated tooth occupying central third; dactylus with strong square-shaped differentiated tooth placed in proximal third. Pereiopods stout; third pereopod with dactylus slightly shorter than propodus, lacking patch of setae on flexor surface. Male abdomen moderately narrow; sixth somite with lateral margins distinctly expanded near base; telson distinctly shorter than sixth abdominal somite, c. twice as wide as long, with distolateral margins convex. Male first gonopod moderately compressed; terminal process strongly elongate, curved outward, with row of spinules laterally, subdistal process rather thin, clearly separated.

Remarks. Previously reported from Australia under the misidentification of *Macrophthalmus* (*Macrophthalmus*) *verreauxi* (= *M. telescopicus* Owen, 1839) by Serène (1973). Komai *et al.* (1995) provided a redescription and illustrations.

Habitat. Burrows in shallow pools on low intertidal soft sandy mud to mud substrates. Can occur in coral reef lagoonal areas, on dead coral reef platforms, and on rocky shores; usually in areas with little freshwater influence.

Distribution. Widely distributed in tropical Indo-West Pacific from African coast (Madagascar to Red Sea) to western Thailand (Komai *et al.* 1995), and northward to Kyushu, Japan (Yamaguchi *et al.* 1987). First recorded from the eastern coast of Australia by Serène (1973).

Macrophthalmus (Macrophthalmus) telescopicus Owen, 1839

(Figs 18, 19)

- Gelasimus telescopicus* Owen, 1839: 78, pl. 24, fig. 1.
Macrophthalmus compressipes Randall, 1840: 123; Gibbes 1850: 180.
Macrophthalmus podophthalmus Souleyet, 1841: 241, pl. 3, fig. 67; Milne Edwards H. 1852: 155; Stimpson 1858: 96; Crosnier 1965: fig. 225.
Macrophthalmus verreauxi Milne Edwards H., 1848: 358; 1852: 155, pl. 4, fig. 25; Haswell 1882b: 89; Crosnier 1965, fig. 226.
Macrophthalmus telescopicus Milne Edwards H., 1852: 155; Dana 1852: 314; Ortmann 1894a: 744; Rathbun 1906: 834; Balss 1922: 146; Chopra & Das 1937: 423; Edmondson 1946: 311, fig. 185a; 1962: 20, fig. 8b; Holthuis 1958: 53; Crosnier 1965, fig. 229; Wada 1978; Takeda 1979: 155; Nagai 1990; Takeda & Komai 1991: 169.
 ? *Macrophthalmus podophthalmus* — Haswell 1882b: 88; Miers 1886: 249; Lanchester 1900b: 760.
Macrophthalmus (Macrophthalmus) telescopicus — Barnes 1970: 219 (part); Serène 1973a: 109, fig. 2c-e, pl. 3A-B, pl. 4D; Takeda 1977: 133, fig. 4D; Tai & Song 1984: 81 (key).
 Not *Macrophthalmus telescopicus* — Stimpson 1907: 95; Tesch 1915: 161, pl. 5, fig. 2; 1918: 58; Kemp 1919: 387, pl. 24, fig. 10 (in part, not fig. 11); Sakai 1935: 73; Shen 1936: 70; 1940: 73, 94 [= *M. serenei* Takeda & Komai, 1991].
 Not *Macrophthalmus telescopicus* — Sakai 1939: 623 (part?), pl. 73, fig. 1 [= *M. microfylacas* Nagai, Watanabe & Naruse, 2006].
 Not *Macrophthalmus telescopicus* — Kemp 1919: fig. 11 [= *M. milloti* Crosnier, 1965].
 Not *Macrophthalmus verreauxi* — Crosnier 1965, fig. 227 [= *M. serenei* Takeda & Komai, 1991].
 Not *Macrophthalmus (Macrophthalmus) telescopicus* — Barnes 1967: 205 (part), fig. 1 (not pl. 1a); Barnes 1970: 219 [= *M. serenei* Takeda & Komai, 1991].
 Not *Macrophthalmus (Macrophthalmus) telescopicus* — Barnes 1967: 205 (part), pl. 1a [= *M. milloti* Crosnier, 1965].
 Not *Macrophthalmus (Macrophthalmus) verreauxi* — Sakai 1976: 610, fig. 334, pl. 210, fig. 3; Yamaguchi *et al.* 1976: 40 [= *M. microfylacas* Nagai, Watanabe & Naruse, 2006, or *M. serenei* Takeda & Komai, 1991].

Material examined. WAM-C16830, ♂ (36.8 × 23.7 mm), Shark Bay, WA, 'Flinders' Stn 11, 5.05.1986. WAM-C16832, ♂ (34.1 × 21.9 mm), ♀ (33.8 × 21.2 mm), data as for preceding. QM-W2400, ♂ (14.9 × 9.0

mm), Cape York, FN Qld, 11°48'S, 142°21'E, 1884. QM-W28480, ♂ (12.2 × 7.9 mm), Percy I., central Qld, 21°40'S, 150°18'E, 15.06.01. QM-W11898, 3 juv. ♂ (4.7 × 3.1, 4.0 × 2.7, 8.4 × 5.8 mm), Triangular I., Shoalwater Bay, ME Qld, 22°23'S, 150°31'E, Feb. 1981, M.R.L. Survey. QM-W11899, ♀ (6.0 × 4.5 mm), Triangular I., Shoalwater Bay, ME Qld, 22°23'S, 150°31'E, Nov. 1982, M.R.L. Survey. QM-W19537, ♂ (6.1 × 4.3 mm), Moreton Bay, SE Qld, 27°31'S, 153°22'E, 03.06.1993, P. Davie & J. Short.

Diagnosis. Carapace relatively smooth, except for low clumps of granules on branchial regions; front deflexed, margins smooth, bilobed distally, markedly constricted between bases of ocular peduncles, median furrow distinct; lateral margins slightly converging, subparallel posteriorly, 3 well defined antero-lateral teeth, exorbital angle projecting in line with following teeth. Ocular peduncles long and narrow, cornea extending beyond tip of exorbital angle for more than one third (up to 60%) of peduncle length. Central region of epistome with pointed protuberance. Merus of third maxilliped smaller than ischium. Palm of male cheliped stout, outer face granular; fixed finger not deflexed, cutting edge with distinct, broad, medio-distal, differentiated tooth; cutting edge of dactylus with small tooth proximally. Meri of ambulatory legs with granular margins, and finely granular surfaces, fringing rows of setae along upper and lower margins.

Remarks. The taxonomy of the *M. telescopicus* (Owen, 1839) group of related species has seen some interest over the last 40 years since the first attempt at a revision by Serène (1973). A number of new species have been described, along with some old names both resurrected and sunk into synonymy (also see Barnes 1976; Serène 1981; Takeda & Komai 1991; Nagai, Watanabe & Naruse 2006; Naruse & Kosuge 2008). The *Macrophthalmus telescopicus* species-group now comprises ten species: *M. ceratophorus* Sakai, 1969, *M. graeffei* A. Milne Edwards, 1873, *M. indicus* sp. nov., *M. latipes* Borradaile, 1903, *M. microfylacus* Nagai, Watanabe & Naruse, 2006, *M. milloti* Crosnier, 1965, *M. philippinensis* Serene, 1971, *M. ryukyuanus* Naruse & Kosuge,



FIG. 18. *Macrophthalmus (M.) telescopicus* Owen, 1839. WAM-C16830, ♂ (36.8 × 23.7 mm), Shark Bay, WA. A, dorsal view; B, frontal margin and orbits.

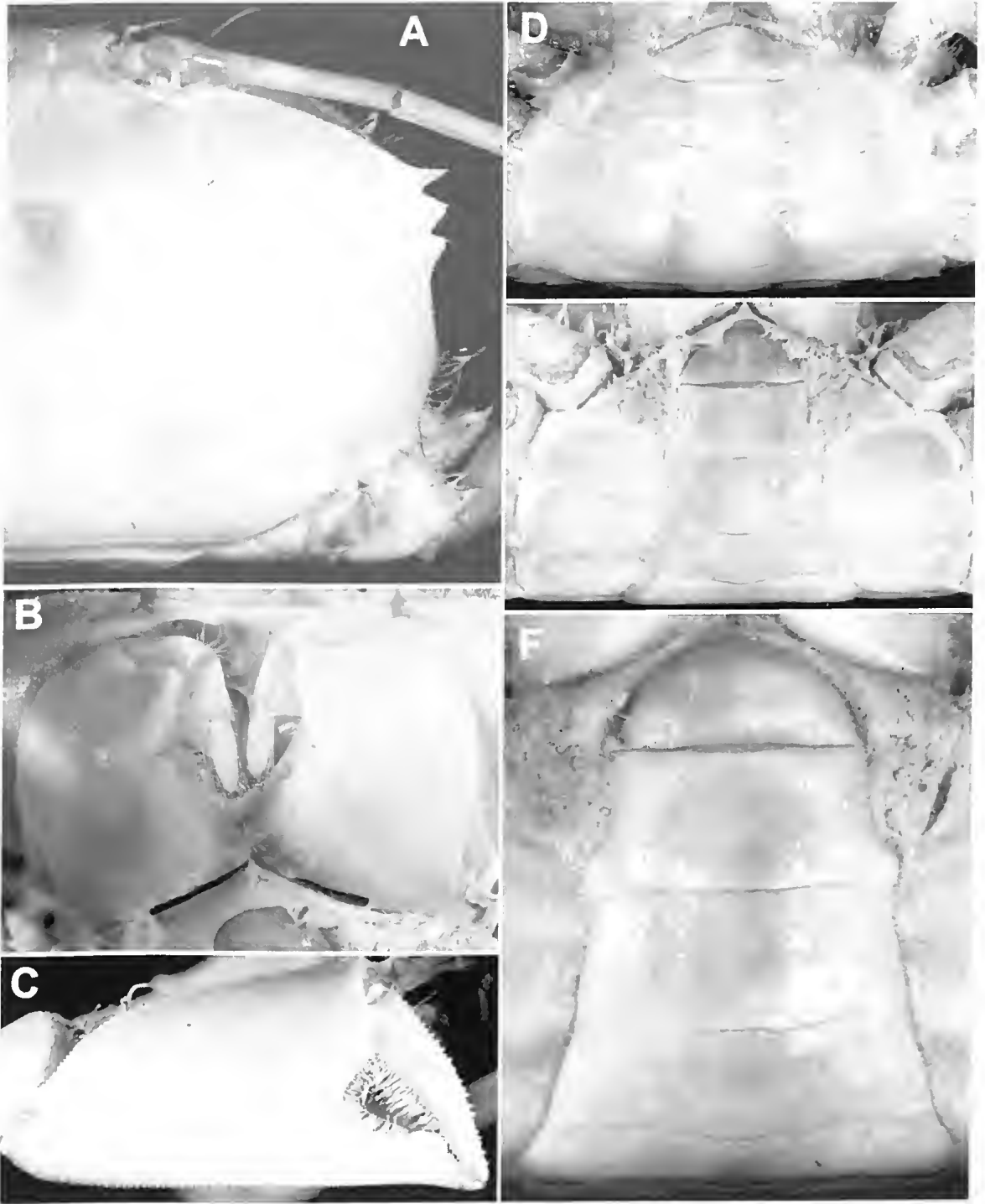
2008, *M. serenei* Takeda & Komai, 1991 (= *M. verreauxi* H. Milne Edwards, 1848, in Barnes, 1976, 1977) and *M. telescopicus* (Owen, 1839). Naruse & Kosuge (2008) and Barnes (2010) have provided keys to enable their identification (with the exception of *M. indicus* sp. nov. described here.

Habitat. Sublittoral, offshore, muddy sand substrates. Members of the broader species-group have been recorded from depths to 80 m.

Distribution. Mergui Archipelago (Chopra & Das 1937); Japan – Ogasawara-shoto (Takeda

1977), Tanabe Bay (Wada 1978), Shiono-misaki (Takeda 1979), Kushimoto (Nagai 1990), Ogasawara and Kushimoto (Takeda & Komai 1991); Torres Strait (Miers 1886); Caroline Islands –

FIG. 19. *Macrophthalmus (M.) telescopicus* Owen, 1839. A, enlarged view of carapace; B, third maxillipeds; C, frontal view of chela; D, female abdomen; E, male sternum; F, male abdomen. A, F: WAM-C16832, ♂ (34.1 × 21.9 mm), Shark Bay, WA.; B, C, E: WAM-C16830, ♂ (36.8 × 23.7 mm), Shark Bay, WA.; D: ♀ (33.8 × 21.2 mm), Shark Bay, WA.



Ponape (Ortmann 1894a); Fiji (Barnes 1970); Hawaii – (Barnes 1970; Serène 1973), Sandwich Islands (Souleyet 1841; Dana 1852; Crosnier 1965), Honolulu Harbor (Rathbun 1906).

Macrophthalmus (Mareotis) abercrombiei

Barnes, 1966

(Figs 20, 21)

Macrophthalmus abercrombiei Barnes 1966a: 43–47, pl. 8, fig. 1; Barnes 1967: 216.

Material Examined. QM-W2493, paratype ♂ (24.9 × 17.2 mm), SE corner of Gulf of Carpentaria, offshore between the Leichardt and Bynoe Rivers, RV *Rama* Stn 482, 17 36'S, 140 09'E, 3.2 m, 16.12.1963, CSIRO Prawn Survey. QM-W19305, 2 ♂ (24.2 × 16.8; 20.9 × 14.7 mm), East Alligator River mouth, Kakadu National Park, NT, 12 05'06"S, 132 33'24"E, estuarine littoral mudflat, 21.06.1982, P. Davie.

Diagnosis. Carapace moderately broad, regions well defined, much of surface granulate except for smooth patches on gastric and cardiac regions; lateral margins convex, greatest carapace breadth occurring across posterior part of second lateral teeth; short concave granular row just above insertion of fourth pereopod, ill-defined broken row vertically on postero-branchial. Front narrow, with deep longitudinal medial furrow, lateral margins markedly constricted between ocular peduncles. Ocular peduncles long and narrow; eyes reaching to bases of external orbital angles. Supraorbital border transverse, moderately sinuous, studded with rounded granules increasing in size towards exorbital tooth. Outer quarter of infra-orbital border without granules. Exorbital angle large, broad, acute, pointed anteriorly, separated from second tooth by deep V-shaped sulcus; second lateral tooth large, broad, bluntly pointed, directed forwards, third lateral tooth very small, separated by shallow incision. Third maxilliped with merus markedly smaller than ischium; ischium external margin straight, antero-external angle pronounced. Male cheliped distinctly elongated. Merus long, inner margin produced into long ridge for most of its length, completely covered in mat of setae, under

surface completely covered with thick setae. Carpus long and narrow, lacking setae, outer surface smooth; inner surface with numerous large granules. Palm elongate, narrow, mostly smooth or microscopically granular only, except for sparse granules along proximal half of upper margin, and clump of forwardly directed tubercles, near joint with dactylus, on both inner and outer surfaces, no longitudinal ridge on outer surface. Fingers long and thin; fixed finger markedly deflected downwards, cutting margin with large, wedge-shaped, serrated tooth, occupying proximal half; dactylus lacking a differentiated tooth on cutting margin. Pereiopods relatively slender; lateral anterior and posterior margins of meri subparallel, under surface covered with 'felt' of small setae, well developed subdistal spines on upper margins of first to third meri. Male abdomen with fourth and fifth segments with straight, convergent lateral margins. Sixth segment with convex lateral margins. Sternum granulated near abdomen. Male G1 straight; tip with shield-like projection externally.

Remarks. *M. abercrombiei* was originally described from only three specimens from the south-eastern Gulf of Carpentaria in Queensland. Subsequently, several specimens from south-western New Guinea were discovered in the collections of the Snellius Expedition (Barnes 1971). The present material from Kakadu National Park marks a significant westerly range extension. It is separable from other species by the characters given in the key. The adult male chela with its strongly deflexed fingers is particularly diagnostic (Fig. 21A).

Habitat. The type material was collected from the mouth of the Norman River, while the two paratype males were caught in a prawn trawl in about 3 m depth from SE corner of the Gulf of Carpentaria (possibly from a mudbank capable of being exposed at low water). This part of the Gulf is typically very muddy, with much sediment washed down during the annual monsoons. The present males from the mouth of the East Alligator were collected from very

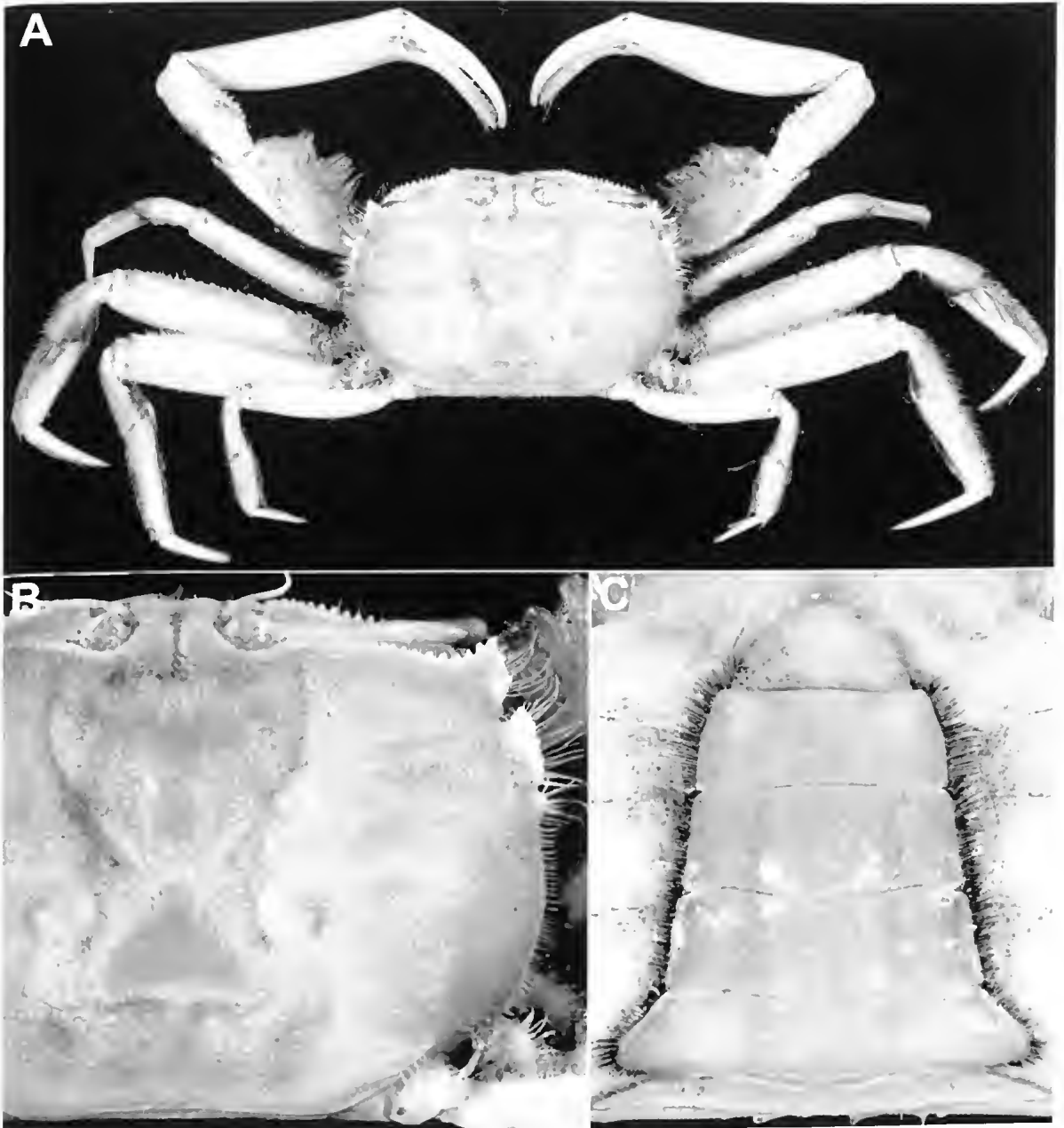


FIG. 20. *Macrophthalmus* (*Mar.*) *abercrombiei* Barnes, 1966. QM-W19305, ♂ (24.0 × 11.3 mm), East Alligator River mouth, Kakadu National Park, NT **A**, dorsal view; **B**, enlarged view of carapace; **C**, male abdomen.



FIG. 21. *Macrophthalmus (Mar.) abercrombiei* Barnes, 1966. QM-W19305, ♂ (24.0 × 11.3 mm), East Alligator River mouth, Kakadu National Park, NT A, frontal view of chela; B, frontal margin and orbits; C, third maxillipeds.

soft mud at the waters edge at low water neap. It can be presumed that this species prefers soft mud at extreme low water, or perhaps even in the shallow subtidal.

Distribution. Northern Australia: from Gulf of Carpentaria and East Alligator River; south-western New Guinea.

Macrophthalmus (Mareotis) darwinensis

Barnes, 1971

(Figs 22, 23)

Macrophthalmus (Mareotis) darwinensis Barnes, 1971: 25, figs 1-7; Davie 2002: 353; Ng *et al.* 2008: 237.

Macrophthalmus (Mareotis) crinitus — Barnes 1967: 221, pl. 2c, fig. 7 [not *Macrophthalmus (Mareotis) crinitus* Rathbun, 1913].

Macrophthalmus darwinensis — Poupin & Junker 2010: 96-97 (colour figs C, D on p. 97).

Material Examined. QM-W19304, 8 ♂ (20.5 × 14.6, 21.9 × 16.5, 20.6 × 14.8, 20.3 × 13.8, 20.8 × 15.3, 14.1 × 11.1, 13.0 × 10.4, 10.3 × 7.9), 7 ♀ (21.0 × 16.3, 23.1 × 17.5, 19.9 × 14.6, 17.8 × 13.9, 12.5 × 9.5, 11.1 × 9.0, 14.2 × 11.2 mm), small creek south of Bohle River mouth near Townsville NEQ, 19°11.5'S 146°32.7'E, P. Davie, J. Short, A. Humpherys, estuarine, littoral, mudflat in burrows 27.10.1993. QM-W10597, ♂ (21.8 × 15.9 mm), Ross River, Townsville, North Bank, near mouth, 19°22.0'S, 146°44'0 E, July 1983; estuarine, littoral, sandy mud flat, lower estuary, P. Davie. QM-W10907, ♂ (11.4 × 8.2 mm), Ross River, Townsville, North Bank, near mouth, 19°17.0'S, 146°49.0'E, estuarine, littoral, sandy mud flat, lower estuary, July 1983, P. Davie. QM-W7423, ♂ (18.3 × 13.6 mm), Bessie Point, Trinity Inlet, Cairns, 16°54.0'S, 145°49.0'E, 15.12.1975; R. Timmins. QM-W18171, 5 ♂ (15.1 × 11.6, 12.0 × 9.2, 14.0 × 11.0, 13.9 × 10.2, 9.4 × 7.5 mm), 4 ♀ (15.2 × 11.5, 13.3 × 10.2, 12.0 × 10.5, 11.0 × 8.5 mm), Starcke River, inlet just south of mouth, N. Qld. 11.11.1992, P. Davie & J. Short. NTM-Cr010920, ♂ (12.9 × 10.0 mm), Channel I., Darwin Harbour, NT, 4.3.1992, Melanie Burke. NTM-Cr 010921, 2 ♂ (16.9 × 12.6, 13.7 × 10.6 mm), ♀ (15.6 × 11.7mm), Channel I., Darwin Harbour, NT, 17.3.1992, Melanie Burke. QM-W19190, 7 ♂ (19.1 × 13.8, 15.2 × 10.8, 16.9 × 12.1, 8.9 × 6.3, 10.5 × 8.3, 14.1 × 10.3, 13.9 × 10.4 mm), 2 ♀ (11.7 × 8.0, 10.6 × 7.3 mm), 4 ovig. ♀ (14.3 × 10.7, 15.7 × 11.0, 13.8 × 10.2, 12.9 × 9.0 mm), Channel I., Darwin Harbour, NT, 12°33'S, 130°52'E, marine littoral, mangrove, in mud under *Sonneratia*, 07.05.1993, P. Davie. QM-W21037, ♂ (6.8 × 5.1 mm), Turtle Bay & unnamed bay to south, Lacrosse I., Cambridge Gulf, WA, 14°45'S, 128°18'E, littoral, mudflat near mangroves, 20.11.1995, J. Short. QM-W20993, 4 ♀ (9.8 × 6.7, 8.0 × 5.7, 7.3 × 5.8, 8.9 × 6.8 mm), Myrmidon ledge, Vancouver Point, Cambridge Gulf, Kimberley Coast, WA, 14°50'S, 128°11'E, littoral, mangroves under *Sonneratia/Zostera* in mud, 18.11.1995, J. Short. QM-W20268, ovig. ♀ (13.8 × 10.5 mm), Bedford I., Kimberley Coast, WA, 16°08'S, 123°18'E; littoral flat, 19.11.1994,

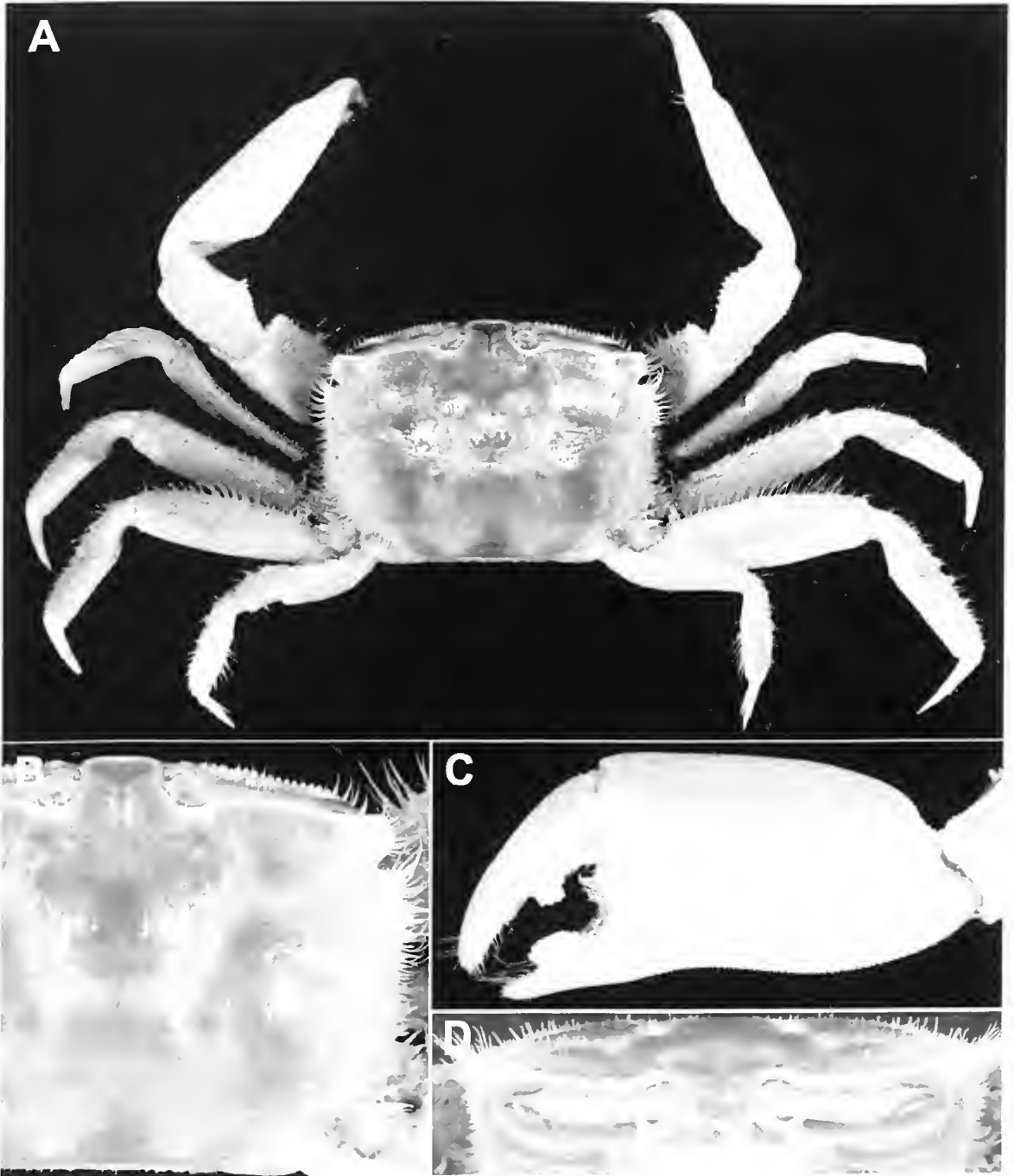


FIG. 22. *Macrophthalmus* (*Mar.*) *darwinensis* Barnes, 1971. QM-W19190, ♂ (19.1 × 13.8 mm), Darwin Harbour, NT. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

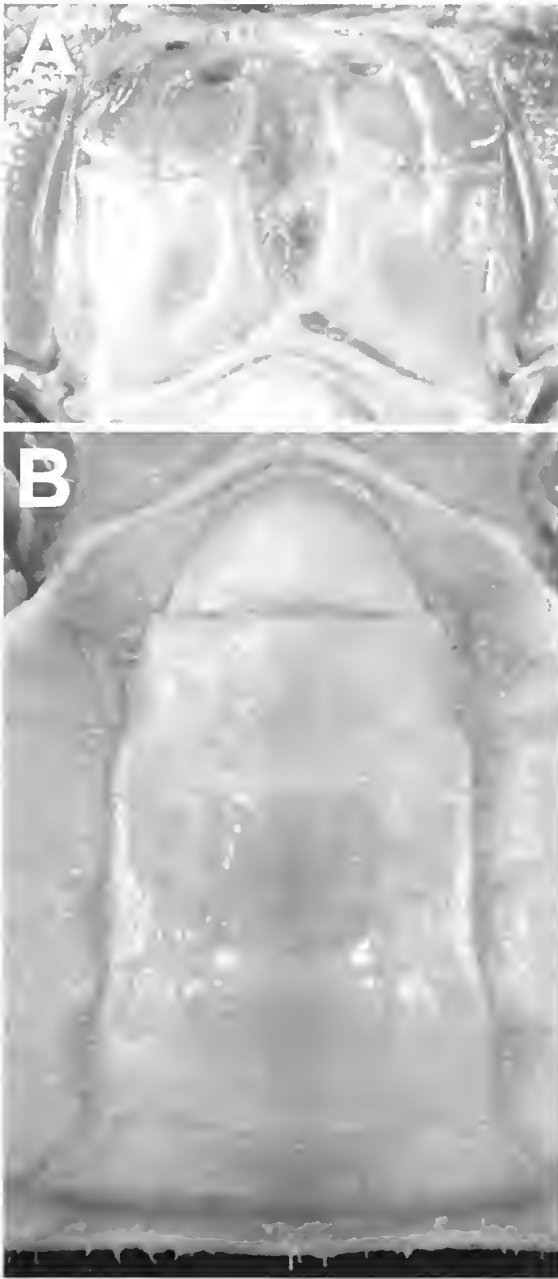
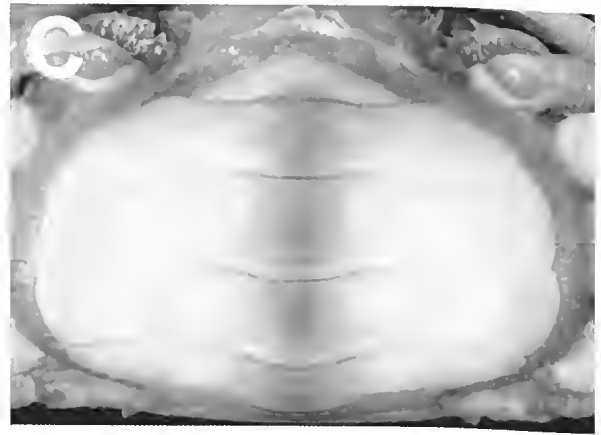


FIG. 23. *Macrophthalmus (Mar.) darwinensis* Barnes, 1971. A, third maxillipeds; B, male abdomen; C, female abdomen. A, B: QM-W19190, ♂ (19.1 × 13.8 mm), Darwin Harbour, NT.; C: QM-W20268, ovig. ♀ (13.8 × 10.5 mm), Bedford Island, Kimberley Coast, WA.



J. Short. WAM-C21023, 2 ♀ (13.2 × 10.0; 13.1 × 9.9 mm), 3 ♂ (10.8 × 8.3; 13.6 × 9.9; 14.0 × 9.9 mm), between Lord and Byron Is., 16°10'S, 123°28'E, Stn 40, D.S. Jones, 25.06.1991. MNHP-Unreg., ♂ (15.9 × 12.0 mm), ♀ (16.1 × 12.1 mm), Ouémo mangrove, Nouméa, New Caledonia, 22°16'49"S, 166°28'21"E, Stn 5, low tide mangrove next to public pathway, J. Poupin, 8.03.2009. MNHP-Unreg., ♂ (16.3 × 12.2 mm), ♀ (17.5 × 12.8 mm), IFREMER mangrove, Ouémo mangrove, Koné, Nouméa, New Caledonia, 21°5'51"S, 164°49'2"E, Stn 6, low tide mangrove, J. Poupin, 9.03.2009. MNHP-Unreg., 3 ♂ (21.6 × 15.6; 13.8 × 10.3; 8.1 × 6.4 mm), ♀ (15.9 × 12.0 mm), 2 juv. ♀ (10.2 × 7.7; 7.3 × 5.6 mm), Oundjo mangrove, Voh, New Caledonia, 21°3'4"S, 164°44'31"E, Stn 8, J. Poupin & M. Juncker, 11.03.2009.

Diagnosis. Carapace subrectangular; 3 anterolateral teeth, exorbital tooth broad, separated from second tooth by wide sulcus, second tooth blunt, slightly wider than exorbital, third small, often poorly defined; surface granulation restricted to branchial and hepatic regions; frontal margins smooth, anterior margin straight to faintly bilobed, distinct medial furrow; upper orbital border sinuous. Merus of male cheliped with inner margin bearing long setae and tubercular granules at distal angle, outer margin with row of large pointed granules, largest distally, without mat of setae, lower surface with large rounded granules beneath mat of setae. carpus with several prominent tubercular spines present along inner medial edge. Outer surface of palm and fixed finger

lacking longitudinal ridge or row of granules in adult, but present in juveniles; cutting margin of fixed finger with large, long, central crenulated tooth in adults; lateral margins of sixth segment of male abdomen straight. Third maxillipeds merus smaller than ischium; with internal margin of ischium straight. Male G1 with well developed terminal process.

Remarks. *Macrophthalmus darwinensis* was originally referred to *M. crinitus* with which it shares a superficial similarity. Previous records of this species have been confined to the Northern Territory, mostly within the Darwin/Kakadu National Park region, but careful comparison of specimens from north-eastern Queensland has demonstrated these specimens to be inseparable from those of the Northern Territory. As well I have recently examined specimens from New Caledonia which are unquestionably this species (see Poupin & Junker 2010), so this marks a significant easterly range extension into the Coral Sea.

Habitat. Burrows in soft mud; usually seaward fringes especially near pools and drainage channels; often associated with mangroves, but can extend out onto mud flats. Always regularly inundated sites.

Distribution. Northern Australia, between Darwin and Townsville; New Caledonia.

Macrophthalmus (Marcotis) gagudju sp. nov.
(Figs 24, 25, 26)

Material Examined. HOLOTYPE: QM-W19918, ♂ (16.3 × 11.8 mm), Kakadu National Park, Northern Territory, mudflat, P. Davie. PARATYPES: QM-W19094, 3 ♂ (10.8 × 8.1, 12.1 × 8.9, 10.8 × 8.0, 8.0 × 6.3), Camerons Beach, Shoal Bay, Northern Territory, 12°21'S, 130°59.6'E, 23.06.1982, soft mud flat under *Avicennia*, P. Davie. QM-W19188, 2 ♂ (12.2 × 8.9, 11.5 × 8.4 mm), 2 ♀ (10.5 × 7.9, 9.5 × 7.2 mm) Ludmilla Creek, Northern Territory, 12°44'S, 130°50'E, mangroves, edge of channel, 07.05.1993, P. Davie. QM-W19189, 31 ♂ (9.1 × 6.6, 11.6 × 8.1, 10.7 × 8.0, 11.2 × 8.0, 10.6 × 7.4, 10 × 7.1, 10.8 × 7.2, 10.1 × 7.1, 8.0 × 6.0, 10.1 × 7.3, 10.0 × 7.3, 8.6 × 6.3, 9.0 × 6.6, 11.6 × 8.0, 13.8 × 9.8, 10.1 × 7.5, 8.8 × 6.6, 8.0 × 6.0, 7.8 × 5.5, 7.9 × 6.1, 7.7 × 5.6, 9.0 × 6.8, 7.5 × 5.8, 7.2 × 5.5, 7.4 × 5.5, 6.9 × 5.1, 6.0 ×

5.1, 7.0 × 5.3, 6.5 × 5.2, 9.6 × 6.7, 11.7 × 8.4 mm), 21 ♀ (11.4 × 8.3, 9.0 × 7.6, 12.0 × 8.9, 10.2 × 7.5, 11.0 × 8.5, 10.0 × 7.5, 11.3 × 8.6, 9.8 × 7.4, 10.8 × 7.9, 9.2 × 6.8, 8.2 × 6.6, 10.3 × 8.0, 10.1 × 7.5, 7.5 × 5.9, 7.1 × 5.4, 7.3 × 6.1, 8.6 × 6.8, 6.8 × 5.2, 10.3 × 7.2, 6.8 × 5.2, 6.7 × 5.1, 12.9 × 9.9, 11.2 × 8.6), Channel I, Darwin Harbour, 12°33'S, 130°52'E, marine littoral soft mud, P. Davie. QM-W19192, 4 ♂ (12.2 × 8.5, 12.5 × 9.0, 14.2 × 9.9, 9.9 × 6.0 mm), 2 ♀ (8.3 × 5.4, 9.5 × 7.0 mm), ovig. ♀ (12.0 × 8.8 mm), East Alligator river mouth, Kakadu, NT, 12°07'S, 132°32'E, 16.06.1982, P. Davie. QM-W20270, ♀ (9.8 × 7.2 mm), Bedford I., Kimberley Coast, WA, 16°08'S, 123°18'E, marine, littoral flat, 19.11.1994, J. Short. QM-W20394, 2 ♂ (10.1 × 7.8, 6.8 × 5.3 mm), 2 ♀ (13.1 × 10.4, 6.4 × 5.0 mm), ovig. ♀ (10.4 × 7.4 mm), Talbot Bay, Unnamed Island, Kimberley Coast, WA, 16°12'S, 123°51'E, estuarine, littoral, mudbank, 24.11.1994, J. Short. QM-W20243, ♀ (8.2 × 6.4 mm), 3 ♂ (12.2 × 8.2, 11.5 × 8.5, 9.7 × 7.0 mm), Gregory I., Kimberley Coast, WA, 16°19'S, 123°19'E, marine, littoral, mudflat near mangroves, *Sonneratia*, 19.11.1994, J. Short.

Description. Carapace. Front deflexed, constricted between bases of ocular peduncles; margins smooth with well defined median groove. Upper orbital border curved; margin bearing tubercular granules. Ocular peduncle of moderate length, comparatively stout and not projecting beyond tip of exorbital angle. Central region of epistome distinctly concave. Margin of carapace anteriorly narrowed; the lateral margin convex. Three anterolateral teeth, first two distinct, third indistinct. Exorbital angle not pronounced, somewhat blunt, directed outwards and slightly forward; broadly separated from second lateral tooth; second tooth triangular, projecting outwards and slightly forwards, slightly wider than exorbital angle. Third tooth ill-defined, scarcely more than small notch with raised tubercle; positioned well rearward of second lateral tooth and often obscured by setae. Greatest carapace breadth across third lateral teeth behind which lateral margins somewhat parallel; only slightly forward of the mid-point on the lateral margin. Dorsal surface extensively covered with rounded granules; somewhat flattened, regions moderately well defined, with variable, but sparse, covering of setae laterally and posteriorly.

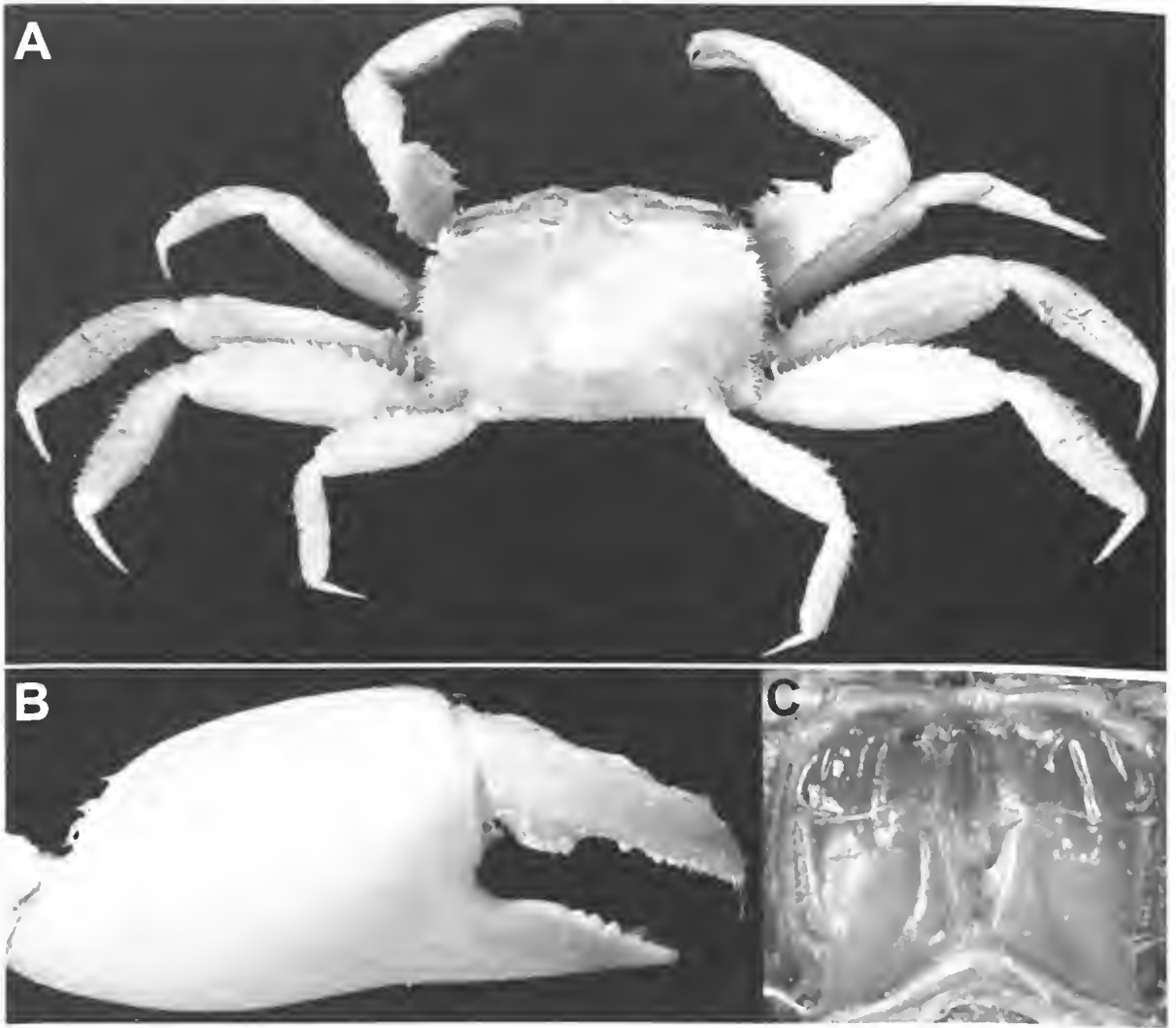


FIG. 24. *Macrophthalmus (Mar.) gagudju* sp. nov. Holotype, QM-W19918, ♂ (16.3 × 11.8 mm), Kakadu National Park, NT. A, dorsal view; B, chela; C, third maxillipeds.

Anterolateral and mid-lateral margins thickly fringed with fine setae. Third Maxilliped: merus markedly smaller than ischium; internal and external margins of ischium straight or nearly so; internal margin of merus convex.

Male Cheliped. Merus: inner and outer margins covered with a mat of fine setae; row of long setae bordering upper and lower margins.

Carpus: outer surfaces appearing smooth, with only sparse setae; inner surface below oblique median line, densely covered with setae. Oblique median line composed of a row of blunt tubercles. Surface above median line appearing smooth (without setae) or nearly so. Palm with inner surface lacking spine near carpus; upper and median two-thirds covered

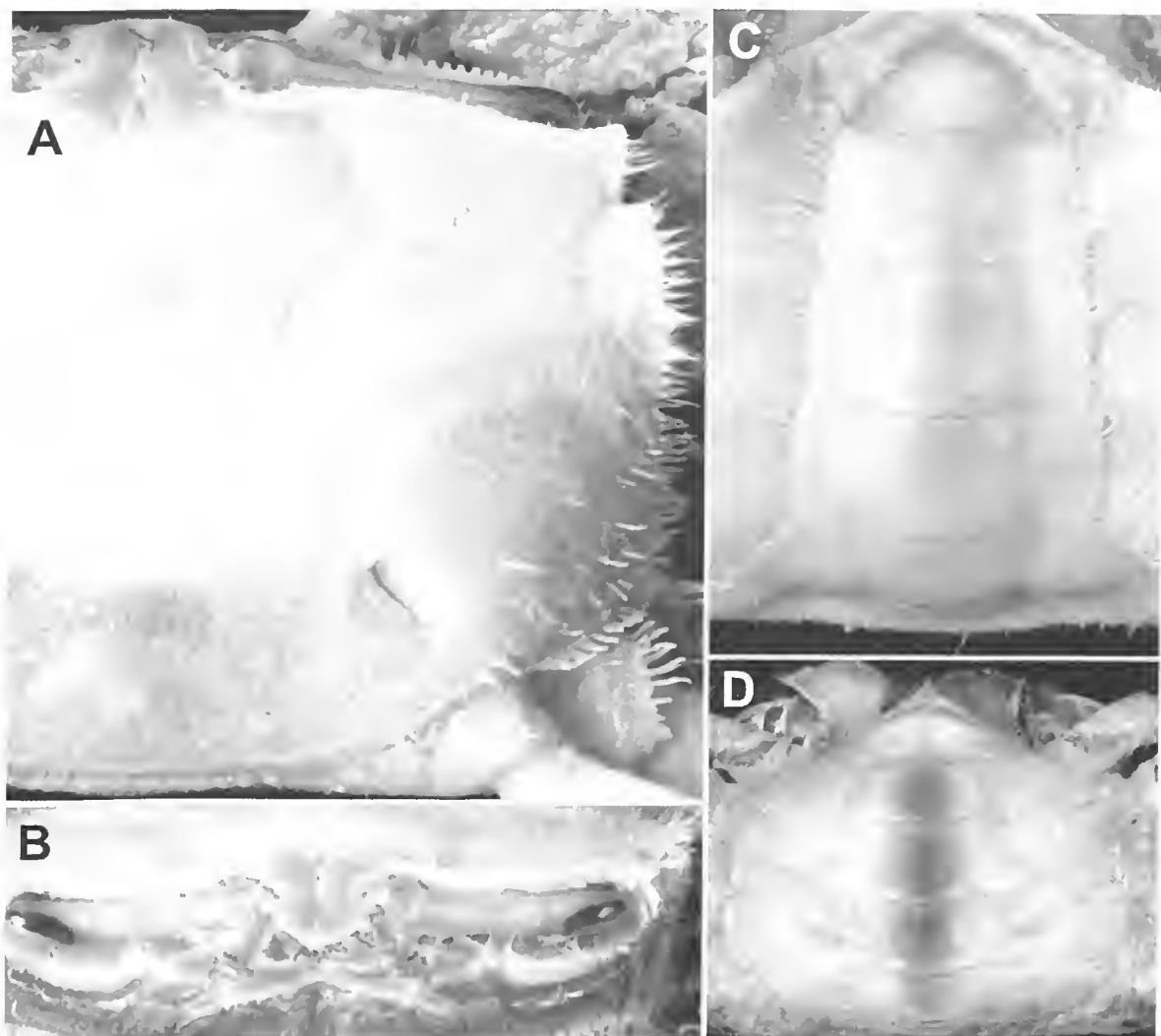


FIG. 25. *Macrophthalmus* (*Mar.*) *gagudju* sp. nov. QM-W19192, ♂ (14.2 × 9.9 mm), ♀ (9.5 × 7.0 mm), East Alligator river mouth, Kakadu, NT. A, enlarged view of carapace; B, frontal view of chela; C, male abdomen; D, female abdomen.

with a thick mat of setae; lower third without setae and sparsely granular; outer surface appearing smooth with only sparse rows of fine granules on upper and lower margins and supramarginal regions; lower margins with fine granular rows. Fixed finger slightly deflexed; outer surface appearing smooth with line of fine granules on lower margins; inner

surface densely setose; cutting margin with series of pointed granules extending almost full length of finger. Dactylus curved; outer surface smooth or finely granular in part; upper margin finely granular with a fringe of setae close to inner surface; cutting margin with large crenulated tooth proximal to centre, with a series of tooth-like granules distally. Walking

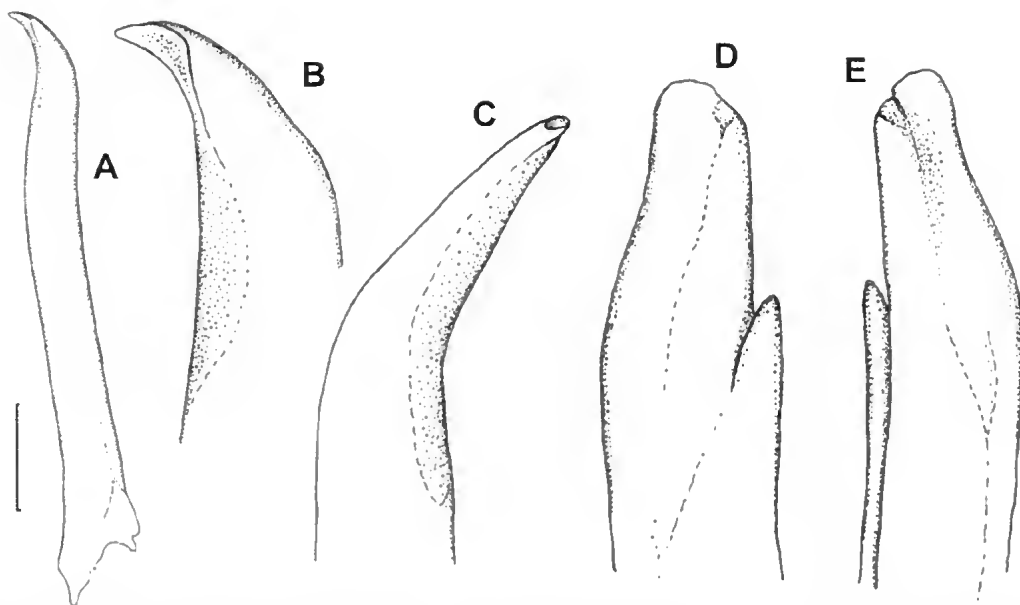


FIG. 26. *Macrophthalmus (Mar.) gagudju* sp. nov. Holotype, QM-W19918, ♂ (16.3 × 11.8 mm), Kakadu National Park, NT. Male first gonopod various views. Scale = 1 mm.

legs stout, thickly covered in fine close setae; meri with subdistal spine on upper margin.

Male abdomen with lateral margins of somites sub-parallel or slightly convex; margins of sixth somite often small medial concavity; thoracic sternites conspicuously granulate. Male first gonopod slightly curved, apical part in the form of a flattened flange, projecting obliquely upwards; well developed narrow subdistal palp; stiff setae present distally on inner and outer margin.

Remarks. Based on overall morphology *Macrophthalmus gagudju* has its closest affinities with the subgenus *Mareotis* Barnes, 1967. This subgenus is characterised by having a very narrow front, a moderately broad carapace (1.4–1.5 times wider than long), lateral teeth broad based and rectangular, cornea extending to base of exorbital angles, and the central region of the epistome with a concave excavation. Of the species in *Mareotis*, *Macrophthalmus gagudju* most closely resembles *M. darwineusis*, *M. depressus*, *M. definitus*, *M. pistrosinus*, *M. banzai*,

M. japonicus and *M. pacificus*. The new species bears a superficial resemblance to *M. latreillei* and *M. laeviuuuus* in the subgenus *Venitus* Barnes, 1967, but they are not close allies.

Macrophthalmus gagudju can be distinguished from allied species by:

1. The overall shape of the carapace, is sub-quadrate and anteriorly narrowed. *M. pistrosinus* and *M. japonicus* have a proportionately broader carapace, whilst in *M. depressus* the anterior of the carapace does not appear to narrow appreciably (cf figure in Barnes (1970)).

2. The anterolateral teeth in *M. gagudju* are conspicuously less acute and do not project as far outwards or forwards as most of its congeners. Its similarities in this regard lie with *M. darwineusis*, *M. definitus* and *M. pacificus* and less closely with *M. pistrosinus* and *M. japonicus*. The third lateral tooth is among the least conspicuous of any species examined. This feature allows it to be distinguished from *M. definitus* and *M. pacificus* and in most cases from *M. darwineusis*.

3. The carapace granulation is marked in the new species and reliably differentiates it from *M. darwinensis* and *M. pacificus*, both of which appear smooth to the naked eye. The surface granulation of *M. pistrosinus*, *M. japonicus* and *M. depressus*, although similar to the new species, is noticeably coarser and in some specimens examined, less extensive overall.

4. The presence of thick setae on the inner surface of the palm effectively distinguishes it from *M. pistrosinus*, *M. japonicus* and *M. pacificus* in which the setal covering is significantly sparser or non-existent.

5. The lack of a defined 'tooth' on the index of the chela in *M. gagudju* is an important distinguishing character. *M. pistrosinus*, *M. darwinensis*, *M. japonicus* and *M. definitus* all have a more or less defined crenulated tooth, whilst there is no defined tooth-like structure on the new species. Whilst there is also no well-defined tooth on the index in *M. pacificus*, the shape and arrangement of tubercles on the cutting margin differentiates it from *M. gagudju*.

6. A well defined, though shallow, deflection in the index of the chela helps distinguish the new species from *M. darwinensis*, *M. japonicus*, *M. pacificus* and *M. definitus* which have straight or less deflexed indexes. In contrast the indexes of *M. pistrosinus* and *M. banzai* are markedly more deflected. In addition, the chela of *M. japonicus* appears proportionately smaller than the new species.

7. *Macrophthalmus gagudju* is a comparatively small species which helps distinguish it from adult *M. definitus*, *M. pistrosinus*, *M. banzai*, *M. japonicus* and *M. pacificus* which are all considerably larger. Only *M. darwinensis* and *M. depressus* are of somewhat similar size. Male specimens of *M. darwinensis* examined are on average slightly larger than their *M. gagudju* counterparts. Unfortunately no specimens of *M. depressus* were available for study but based on dimensions given in Barnes (1970) it would appear that that species may be slightly smaller than the new species.

8. Male G1. The terminal process of the male gonopod is more elongate and projects further laterally in *Macrophthalmus gagudju* than in *M. darwinensis*, *M. definitus* and *M. pacificus*.

Etymology. *Gagudju*, from which the name for Kakadu National Park was derived, is a language of the aboriginal people of the East Alligator Region of the Northern Territory. The species was first found during an ecological survey of the East Alligator estuary. It is used as a noun in apposition.

Habitat. Prefer soft mud flats or mud banks on the edge of channels, often under or near seaward mangroves (*Avicennia*, *Sonneratia*).

Distribution. Known only from the Northern Territory to the Kimberley coast of north-western Australia.

Macrophthalmus (Mareotis) pacificus

Dana, 1851

(Figs 27, 28)

Macrophthalmus pacificus Dana, 1851a: 248; Dana 1852: 314; Dana 1855: pl. 19, fig. 4a-c; Stimpson 1858: 97; de Man 1890: 79, pl. 4, fig. 10; de Man 1895: 579; Ortmann 1897: 342; Stimpson 1907: 97; Tesch 1915: 155(key), 190, pl. 8, fig. 11; Kemp 1919: 391; Rathbun 1924: 13; Sakai 1939: 628; Kamita 1941: 168; Tweedie 1950: 359; Chhappgar 1957: 52, pl. 15 a-d; Kim 1970: 18; Starobogatov 1972: 345; Barnes 1977: 278 (key); Davie 1992: 348 (key).

? *Macrophthalmus bicarinatus* Heller, 1865: 36, pl. 4, fig. 2; de Man 1902: 496.

Macrophthalmus depressus — Lanchester 1900a: 259. [not *M. depressus* Rüppell, 1830]

Macrophthalmus (Mareotis) pacificus — Barnes 1967: 218, 221, pl. 2b, fig. 6; Barnes 1970: 232; Kim 1973: 452, 645, fig. 192, pl. 90, fig. 147a-b; Lundoer 1974: 8(list); Sakai 1976: 614, fig. 337; Takeda 1981: 72; Miyake 1983: 167, pl. 56, fig. 2; Dai *et al.* 1986: 435, fig. 242(3-4), pl. 60(5); Dai & Yang 1991: 476, fig. 242(3-4), pl. 60(5); Komai *et al.* 1995: 128, fig. 11; Muraoka 1998: 50; Rahayu & Setyadi 2009: 119, 1 colour fig.

Not *Macrophthalmus pacificus* — Rathbun 1910b: 307, pl. 1, fig. 3 (= *M. crinitus* Rathbun, 1913); Snelling 1959: 70 (= *M. setosus* H. Milne Edwards, 1852).

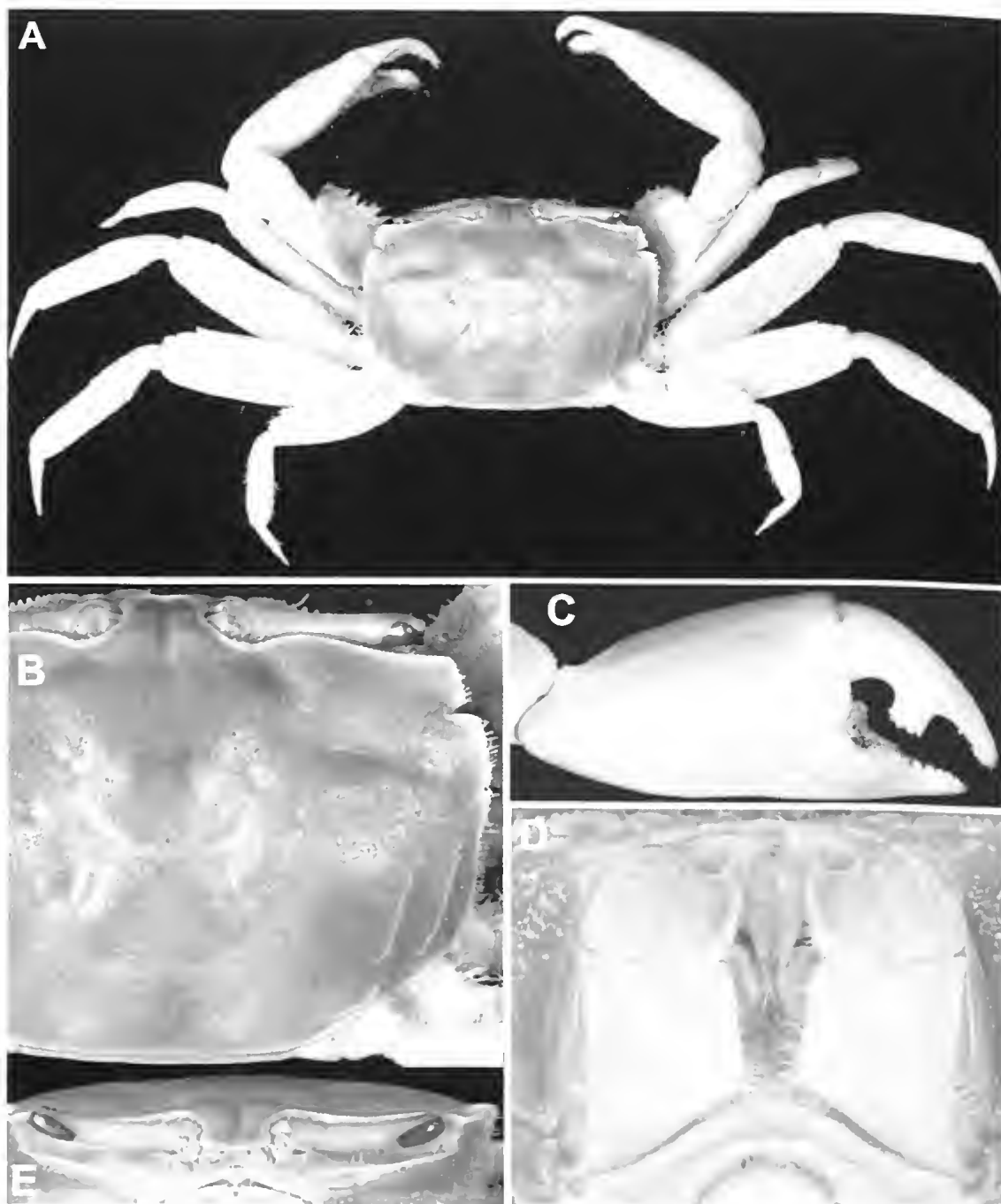


FIG. 27. *Macrophthalmus (Mar.) pacificus* Dana, 1851. QM-W5394, ♂ (22.2 × 16.1 mm), Hervey Bay, SE Qld. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, third maxillipeds; E, frontal margin and orbits.

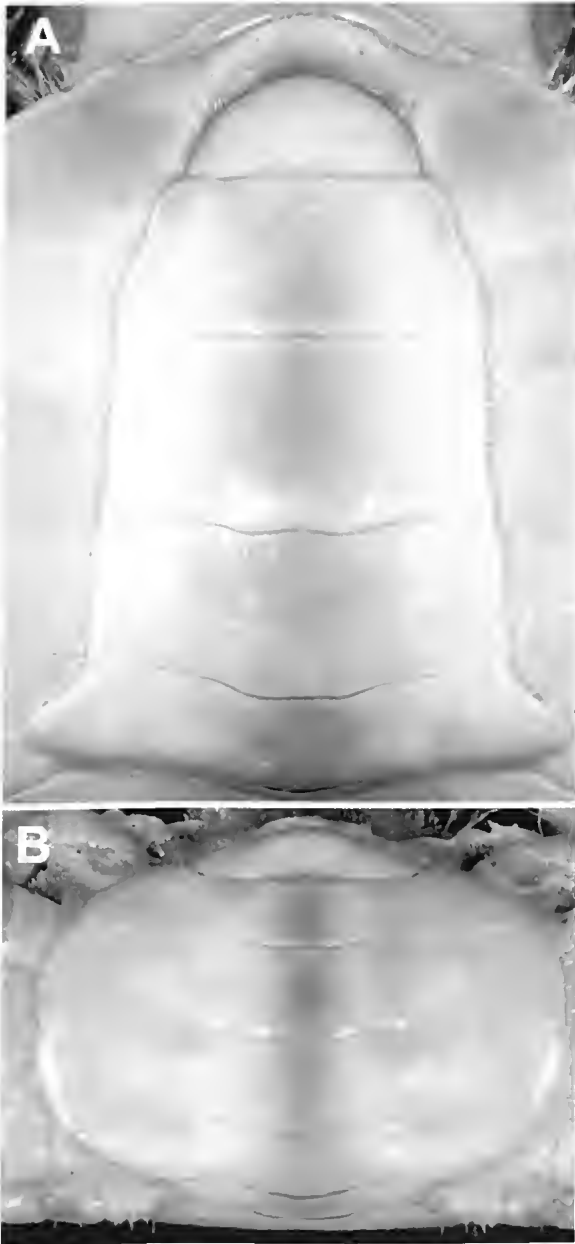


FIG. 28. *Macrophthalmus (Mar.) pacificus* Dana, 1851. QM-W5394, ♂ (22.2 × 16.1 mm), Hervey Bay, SE Qld. QM-W18171, ♀ (12.0 × 9.2 mm), south of mouth of Starke R., N Qld. A, male abdomen; B, female abdomen.

Material Examined. QM-W5394, 2 ♂ (22.2 × 16.1, 18.6 × 13.2 mm), Eli Creek, North Uranang, Hervey Bay, SE Qld, 25°17'S, 152°49'E, thick mud, mangrove patch on terrestrial fringe, 26.10.1975, P. Davie. QM-W3994, 2 ♀ (15.5 × 12.2, 12.8 × 9.6 mm), ♂ (10.3 × 7.5 mm), Port Douglas, NE Qld, 16°29'S, 145°28'E, 17.02.1966, L. Curlis. QM-W16872, ♀ (12.5 × 9.2 mm), Red Beach, near Weipa, FN Qld, 12°35'S, 141°52'E, estuarine, 03.11.1990, P. Davie & J. Short. QM-W4592, ♂ (15.5 × 11.1 mm), Trinity Inlet, Cairns, NE Qld, 16°58'S, 145°47'E, in low *Avicennia* stand, rocky mud, 07.05.1952, P. Davie & J. Short. QM-W19230, ♂ (10.7 × 7.8 mm), creek off road to AIMS, near Townsville, NE Qld, 19°17'S, 147°01'E, estuarine, mangroves, in *Rhizophora*, 28.10.1993, P. Davie, J. Short & A. Humphreys. QM-W18171, 5 ♀ (12.0 × 9.2, 9.4 × 7.1, 13.0 × 10.2, 14.9 × 10.9, 10.9 × 7.9 mm), 4 ♂ (13.9 × 10.4, 11.7 × 8.9, 14.9 × 11.0, 13.7 × 10.4 mm), south of mouth of Starke River inlet, FN Qld, 14°47'S, 145°01'E, marine, littoral, lower mudflat in burrows, salinity 35 ppt, 11.11.1992, P. Davie & J. Short. QM-W16765, 2 ♂ (7.7 × 6.0, 6.9 × 5.5 mm), ♀ (8.8 × 6.8 mm), ovig. ♀ (13.0 × 9.5 mm), Muddy Bay, FN Qld, 10°44'S, 142°33'E, estuarine, in burrows near *Rhizophora* forest, mid-tide, mud, 26.10.1990, P. Davie & J. Short. WAM-C42680, ♂ (15.3 × 11.0 mm), NE end of Coolgra Pt., east of Onslow, Western Australia, Site 44, B.R. Wilson, 9.05.2009.

Diagnosis. Carapace surface smooth and shiny, except for long, slightly oblique rows of granules on branchial regions; front deflexed, slightly constricted between bases of ocular peduncles, lateral margins smooth, straight distally, median furrow deep; carapace margins subparallel posteriorly, convergent anteriorly, widest point across third anterolateral teeth; exorbital tooth broadly triangular, blunt, second lateral tooth similarly large with long outer margin, third tooth tiny but clearly defined. Ocular peduncles moderately long, cornea extending not quite to base of exorbital angle. Central region of epistome excavated. Merus of third maxilliped markedly smaller than ischium. Palm of male cheliped stout, outer face smooth, inner face with dense patch of setae centrally near distal margin continuous with setae on fixed finger, with small scattered granules; fixed finger not deflexed, cutting edge with a series of large rounded granules, but without differentiated tooth, inner surface

with dense mat of setae near cutting margin; dactylus cutting margin with large, distally enlarged, crenulated tooth proximally. Meri, carpi and propodi of ambulatory legs finely granular, with sparse setae along upper margins; meri of first two pairs with thicker elongated patch of setae anteroproximally.

Remarks. One of the most distinctive *Macrophthalmus* species because of its smooth, rounded, carapace, and the pretty sky-blue claws of the adult males.

Habitat. Appears to prefer lower estuarine habitats, making burrows in thicker firm mud, and rocky mud, often associated with more open mangrove forest (low *Avicennia*, *Rhizophora*), from lower-tidal level nearly to the terrestrial fringe.

Distribution. Type locality: Upolu, Samoa. India – Okha (Chhapgar 1957); Nicobar Islands (Heller, 1865); Thailand – Phuket (Komai *et al.* 1995); Penang (de Man, 1895); Japan – Okinawa (Stimpson 1907), Ishigaki-jima and Iriomote-jima (Sakai 1976), Ishigaki-jima (Miyake 1983); Korea Strait (Kamita 1941); Taiwan (Barnes 1970); Hong Kong (Barnes 1970); Malaysia – Buntal (Barnes 1970); Philippines (Barnes 1970, Komai *et al.* 1995); Borneo – (Tweedie 1950), Pontianak (de Man, 1895); New Guinea – Kaimare and Dru I. (Barnes 1967); Solomon Islands – Ysabel I. (Barnes 1967); Upolu, Samoa (Dana, 1852). In Australia from Onslow and Broome, WA (present record; Rathbun 1924), around tropical Australia south to Hervey Bay, with unconfirmed report that can reach Moreton Bay (Barnes 1967; present records and pers. obs.).

Macrophthalmus (Mareotis) pistrosinus

Barnes & Davie, 2008

(Figs 29, 30)

Macrophthalmus (Mareotis) pistrosinus Barnes & Davie, 2008: 63–68, figs 1–4.

Macrophthalmus (Mareotis) japonicus – Barnes 1967: 224–226, fig. 8, pl. 2(d) [not *Macrophthalmus (Mareotis) japonicus* (De Haan, 1835)].

Macrophthalmus (Mareotis) aff. japonicus – Kitaura *et al.* 2002: 1–8; 2006: 46.

Material Examined. HOLOTYPE: WAM 655-65, ♂ (30.9 × 20.4 mm), Teggs Channel, Shark Bay, WA, 14.8.1963, R. Slack-Smith. PARATYPES: WAM 655-65, 2 ♀ (26.6 × 14.1, 22.0 × 15.1 mm), same data as holotype. WAM 651-65, ♀, Denham Hummock, Shark Bay, WA from burrow near mangrove creek, 9.1.1963, R. Slack-Smith.

Diagnosis. Carapace surface, excepting small central area, entirely covered by large granules; regions well defined; transverse granular and setal row extending across anterior branchial region from level of third lateral tooth; similar transverse row above insertion of fourth pereopod; two subparallel longitudinal rows of granules and setae branchially. Greatest carapace breadth across second lateral teeth. Front deflexed, constricted between bases of ocular peduncles; anterior margin bilobed with deep median furrow. Upper orbital border with slightly oblique, sinuous margin; edged with large tubercular granules. Three anterolateral teeth. Exorbital angle pronounced, large, broad, rectangular, pointed anteriorly, directed outwards and slightly forwards; second lateral tooth large, broad, subtriangular, projecting beyond exorbital angle by wide U-shaped sulcus; third lateral tooth small, conical, separated by small but distinct incision. Posterolateral margins subparallel. Ocular peduncles long and narrow; cornea extending almost to tip of exorbital angle. Central region of epistome distinctly concave. Third maxilliped with merus markedly smaller than ischium; internal margin of merus slightly convex; external margin with marked posteroexternal convexity. Merus of male cheliped elongate, upper margin with distal row of tubercular granules; outer margin finely granular. Carpus inner superior margin with crest of pointed tubercles, highest medially. Palm elongate; upper and lower margins markedly granulate; outer surface finely granular, granules increasing in size towards carpus, without longitudinal ridge near lower margin, with slight depression near base of fixed finger; fixed finger deflexed, cutting margin with large, wedge-shaped, crenulated tooth occupying proximal half;

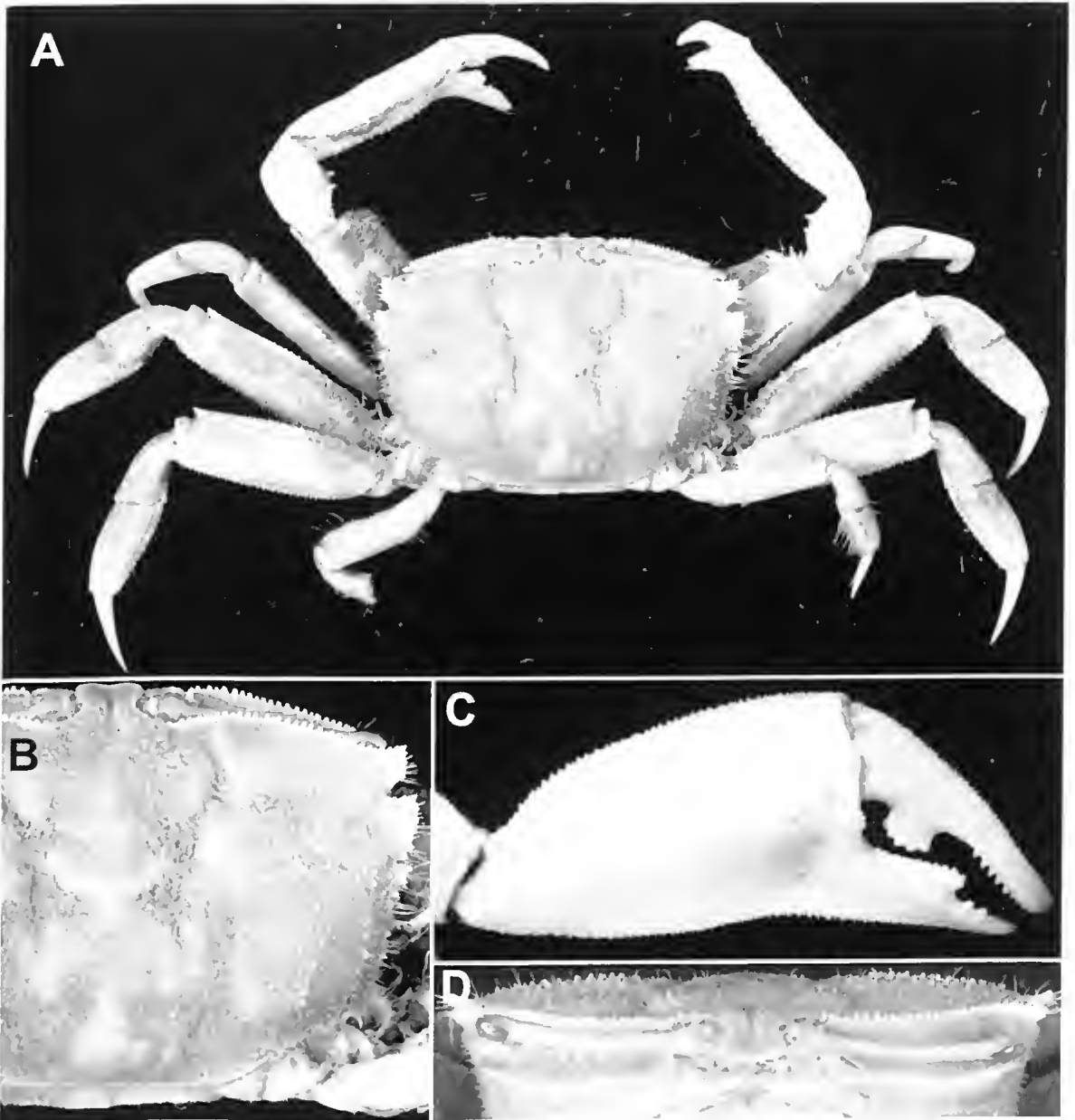


FIG. 29. *Macrophthalmus* (*M.*) *pistrosinus* Barnes & Davie, 2008. Holotype, ♂ (30.9 × 20.4 mm), WAM 655-65, Shark Bay, WA. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

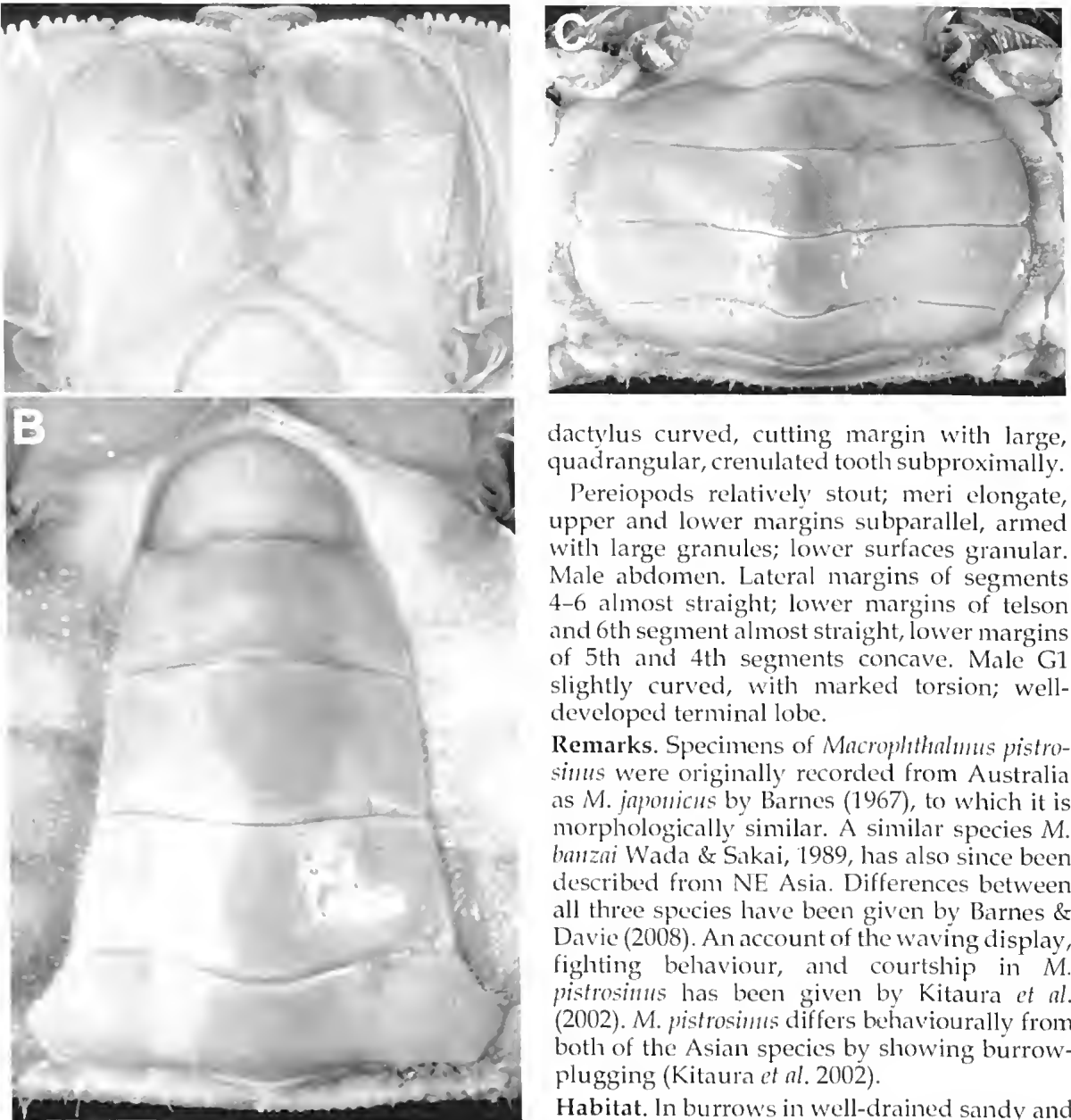


FIG. 30. *Macrophthalmus (Mar.) pistrosinus* Barnes & Davie, 2008. Holotype, ♂ (30.9 × 20.4 mm), WAM 655-65, Shark Bay, WA. A, third maxillipeds; B, male abdomen; C, female abdomen (WAM 651-65, Shark Bay, WA).

dactylus curved, cutting margin with large, quadrangular, crenulated tooth subproximally.

Pereiopods relatively stout; meri elongate, upper and lower margins subparallel, armed with large granules; lower surfaces granular. Male abdomen. Lateral margins of segments 4–6 almost straight; lower margins of telson and 6th segment almost straight, lower margins of 5th and 4th segments concave. Male G1 slightly curved, with marked torsion; well-developed terminal lobe.

Remarks. Specimens of *Macrophthalmus pistrosinus* were originally recorded from Australia as *M. japonicus* by Barnes (1967), to which it is morphologically similar. A similar species *M. banzai* Wada & Sakai, 1989, has also since been described from NE Asia. Differences between all three species have been given by Barnes & Davie (2008). An account of the waving display, fighting behaviour, and courtship in *M. pistrosinus* has been given by Kitaura *et al.* (2002). *M. pistrosinus* differs behaviourally from both of the Asian species by showing burrow-plugging (Kitaura *et al.* 2002).

Habitat. In burrows in well-drained sandy and muddy sediments adjacent to both salt-marsh and mangroves.

Distribution. Only known from the type locality, Shark Bay, WA, from Carnarvon (24°9' S, 113°7' E) to Long Point (25°5' S, 113°9' E).

Macrophthalmus (Mareotis) setosus

H. Milne Edwards, 1852

(Figs 31, 32)

Macrophthalmus setosus H. Milne Edwards, 1852: 159, pls. 3, 4; Haswell 1882a: 89; de Man 1888b: 356, pl 9, figs 2, 2(a); Ortman 1897: 343; Tesch 1915: 189; Etheridge & McCulloch 1916: 12, pls 5-6; Snelling 1959: 70; McNeill 1962: 42; Poore 2004: 496, fig. 156c; Davie 2011: 243, colour picture.

Macrophthalmus (Mareotis) setosus – Barnes 1967: 216–218, pl. 2(a), fig. 5; Ng *et al.* 2008: 238; Davie 2002: 354.

Macrophthalmus pacificus – Snelling 1959: 70.

Material examined. QM-W5334, ♀ (11.0 × 7.0 mm), ♂ (12.7 × 7.8 mm), Moon Creek, Fraser I., SE Qld, 25°11'S, 153°4'E, 20.07.1975, R. Timmins. QM-W5345, 2 ♂ (13.5 × 17.8, 9.5 × 5.1 mm), south of Urangan boat harbour, Hervey Bay, 25°18'S, 152°55'E, marine, littoral, mudflat, superficial and infaunal, 23.01.1975, P. Davie & R. Timmins. QM-W5385, ♂ (20.2 × 13.0 mm), Pulgum Creek, south of Urangan, Hervey Bay, 25°19'S, 152°54'E, 19.07.1975, P. Davie. QM-W2394, 5 ovig. ♀ (30.0 × 17.8, 22.4 × 14.0, 16.4 × 10.5, 20.3 × 12.8, 20.5 × 12.7 mm), 4 ♀ (18.7 × 12.0, 21.6 × 12.9, 19.8 × 12.0, 19.5 × 12.2 mm), 4 ♂ (24.1 × 13.6, 19.6 × 11.9, 17.6 × 11.0, 23.4 × 14.1 mm), Brisbane River, SE Qld, 27°14'S, 152°30'E, May 1884. QM-W5256, 2 ovig. ♀ (23.0 × 13.4, 16.2 × 9.9 mm), ♀ (11.7 × 7.2 mm), Jacksons Ck, Cribb I., 27°23'S, 153°5'E, 12.10.1972, B. Campbell *et al.* QM-W15342, 3 ♀ (22.0 × 13.4, 21.2 × 12.4, 14.9 × 9.1 mm), 2 ovig. ♀ (20.6 × 12.6, 16.0 × 9.7 mm), 2 ♂ (21.8 × 12.7, 11.0 × 16.8 mm), Boggy Creek, Myrtle town, SE Qld, 27°24'S, 153°8'E, in burrows in mudbank near walking bridge, 12.07.1988, J. Short, J. Johnson & P. Lawless. QM-W15344, 3 ♂ (24.5 × 14.7, 17.7 × 10.7, 14.9 × 8.4 mm), 2 ovig. ♀ (19.9 × 12.1, 15.9 × 9.6 mm), Bulwer I., Brisbane River, SE Qld, 27°25'S, 153°8'E, in burrows in mud at low tide, 12.07.1988, J. Short, J. Johnson & P. Lawless. QM-W15521, ♂ (25.5 × 14.7 mm), Bulwer I., Brisbane River, SE Qld, 27°25'S, 153°8'E, estuarine, 12.07.1953, J. Short, J. Johnson & P. Lawless. QM-W23946, ♂ (22.0 × 12.3 mm), Dunwich, North Stradbroke I., SE Qld, 27°30'S, 153°08'E, estuarine, littoral, 29.07.1997, P. Davie & J. Short. QM-W4752, ♂ (15.2 × 8.7 mm), Coomera I., near Southport, SE Qld, 27°58'S, 153°25'E, 28.12.1974, Australian Littoral Society. QM-W23888, ♂ (22.0 × 12.3 mm), Boggy Creek, Myrtle town, SE Qld, 27°74'S, 153°08'E, estuarine, littoral, 29.07.1988, P. Davie. QM-W1934, ovig. ♀ (23.9 × 14.7 mm), Port Stephens, NSW, 32°42'S, 152°6'E, 26.09.1953, I. Filmer.

Diagnosis. Carapace surface finely but distinctly granular, except for smooth central regions; regional grooves moderately well defined; setal covering short but variable variable in extent and may completely cover carapace; two longitudinal subparallel rows on branchial region adjacent posterolateral margins. Ocular peduncles long and narrow; cornea extending to base of exorbital angle. Front deflexed, constricted between bases of ocular peduncles, with median furrow, smooth surface; anterior margin almost straight. Upper orbital border moderately curved, sloping backward; distinctly granulate; lower orbital border serrated by tubercular granules. Exorbital angle large, somewhat rectangular, outer margin convex; separated from second lateral tooth by narrow fissure; marking greatest carapace width. Second lateral tooth similar in shape but smaller; third lateral tooth small and completely hidden in thick setae; lateral margins weakly convergent. Third maxilliped with inner margin of ischium markedly concave; merus external margin with marked posteroexternal convexity. Male cheliped merus with inner and upper margins heavily setose; lower surface and upper parts of inner and outer surfaces heavily granulated. Carpus with inner surface bearing large granules; row of tubercles near articulation with palm. Inner surface of palm densely setose; weakly developed longitudinal ridge subparallel to lower margin; fixed finger moderately deflexed, cutting margin without distinctly enlarged differentiated tooth; dactylus cutting margin with large, long, crenulated tooth occupying proximal quarter. Pereiopod meri and carpi densely setose, anterior subdistal spine small. Male abdomen with lateral margins of segments 4–6 more or less straight, weakly convergent. Male G1 with marked terminal lobe.

Remarks. As mentioned by Barnes (1967), juveniles less than about 7.5 mm carapace breadth differ from adults in being proportionately narrower, and by having narrower exorbital

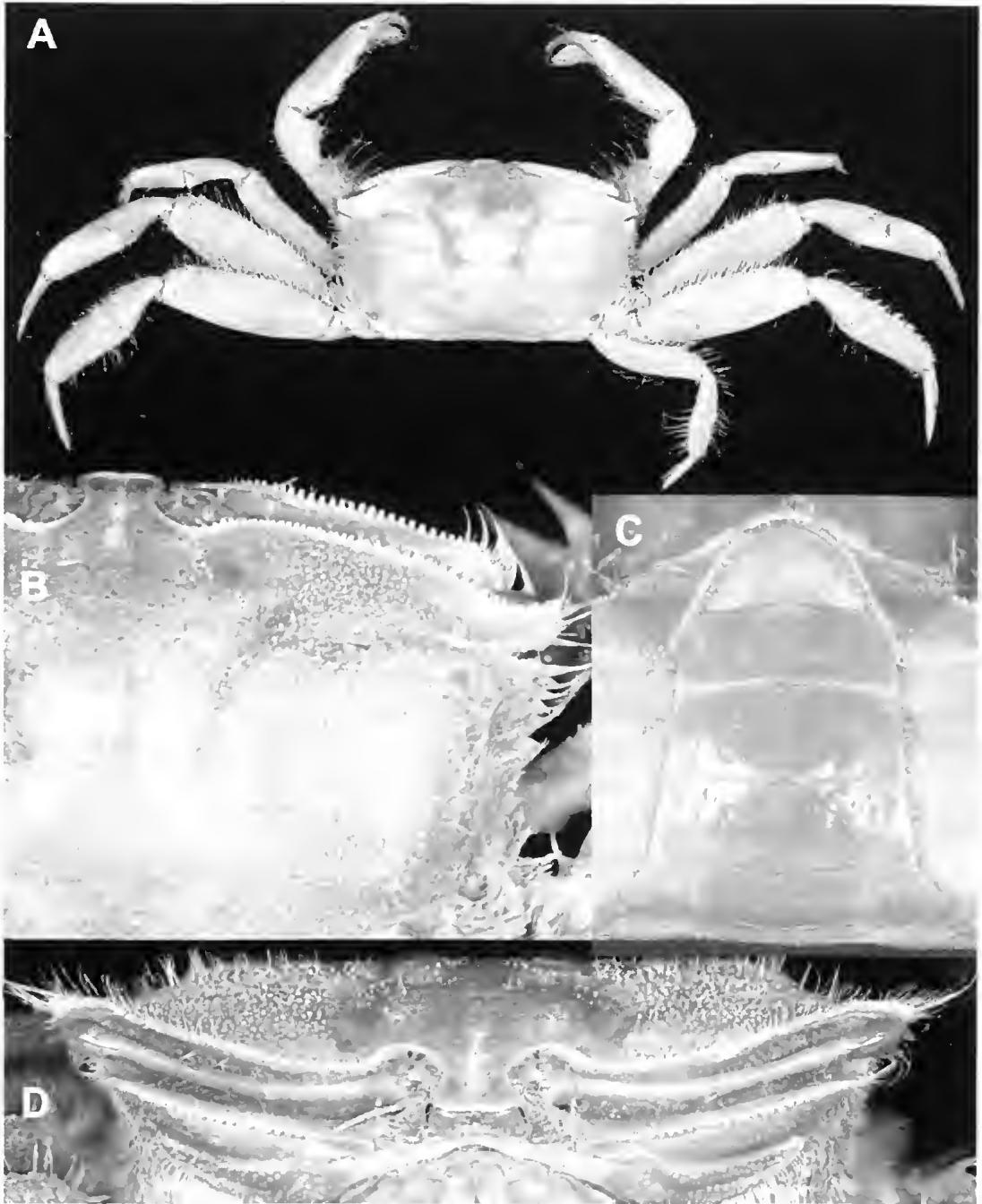


FIG. 31. *Macrophthalmus (Mar.) setosus* H. Milne Edwards, 1852. QM-W15521, ♂ (25.5 × 14.7 mm), Bulwer I., Brisbane R., SE Qld. A, dorsal view; B, enlarged view of carapace; C, male abdomen; D, frontal margin and orbits.

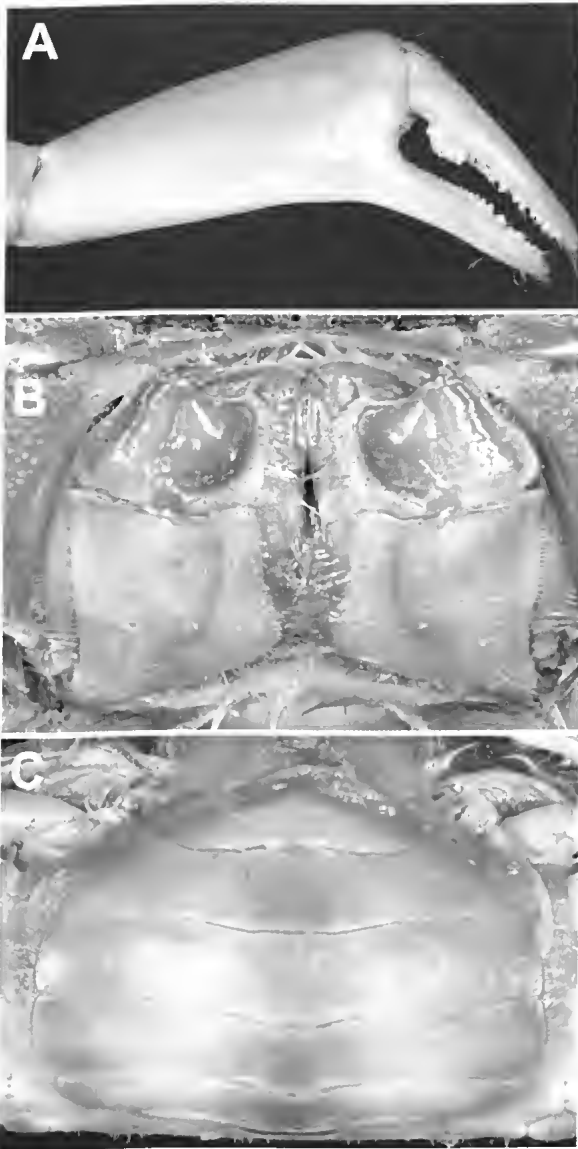


FIG. 32. *Macrophthalmus (Mar.) setosus* H. Milne Edwards, 1852. QM-W15521, ♂ (25.5 × 14.7 mm), Bulwer I., Brisbane R., SE Qld. A, male chela; B, third maxillipeds; C, female abdomen (QM-W15342, ♀ (22.0 × 13.4 mm), Boggy Ck, Myrtletown, SE Qld).

misidentify juveniles from the Brisbane River as *M. pacificus*.

Habitat. Prefers mid-littoral zone. Commonly found burrowing in sandy-mud to mud substrates on intertidal flats, within exposed seagrass areas, low on river and creek banks, and sometimes alongside and amongst open mangroves.

Distribution. Type locality: Australia (as 'Nouvelle-Hollande'). Indigenous to eastern Australia, known only from about Sydney, NSW, north to Port Curtis, Qld.

Macrophthalmus (Paramareotis) erato
De Man, 1888
(Figs 33, 34)

Macrophthalmus erato De Man, 1888a: 125, pl. 8, figs 12–14; 1895: 579; Alcock 1900: 381; Rathbun 1910: 323; Tesch 1915; Kemp 1919: 390; Tweedie 1937: 163–164; Chopra & Das 1937: 424–425; Barnes 1970: 232–235; 1971: 22; Dai & Yang 1984: 479; Rahayu & Setyadi 2009: 120, 1 colour fig.

Material Examined. QM-W19191, 3 ♂ (10.4 × 7.5, 7.5 × 5.2, 7.3 × 5.5 mm), 2 ♀ (11.1 × 8.0, 8.9 × 5.9 mm), Channel I., Darwin Harbour, NT, 07.05.1993, P. Davie. NTM-CR010922, 2 ♂ (9.4 × 6.7, 6.7 × 5.0 mm), Ludmilla Creek, Darwin, NT., 03.03.1992, M. Burke.

Description. Carapace with front deflexed, narrow, no marked constriction between bases of ocular peduncles; margins smooth with a defined median groove. Upper orbital border curved; margin marked with line of small granules. Lower orbital border with ridge of six small granular on inner third followed externally by short deep concavity; outer two-thirds with smooth lobiform protuberance and horny rim, ending in swollen protuberance on extreme outer section of lower border. Central region of epistome with wide, shallow concavity. 'Woolly' setae extensively fringing lower margins of pterygostomian region and upper borders of thoracic sternites. Two clearly defined antero-lateral teeth. The exorbital angle with a broad, triangular, sharply pointed tooth, directed outwards and forwards; separated from second tooth by wide U-shaped sulcus; second lateral

angles, such that the greatest breadth occurs between the second and third lateral teeth. It is these differences that led Snelling (1959) to

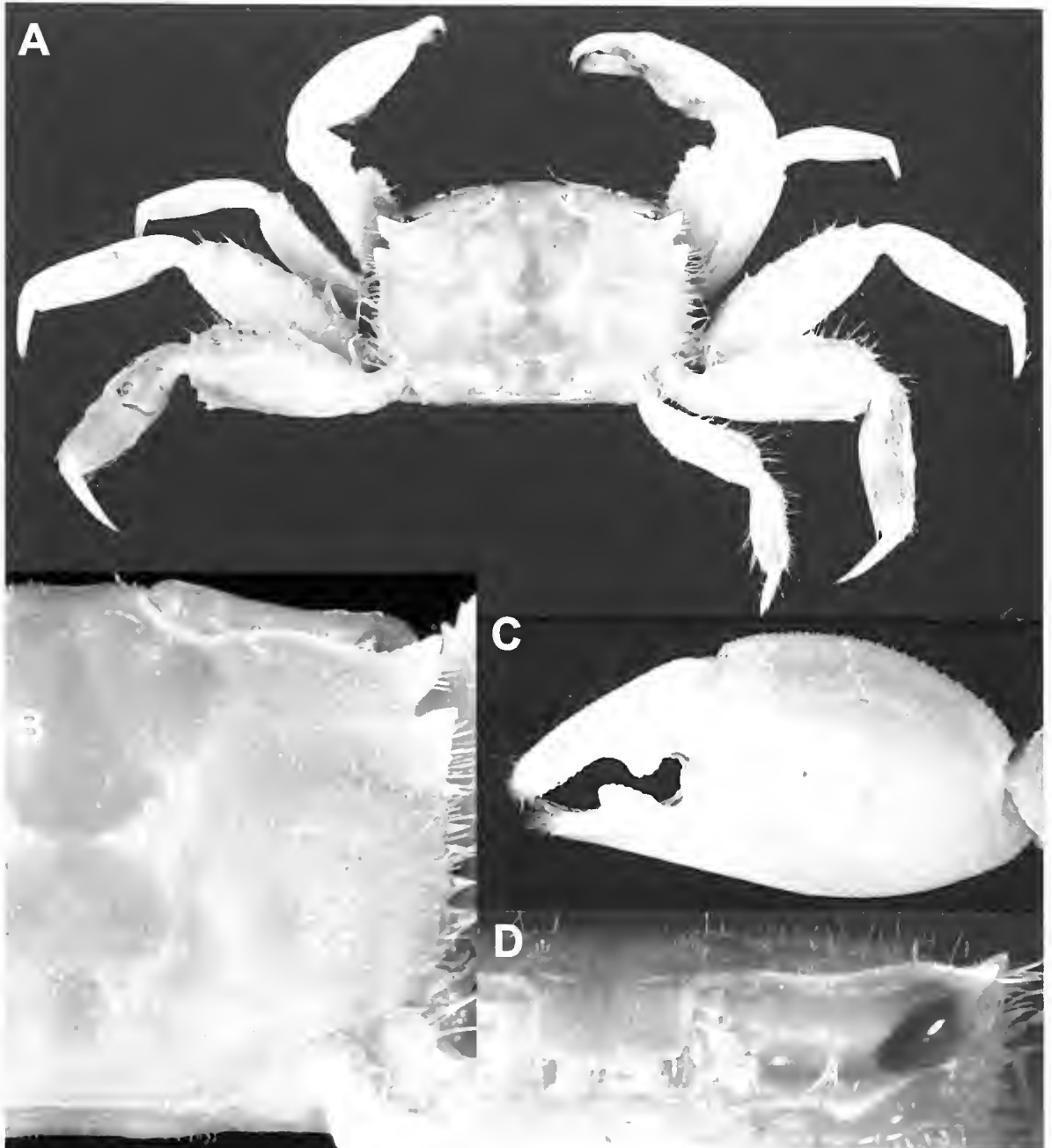


FIG. 33. *Macrophthalmus (P.) erato* De Man, 1888. QM-W19191, ♂ (10.4 × 7.5 mm), Darwin Harbour, NT. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

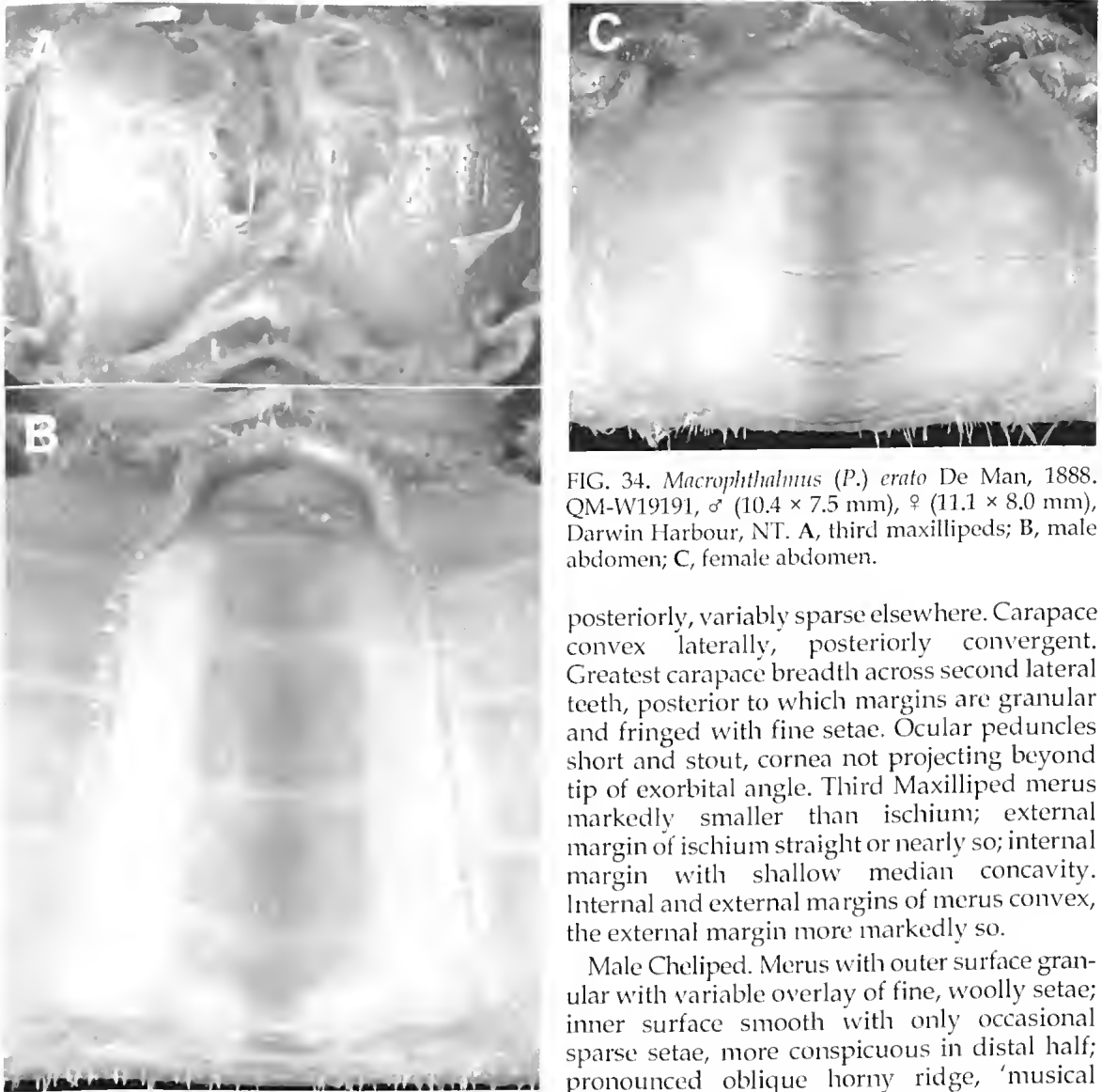


FIG. 34. *Macrophthalmus* (*P.*) *erato* De Man, 1888. QM-W19191, ♂ (10.4 × 7.5 mm), ♀ (11.1 × 8.0 mm), Darwin Harbour, NT. A, third maxillipeds; B, male abdomen; C, female abdomen.

tooth acute, projecting further laterally; third lateral tooth absent. Lateral margin granulate marked with shallow concavity and fringe of fine setae. Surface of carapace smooth centrally, with hirsute, finely granular patches on branchial and hepatic regions. Increasing concentrations of stiff, bristle-like setae laterally and

posteriorly, variably sparse elsewhere. Carapace convex laterally, posteriorly convergent. Greatest carapace breadth across second lateral teeth, posterior to which margins are granular and fringed with fine setae. Ocular peduncles short and stout, cornea not projecting beyond tip of exorbital angle. Third Maxilliped merus markedly smaller than ischium; external margin of ischium straight or nearly so; internal margin with shallow median concavity. Internal and external margins of merus convex, the external margin more markedly so.

Male Cheliped. Merus with outer surface granular with variable overlay of fine, woolly setae; inner surface smooth with only occasional sparse setae, more conspicuous in distal half; pronounced oblique horny ridge, 'musical crest', mounted on short flange, close to lower margin, together with tuft of long, stiff setae which partially obscures it; ventral surface covered with a mat of fine, woolly, setae. Carpus with outer surface finely granular; convex row of slightly raised granules present close to upper margin; inner surface partially obscured by mat of woolly setae over lower

two-thirds; upper one-third without setae except for fringe around upper border; 3 large dentiform tubercles on inner supra-marginal area. Palm with outer surface closely covered in minute granules, upper margin with bordering row of tubercles; inner surface covered in dense mat of setae in median and distal two-thirds extending into, and obscuring proximal portion of gape of chela; small patches of setae on upper inner surface below margin; lower marginal, sub-marginal and proximal third, smooth or finely granulate and without setae. Fixed finger slightly deflexed; almost straight; outer surface finely granulate with row of long, fine setae on distal portion close to cutting edge; inner surface densely setose proximally; distal two-thirds smooth with median row of long, fine setae; lower margin with row of small granules; cutting margin with large wedge shaped, crenulated tooth in centre extending backwards towards base; single raised granule close to distal end. Dactylus curved; outer surface smooth or finely granulate; upper surface more densely and coarsely granulate; cutting margin with large crenulated tooth proximal to centre with series of tooth-like granules distally; row of long, fine, brush-like setae present on lower distal margin close to cutting edge and partially covering distal half of same.

Upper surfaces of walking legs: covered with a mat of woolly setae interspersed with sparse rows of stiff, bristle-like setae on upper marginal and sub-marginal parts.

Male abdomen with abdominal somites 1-5 parallel or nearly so; sixth somite converging distally. Male G1 curved; chitinous terminal process obscured by thick brush-like setae.

Remarks. *Macrophthalmus erato* has been previously known only from South-East Asia. It is one of a group of five species which possess a horny stridulatory ridge, the so called 'musical crest', on the merus of the cheliped, and an adjacent row of protuberances on the infero-orbital border. The other species in this group,

M. pectinipes, *M. tomentosus*, *M. quadratus*, *M. boteltobago* are as yet unknown from Australia.

Habitat. Soft mud around mangroves, mid intertidal.

Distribution. Mergui, Johore, Canton (Barnes 1970), Soerabaja, E. Java (Barnes 1971), Guangdong (including Hainan Is.) Fujian (China); Indonesia, Gulf of Siam, India (Dai & Yang 1984). Within Australia currently known from Darwin Harbour, Northern Territory.

Macrophthalmus (Venitus) latreillei
(Desmarest, 1822)

(Figs 35-37)

Gonoplax latreillei Desmarest, 1822: 99, pl. 9, figs 1, 4.
Macrophthalmus Latreillei — H. Milne Edwards 1837: 66; A. Milne-Edwards 1865: 193; 1873: 278, pl. 13, fig. 3.

Macrophthalmus latreillei — Ortmann 1894: 747; Laurie 1906: 427; fig. 12, pl. 2, fig. 3; Rathbun 1910: 306; Tesch 1915: 154 (key), 181; 1918: 59; Kemp 1919: 385; Tweedie 1937: 163; Sakai 1939: 626, pl. 105, fig. 2; Suvatti 1950: 154; Barnard 1955: 22; Chhapgar 1957: 51, pl. 14u-y; Kaneko 1958: 331-339; Kesling 1958: 207-263; Crosnier 1965: 131, figs 239-242; Barnes 1966: 46; Hashmi 1969: 42; Idris 1989a: 207; 1989b: 45; Davie 1992: 348 (key); Ng *et al.* 2001: 38; Poore 2004: 496, fig. 156d; Davie 2011: 242, colour picture; Ng *et al.* 2008: 238 (list); McLay *et al.* 2010: 487.

Macrophthalmus desmaresti Lucas, 1839: 567, pl. 20.

Macrophthalmus serratus — Adams & White 1848: 51; H. Milne Edwards 1852: 159; Stimpson 1858: 97; Meirs 1886: 250, pl. 20, fig. 1; Stimpson 1907: 96, pl. 13, fig. 3; Rathbun 1910: 323; Etheridge & McCulloch 1916: 11, pl. 4.

Macrophthalmus polleni Hoffmann, 1874: 19, pl. 4, figs 27-30; de Man 1879: 66; Lenz & Richters 1881: 424, figs 24-27.

Macrophthalmus laniger Ortmann, 1894: 746, pl. 23, fig. 15.

Macrophthalmus granulatus de Man, 1904: 266, pl. 10, fig 5; Ward 1941: 3.

Macrophthalmus latreillei — Rathbun 1924: 12; Hashmi 1969: 42.

Macrophthalmus (Venitus) latreillei — Barnes 1967: 232, fig. 11, pl. 3c; 1970: 236; Sakai 1976: 616, pl. 210, fig. 2; Tai & Song 1984: 79, figs 1c, 2c, 3g-h; Dai & Yang 1991: 480, fig. 245, pl. 61(2); Ng *et al.*

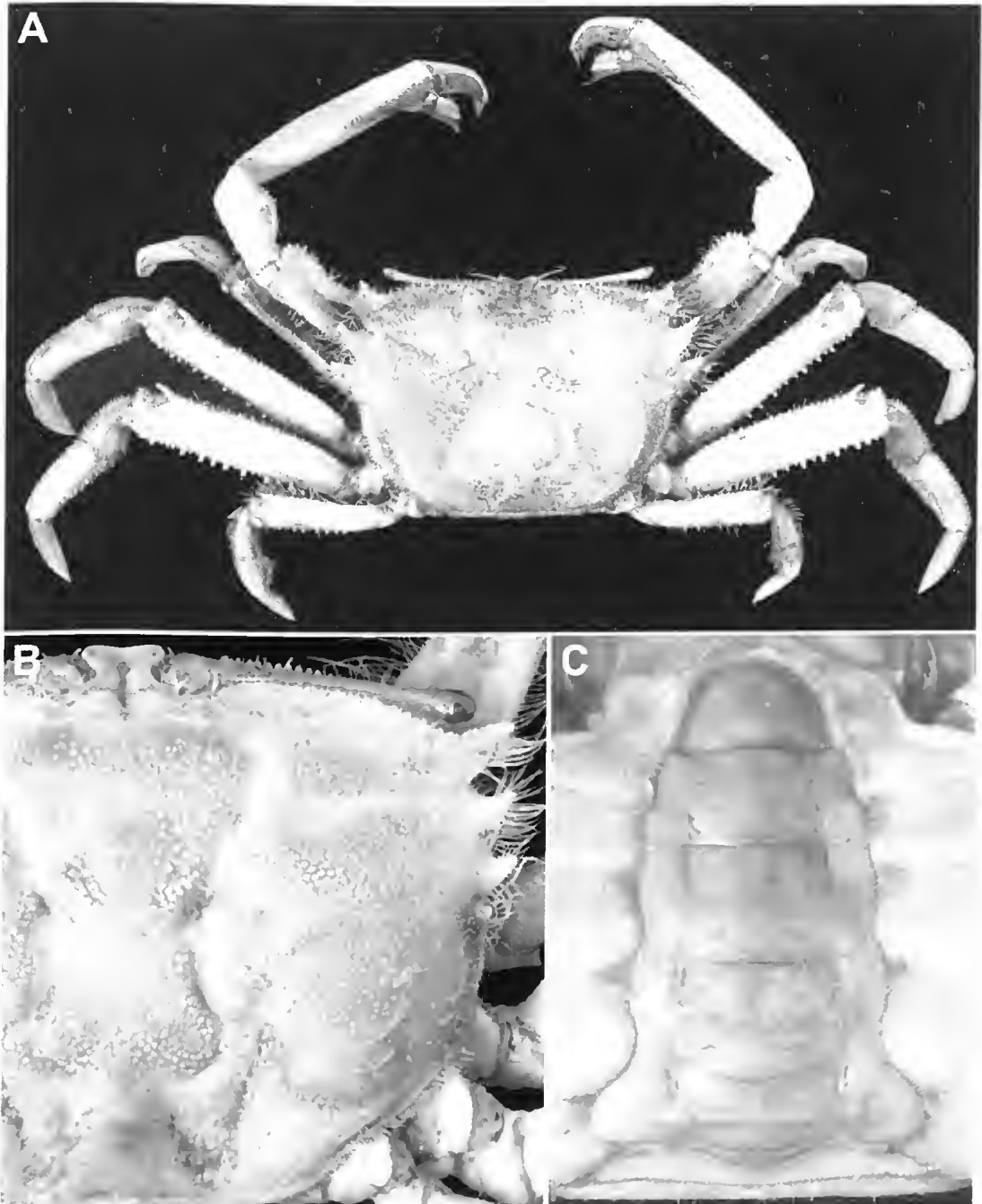


FIG. 35. *Macrophthalmus (V.) latreillei* (Desmarest, 1822). A, dorsal view; B, enlarged view of carapace; C, male abdomen. A, QM-W4030, ♂ (52.1 × 38.5 mm), Calliope River, Gladstone, SEQ; B, QM-W15234, ♂ (59.9 × 43.4 mm), Gladstone, SEQ; QM-W4561, ♂ (45.3 × 34.0 mm), Trinity Inlet, Cairns, NQ.

- 2008: 238 (list); Rahayu & Setyadi 2009: 123, 2 colour figs.
- Macrophthalmus (Euplax) latreillei* – Wada 1995: 417, pl. 118, fig. 6.
- Macrophthalmus (Ventius) latreillei* – Ghani 2002: 633–635, fig. 1.
- Material Examined.** QM-W8893, ♂ (42.0 × 33.1 mm), Victoria Point, Moreton Bay, SE Qld, 27°35'S, 153°19'E, 20.06.1980, J. Moverly. QM-W5335, ♂ (27.4 × 21.0 mm), ♀ (30.9 × 22.8 mm), Bogimbah Ck, Fraser I., 25°19'S, 153°05'E, Intertidal, from burrows in creek bed, 22.07.1975, R. Timmins. QM-W5375, ♂ (42.0 × 30.5 mm), ♀ (34.3 × 25.1 mm), Mary R., South Head, Hervey Bay, 25°26'S, 152°56'E, mudbank in 50 cm burrow, 04.07.1975, P. Shanco. QM-W16409, ovig. ♀ (57.5 × 42.5 mm), Port Curtis, Curtis I., 23°38'S, 151°10'E, estuarine, mudflats, 22.11.1989, R. Morton, Queensland Fisheries Service. QM-W4033, ♂ (34.8 × 27.1 mm), Calliope R., The Loop, Gladstone, 23°55'S, 151°01'E, lower mud bank, 03.04.1974, B. Campbell. QM-W4030, ♂ (52.1 × 38.5 mm), Calliope R., near The Loop, Gladstone, 23°55'S, 151°01'E, mud bank, 03.04.1974, B. Campbell. QM-W15216, 2 ♂ (37.3 × 27.8, 10.7 × 8.3 mm), 2 ♀ (18.6 × 13.7, 15.8 × 12.1 mm), ovig. ♀ (27.4 × 20.5 mm), Gladstone Queensland Electricity Commission Survey 1974–1983, 23°51'S, 151°16'E, P. Saenger. QM-W11525, 2 ♂ (40.9 × 29.5, 29.2 × 22.2 mm), The Narrows between Curtis I. & mainland, Gladstone, 23°40'S, 151°07'E, estuarine, mudflats, in burrow 20 cm beneath surface, P. Shanco, 08.04.1979, Australian Littoral Society. QM-W15234, ♂ (59.9 × 43.4 mm), The Narrows, between Curtis I. and mainland, Gladstone, 23°40'S, 151°06'E, estuarine, mudbank, 08.04.1979, P. Davie. QM-W11931, ♂ (7.0 × 5.6 mm), Triangular I., Shoalwater Bay, 22°23'S, 150°31'E, M.R.L survey, Sep 1981. QM-W11930, ♂ (7.5 × 6.3 mm), Triangular I., Shoalwater Bay, 22°23'S, 150°31'E, M.R.L Survey, Nov. 1982. QM-W4762, ♂ (41.2 × 29.5 mm), Corio Bay, Nth of Yeppoon, NQ, 22°56'S, 150°46'E, 06.07.1974, P. Shanco. QM-W8179, 2 ♀ (14.8 × 11.6, 19.7 × 14.7 mm), 2 ♂ (11.7 × 8.9, 15.8 × 12.0 mm), Murray R., NQ, 18°01'S, 145°53'E, marine, littoral, sandy shore, 19.05.1978, P. Davie. QM-W8600, ♀ (43.8 × 33.1 mm), ♂ (21.8 × 16.7 mm), Murray R., north of Cardwell, 18°01'S, 145°53'E, estuarine, littoral open mud flat, 21.05.1978, R. Timmins. QM-W2399, 2 ♂ (34.0 × 25.3, 36.1 × 27.3 mm), Mackay, ME Qld, 21°9'S, 149°11'E, 1924. QM-W4561, ♂ (45.3 × 34.0 mm), Trinity Inlet, Cairns, NE Qld, 16°58'S, 145°47'E, 10.12.1974, R. Timmins. QM-W3998, ♂ (41.2 × 30.7 mm), Cairns, NQ, 16°55'S, 145°46'E, burrowing in mud on mudflats, 10.02.1966, L. Curlis. QM-W4560, 3 ♂ (32.9 × 25.2, 31.2 × 23.6, 31.5 × 24.1 mm), Trinity Inlet, Cairns, NQ, 11.12.1974, R. Timmins. QM-W6431, 3 ♂ (44.5 × 34.1, 44.0 × 32.4, 44.7 × 33.4 mm), Barron R., Cairns, NQ, 16°52'S, 145°42'E, 16.12.1975, R. Timmins. QM-W6434, 2 ♂ (34.4 × 25.3, 27.0 × 20.2 mm), Barron R., Cairns, 16°52'S, 145°42'E, 16.12.1975, R. Timmins. QM-W16764, ♀ (18.5 × 13.3 mm), Muddy Bay, NQ, 10°44'S, 142°33'E, estuarine, 26.10.1998, P. Davie & J. Short.
- Diagnosis.** Carapace surface markedly granular, granules large and rounded; front deflexed, markedly constricted between bases of ocular peduncles, small granules on margins, distally bilobed, median furrow deep; lateral margins subparallel or slightly convex, 3 prominent anterolateral teeth and sometimes fourth smaller tooth. Ocular peduncles long and narrow, cornea extending to base of exorbital angle. Central region of epistome straight. Merus of third maxilliped smaller than ischium. Palm of male cheliped stout, outer face smooth, inner face with dense setae in upper and distal portions, heavily granular in lower and proximal portions; index finger not deflexed, cutting edge without differentiated tooth except in large individuals; cutting edge of dactylus proximally with a large, quadrangular, and crenulated tooth, and a few widely spaced cylindrical granules distally. Meri of ambulatory legs heavily granular and with variable setae.
- Remarks.** The largest species of *Macrophthalmus* found in Australia. Barnes (1967) has discussed the variability of this species, and earlier records and probable misidentifications. Allometric growth changes are marked for this species, with juveniles relatively more quadrate; similarly the anterolateral teeth are small and poorly defined in smaller crabs (Fig. 37a), and become progressively more prominent, such that the second and third teeth in particular become spinous and more laterally projecting (Fig. 37c).
- Habitat.** Burrows on open mudflats in very soft mud. In Queensland, at least, it is commonly found as a sub-fossil (1000–5000 years-old) during channel dredging of estuarine and inshore environments (Davie 2011). Literature

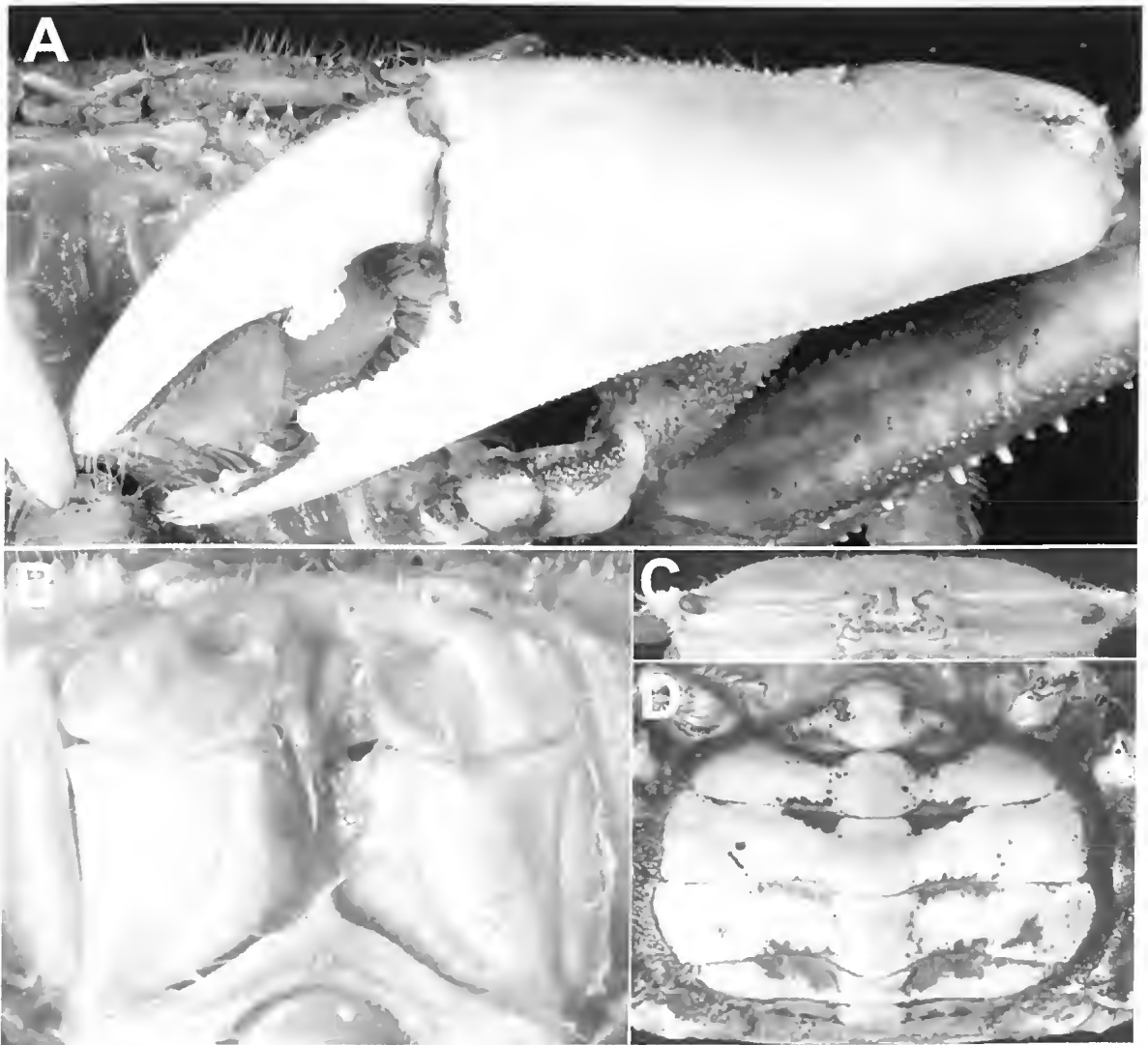


FIG. 36. *Macrophthalmus* (*V.*) *latreillei* (Desmarest, 1822). A, male chela; B, third maxillipeds; C, frontal margin and orbits; D, female abdomen. A, QM-W4030, ♂ (52.1 × 38.5 mm), Calliope River, Gladstone, SEQ; B, C, QM-W4561, ♂ (45.3 × 34.0 mm), Trinity Inlet, Cairns, NQ; D, QM-W8600, ♀ (43.8 × 33.1 mm), Murray R., NQ.

records to 20 m depth, but this seems unlikely as it is an animal of the low intertidal zone. Subtidal records presumably refer to trawls or dredges over intertidal flats taken at high tide.

Distribution. Broadly distributed in the Indo-west Pacific Oceans from South Africa to Japan, Philippines and New Caledonia. In Australia it

has been previously noted from Fremantle, WA. (Barnes 1967), Broome (Rathbun 1924; Barnes 1967), Darwin (McLay *et al.* 2010), and is here recorded from the tip of Cape York to Moreton Bay on the eastern coast. Although it reaches Moreton Bay, it is rare there, and this could be considered its southern limit.

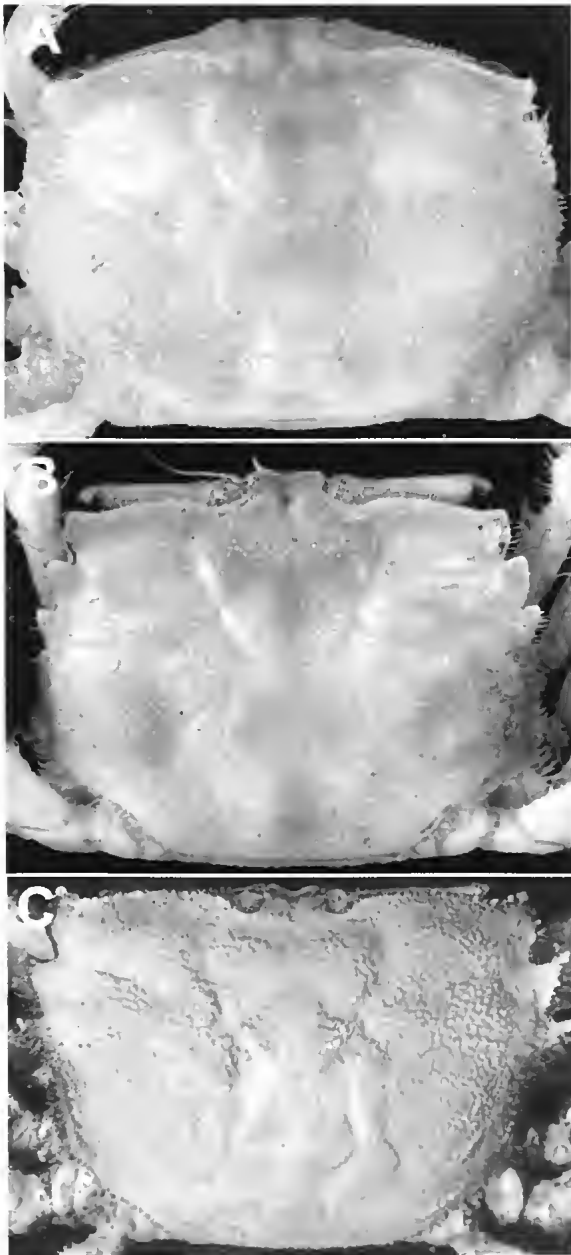


FIG. 37. *Macrophthalmus* (*V.*) *latreillei* (Desmarest, 1822). Allometric change in carapace proportions with growth. A, QM-W11931, ♂ (7.0 × 5.6 mm), Triangular I., Shoalwater Bay; B, QM-W8179, ♂ (15.8 × 12.0 mm), Murray R., N Qld; C, QM-W4561, ♂ (45.3 × 34.0 mm), Trinity Inlet, Cairns, N. Qld.

Chaenostoma Stimpson, 1858

Macrophthalmus (*Chaenostoma*) Stimpson, 1858: 97; Davie 2002: 351; Ng *et al.* 2008: 237 (list). Type species: *Chaenostoma orientale* Stimpson, 1858, (= *Macrophthalmus boscii* Audouin, 1826) by monotypy; gender neuter.

Macrophthalmus (*Mopsocarcinus*) Barnes, 1967: 203; Komai *et al.* 1995: 136. Type species: *Macrophthalmus boscii* Audouin, 1825 by original designation; gender masculine.

Chaenostoma – Davie 2009: 817; McLay 2010: 495.

Diagnosis. Small, carapace breadth <15 mm; not markedly broadened, c. 1.1–1.4 times wider than long; ocular peduncles short and stout, not projecting beyond lateral carapace margins, subequal in length to breadth of front or shorter; front broad, not constricted between bases of ocular peduncles, where its breadth is 0.2–0.30 times distance between exorbital angles; ischium of third maxilliped c. 1.25 times length of merus; carapace breadth < 1.3 times length, lateral margins parallel, broad-based subrectangular anterolateral teeth, without conspicuous rows or clumps of granules on branchial regions; central region of posterior border of epistome straight (*C. boscii*, *C. lisae*) or distinctly convex (*C. punctulatus*); males without stridulatory apparatus; fingers of male chela short with index straight or slightly deflexed, dentition variable, without an enlarged tooth differentiated on either finger (*C. lisae*), a tooth only on dactylus (*C. boscii*), or a tooth on both fingers (*C. punctulatus*). Intertidal. (Modified after Barnes, 2010: 37).

Remarks. Davie (2009) and McLay *et al.* (2010) have indicated that *Chaenostoma* Stimpson, 1858, should be elevated to a distinct genus in its own right, and this is formally followed here. As discussed earlier, Barnes (1967) erected *Macrophthalmus* (*Mopsocarcinus*) (type species *Macrophthalmus boscii* Audouin, 1826), unaware that there was an earlier name, *Chaenostoma* Stimpson, 1858 (type species *C. orientale* Stimpson, 1858). Since *Chaenostoma orientale* Stimpson, 1858, is now regarded as a junior synonym of *Macrophthalmus boscii*

Audouin, 1826, the name *Chaenostoma* Stimpson, 1858, must have priority as the subgeneric name (see Stimpson 1858; Ng *et al.* 2008).

Chaenostoma contains three species: *C. boscii* (Audouin, 1826), *C. punctulatus* Miers, 1884, and *C. lisae* Poupin & Bouchard, 2010.

Barnes (2010) commented that the central region of the epistome is straight for *Chaenostoma*, however this is not true for *C. punctulatus* which has a distinct convexity (see 'Remarks' under that species for further elaboration). He also commented 'but unusually for *Macrophthalmus*, mainly associated with rocky or stony habitats'. While this is true for *C. boscii* it is not true for the other two species: *C. punctulatus* is found burrowing into firm mud or muddy-sand on the upper shore; and similarly *C. lisae* digs burrows on sandy mudflats 'on the upper part of the intertidal area' (Poupin & Bouchard 2010: 65).

Chaenostoma boscii (Audouin, 1826)
(Figs 38, 39)

Macrophthalmus boscii Audouin, 1826: 77-98, pl. 2, fig. 1; Krauss 1843: 40, pl. 2, fig. 5; Lenz & Richters 1881: 425; Nobili 1906: 319; Kemp 1919: 383, pl. 24, fig. 6; Balss 1935: 141; Barnard 1950: 103, fig. 20f-i; Barnard 1950: 10, fig. 20; Fourmanoir 1954: 3, fig. 3; Holthuis 1958: 53; Crosnier 1965: 134, figs. 244-248; Barnes 1966b: 371; 1977: 277 (key), 279 (list); Sakai 1976, 1-773, 1-16, pls. 251; Seréne & Vadon 1981: 125; Takeda 1982: 211; Yang 1991: 479-480, fig. 244; Jeng 1997; Ng *et al.* 2001: 38; Sakai *et al.* 2004: 1224, 6 figs.

Euplax (*Chaenostoma*) *boscii* — A. Milne-Edwards 1852: 160; 1873: 281; de Man 1880d: 71; 1888b: 357; Miers 1884: 540; 1886: 252; Ortmann 1894b: 58; Lenz 1905: 367; Nobili 1906: 319; Stebbing 1910: 329; Tesch 1918, 60; Sakai 1939: 630, fig. 100.

Cleistomostoma boscii — Dana 1852: 313, pl. 19, fig. 3; 1855: pl. 19, figs. 3a-d.

Chaenostoma orientale Stimpson, 1858: 97; 1907: 98.

Chaenostoma crassinanus Stimpson, 1858: 97; 1907: 98.

Euplax boscii — H. Milne Edwards 1852: 160; de Man 1888b: 357; Ortmann 1894b: 58; Lenz 1905: 367; Stebbing 1910: 329.

Euplax boscii — Tesch 1918: 60; Sakai 1939: 630, fig. 100; 1955: 111; Lin 1949: 27.

Euplax (*Chaenostoma*) *boscii* — A. Milne-Edwards 1873: 281; Miers 1884: 542; Miers 1886: 252; Nobili 1906: 319.

Macrophthalmus franchettii Maccagno, 1936: 177.

Macrophthalmus (*Euplax*) *bosci* (sic) — Guinot 1967: 282.

Macrophthalmus franchettii — Guinot 1967: 283 (list); Froggia 1978: 222, fig. 1 (synonomized with *M. boscii*).

Macrophthalmus (*Mopsocarcinus*) *boscii* — Barnes 1967: 227, pl. 3, fig. 9; 1971: 30; Lundoer 1974: 9 (list); Hartnoll 1975, 309 (list); Sakai 1976: 615 pl. 211, figs 9E-F, 10B; Lewinsohn 1977: 76; Chen 1980: 136, fig. 19; Takeda 1981: 74; Miyake 1983: 168, pl. 56, fig. 2; Dai *et al.* 1986: 437, pl. 61(1), fig. 244; Dai & Yang 1991: 479, fig. 244, pl. 61(1); Huang *et al.* 1992, 149, fig. plate 1H; Komai *et al.* 1995: 136, fig. 1; Kitaura & Wada 2005: 71-73.

Macrophthalmus (*Mopsocarcinus*) *bosci* — Barnes 1970: 242.

Macrophthalmus (*Mopsocarcinus*) *franchettii* — Barnes 1967: 203 (list).

Macrophthalmus quadratus — McNeill 1968: 84, pl. 2, figs 2-4. [not *M. quadratus* A. Milne-Edwards, 1873].

Macrophthalmus (*Mareotis*) *quadratus* — Takeda & Nunomura 1977: 82. [not *M. quadratus* A. Milne-Edwards 1873].

Macrophthalmus (*Chaenostoma*) *boscii* — Davie 2002: 351; Ng *et al.* 2008: 237, 238 (list), 239 fig. 183 (photo of *M. aff. boscii*). Barnes 2010: 36, 37; Poupin & Bouchard 2010: 65.

Material examined. QM-W3995, ♂ (11.1 × 9.8 mm), North of Rocky Point, North of Mossman, 16°23'S, 145°25'E, in sand, 01.05.1966, L. Curlis. QM-W22637, ♂ (7.6 × 5.5 mm), Coringa-Herald Nature Reserve, Coral Sea, NE Qld, 16°56'S, 149°11'E, marine, reef, beach rock, on algal turf, RGSQ Herald Cay Expedition, 23.06.1997, P. Davie. QM-W1101, ♂ (11.2 × 9.8 mm), ♀ (9.7 × 6.5 mm), Orpheus I., 18°40'S, 146°30'E, in sand, 26.11.1987, P. Davie. QM-W14543, 2 ♀ (10.0 × 8.8, 10.0 × 8.7 mm), 4 ♂ (9.8 × 6.6, 8.7 × 6.5, 9.8 × 7.6, 9.8 × 7.6 mm), Coconut Beach, west side of Lindeman I.; intertidal, 20°27'S, 149°2'E, marine, fringing reef, under rocks and dead coral, 26.03.1987, P. Davie & J. Short. QM-W14496, ♂ (7.6 × 4.4 mm), entrance to a small creek, west side of Lindeman I., 20°27'S, 149°2'E, estuarine, littoral, mud bank, under rocks, 23.03.1987, P. Davie & J. Short. QM-W14542 ♂ (9.9 × 7.6 mm), 2 ♀ (9.9 × 8.7, ovig, 8.7 × 6.6 mm), Lindeman I., 20°27'S, 149°2'E, estuarine, littoral, mud bank, under rocks; burrow in mud, 23.03.1987, P. Davie & J. Short. QM-W14484, ♂ (9.9 × 8.7 mm),

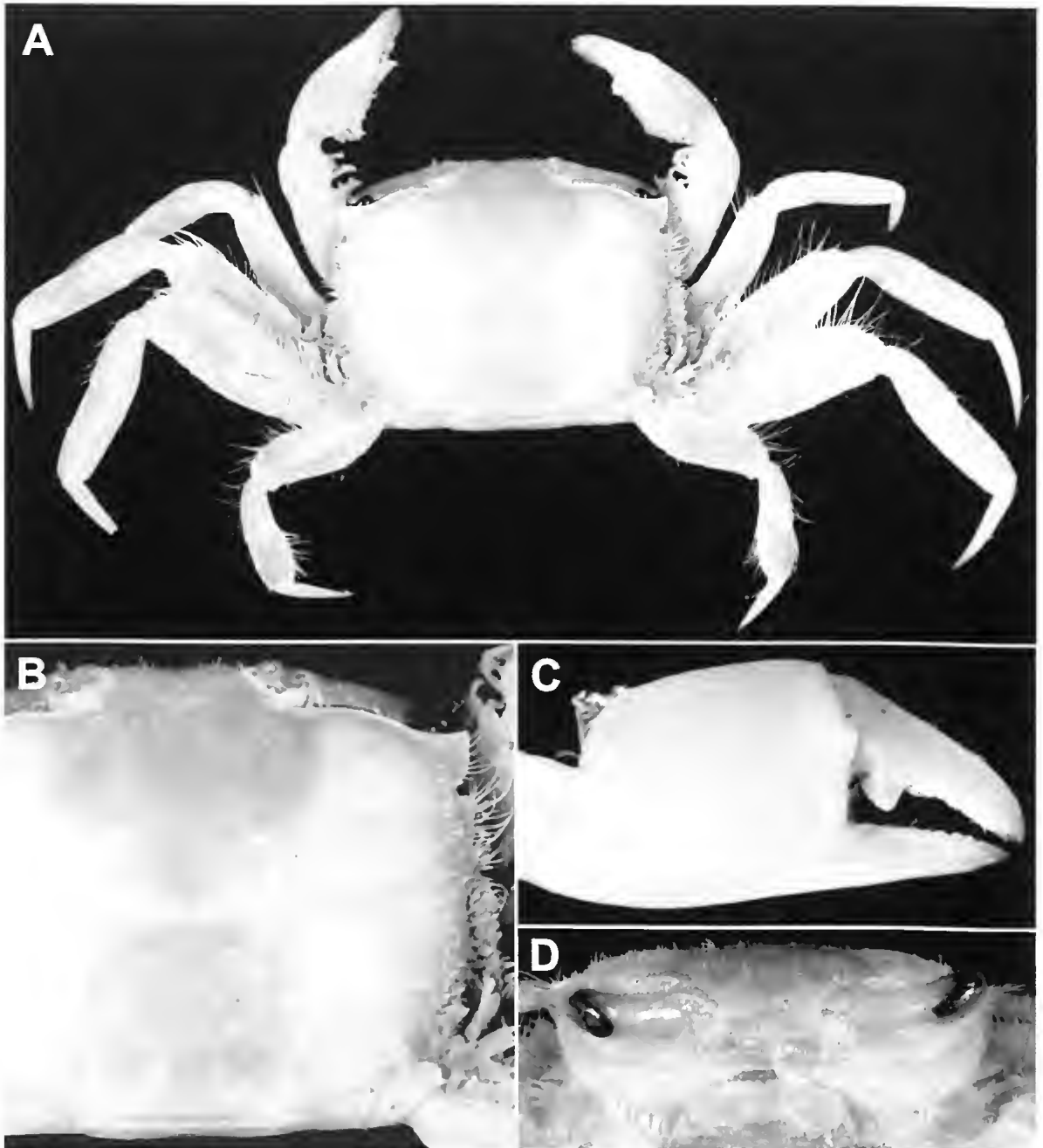


FIG. 38. *Chaenostoma boscii* Audouin, 1826. QM-W14484, ♂ (9.9 × 8.7 mm), Seaforth I., ME Qld. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits.

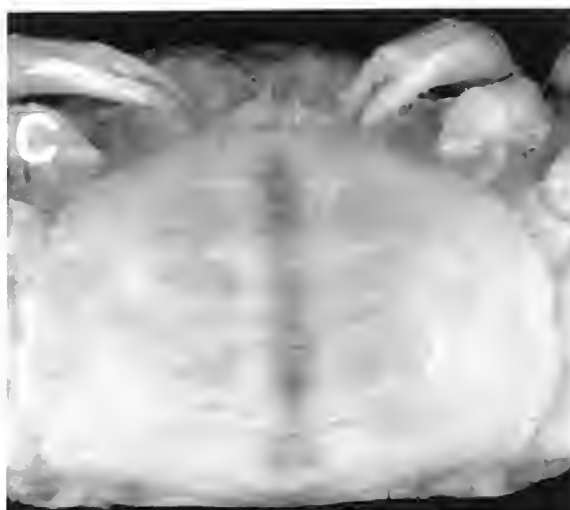
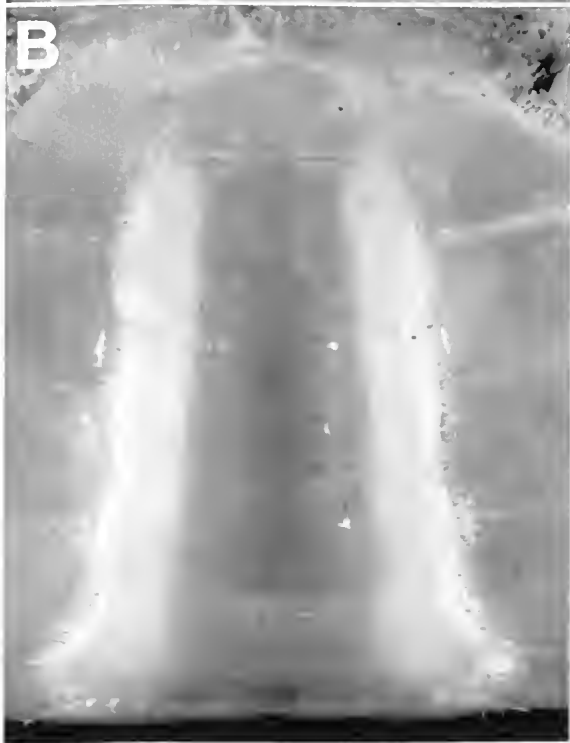
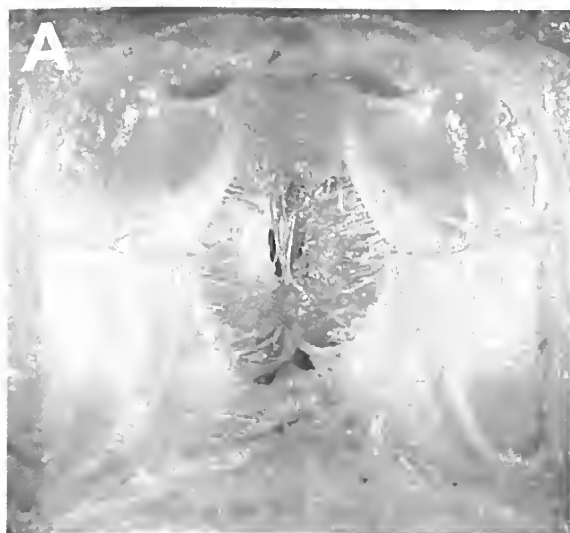


FIG. 39. *Chaenostoma boscii* Audouin, 1826. A, third maxillipeds; B, male abdomen; C, female abdomen. A, B: QM-W14484, ♂ (9.9 × 8.7 mm), Seaforth I., ME Qld; C, QM-W14543, ♀ (10.0 × 8.8 mm), Lindeman I., ME Qld.

Seaforth I., 20°28'S, 149°2'E, marine, fringing reef, under rocks and dead coral, 24.03.1987, P. Davie & J. Short. QM-W21538, ♂ (5.5 × 3.3 mm), Kings Headland, Caloundra, 26°48'S, 153°9'E, rocky shore, under rocks, 27.09.1996, P. Davie.

Diagnosis. Carapace covered by small evenly spaced granules, few scattered setae on branchial regions; 3 anterolateral teeth, two large, third indistinct; greatest breadth between exorbital teeth; front deflexed, slightly constricted between bases of ocular peduncles, with smooth margins, clearly bilobed distally, median furrow deep; postero-lateral longitudinal rows, absent, branchial transverse rows, absent but two indistinct small longitudinal rows of granules with setae present. Eyestalks stout not projecting beyond exorbital angle. Upper orbital border: sinuous, bordered by small tubercular granules. Lower orbital margin studded with wide tubercular granules along entire length. Central region of epistome straight. Third maxilliped, merus subequal to ischium. Male cheliped with palm inflated, outer face appearing smooth, with longitudinal, feebly granular, ridge on lower third, inner face with dense setae, covering scattered granules; immovable finger slightly deflexed, cutting edge without a larger tooth, granulate from base to beginning of spooned tip; cutting edge

Chaenostoma punctulatus Miers, 1884

(Figs 40, 41)

Macrophthalmus (*Chaenostoma*) *punctulatus* Miers, 1884: 237, pl. 25 fig. a; Tesch 1915: 187; Snelling 1959: 70; Davie 2002: 352; Ng *et al.* 2008: 237 (list); Morgan & Jones 1991: 494; Poore 2004: 496, fig. 156b; Davie 2011: 242, colour picture.

Macrophthalmus (*Mopsocarcinus*) *punctulatus* — Barnes 1967: 229, pl. 3(b), fig. 10.

Material Examined. QM-W5166, ♂ (8.8 × 6.4 mm), QM-W5174, ♂ (9.6 × 7.1 mm), QM-W5280, QM-W5285, ♂ (9.9 × 6.8 mm), Serpentine Ck, SE Qld, 27°24'S, 153°7'E, B. Campbell *et al.*, Aug.–Sept. 1972. QM-W5246, QM-W5271, 2 ♀ (5.5 × 4.2, 4.8 × 3.6 mm), ♂ (5.8 × 4.6 mm), Jacksons Ck, SE Qld, 27°23'S, 153°5'E, B. Campbell *et al.*, Sept.–Oct. 1972. QM-W5295, ♂ (6.9 × 5.0 mm), Juno Pt., mouth of Serpentine Ck, SE Qld, 27°24'S, 153°7'E, B. Campbell *et al.*, 13.12.1972. QM-W15551, 2 ♀ (6.3 × 5.5, 5.1 × 3.9 mm), ♂ (6.3 × 5.0 mm), QM-W15569, 3 ♂ (6.5 × 4.6, 6.3 × 4.3, 5.8 × 4.3 mm), 2 ♀ (6.4 × 4.5, 4.5 × 3.2 mm), Bulwer I., near boat ramp, Brisbane R. mth, SE Qld, 27°25'S, 153°8'5" E, J.W. Short, J. Johnson, P. Lawless, 12.07.1988. QM-W15571, Fishermen Is., Brisbane R. Mouth, SE Qld, 27°22' 5"S, 153°10'E, J.W. Short, J. Johnson, P. Lawless, 12.07.1988. QM-W15528, ♂ (10.7 × 8.0 mm), QM-W15550, 3 ♂ (10.8 × 8.0, 10.5 × 7.8, 9.5 × 7.0 mm), 2 ovig. ♀ (10.5 × 7.7, 8.2 × 6.3 mm), ♀ (8.6 × 6.2 mm), Boggy Ck., nr walk bridge to BP refinery, Myrtle town, SE Qld, 27°24' 5"S, 153°8'E, J.W. Short, J. Johnson, P. Lawless, 12.07.1988. QM-W23894, 2 ♂ (11.2 × 8.3, 9.5 × 7.1 mm), Boggy Ck, Myrtle town, SE Qld, 27°24'S, 153°8'E, P. Davie, J.W. Short, 29.07.1997. QM-W24035, 2 ♂ (9.8 × 7.3, 7.6 × 5.5 mm), Fisherman I., nr mth of Brisbane R, Moreton Bay, SE Qld, 27°22'S, 153°10'E, P. Davie, 02.06.1998, sandy mud, upper shore. QM-W5300, 4 specs, Moon Ck., Fraser I., SE Qld, 25°11'S, 153°4'E, P. Davie, R. Timmins, 21.07.1975. QM-W5304, ♂ (5.0 × 3.3 mm), Pulgul Ck., Hervey Bay, SE Qld, 25°19'S, 152°54'E, P. Davie, R. Timmins, 23.07.1975. QM-W5307, 2 ♀ (7.7 × 5.1, 5.8 × 4.2 mm), QM-W5329, ♀ (6.6 × 4.8 mm), Mary R., Nth Head, Hervey Bay, SE Qld, 25°26'S, 152°56'E, P. Davie, R. Timmins, 25.07.1975. QM-W5366, ♂ (7.9 × 5.7 mm), Moon Ck., Fraser I., SE Qld, 25°11'S, 153°4'E, R. Timmins, 21.07.1975. QM-W5369, ♂ (6.6 × 5.1 mm), ovig. ♀ (7.9 × 6.6 mm), Pulgul Ck. mth, S. of Urangan, Hervey Bay, SE Qld, 25°19'S, 152°54'E, P. Davie, 25.07.1975. QM-W5384, QM-W5386, 6 ♂ (7.9 × 5.8, 7.5 × 5.8, 7.2 × 5.6, 6.6 × 5.6, 6.0 × 4.0, 7.4 × 5.6 mm), QM-W6400, 13 specs, mouth of Pulgul Ck., S. of Urangan, Hervey Bay, SE Qld, 25°19'S, 152°54'E,

of dactylus with large quadrangular tooth in distal third, distally denticulate. Merus lacking horny ridge on inner margin; inner, outer and upper surfaces with longitudinal rows of large tubercular granules; dense setae concealing most or all of surface. Upper margins of meri of ambulatory legs with long setae.

Remarks. *Chaenostoma boscii* was most likely originally described from the Red Sea. Its identity has been considered relatively unproblematic, though the recent discovery of a sister species, *C. lisae* Poupin & Bouchard, 2010, from Mayotte Island in the western Indian Ocean, and the possibility of other new cryptic species being described from the western Pacific, indicates a neotype designation will be important as part of future revisionary work. Barnes (1967: 227) gave a redescription of Australian specimens. McNeill (1968) recorded *Macrophthalmus quadratus* A. Milne-Edwards, 1873, from Low Isles and Three Isles, in north Queensland, and noted that it was common on intertidal sandy reef flats of a number of islands along the tropical Queensland coast. Barnes (1970: 242) examined McNeill's material of *M. quadratus*, lodged in the Natural History Museum, and reidentified it as *M. boscii*. Indeed, McNeill's figures (1968: pl. 2, figs 2–4) clearly agree with the present material of *C. boscii*.

Habitat. Typically, short shallow burrows in well drained sandy and slightly muddy substrates on lower tidal levels of coastal marine habitats. Commonly burrows in algal turf on rocky shores, and on beach rock on coral cays. Litulo (2005) gave an interesting account of the life history of this species based on his study area in southern Mozambique.

Distribution. Broad Indo-west Pacific range: east Africa to Japan, and south to Solomon Islands, Santa Cruz Islands, New Caledonia and Fiji. In Australia: known to extend along the eastern coast, and on the Great Barrier Reef, southward from Cooktown to Caloundra, Moreton Bay (Barnes 1967; present study); and from Monte Bello I., WA (Barnes 1970).

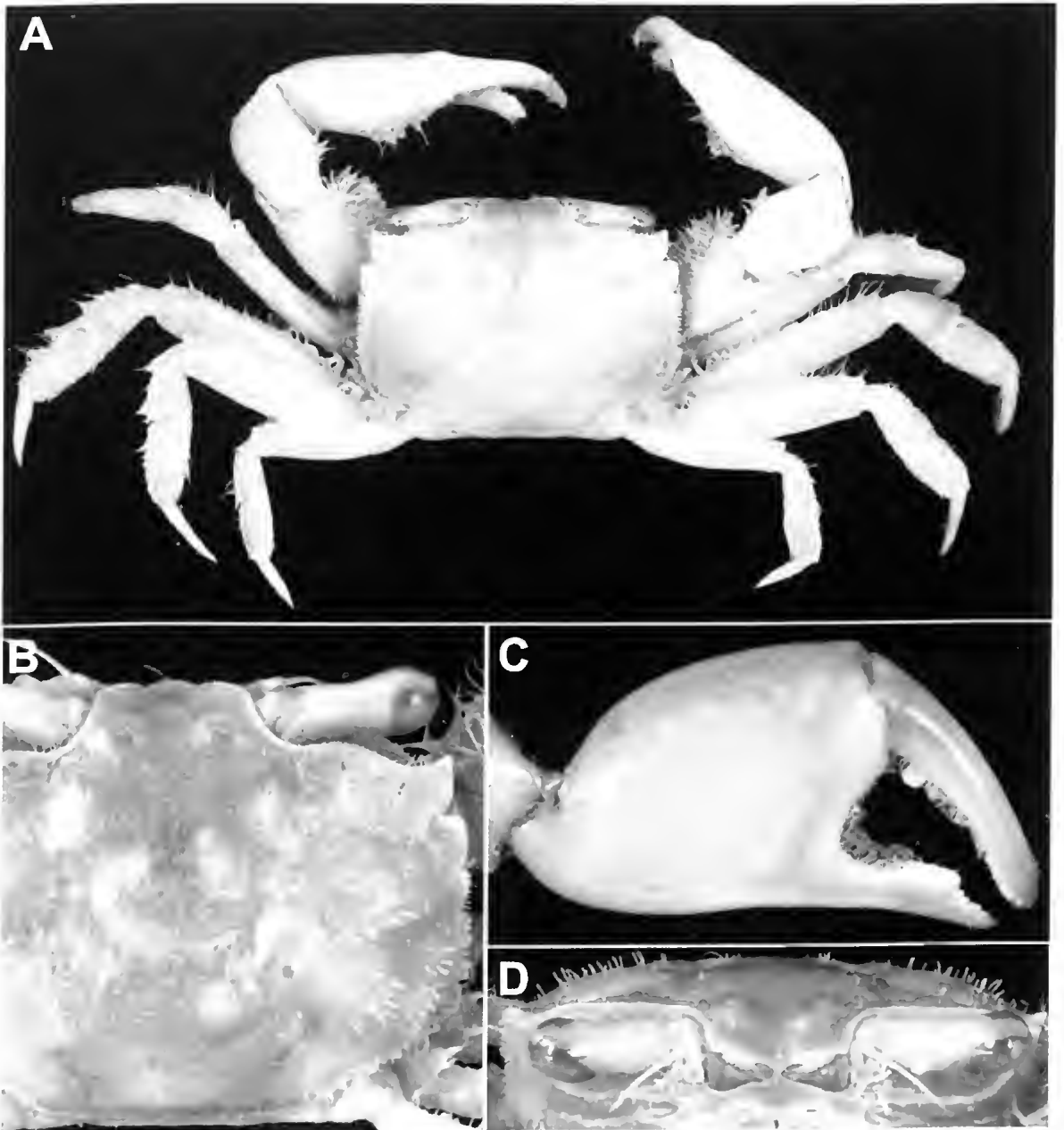


FIG. 40. *Chaenostoma punctulatus* Miers, 1884. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits. A, B, C: QM-W15550, ♂ (10.8 × 8.0 mm), Boggy Ck., SE Qld; D, QM-W19271, ♂ (9.8 × 7.6 mm), Hervey Bay, SE Qld.



FIG. 41. *Chaenostoma punctulatus* Miers, 1884. A, third maxillipeds; B, male abdomen; C, female abdomen. A: QM-W15550, ♂ (10.8 × 8.0 mm), Boggy Ck., SE Qld; B, QM-W19271, ♂ (9.8 × 7.6 mm), Hervey Bay, SE Qld; C, QM-W5369, ovig. ♀ (7.9 × 6.6 mm), Hervey Bay, SE Qld.

P. Davie, R. Timmins, 23.07.1975. QM-W19271, ♂ (9.8 × 7.6 mm), Urangan boat harbour, Hervey Bay, SE Qld, 25°17'S, 152°54'E, P. Davie, J.W. Short, A. Humpherys, 25.10.1993, mudflat, under stones. QM-W6901, 10.5 km from mouth of Calliope R. Qld, 23°55'S, 151°11'E, P. Saenger, Oct. 1976. QM-W11926, ♂ (6.9 × 5.3 mm), QM-W11927, ovig. ♀ (4.5 × 3.8 mm), Triangular I., Shoalwater Bay Qld, 22°23'S, 150°31'E, M.R.L. Survey, Sep. 1981. QM-W29109, 2 ♂ (9.5 × 6.9; 10.8 × 7.9 mm), ovig. ♀ (10.4 × 7.6 mm), juv. ♀ (5.9 × 4.6 mm), Port Augusta, Spencer Gulf, SA, around mangroves, October 2008, Sabine Dittman. WAM-C1051, ♂ (14.0 × 10.4 mm), Canning Bridge, Swan River, Perth, WA, P.N. Chalmer, 3.01.1973.

Diagnosis. Carapace smooth; 3 anterolateral teeth, first triangular, pointed forward, not projecting beyond second tooth, second broad, third indistinct; greatest breadth situated between third antero-lateral teeth; branchial and lateral margins setose; postero-lateral longitudinal rows absent; branchial transverse rows absent. Eystalks not projecting beyond exorbital angle. Front: anterior margin bilobed, median furrow present. Lower orbital margin with tubercular granules along entire length. Upper orbital border finely granular, sinuous. Epistome medially convex. Third maxilliped merus and ischium subequal. Male cheliped with palm relatively swollen, slightly longer than broad; inner surface setose, outer surface with longitudinal ridge subparallel with lower margin. Dactylus slightly deflexed, with small,

strong, quadrate tooth proximally on cutting margin. Index with broad differentiated tooth. Merus: horny ridge on inner margin absent; setae concealing most or all of surface. Upper margins of meri of ambulatory legs with long setae.

Remarks. I have examined a range of specimens from Queensland to Perth, and all agree precisely with Miers' original illustration (1884: pl. 25 A); the claw in particular is identical. Barnes (2010) says that *Chaenostoma* claws have a 'differentiated tooth only on the dactylus', however Miers' figure of *Macrophthalmus punctulatus* clearly shows a very strong tooth on the index as well. The figure of the chela (Fig. 10a) in Barnes's 1967 Australian paper is a little unusual, and I think it can be assumed that the index finger of that specimen was damaged, with the cutting margin unusually serrated, and the tip broken off. Also, Barnes illustration of the abdomen of *M. punctulatus* (fig. 10c) is somewhat broader and more divergent than is typical, and perhaps was a problem of parallax; his figure of the male G1 (fig. 10d) is also drawn at an unusual angle, and needs care in interpreting. Most importantly, the degree of protruberance of the epistome is unreliable. For *Chaenostoma*, Barnes (2010) states: 'central region of posterior border of epistome straight'. This is true for *C. boscii* but not for *C. punctulatus*. Sometimes some smaller specimens of *C. punctulatus* can appear almost straight if viewed from the front, but certainly not from dorsal view. Joseph Poupin (in lit.) has examined the holotype male (5.65 × 7.32 mm) in the Natural History Museum, London (BM 1881.31), originally described from Port Jackson. He confirmed, 'The central region of epistome is distinctly convex, with a short longitudinal carina beneath, as for Australian specimens. Other characters, aspect of carapace, chelae, and ambulatory legs are also similar to your Australian specimens.'

Habitat. A very common component of the upper shore zone mangrove fauna of southern

Queensland. Typically burrows into firm mud or muddy-sand, and often around rocks.

Distribution. An Australian endemic: originally described from Port Jackson, it is found along the central eastern coast from about Shoalwater Bay, at least to Sydney; it also has a patchy southern distribution being known from St Vincent Gulf, SA, and from southwestern WA (Swan River, Perth; Albany). Interestingly, it was never previously recorded from South Australia, despite the fauna of these coasts being well studied and thoroughly reported by Hale (1927). It seems that the upper part of Spencer Gulf and Gulf St Vincent, have relatively warmer pockets of water that allow the survival of otherwise more subtropical or warm temperate species. The presence of ovigerous females indicates a self-sustaining population is present. Of course, this is also one of the last areas of muddy habitat before reaching the southwestern coast of Western Australia, where *Chaenostoma punctulatus* has also only relatively recently been reported (Morgan & Jones 1991: 494).

Tasmanoplax Barnes, 1967

Macrophthalmus (Tasmanoplax) Barnes, 1967: 204.
Tasmanoplax – Davie 2009: 817; McLay 2010: 495.

Type species: *Macrophthalmus latifrons* Haswell, 1882, by original designation; gender feminine).

Diagnosis. Medium-sized, to about 30 mm carapace breadth; carapace 1.5–1.6 times wider than long; lateral margins subparallel, large, broad-based, subrectangular anterolateral teeth; branchial regions with transverse and longitudinal rows of granules; ocular peduncles elongate but not projecting beyond lateral carapace margins, longer than breadth of front; front moderately narrow, not constricted between bases of ocular peduncles, breadth c. 0.2 times distance between exorbital angles; central region of posterior border of epistome with large convexity; ischium of third maxilliped c.1.2 times length of merus. Male chelipeds lacking stridulatory apparatus; fingers

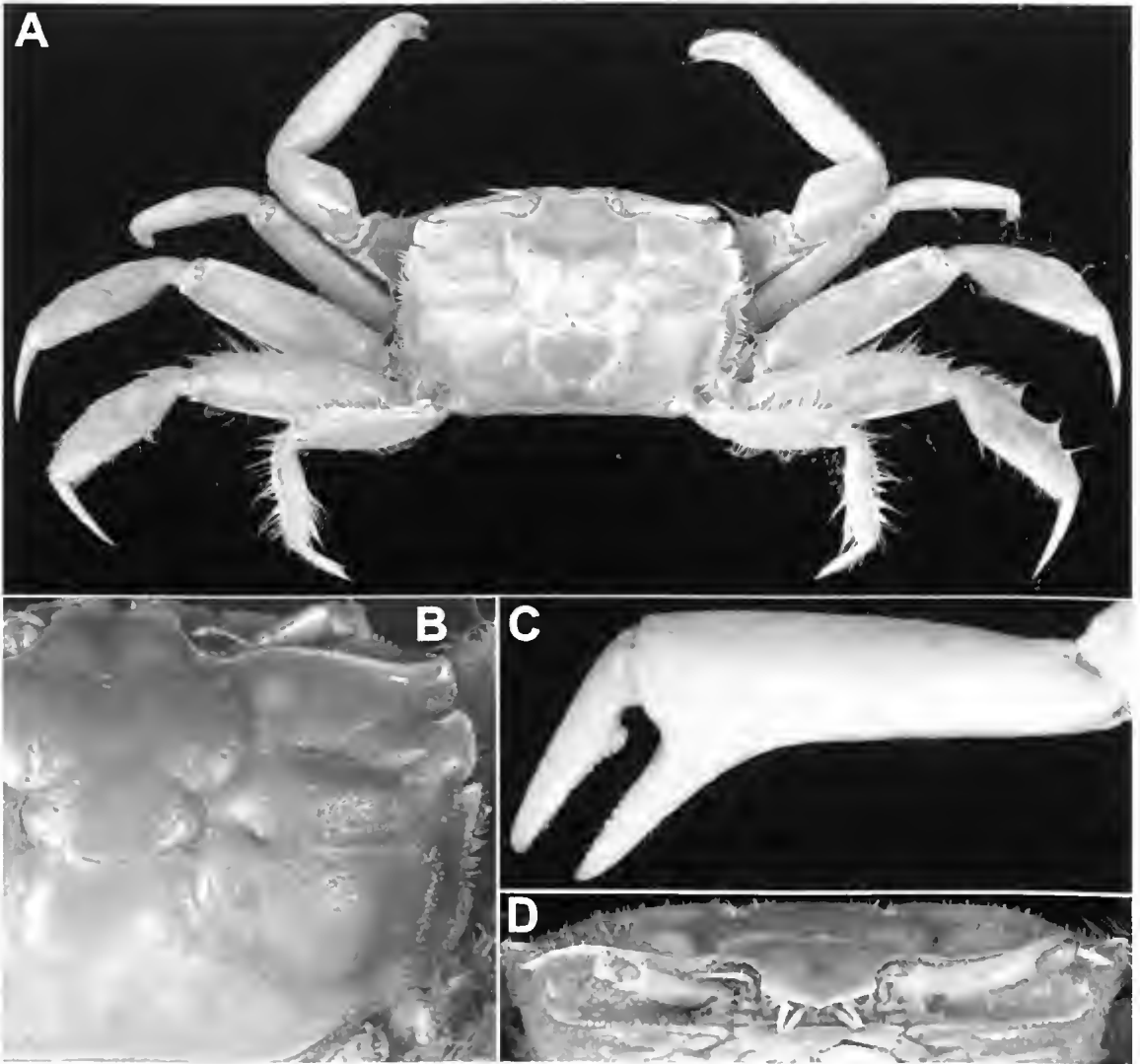


FIG. 42. *Tasmanoplax latifrons* Haswell, 1882. A, dorsal view; B, enlarged view of carapace; C, frontal view of chela; D, frontal margin and orbits. A, B: QM-W19925, ♂ (19.8 × 12.2 mm) Hunter River, NSW; C, D: QM-W19927, ♂ (24.1 × 15.3 mm), Hunter River, NSW.

of chelae elongate with index deflexed; differentiated tooth on dactylus only. Intertidal in soft sediments. (After Barnes 2010).

Remarks. Davie (2009) and McLay *et al.* (2010) have both indicated that *Tasmanoplax* Barnes, 1967, should be recognised as a distinct genus in its own right.

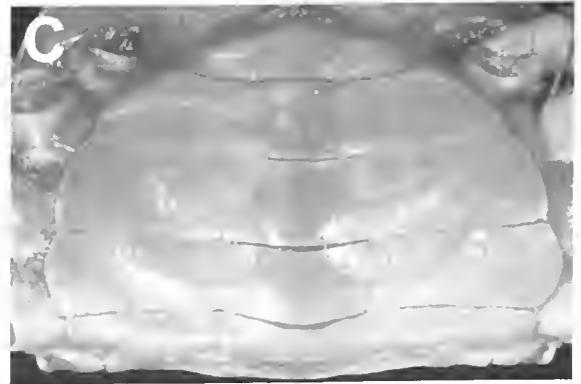
Tasmanoplax latifrons Haswell, 1882

(Figs 42, 43)

Macrophthalmus latifrons Haswell, 1882a: 549: 1882b: 90; Tesch 1915: 189; Poore 2004: 495, fig. 156c, f. *Microphthalmus* [sic] *latifrons* – Fulton & Grant 1906: 19.



FIG. 43. *Tasmanoplax latifrons* Haswell, 1882. A, third maxillipeds; B, male abdomen; C, female abdomen. A: QM-W19927, ♂ (24.1 × 15.3 mm), Hunter River, NSW; B, QM-W19925, ♂ (19.8 × 12.2 mm) Hunter River, NSW; C, QM-W10954, ♀ (22.8 × 15.2 mm), Snug River, SE Tasmania.



Hemiplax latifrons – Etheridge & McCulloch 1916: 13, pls 4, 6; Hale 1927: 186, fig. 187; Tweedie 1941: 25, fig. 10; Griffin 1968: 291.

Tasmanoplax latifrons – McLay, Kitaura & Wada 2010: 496, fig. 5.

Macrophthalmus (Tasmanoplax) latifrons – Barnes 1967: 239, pl. 4a, fig. 13; Ng, *et al.* 2008: 238 (list).

Material Examined. QM-W10954, ♂ (26.7 × 18.0 mm), 2 ♀ (22.8 × 15.2, 21.4 × 14.3 mm), mouth of Snug River, Snug, North West Bay, SE Tasmania, in burrows on mudflats, 25.3.1973, T.M. Walker. QM-W19927, ♂ (24.1 × 15.3 mm), Kooragang I., Hunter River, near Newcastle, NSW, 07.03.94, D.B. Conroy. QM-W19926, 2 ♂ (12.5 × 8.3, 10.9 × 7.3 mm), ♀ (10.7 × 7.0 mm), data as for W19927. QM-W19925, ♂ (19.8 × 12.2 mm) data as for W19927.

Remarks. *Tasmanoplax* is a monotypic genus indigenous to Australia, and *T. latifrons* is the only species of Australian macrophthalamid that has an exclusively temperate distribution. Its range is here considerably extended northwards as a result of recent collections from the Hunter River, near Newcastle, NSW. Previously, this species was known only from Tasmania, South Australia, and central, southern Victoria (Hale 1927; Tweedie 1955; Barnes 1967; Phillips *et al.* 1984). It is surprising that such a comparatively large species has been overlooked for so long in this well collected region so close to Sydney.

Habitat. Found on intertidal mudflats and sea grass beds in Victoria, South Australia and Tasmania (Poore 2004).

Distribution. Southern Australia: from Gulf of St. Vincent, S.A., eastwards to Hunter River, NSW, and Tasmania.

ACKNOWLEDGMENTS

This review has been in progress for a number of years, and as a result there have been numerous colleagues who have provided help and assistance along the way. In particular I would like to thank Andrew Humpherys who gave invaluable help in sorting and identifying field samples and working on an early draft of the paper. Dr Keiji Wada kindly sent comparative material of *M. japonicus* and *M. bauzai*. Collections from the Northern Territory were supplemented with the help of Russell Hanley and Karen Coombes, and Gavin Dally and Sue Horner of the Northern Territory Museum graciously provided access to the collection under their care. Similarly Diana Jones and Andrew Hosie were gracious hosts during my visits to the Western Australian Museum, Perth, and loaned material as needed. Sabina Dittman is thanked for providing me specimens of *C. punctulatus* from South Australia, and D.B. Conroy kindly sent specimens of *T. latifrons* collected from Newcastle. Lisa Pabricks and Maria Bavins assisted with specimen photography and processing of material. This work has also relied heavily on the legacy of work on Australian and Indo-West Pacific *Macrophthalmus* by Dr Richard Barnes, and it has been a privilege to be able to meet, correspond, and publish with him over the last few years. Finally, the Australian Biological Resources Study (ABRS) is gratefully acknowledged for financial support under Grant Nos. 207-50 and 208-72.

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A revision of *Neosesarma* (Crustacea: Brachyura: Sesarmidae) with the description of a new species

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Davie, P.J.F. 2012 02 17. A revision of *Neosesarma* (Crustacea: Decapoda: Sesarmidae) with the description of a new species. *Memoirs of the Queensland Museum – Nature* 56(1): 221–233. Brisbane. ISSN 0079–8835. Accepted 25 November 2011.

ABSTRACT

The Indo-west Pacific mangrove crab genus *Neosesarma* Serène & Soh, 1970, is revised. A new species, *N. hirsutus*, is described from northern Australia. The distribution of *N. rectipectinatum* is extended south to northern Australia and southern Papua. All species can be separated by differences in male claw tuberculation, the length and number of teeth of the pectinated crest on the dorsal surface of the cheliped palm, and the shape of the male first gonopods. □ *Crustacea, Brachyura, Grapsidae, Sesarmidae, mangroves, Indo-West Pacific, new species.*

The present paper is part of an ongoing study of the Sesarminae. Previous papers have dealt with revisions of *Sarmatium* (Davie, 1992) and *Neosarmatium* (Davie, 1994; Rahayu & Davie, 2006), and new species and new records of *Parasesarma* (Davie 1993; Davie & Pabriks 2010); *Metasesarma* and *Geosesarma* (Ng & Davie, 1995); *Perisesarma* (Rahayu & Davie, 2002; Davie, 2003; Davie 2010); *Metaplax* (Davie & Nguyen, 2003); and *Sesarmoides* (Davie & Ng, 2007).

Neosesarma Serène & Soh, 1970, was diagnosed to include a number of Indo-West Pacific species previously included in *Sesarma* (*Sesarma*), viz., *S. gemmiferum* Tweedie, 1936, *S. rectipectinatum* Tweedie, 1950, *S. aequifrons* Rathbun, 1914, and tentatively, *Sesarma laeve* A. Milne-Edwards, 1869. Davie (1994) has shown that *S. aequifrons* is a junior synonym of *S. laeve*, and transferred that species to *Neosarmatium* Serène & Soh, 1970. Collections of sesarmids from northern Australia have revealed the presence of a new species of *Neosesarma* from the Northern Territory, and considerably extend the range of *N. rectipectinatum*.

Abbreviations used in the text are: QM, Queensland Museum, Brisbane; NT, Northern Territory; NHM, Natural History Museum, London; MNHN, Muséum national d'Histoire naturelle, Paris; ZRC, Zoological Reference Collection of the Raffles Museum, National Museum of Singapore.

SESARMIDAE Dana, 1851

Neosesarma Serène & Soh, 1970

Neosesarma Serène & Soh, 1970: 394, 405; Ng *et al.* 2008: 222 (in list).

Type species: *Sesarma gemmiferum* Tweedie, 1936, by original designation. Type locality: Johore Straits, Singapore. Gender neuter.

Diagnosis. Carapace not deeply vaulted; a single acute epibranchial tooth, distinctly separated from exorbital angle by sulcus; anterior frontal margin nearly straight, without well-marked median concavity; antennal peduncle not excluded from orbit; postfrontal lobes subequal in width; not markedly swollen. Male cheliped with a single longitudinal pectinated crest on upper surface of palm separated from inner

margin; a row of regular, more or less conical dactylar tubercles. Posterodistal border of merus of ambulatory legs generally unarmed, but may be denticulate (P2-4 of *N. hirsutus* with 5-8 small spines; P5 with spaced granules).

Species included: *N. gemmiferum* (Tweedie, 1936); *N. hirsutus* sp. nov.; *N. rectipectinatum* (Tweedie, 1950).

KEY TO SPECIES OF *NEOSESARMA*

1. Dactyl of male cheliped with 21-26 tubercles along superior margin; propodus of third walking leg slender, more than 3 times width. *N. hirsutus* sp. nov.
- Dactyl of male cheliped with 6-10 tubercles along superior margin; propodus of third walking leg stouter, less than 3 times width. 2
2. Pectinate crest on upper surface of palm of male cheliped short, consisting of c. 18 horny teeth; dactyl of male cheliped with 9-10 tubercles *N. gemmiferum* (Tweedie, 1936)
- Pectinate crest long, consisting of c. 60 horny teeth; dactyl of male cheliped with 6-9 tubercles along superior margin *N. rectipectinatum* (Tweedie, 1950)

Neosesarma gemmiferum (Tweedie, 1936)

(Figs 1, 2, 6A, B)

Sesarma gemmifera Tweedie, 1936: 58-61, text-fig. 2, pl. 15, fig. 1; 1950: 342, fig. 1d.

Neosesarma gemmiferum – Serène & Soh 1970: 394, 405, pl. 2A, B; Ng *et al.* 2008: 222 (in list).

Material examined. LECTOTYPE (here designated), ♂ (22.3 × 20.3 mm), NHM-1947.11.18.20, Johore Strait, Singapore, mangrove swamps, Oct. 1934, M.W.F. Tweedie. PARALECTOTYPE, ♀ (24.6 × 23.2 mm), NHM-1947.11.18.19, Johore Strait, Singapore, mangrove swamps, Oct. 1934, M.W.F. Tweedie. Other material: MNHN-B21500, 2 ♂ (27.1 × 24.5; 27.1 × 24.7 mm), river at Ama Keng, Singapore, C.L. Soh, 17.11.1965; QM-W25704, ♂ (20.4 × 18.8 mm); ♀ (19.7 × 17.7 mm), Sungei Buloh, Singapore, mangroves, C. Schubart & Sivasothi, 6.08.1999. ZRC-1987.562, ♂ (25.5 × 21.7 mm), Kranji, Singapore, mangroves, Peter Ng, 1983. QM-W14836, ♀ (19.0 × 16.3 mm), end of Lim Chu

Kang Rd, north-western Singapore, mangroves, P. Davie & P. Ng, 06.09.87. QM-W14871, ♂ (17.25 × 16.5 mm), Lim Chu Kang Rd, north-western Singapore, mangroves, P. Davie & P. Ng, 06.09.1987.

Description. Carapace c. 1.1 times broader than long, maximum breadth across exorbital teeth; single epibranchial tooth separated by deep gap; lateral margins slightly convergent posteriorly. Front sharply deflexed, margin finely beaded, almost straight, with only very shallow median emargination. Frontal width c. 0.65 times fronto-orbital width. Post-frontal lobes equal in breadth, median pair placed slightly in advance of lateral pair, rugose anteriorly; laterals bounded anteriorly by low polished granules. Regions: gastric region moderately well defined; low slightly rugose ridge separating urogastric and cardiac regions; protogastric lobe extending forward as a groove, becoming deep and narrow between median postfrontal lobes; cardiac and intestinal regions moderately defined. Carapace with dense covering of curved bristles and longer setae, often irregularly tufted; surface smooth, with scattered punctations. Dense setation extends onto pereopods, except for undersurface of meri of walking legs, lower and inner faces of palm of cheliped, and distally on fingers of chelae.

Chelipeds robust, equal; chela c. 1.7 times dactylus length. Merus with upper border bearing small sub-distal tooth; outer surface covered in transverse squamiform markings, and sparsely scattered setae; inner border expanded and flattened distally, rounded or obtusely angled, margin bluntly denticulate. Palm with single longitudinal pectinate crest of about 18 fine horny teeth, continued each end as granular crest (in female reduced to simple granular crest over entire length); upper two-thirds of outer surface sparsely to coarsely granular, often covered with setae on especially in smaller males, but setae may become sparse in large males and females; lower third and ventral surface without setae, punctate, with some obliquely disposed squamiform markings proximo-ventrally; inner surface coarsely

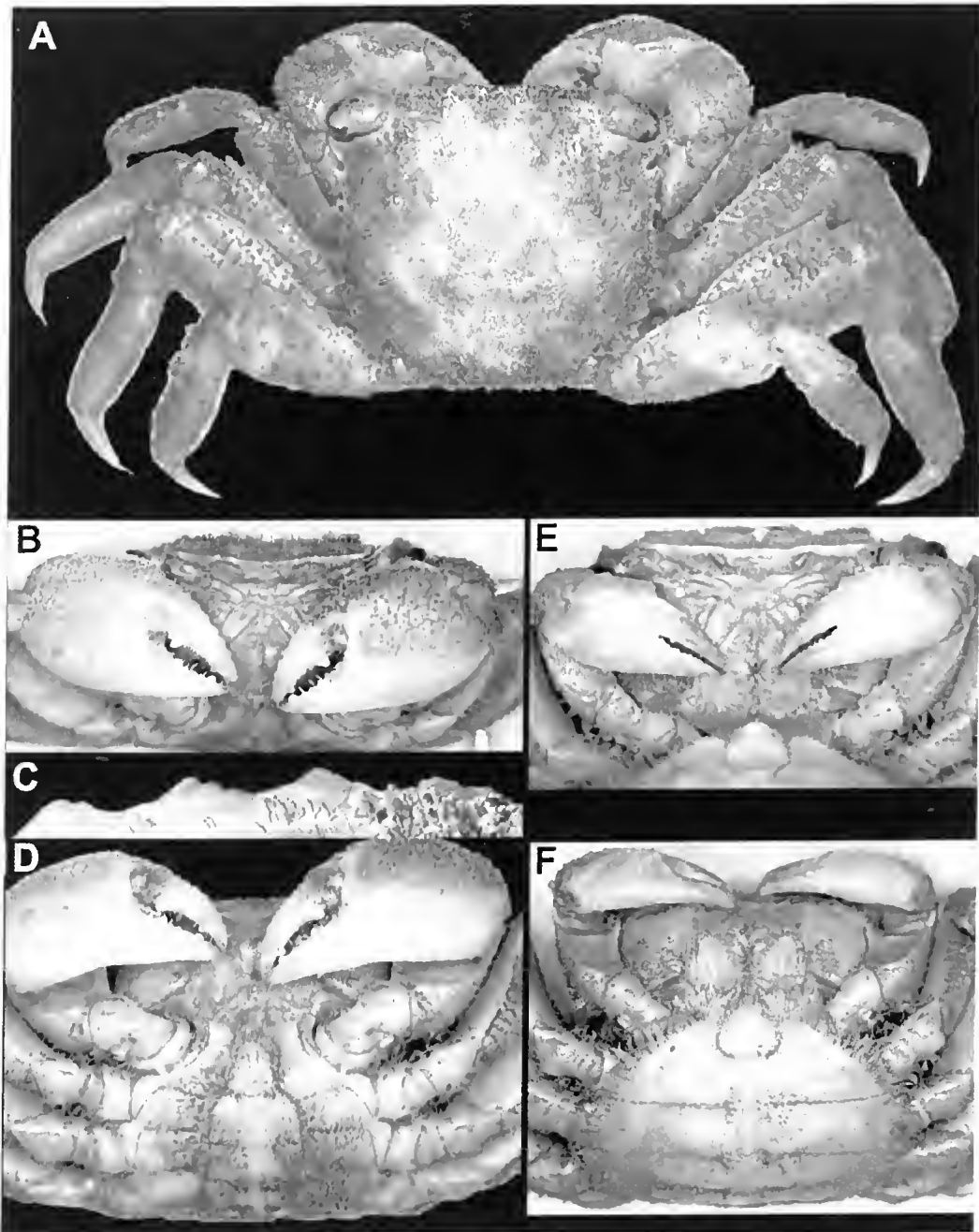


FIG. 1. *Neosesarma gemmiferum* (Tweedie, 1936). A–D: Lectotype male, (NHM-1947.11.18.20); E, F: Paralectotype female (NIM-1947.11.18.19). A, dorsal view; B, frontal view of male carapace and claws; C, magnified lateral view of cheliped dacylar tuberculation; D, sternum and male abdomen; E, frontal view of female carapace and claws; F, female abdomen.

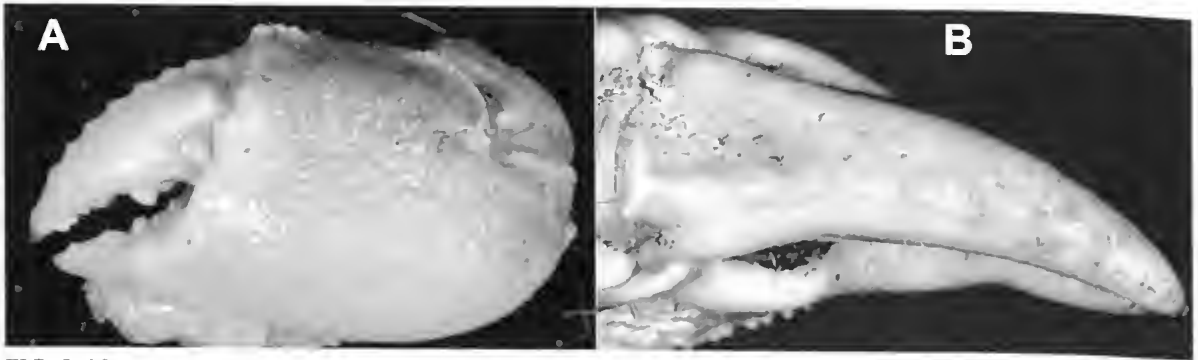


FIG. 2. *Neosesarma gemmiferum* (Tweedie, 1936). ♂ (27.1 × 24.5 mm), MNHN-B21500, Singapore. A, frontal view of male chela; B, dorsal view of dactylar tuberculation of male chela.

granular, granules not extending onto fixed finger. Dactylus slightly incurved, moderate gape between fingers. Upper margin, on mature males, with 9–10 tubercles, distal 2 or 3 small and indistinct; tubercles all isolated, each surrounded at base by raised rim; longitudinally oval in dorsal view, proximal slope longer (Fig. 2); 2 transverse grooves on proximal slope (Fig. 1C). Female chela with 5–6 very small dactylar tubercles, confined to basal half.

Walking legs relatively short; with dense covering of setae; broad meri armed with anterior sub-distal spine. Third leg: merus *c.* 1.9–2.1 times longer than wide; combined length of carpus and propodus slightly longer than merus (*c.* 1.1 times); propodus *c.* 2.9 times longer than wide.

Male abdomen with telson *c.* 1.1 times longer than wide; length 1.1–1.2 times length of penultimate segment; sixth somite *c.* 1.9 times wider than long. Female abdomen with telson deeply sunken into sixth somite. Male G1 stout, but relatively slender; subdistally widened into broad sloping shoulder; apex corneous, somewhat truncated, not divided into lobes.

Colour. '... mainly dark brown with some of the margins and rugosities purplish. The chelae are pale yellowish, and the movable finger is usually marked with some irregular purple blotches.' 'Each tubercle is... surrounded... by a slightly raised reddish rim, the tubercles them-

selves being pale yellow. This contrast in colour ... gives the tubercles the appearance of being ... as gems are set in a ring.' (Tweedie 1936).

Remarks. Males of this species are easily identified by the 9–10 characteristically shaped dactylar tubercles on the claw, and the presence of *c.* 18 horny teeth forming the pectinate crest on the upper surface of the chela (the other three species each have more than 20). The male G1 is also distinctive, but of the other described species, it is most similar to *N. hirsutus* sp. nov. (cf. Fig. 6A, B with 6G–I).

Distribution. Singapore: Johore Strait; Serangoon River. Malaysia: Port Swettenham, Selangor (Tweedie 1936). Kuching, Sarawak (Tweedie 1950).

Habitat. Mangrove associated; in soft muddy areas; log infaunal, and often associated with crevices in trees and fallen logs.

Neosesarma rectipectinatum (Tweedie, 1950)
(Figs 3–5, 6C–F)

Sesarma rectipectinata Tweedie, 1950: 348–50, figs 2d, 4a–d.

Neosesarma rectipectinatum — Serène & Soh 1970: 394, 405 (in list); Ng *et al.* 2008: 222 (in list); Rahayu & Setyadi 2009: 49, 2 colour figs.

Material examined. LECTOTYPE, here designated, ♂ (21.0 × 17.7 mm), NHM-1951.2.15.1–2, Labuan, Borneo, G. Nunong, August 1938. PARALECTOTYPE, ♀ (23.8 × 20.8 mm), same data as lectotype. Other Material: QM-W25696, ♀ (18.1 × 16.2 mm), ♂ (21.4 × 19.0; 19.6 ×

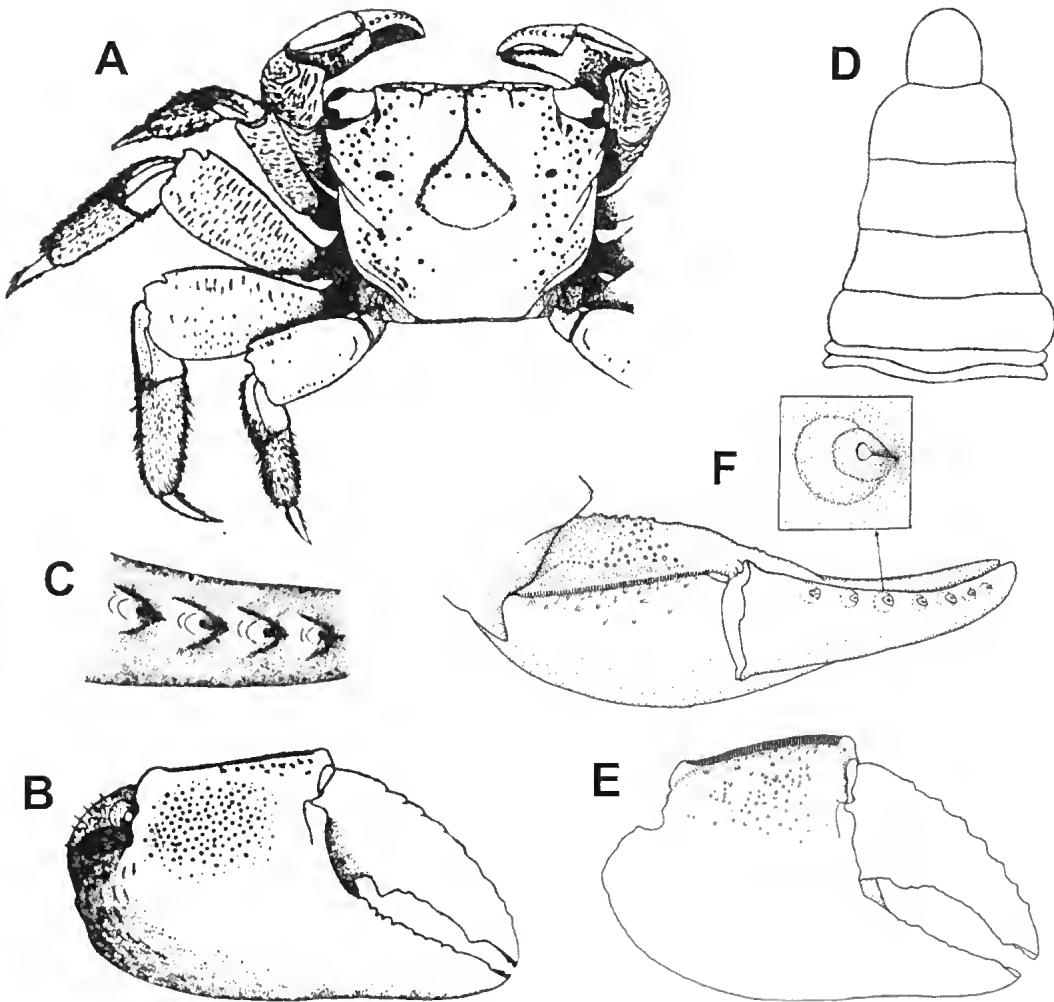


FIG. 3. *Neosesarma rectipectinatum* (Tweedie, 1950). Original figures (Tweedie 1950: fig. 4a-d) of syntype σ from Labuan: A, dorsal view of carpace and legs; B, chela; C, dactylar tubercles in dorsal view; D, male abdomen. QMW4575, holotype σ (28.3 \times 23.7 mm), Trinity Inlet, Cairns NEQ. E, male chela; F, dorsal view of chela showing dactylar tuberculation with magnified view of an individual tubercle.

17.3 mm), Mandai, Singapore, mangroves, C. Schubart, 29.12.1999. QM-W25702, σ (24.3 \times 21.3 mm), Mandai, Singapore, mangroves, C. Schubart, 15.10.1999. QM-W29110, f (20.9 \times 17.9 mm), Mandai Swamp, Singapore, D. Maitland, Nov. 1984. QM-W24932, σ (15.4 \times 13.7 mm); f (21 \times 18.6 mm), West Ajkwa River mouth near P.T. Freeport Cargo Dock area, southern Irian Jaya, Indonesia, mangroves, J.R. Hanley, 09.07.1998, 4 $^{\circ}$ 49.2'S, 136 $^{\circ}$ 51.3'E. ZRC-2003.0476, σ

(18.9 \times 15.9; 13.6 \times 10.5; 14 \times 11.7 mm); f (18.1 \times 15.3; 11.8 \times 10.4 mm), Ajkwa, Irian Jaya, Indonesia, stn A41/I/B, D.L. Rahayu, 16.10.2001. ZRC-2003.0474, σ (19.3 \times 16.6 mm); f (22.2 \times 19.2; 15 \times 14.1 mm), Irian Jaya, Timika, Sungai Tipoeka, Indonesia, D.L. Rahayu, 29.03.2002. ZRC-2003.0477, σ (20.4 \times 17.6 mm); f (8.6 \times 7.3 mm), Kamora, Irian Jaya, Indonesia, stn Kam3/II/A1, D.L. Rahayu, 21.10.2002. QM-W29111, σ (21 \times 18.5 mm), Portside, G. Setyadi, 29.07.1999.

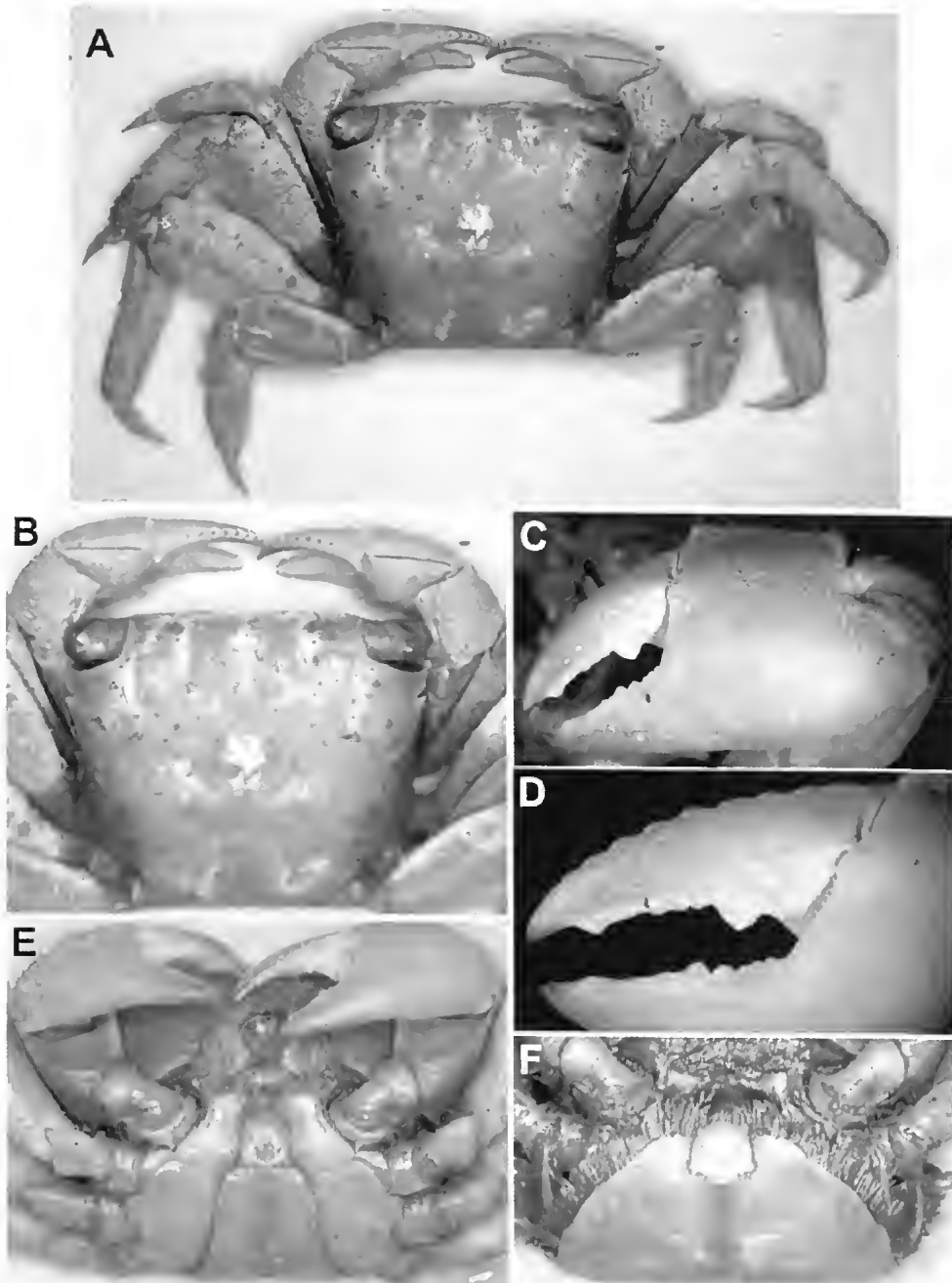


FIG. 4. *Neosesarma rectipectinatum* (Tweedie, 1950). A–E, lectotype ♂ (21.0 × 17.7 mm), NHM 1951.2.15.1-2, Labuan, Borneo; F, paralectotype ♀ (23.8 × 20.8 mm), NHM1951.2.15.1-2, same data as lectotype. A, dorsal view; B, magnified view of carapace; C, chela; D, magnified view of fingers of chela; E, sternum and male abdomen; F, female abdomen.

QM-W8834, ♂ (12.1 × 10.8 mm), Field Island, mouth of South Alligator R., NT, inside rotting log, *Rhizophora* zone, fairly wet, soft muddy substrate (Acc. no. K189), 01.06.2009, P. Davie. QM-W20682, ♂ (18.6 × 16.4 mm), side branch of Norman R., near Karumba, Gulf of Carpentaria, NW Qld, mangroves, mid-estuary, mud, salinity 15 ppt, P. Davie & J. Short. QM-W16747, ♂ (14.1 × 12.3; 9.9 × 9.7; 11.3 × 8.9; 9.1 × 8.0 mm), Fishbone Creek, eastern Cape York, Qld, P. Davie & J. Short, 25.10.1990, 10°57'S, 142°28'E. QM-W16755, ♂ (22 × 19.1 mm), Muddy Bay, Cape York, Qld, P. Davie & J. Short, 26.10.1990, 10°44'S, 142°33'E. QM-W16835, ♂ (8.3 × 7.5 mm), Harmer Creek, eastern Cape York, Qld, Australia, P. Davie & J. Short, 31.10.1990. QM-W16823, ♂ (20.6 × 18.0 mm), Harmer Creek north, eastern Cape York, Qld, P. Davie & J. Short, 31.10.1990, 11°50'S, 142°57'E. QM-W18173, ♀ (22.5 × 19.1; 21.7 × 18.4; 24.7 × 20.8; 16.1 × 10.4 mm); ♂ (23.4 × 20.1 mm), Starke R., inlet just south of mouth, FN Qld, *Rhizophora*, log infauna, salinity 35 ppt, P. Davie & J. Short, 11.11.1992, 14°47.9'S, 145°01.3'E. QM-W4575, ♂ (28.3 × 23.7 mm), Trinity Inlet, Cairns NEQ, 3.12.1974, R. Timmins. QM-W29112, ♂ (20.3 × 17.1 mm), some data as holotype. QM-W4580, ♂ (26.5 × 22.6 mm), Southern tip of Admiralty Island, Trinity Inlet, Cairns, NEQ, 12.12.1974, R. Timmins. QM-W8816, ♂ (21.2 × 18.0 mm), Trinity Inlet, Cairns NEQ, 8.12.1975, R. Timmins. QM-W8814, ♂ (18.4 × 15.8 mm), Trinity Inlet, Cairns NEQ, 14.12.1975, R. Timmins. QM-W8817, ♀ (22.7 × 19.9 mm), Barron R., Cairns NEQ, 11.12.1975, R. Timmins.

Description. Carapace. *c.* 1.14–1.2 times broader than long, maximum carapace breadth across exorbital teeth; single small epibranchial tooth. Lateral margins shallowly concave, slightly convergent posteriorly. Front sharply deflexed with broad, shallow, median concavity. Frontal width 0.63–0.65 times fronto-orbital width. Post-frontal lobes equal in breadth, varying from low and rounded to moderately prominent; mesogastric, cardiac and intestinal regions faintly defined; varying sized clumps of short setae most numerous on hepatic and branchial regions, and anterior margins of post-frontal lobes.

Chelipeds robust, equal; chela length 1.65–2.0 times chela height (former ratio for 28.3 mm male, latter for 20.3 mm male); 1.65–1.75 times dactylus length. Merus with upper border ending in a small, sharp spine; outer surface

covered in transverse rows of squamiform granules; inner border expanded and flattened distally. Dactylus curved, robust, leaving only small gape; upper margin with 6–9 prominent tubercles, lowest distally; proximal slope slightly the longer, rounded, formed by three step like 'wrinkles'; distal slope straight or slightly convex; each tubercle with a disto-medial longitudinal keel, with distinct sulcus on inner side (Fig. 3F). Outer face of palm with band of small tubercles posterior to dactylus, rest of outer surface and dactylus itself smooth, except for proximal row of granules on ventral border. Superior face of palm of male with single pectinate crest of 56–63 tall teeth; border behind pectinate crest composed of irregular prominent tubercles which extend in band down inner face. Inner face smooth behind dactylus and onto immovable finger. Female chela less massive, no gape between fingers; length twice height; dactylar tubercles less prominent than males, as few as five, and characteristic shape less defined; pectinate crest of palm reduced to row *c.* 50 granules continuous to carpus articulation.

Walking legs relatively short; meri broad, armed with anterior sub-distal spine; propodi and distal part of carpi covered with mat of setae. Third leg: merus 1.7–2.0 times longer than wide (north Queensland specimens tend to appear a little broader than other samples); propodus *c.* 2.5 times longer than wide, 1.4–1.8 times dactyl length; combined length of carpus and propodus slightly longer than merus (*c.* 1.1 times).

Male abdomen relatively narrow; telson 1.1–1.36 times longer than wide, length 1.1–1.2 times length of sixth somite; sixth somite 1.9–2.1 times wider than long. Female abdomen with telson deeply sunken into sixth somite. Male G1 stout, but relatively slender; not widened subdistally, but distally broadly tapering towards tip; apex corneous, produced as a tubular elongation, not conspicuously divided into lobes (Fig. 6C–F).

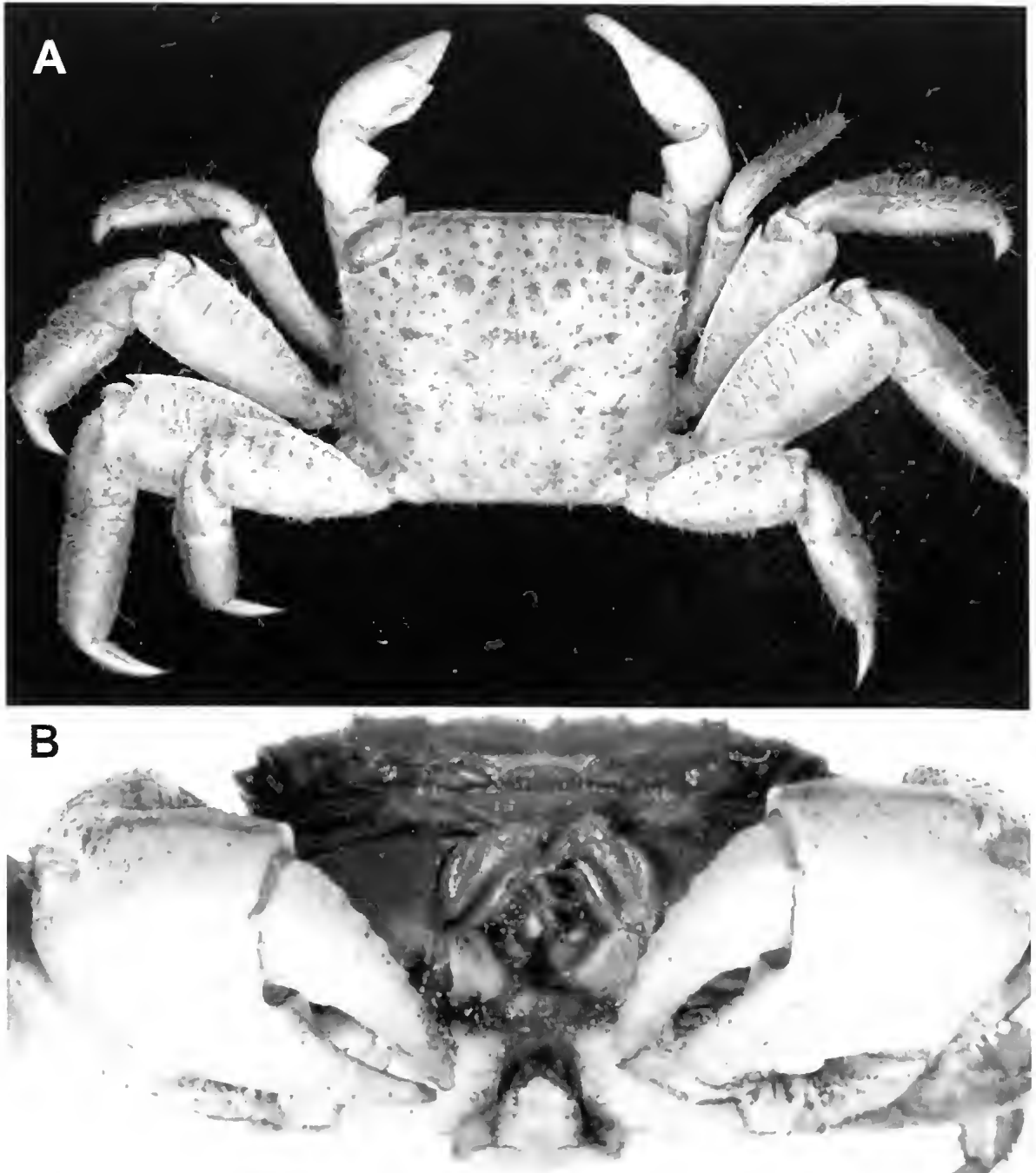


FIG. 5. *Neosesarma rectipectinatum* (Tweedie, 1950): A, dorsal view (QM-W8816, ♂ (21.2 × 18.0 mm), Trinity Inlet, Cairns NEQ). B, frontal view (QMW4575, holotype ♂ (28.3 × 23.7 mm), Trinity Inlet, Cairns NEQ).

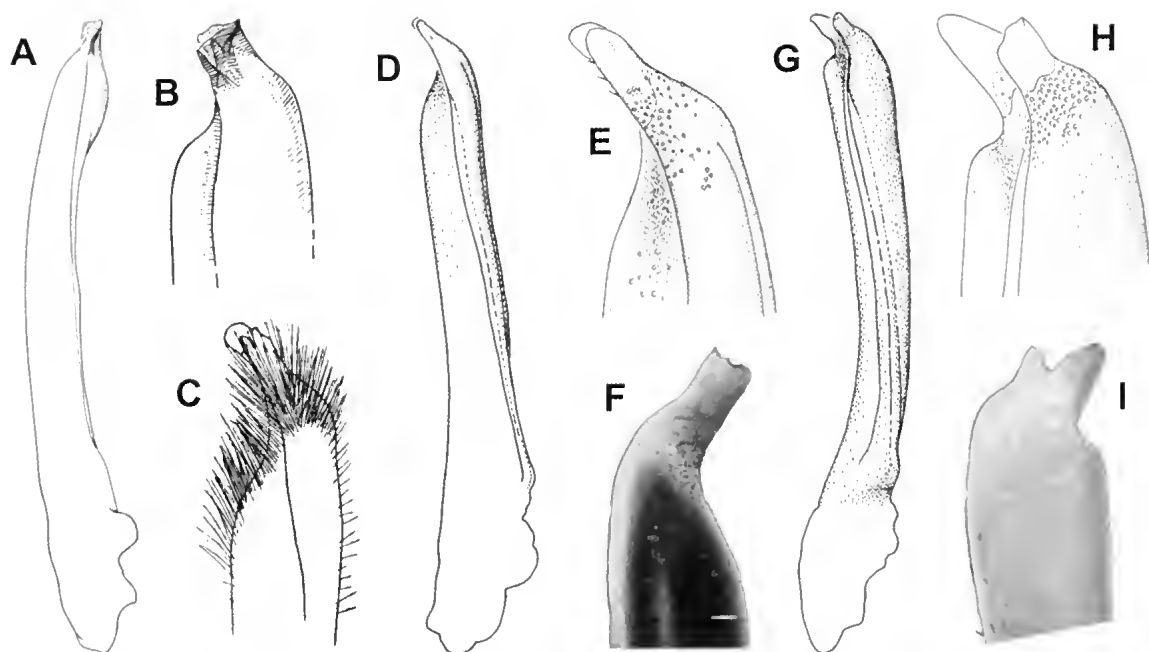


FIG. 6. Male first gonopods: A, B, *Neosesarma gemmiferum* (Tweedie, 1936); C, *N. rectipectinatum* (Tweedie, 1950) (after Tweedie 1950: fig. 2d, but reversed for better comparison); D–F, *N. rectipectinatum* (QM4575, (28.3 × 23.7 mm), Trinity Inlet, Cairns); G–I, *N. hirsutus* sp. nov. (QM-W8786, holotype (23.8 × 21.0 mm), Field Island, Kakadu, NT).

Colour (Australian specimens). Carapace and dorsal surface of legs a dirty purple-grey with lighter mottling. Chelae, and ventral surfaces of legs and sternum yellow-cream. Frontal strip and epistome sometimes deep purple, otherwise as for rest of the carapace. Also see colour photographs in Rahayu & Setyadi (2009: 49).

Remarks. *Neosesarma rectipectinatum* is characterised by having the pectinate crest on the top of the cheliped palm consisting of c. 60 horny teeth, and running for most of the length of the palm. The Australian and Papuan samples examined differ slightly from the Singapore specimens by the dactylar tubercles being slightly more prominent, and often the most proximal is obsolete so that the tubercle count is 6–8 versus 8–9 in the Singapore specimens and the type series. Nevertheless, the shape of the tubercles is essentially the same, albeit that the

proximal slope is formed by more distinct step like ‘wrinkles’ in the Australian specimens (probably because the tubercles are slightly higher). The corneous distal slope is however identical in its peculiar ‘keeled’ shape, with its inner sulcus (Fig. 3F). Because the specimens from across the distributional range are otherwise virtually identical, including the shape of the male gonopods, I must conclude that the observed small differences in tuberculation are simply due to regional variation and do not amount to a real specific level difference.

Distribution. Labuan (type locality); Singapore (present material); southern coast of Papua in south-eastern Indonesia. In Australia from about Cairns, in northeastern Queensland west into the Gulf of Carpentaria, and the Northern Territory.

Habitat. Mangrove associated. Typically in soft muddy areas within the forest. Log infaunal, and often associated with crevices in trees and fallen logs. In burrows, and on open substrate among *Avicennia* pneumatophores. Also in burrows in steep eroding banks. Favours zones inundated by most tides; lower and middle estuary.

Neosesarma hirsutus sp. nov.

(Figs 6G–I, 7, 8)

Material examined. HOLOTYPE: QM-W8786, ♂ (23.8 × 21.0 mm), Field I., Kakadu, NT, May, 1979, P. Davie (Acc. No. K171). PARATYPES: QM-W8830, 3 ♂ (25.7 × 22.3; 26.4 × 23.6; 24.2 × 21.3 mm), 2 ♀ (29.5 × 26.3; 21.0 × 18.7 mm), Darwaronga River, Northern Territory, *Rhizophora* zone, mudbank, 10.10.1975, D. Grace. QM-W8831, ♂ (29.2 × 25.4 mm), Djigagila Ck., Nilingombi Islands, NT, 4.9.1975, D. Grace. QM-W8793, ♂ (30.0 × 26.4 mm), ♀ (21.4 × 19.4 mm), Woolen R., NT, 1 km upstream of mouth of Creek B, *Rhizophora*/mudbank, D. Grace, 16.9.1975, D. Grace. QM-W8832, ♀ (27.7 × 24.2 mm), Darwaronga River, NT, 7.5 km from mouth, east bank, *Rhizophora*/*Ceriops* zone, 9.10.1975, D. Grace. QM-W29113, ♀ (23.7 × 20.9 mm), Field I., Kakadu, NT, from crevices in dead trunk about 2 m above mud in seaward *Rhizophora* zone, 3.05.1979, P. Davie (Acc. No. K171). QM-W8787, ♂ (23.8 × 21.3 mm), Field Island, Kakadu, NT, May, 1979, P. Davie (Acc. No. K181). QM-W8833, ♀ (18.3 × 16.5 mm), western bank of mouth of West Alligator River, Kakadu National Park, from rotten log in *Rhizophora* zone, 4.05.1979, P. Davie (Acc. No. K227). NTM Cr001684, ovig. ♀ (25.0 × 22.5 mm), 12°34.2'S, 130°56.3'E, NT, mangrove, 17.05.1984, J.R. Hanley. QM-W19161, M (19.9 × 17.5 mm), Middle Arm, Darwin, Australia, edge of channel in *Sonneratia*/*Rhizophora* zone, tidally inundated, salinity 32 ppt (low tide), P. Davie, 29.06.1982, 12°32'S, 130°50'E.

Description. Carapace. Fronto-orbital width 1.1–1.15 times greater than mid-line carapace length. Single epibranchial tooth protruding slightly more than external orbital angles and forming greatest carapace width. Lateral margins concave, slightly convergent posteriorly. Front sharply deflexed with broad median concavity, lateral angles acute. Frontal width c. 0.65 times fronto-orbital width, and 2.9–3.3

times maximum orbital length. Post-frontal lobes equal in breadth, outer pair with finely granulate crest on leading edge, median pair rounded but also bearing less prominent crest slightly behind that of outer pair. Carapaces of holotype and specimens QM-W8787 and W8833 have dense clumps of short dark setae giving 'Clistocoeloma-like' appearance (Fig. 7A), but in other specimens setae not so thick as to obscure carapace surface (e.g. Fig. 8).

Chelipeds relatively robust, fronto-orbital width 1.3–1.6 times chela length, more in immature males (× 2.1 for 12.1 mm specimens). Chela length 1.6–1.8 times dactyl length. Single longitudinal pectinate crest of 33–41 horny teeth; becoming raised granular rim proximally and distally. In females and immature males, boundaries of pectinate crest not clearly defined and consequently 'pectinations' may number over fifty, although they are low and often almost granulate. Outer surface of palm and fixed finger smooth or only microscopically granular. Dorsal surface with short setae either side of pectinated crest, may be thick or sparse. Inner surface with large granules evenly scattered, except on fixed finger and near gape; granules slightly larger centrally. Dactyl only slightly recurved, gape between fingers small. Upper margin with 21–26 tubercles, decreasing in size distally, but all obvious; evenly spaced, distal slope longer. Female chela much smaller than male; only slightly granular on inner face; dactylar tubercles also smaller; becoming indistinct distally.

Walking legs. Dorsal surfaces of all legs covered with clumps of short setae especially either side of propodus, and to a lesser extent, carpus. Inside surfaces of merus smooth and naked. Third ambulatory leg a little less than twice width of carapace (c. 1.8–1.9); merus 1.9–2.2 times longer than wide, 2.0–2.4 times length of dactyl; propodus elongated and slender, c. 3.4 times longer than wide, 1.4–1.7 times length of dactyl. Posterodistal border of merus of ambulatory legs 1–3 denticulate (5–8 small spines) reminiscent of *Nanosesarma*.

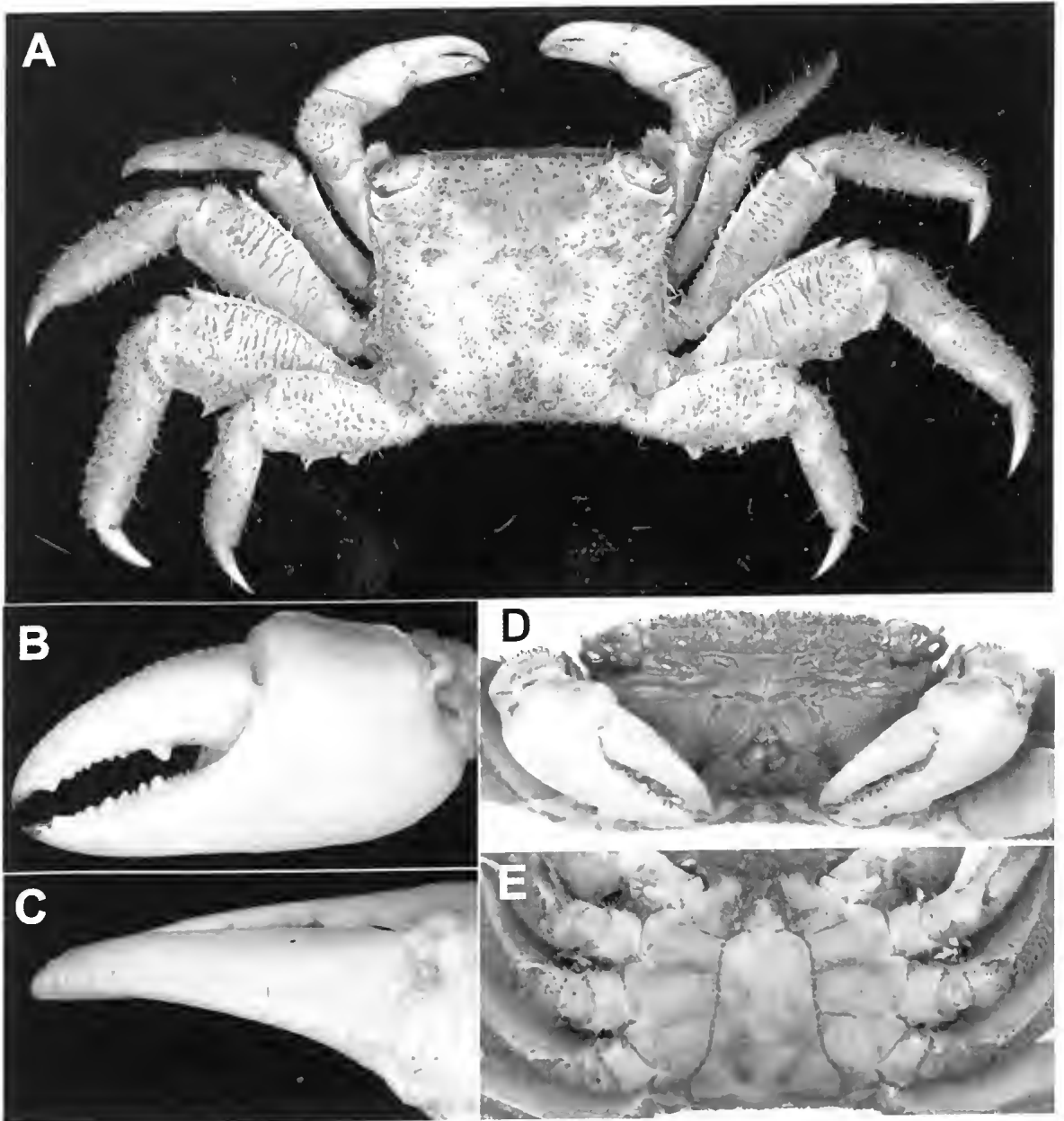


FIG. 7. *Neosesarma hirsutus* sp. nov.: A, dorsal view; B, left chela; C, dorsal view of dactylar tuberculation of chela; D, frontal view; E, sternum and abdomen. A, D, E, QM-W8786, holotype ♂ (23.8 × 21.0 mm), Field Island, Kakadu, NT; B, C, QM-W8793, ♂ (30.0 × 26.4 mm), Woolen R., NT



FIG. 8. Dorsal view of *Neosesarma hirsutus* sp. nov., ♂ (29.2 × 25.4 mm) QM-W8831, Djigagila Ck., Nilingombi Islands, NT

Fourth ambulatory leg without spines but with spaced granules; spines most prominent on smaller individuals.

Male abdomen relatively narrow. Telson 1.1–1.3 times longer than wide; length 1.0–1.2 times length of penultimate segment, but longer in smallest immature male (1.33). Penultimate segment *c.* 1.8 times wider than long. Female abdomen with telson deeply sunken into sixth somite. Male G1 stout, but relatively slender; prominent subdistal shoulder on inner face; apex corneous, somewhat truncated, divided into two deep lobes, inner being slightly broader and more projecting.

Remarks. *Neosesarma hirsutus* sp. nov. is immediately separable from all other *Neosesarma* species by the slightly more slender walking legs (propodus of third walking leg more than 3 times width), but most significantly by the much more numerous dorsal dactylar tubercles (21–26 versus a maximum of

10 in other species). Its closest relative, certainly in terms of the shape of the male G1, is *N. gemmiferum* (compare Figs 6A, B and 6G–I). It can also be separated from that species by the length of the pectinate crest on upper surface of the palm of the male cheliped – in *N. gemmiferum* it is relatively shorter, consisting of *c.* 18 horny teeth, whereas in *N. hirsutus* there are 33–41 horny teeth. Finally, the first 3 pairs of walking legs of *N. hirsutus* are unusual in having the posterodistal border of the merus with 5–8 small spines.

Etymology. Name refers to the thick clumps of setae that cover the carapace and legs, and that makes identification easy, at least within the north Australian region where they occur. It is used here as a noun in apposition.

Habitat. Typically occurs in crevices in logs or trees, or in dead timber up to a height of at least 2 m, in seaward mangrove zones, or on creek banks; typically in high saline areas. Appears to

prefer soft mudbanks in *Rhizophora*, or *Sonneratia/Rhizophora* and *Rhizophora/Ceriops* mangrove forest associations.

Distribution. Presently only known from the Northern Territory, Australia.

ACKNOWLEDGEMENTS

I am grateful to Dr Peter K.L. Ng and the staff of the Zoological Reference Collection (ZRC), National University of Singapore, are especially thanked allowing me access to the specimens in their care, and in particular the types of Michael Tweedie. Dr Dwi Listyo Rahayu of the Research Centre for Oceanography, Indonesian Institute of Sciences (LIPI), kindly sent specimens of *Neosesarma rectipectinatum* from Papua to be included in this study. Lisa Pabricks and Maria Bavins kindly assisted with specimen photography and processing of material. The Australian Biological Resources Study (ABRS) is gratefully acknowledged for financial support under Grant Nos. 207-50 and 208-72.

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IN MEMORIUM
Patricia Mather (née Kott)
(1925–2012)



Dr Patricia Mather at her desk in the old Queensland Museum in Fortitude Valley in February 1981.

Patricia Mather AO, PhD, DSc, DSc (hon. causa), FAI Biol, FMLS, passed away at the age of 86, on the evening of 4 January 2012 following a period of illness.

Charming, passionate, fierce, tenacious, obstinate, argumentative, persistent, productive, industrious, focussed, reliable, loyal, devoted (to a cause, and to her family), and a wonderful hostess – these are just some of the epithets that have been applied when mentioning the name ‘Patricia Mather’.

Born in Perth, Western Australia, on 12 December 1925, Patricia was the eldest of four daughters to Max Kott, lawyer, and Lillian May, née Lucas. She attended St Hilda’s Church of England Girl’s School, Mosman, where her indomitable spirit led her to excel in all facets of school life – not only did she have a sharp intellect, but she was also a fine sportswoman. By all accounts, she had a very happy childhood, and despite living most of her life in Brisbane, Queensland, it was clear to



Patricia in the field in 1949, at the beginning of her career in marine biology (Courtesy of Patricia Mather).

those who knew her, that Perth always held a special place in her heart.

She entered the University of Western Australia in 1943, graduating with First Class Honours in 1948, for a thesis on the taxonomy of two families of Polychaeta (Nereidae and Eunicidae), which was the basis for her first scientific paper in 1951. As an undergraduate she undertook holiday jobs with her fellow student Ron Kenny, sorting plankton for Keith Sheard at the CSIR (later to become CSIRO) Fisheries Division labs. This background, along with the recommendation of her thesis examiner, the renowned Professor W. Dakin (of *Australian Seashores* fame), led her to be offered a research position as plankton officer in the Fisheries Division of CSIR in Cronulla, NSW. Thus, shortly after her 23rd birthday, on New Years Day, 1948, she arrived in eastern Australia to begin a professional career that would continue until her death, 64 years later.

Building on the earlier milestone works on plankton by Dakin & Colefax, and on pelagic tunicates by Harold Thompson, Patricia's major contribution from this time was the station lists that documented the New South Wales coastal zooplankton up to the mid 1950s. She also

developed a spinning device (still in use) to divide plankton-net catches into reliable subsamples. It was Harold Thompson, then chief of the Division, who suggested that she might like to begin taxonomic studies of the Ascidiacea 'in her spare time'. This would become her life's work.

At the end of 1949, Patricia won a CSIRO overseas studentship to spend a term at University College (London University) undertaking a course on experimental biology of invertebrates (with G.P. Wells), and several months studying the ascidian collections in what was then the British Museum (Natural History). This was followed by 20 months at the prestigious Laboratory of the Marine Biological Association of the United Kingdom at Plymouth, where she did pioneering work on spontaneous contractions of solitary ascidians, as well as taxonomic studies on English Channel ascidians. This was a very happy period for her, and she regaled many a social occasion throughout her life with stories of her escapades. Although returning to Australia in late 1951 to resume her position as plankton officer in Cronulla, she became increasingly consumed by her fascination with the Ascidiacea.

In 1955 she married Wharton B. Mather, a geneticist and lecturer in the Zoology Department of the University of Queensland, and this brought her CSIRO career to an end and heralded the move to Brisbane and a period dominated by family. During the next decade she alternated having children with periods of research on ascidians funded by small Science and Industry Endowment Fund grants (1955, 1957) and a Commonwealth Graduate Student Award (1961–62) that led to her PhD degree from the University of Queensland, but which terminated with the birth of her third son. By 1963, she had already established herself internationally as an authority on ascidians, and despite her still young family, Patricia returned to full time work, as a Research Fellow in the University of Queensland funded by Personal Service Contracts (1965–1968) from the United States National Museum of Natural History (Smithsonian Institution) to work on the American national collections. From this she was to produce an important monograph on Antarctic ascidians, a major work for which Patricia received a Doctorate of Science from the University of Western Australia (1970). With these contracts finished, in 1969 she obtained the first of many subsequent grants from the Australian Research Grants Committee. At this time, 'soft money' from research grants and consultancies was relatively uncommon, and such funding for so long (1963–1973) was a testament to Patricia's research productivity. More importantly it made it possible to employ a loyal daily housekeeper who helped run the household, the children, and the two Labrador dogs.

However, in 1973, with her three children now schoolboys, Patricia started to look for more career stability, and where better for a taxonomist, than at the local Queensland Museum. The problem was that the only available vacancy was for a Curator of Mollusca. The Director of the time, the young palaeontologist, Alan Bartholomai, recalls

Patricia's confident response to the news, 'Molluscs? No problem, I can do molluscs'. Despite some understandable misgivings, the Museum didn't want to lose someone of Patricia's stature and experience, especially at a time when they were growing rapidly, and for the first time in their history establishing a stable of first-class taxonomists across a range of disciplines. Two years later the position of Curator of Higher Invertebrates was created especially for Patricia, and she was finally given *carte blanche* to pursue her full-time study of ascidians. She wasted no time in turning a modest holding of ascidians into the most significant collection of Australian and Indo-West Pacific species in the world. Under her stewardship the collection, grew to over 10,000 specimens encompassing more than 800 species, representing all the families and genera known from intertidal and shallow, sub-tidal habitats, including coral reefs (especially her beloved Heron Island!). Always a hard task-master, she was not easy to work for, and for many years there was to be a steady succession of technical assistants coming and going. One memorable story concerned a handsome, tall, young man, of whom Patricia seemed particularly pleased, except that he used to have frequent short periods of sick leave. One morning Pat stormed into work holding a shop-catalogue in which appeared numerous pictures of her moon-lighting assistant as a male-model! Patricia loudly proclaimed, 'that's it, from now on I am only going to employ ugly technicians!' Nevertheless she was genuinely fond of many of her assistants, and was to count some as long-time friends.

During her years at the Museum she worked hard and published prolifically. She continued to raise her international profile by working visits to leading museums and marine laboratories in Europe and the US, including spending several months over two successive years as a visiting research fellow in the University of the South Pacific. These were also the years of productive collaboration with Professor Cliff Hawkins of the University of

Queensland (who was investigating the inorganic chemistry of the Ascidiacea); and with botanists and cell biologists of Sydney University studying the newly discovered *Prochloron*/ascidian symbioses. Patricia discovered some 20 of these associations, as well as describing the means by which the *Prochloron* is passed on to subsequent generations. She always published her research under her maiden name, Patricia Kott, reserving 'Mather' for ancillary publishing activities. Overall she produced over 130 published works across the broad spectrum of her interests, however undoubtedly the work she was most proud of was her major monograph on the 'Australian Ascidiacea' (published in four parts between 1985 and 2001).

She also formed a deep love of museums, and threw herself into many of the diverse range of activities demanded of a curator. She was always a strong advocate of the role of museums in documenting and interpreting the natural world, and the need for proper funding of taxonomic research in Australia. In her latter years she continued to lobby governments to establish a 'National Institute of Taxonomy', which she believed was a vital step in reversing the ever worsening 'taxonomic impediment' in Australia. She often repeated the simple truth that 'taxonomy is the integrative basis of biology', and bemoaned the fact that many museums appear to be eschewing the support of taxonomic research, and changing their emphases from science to user-pays consultancies and popular entertainment.

Patricia was fiercely loyal to the Queensland Museum and everything it represented or aspired to become – even at times when she perceived it might be heading in a direction she did not support. It was not in her nature to hold back on her opinions, and while certain senior managers might have shown the scars of battle, few ever questioned her passion or commitment to the Museum. Her vision was for a respected and venerable institution, built on the authority that arises out of a strong record of evidence-based research on world class

collections – a vision that continues to drive us all. Pat was also passionate in her efforts to communicate knowledge from scientific research to influence politicians and decision-makers towards the protection of our natural resources. Indeed, during the 1970s, in her roles as Secretary and President of the Great Barrier Reef Committee, Pat played a significant part in the 'Save the Barrier Reef' conservation campaign that was to forever prevent oil drilling in Great Barrier Reef waters. She also played a vital role in drafting the initial Bill for an Act for the Great Barrier Reef that would eventually lead to the creation of the GBR Management Authority.

Required to officially retire in 1990 (ironically non-compulsory retirement was to be introduced into the Queensland Public Service only a short time later), she was immediately made an Honorary Research Associate and allowed to maintain her office. She continued to come to work as if nothing had happened for the next 21 years – it was often humourously remarked that she had a better record of attendance than most of the paid staff. Indeed Patricia lived for her work, first and foremost, and could not imagine a life without it. For much of this time she also continued to win grant money to keep a full time research assistant employed to assist her. Of the 396 species she described whilst at the Museum, 275 were described following her retirement! Also, rather typically, once she could no longer avoid it, she took the bull-by-the-horns and became proficient with basic personal computing and email. She had rebuked her younger colleagues vociferously for many years about always having their eyes glued to their monitors instead of their microscopes, but by then she was grateful for their ready help to get her out of trouble!

Some major accolades followed on closely after her retirement, including a Queensland Museum Medal (1991), the Australian Marine Science Association (AMSA) Jubilee Prize (1992), and an Officer in the Order of Australia (1992).

While Patricia enjoyed robust good health for most of her life, she had also been a heavy



A proud Dr Mather at the unveiling of 'Patricia Mather Place' at the new Queensland Biosciences Precinct at Boggo Road, Dutton Park in April 2011.

smoker. In her inimitable style, when she was in her early sixties she just simply stopped smoking. No fuss, just her iron will. Unfortunately, although it was some years later before it became evident, there had been significant damage to her lungs. As the years progressed she struggled more and more to breathe. In an attempt to keep her disease at bay, she actively took up walking all over the steep terrain of the suburb of Spring Hill where she lived, and would swim many lengths of her small pool, even on the coldest days in winter. Such was her nature. In late 2009 she succumbed to a very serious bout of double pneumonia, and hovered close to death for some weeks, however she had not finished her work at the Museum, and although it took many months, and she was no longer allowed to drive, eventually she was back in her beloved office. As a small concession to what she had gone through, she now only came four days a week, and a little later in the morning than she used to!

Always a great admirer of Charles Darwin, she once said that her view of biology was best summed up in Darwin's words from the last paragraph of the *Origin of Species* – 'there is grandeur in this view of life ... that from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved'.

Qualifications and awards

- Officer of the Order of Australia (1992)
- Bachelor of Science with first class honours (UWA, 1948)
- Doctor of Philosophy (UQld, 1962)
- Doctor of Science (UWA, 1970)
- Doctor of Science honoris causa (UQld, 1990)
- Elected Fellow of the Australian Institute of Biology (1989)
- Foreign Member of the Linnean Society London (2001)

- Elected Life Member of the Australian Coral Reef Society (1985)
- Winner of the Australian Marine Science Association Jubilee Prize (1992)
- Winner of the Queensland Museum Medal (1991)
- Winner of two Whitley Awards for the best book on science history ('Time for a Museum'. The History of the Queensland Museum, 1986), and as co-editor with the late Isobel Bennett, for the best natural history book ('The Coral Reef Handbook', 1993).
- Reef Committee Heron Island Research Station Board (1970–1980)
- Member of the Lizard Island Research Station Board of Consultants (1976–1979)
- A number of editorial roles such as the University of Queensland Research Committee's 'Research' (1969, 1971), the Queensland Museum 'National Estate in the Moreton-Wide-Bay Burnett' (1975, 1976), the Queensland Museum's 'The Small Museum' (1979, 1984), and more recently, the subject editor for Ascidiacea at the online taxonomic journal *Zootaxa* (2001–2010).

Contributions to science policy, infrastructure for research funding, and conservation biology

- Marine Research Allocations Advisory Committee (MST 1986–1987)
- Australian Research Council's Biological Panel (1988–1992)
- Australian Biological Resources Study Advisory Committee (1989–1994)
- Hon. Secretary (1966–74), and subsequently President, of the Great Barrier Reef Committee (1976–1977)
- Foundation member of the Great Barrier Reef Marine Park Authority Consultative Committee (1976–85)
- Organising committee and co-convenor of the Second International Coral Reef Symposium (1973)
- Councillor and a member of the Executive Committee Australian Conservation Foundation (1972–1973)
- Member of the Australian Academy of Science, Fauna Standing Committee (1973–1980), and its successor, the Australian Academy National Committee for Animal and Veterinary Science – Fauna Subcommittee (1981–1996), participating in the successful establishment of the Australian Biological Resources Study
- Member of the Board and Executive of the University of Queensland and Great Barrier

Taxonomic milestones

- 98 papers on taxonomy, biogeography, or ecology of marine invertebrate, mostly ascidians, and especially the 1,424 pages of the Australian Ascidiacea (Parts 1–4), published in the *Memoirs of the Queensland Museum*.
- Discovered more than three-quarters (585) of the 726 species of ascidians now known from Australia (about 25% of the estimated world diversity), with 462 species being newly described by her.
- Described 15 new genera and 5 new families.
- Developed a collection of specimens of ascidians from almost nothing, when she started, to more than ten thousand specimens and over 800 species – without doubt one of the most comprehensive and best curated ascidian collections in the world.

Her self-confessed most significant achievements

- The Great Barrier Reef Committee's significant contribution to the proceedings of the Royal Commissions on Oil Drilling in the Great Barrier Reef, ensuring that objective evidence on the Reef's structure and biology was put before the Commissions
- Drafting the initial Bill for an Act for the Great Barrier Reef, which subsequently formed the basis for legislation leading to the existence of the Great Barrier Reef Marine Park Authority.

- Serving on the Ministerial Biodiversity Advisory Committee to the Federal Minister of the Environment on science policy in Australia.
- Having a street named 'Patricia Mather Place', in the Biosciences Precinct at Dutton Park, alongside two other Queensland science luminaries, Dr Joe Baker and Dr Peter Doherty.

'What am I most proud of? I have described 500 of the 700 species of ascidians now known from Australia — I suppose I'm quite proud of that. And I'm really proud of my three sons.'

NAMES CREATED TO HONOUR PATRICIA MATHER (NEE KOTT)

Tunicata

- Pycnoclavella kottae* (Millar, 1960)
Phallusia kottae (Monniot & Monniot, 1996)
Styela kottae Monniot & Monniot, 1991
Octacnemus kottae Sanamyan & Sanamyan, 2002
Aplidium kottae Brunetti, 2007

Crustacea

- Pericliuenaeus kottae* Bruce, 2005
Pericliuenaeus matherae Bruce, 2005

Arachnida

- Encyocrypta kottae* Raven & Churchill, 1991
Eupograptia kottae Raven, 2009

Chemical

- Kottamide E, a novel alkaloid isolated from *Pycnoclavella kottae*.

Author Citations for Honorifics

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Kurchatov, cruise 11). *Journal of Natural History* 36(3): 305-359.

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- Bruce, A.J. 2005. New species of *Pericliuenaeus* Borradaile (Crustacea: Decapoda: Pontoniinae) from Ashmore Reef, north Western Australia, with remarks on *P. pachydentatus* Bruce, 1969. *Records of the Western Australian Museum* 22(4): 325-342.
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- Raven, R.J. & Churchill, T.B. 1991. A revision of the mygalomorph spider genus *Encyocrypta* Simon in New Caledonia (Araneae Barychelidae). *Memoires du Museum National d'Histoire Naturelle Serie A Zoologie* 149: 31-86.

LIST OF ASCIDIAN TAXA (TUNICATA) DESCRIBED BY PATRICIA KOTT

Families (6)

- Stomozoidae Kott, 1957
 Plurellidae Kott, 1973
 Pycnoclavellidae Kott, 1990
 Protopolyclinidae Kott, 1992
 Ritterellidae Kott, 1992
 Vitrumidae Kott, 2009

Genera (16)

- Stomozoa* Kott, 1957
Adagnesia Kott, 1963
Minostyela Kott, 1969
Protoholozoa Kott, 1969
Monoandrocarpa Kott, 1972
Plurella Kott, 1973
Atriolum Kott, 1983
Microgastra Kott, 1985
Asajirus Kott, 1989
Brevicollus Kott, 1990

Euclavella Kott, 1990
Neodistoma Kott, 1990
Polydistoma Kott, 1990
Anadistoma Kott, 1992
Condominium Kott, 1992
Claudemns Kott, 1998
Clitella Kott, 2001
Salix Kott, 2005
Vitrum Kott, 2009

Species (504)

Ascidia prolata Kott, 1985
Corella halli Kott, 1951
Ascidia thompsoni Kott, 1952
Cnemidocarpa longata (Kott, 1952)
Ecteinascidia flora Kott, 1952
Lissoclinum cupuliferum Kott, 1952
Microcosmus stoloniferus Kott, 1952
Molgula batemani Kott, 1952
Perophora multistigmata Kott, 1952
Polyandrocarpa australiensis Kott, 1952
Polyandrocarpa triggsiensis Kott, 1952
Polycarpa capricornia Kott, 1952
Polycitor searli Kott, 1952
Pyura leenwinia Kott, 1952
Pyura parvispinatus Kott, 1952
Pynra plicata Kott, 1952
Agnezia complicata Kott, 1954
Aplidium antarcticum Kott, 1954
Aplidium punctans (Kott, 1954)
Ascidia plicata Kott, 1954
Cnemidocarpa lobata (Kott, 1954)
Cystodytes tasmanensis Kott, 1954
Leptoclinides kerguelenensis Kott, 1954
Leptoclinides multilobatus Kott, 1954
Molgula kerguelenensis Kott, 1954
Molgula macquariensis Kott, 1954
Molgula spiralis Kott, 1954
Molguloides tennis Kott, 1954
Parengyrioides macquariensis Kott, 1954
Polycitor columna Kott, 1954

Sycozoa tasmanoides Kott, 1954
Synoicum circumvolutum Kott, 1954
Pynra littoralis (Kott, 1956)
Clavelina baudinensis Kott, 1957
Clavelina dagysa Kott, 1957
Distaplia viridis Kott, 1957
Eudistoma arenosum Kott, 1957
Eudistoma globosum Kott, 1957
Eudistoma murrayi (Kott, 1957)
Enhherduania australis Kott, 1957
Monniotus australis (Kott, 1957)
Polycitor longitube Kott, 1957
Polycitor subarborensis Kott, 1957
Polycitor translucida Kott, 1957
Polycitor translucidus Kott, 1957
Pseudodistoma australe Kott, 1957
Pycnoclavella diminuta (Kott, 1957)
Ritterella dispar Kott, 1957
Sigillina fantasiana (Kott, 1957)
Stomozoa murrayi Kott, 1957
Trididemnum aspiculatum Kott, 1957
Didemnum rotnesti Kott, 1962
Leptoclinides coelenteratus (Kott, 1962)
Leptoclinides imperfectus (Kott, 1962)
Polysyncraton circulum Kott, 1962
Polysyncraton discoides Kott, 1962
Polysyncraton orbiculum Kott, 1962
Trididemnum pseudodiplosoma (Kott, 1962)
Trididemnum spiculatum Kott, 1962
Adagnesia opaca Kott, 1963
Aplidium amorplatum Kott, 1963
Aplidium australiense Kott, 1963
Aplidium brevilarvacium Kott, 1963
Aplidium coniferum Kott, 1963
Aplidium jacksoni Kott, 1963
Aplidium opacum Kott, 1963
Aplidium parvum Kott, 1963
Aplidium rubricollum Kott, 1963
Aplidium triggsense Kott, 1963
Placentela areolata Kott, 1963
Polyclinum marsupiale Kott, 1963

In Memorium

- Pseudodiazona claviformis* (Kott, 1963)
Synoicum atopogaster Kott, 1963
Adagnesia antarctica Kott, 1969
Aplidium abyssum Kott, 1969
Caenagnesia schmitti Kott, 1969
Diplosoma antarcticum Kott, 1969
Hypsistozoa obscura Kott, 1969
Minostyela clavata Kott, 1969
Placentela translucida Kott, 1969
Protoholozoa pedunculata Kott, 1969
Pyura tunica Kott, 1969
Synoicum ramulosum Kott, 1969
Synoicum tentaculatum Kott, 1969
Molgula millari Kott, 1971
Aplidium elatum Kott, 1972
Claudeus autipodus (Kott, 1972)
Clavelina mirabilis Kott, 1972
Eugyra moretonensis Kott, 1972
Hypodistoma mirabile (Kott, 1972)
Leptoclinides fungiformis Kott, 1972
Metandrocarpa indica Kott, 1972
Molgula diversa Kott, 1972
Molgula ellistoni Kott, 1972
Molgula rima Kott, 1972
Molgula sphaera Kott, 1972
Pareugyrioides exigua (Kott, 1972)
Placentela ellistoni Kott, 1972
Polyandrocarpa simulans Kott, 1972
Polycitor obeliscus Kott, 1972
Pycnoclavella arenosa Kott, 1972
Pyura scoresbiensis Kott, 1972
Pyura tendata Kott, 1972
Stolonica truncata Kott, 1972
Symplegma arenosa Kott, 1972
Aplidium directum Kott, 1973
Monoandrocarpa plaua Kott, 1973
Plurella elongata Kott, 1973
Aplidium prorum Kott, 1975
Leptoclinides volvus Kott, 1975
Microcosmus planus Kott, 1975
Clavelina pseudobaudinensis (Kott, 1976)
Lissoclinum punctatum Kott, 1977
Trididemnum clinides Kott, 1977
Trididemnum miniatum Kott, 1977
Diplosoma multipapillata Kott, 1980
Trididemnum nubilum Kott, 1980
Trididemnum paracyclops Kott, 1980
Trididemnum strigosum Kott, 1980
Endistoma discederata Kott, 1981
Endistoma vitata Kott, 1981
Lissoclinum pacificense (Kott, 1981)
Didemnum etiolum Kott, 1982
Trididemnum paraclinides Kott, 1982
Atrium robustum Kott, 1983
Trididemnum tegulum Kott, 1984
Adagnesia venusta Kott, 1985
Amphicarpa meridiana Kott, 1985
Amphicarpa nodula Kott, 1985
Ascidia decepta Kott, 1985
Ascidia nereia Kott, 1985
Ascidia occidentalis Kott, 1985
Ascidia parasamea Kott, 1985
Cnemidocarpa aculeata Kott, 1985
Cnemidocarpa completa Kott, 1985
Cnemidocarpa fissa Kott, 1985
Cnemidocarpa intestinata Kott, 1985
Cnemidocarpa tripartita Kott, 1985
Ctenyura tetraplexa Kott, 1985
Ctenyura tortuosa Kott, 1985
Ecteinascidia maxima Kott, 1985
Eugyra mammillata Kott, 1985
Eugyra millimetra Kott, 1985
Metandrocarpa agitata Kott, 1985
Metandrocarpa miniscula Kott, 1985
Microcosmus tuberculatus Kott, 1985
Molgula incidata Kott, 1985
Perophora clavata Kott, 1985
Perophora modificata Kott, 1985
Phallusia barbarica Kott, 1985
Phallusia millari Kott, 1985
Polyandrocarpa sparsa Kott, 1985
Polyandrocarpa wastonia Kott, 1985

- Polyandrocarpa watsonia* Kott, 1985
Polycarpa flava Kott, 1985
Polycarpa intonata Kott, 1985
Polycarpa uota Kott, 1985
Polycarpa papyra Kott, 1985
Polycarpa pleniovata Kott, 1985
Polycarpa stirpes Kott, 1985
Polycarpa tinctorella Kott, 1985
Pyura abradata Kott, 1985
Pyura confragosa Kott, 1985
Pyura crassacapitata Kott, 1985
Pyura isobella Kott, 1985
Pyura navicula Kott, 1985
Pyura scortea Kott, 1985
Pyura tasmanensis Kott, 1985
Pyura viarecta Kott, 1985
Stolonica aluta Kott, 1985
Botryllocarpa elongata Kott, 1990
Brevicollis tuberosus Kott, 1990
Clavelina nigra Kott, 1990
Clavelina oliva Kott, 1990
Clavelina robusta Kott, 1990
Distaplia cuscina Kott, 1990
Distaplia florida Kott, 1990
Distaplia wuriella Kott, 1990
Distaplia pallida Kott, 1990
Distaplia prolifera Kott, 1990
Distaplia racemosa Kott, 1990
Distaplia regina Kott, 1990
Distaplia retinaculata Kott, 1990
Distaplia tokiokai Kott, 1990
Distaplia violetta Kott, 1990
Eucoelium orientalis (Kott, 1990)
Eudistoma anaematuum Kott, 1990
Eudistoma aureum Kott, 1990
Eudistoma bulbatum Kott, 1990
Eudistoma carnosum Kott, 1990
Eudistoma constrictum Kott, 1990
Eudistoma eboreum Kott, 1990
Eudistoma gracilium Kott, 1990
Eudistoma incubitum Kott, 1990
Eudistoma maculosum Kott, 1990
Eudistoma ualun Kott, 1990
Eudistoma microlaruum Kott, 1990
Eudistoma pratulum Kott, 1990
Eudistoma purpureum Kott, 1990
Eudistoma regium Kott, 1990
Eudistoma sabulosum Kott, 1990
Eudistoma superlatum Kott, 1990
Eudistoma tigrum Kott, 1990
Eudistoma tunidum Kott, 1990
Eusystyela grandis Kott, 1990
Neodistoma manumillatum Kott, 1990
Perophora sabulosa Kott, 1990
Polycarpa directa Kott, 1990
Polycarpa kapala Kott, 1990
Polycitor annulus Kott, 1990
Polycitor calamus Kott, 1990
Polycitor cerasus Kott, 1990
Polycitor emergens Kott, 1990
Polycitor nubilus Kott, 1990
Polydistoma fungiforme Kott, 1990
Polyzoa exigua Kott, 1990
Polyzoa nodosa Kott, 1990
Pycnoclavella aurantia Kott, 1990
Pycnoclavella elongata Kott, 1990
Pycnoclavella tabella Kott, 1990
Pyura rapaformis Kott, 1990
Sigillina grandissima Kott, 1990
Stomozoa australiensis Kott, 1990
Stomozoa bellissima Kott, 1990
Sycozoa brevicauda Kott, 1990
Sycozoa cavernosa Kott, 1990
Atadistoma attenuatum Kott, 1992
Aplidiopsis confluata Kott, 1992
Aplidiopsis manumillata Kott, 1992
Aplidiopsis sabulosa Kott, 1992
Aplidium acroporium Kott, 1992
Aplidium bacculum Kott, 1992
Aplidium clivosum Kott, 1992
Aplidium congregatum Kott, 1992
Aplidium distaplium Kott, 1992

- Aplidium filiforme* Kott, 1992
Aplidium fluoescum Kott, 1992
Aplidium gastrolineatum Kott, 1992
Aplidium gelasinum Kott, 1992
Aplidium geminatum Kott, 1992
Aplidium incubatum Kott, 1992
Aplidium inflorescens Kott, 1992
Aplidium lenticulum Kott, 1992
Aplidium lodix Kott, 1992
Aplidium lunacratum Kott, 1992
Aplidium macrolobatum Kott, 1992
Aplidium magnilarvum Kott, 1992
Aplidium minisculum Kott, 1992
Aplidium multilineatum Kott, 1992
Aplidium ornatum Kott, 1992
Aplidium parolineatum Kott, 1992
Aplidium parastigmaticum Kott, 1992
Aplidium petrosum Kott, 1992
Aplidium robustum Kott, 1992
Aplidium rosarium Kott, 1992
Aplidium tabascum Kott, 1992
Cnemidocarpa ampliora Kott, 1992
Cnemidocarpa tribranchiata Kott, 1992
Cystodytes ramosus Kott, 1992
Eulherdmania translucida Kott, 1992
Monniotus radiatus Kott, 1992
Morchellium albidum Kott, 1992
Morchellium pannosum Kott, 1992
Polyandrocarpa colemani Kott, 1992
Polyclinum nudum Kott, 1992
Polyclinum orbitum Kott, 1992
Polyclinum tenuatum Kott, 1992
Polyclinum terranum Kott, 1992
Protoholozoa australiensis Kott, 1992
Pseudodistoma acutum Kott, 1992
Pseudodistoma candens Kott, 1992
Pseudodistoma gracilum Kott, 1992
Pseudodistoma inflatum Kott, 1992
Pseudodistoma oriens Kott, 1992
Pseudodistoma pilatum Kott, 1992
Pseudodistoma pulvinum Kott, 1992
Ritterella compacta Kott, 1992
Ritterella cornuta Kott, 1992
Ritterella multistigmata Kott, 1992
Ritterella papillata Kott, 1992
Ritterella tokiokai Kott, 1992
Syonicum angustum Kott, 1992
Syonicum buccinum Kott, 1992
Syonicum castellatum Kott, 1992
Syonicum chrysanthemum Kott, 1992
Syonicum citrum Kott, 1992
Syonicum concavatum Kott, 1992
Syonicum erectum Kott, 1992
Syonicum longistriatum Kott, 1992
Syonicum obscurum Kott, 1992
Syonicum sacculum Kott, 1992
Syonicum suarenium Kott, 1992
Styela complexa Kott, 1995
Aplidium grisiatum Kott, 1998
Syonicum saxum Kott, 1998
Atriolum bucinum Kott, 2001
Atriolum eversum Kott, 2001
Atriolum lilium Kott, 2001
Atriolum marinense Kott, 2001
Atriolum tubiporum Kott, 2001
Clitella nutricula Kott, 2001
Didemnum arancium Kott, 2001
Didemnum astrum Kott, 2001
Didemnum bicolor Kott, 2001
Didemnum bisectatum Kott, 2001
Didemnum clavum Kott, 2001
Didemnum complexum Kott, 2001
Didemnum crescente Kott, 2001
Didemnum cygnus Kott, 2001
Didemnum delectum Kott, 2001
Didemnum effusium Kott, 2001
Didemnum fragum Kott, 2001
Didemnum herba Kott, 2001
Didemnum inveteratum Kott, 2001
Didemnum jucundum Kott, 2001
Didemnum levitas Kott, 2001
Didemnum linatum Kott, 2001

- Didemnum lissoclinum* Kott, 2001
Didemnum macrosiphonium Kott, 2001
Didemnum mantile Kott, 2001
Didemnum microthoracicum Kott, 2001
Didemnum minisculum Kott, 2001
Didemnum monile Kott, 2001
Didemnum multispirale Kott, 2001
Didemnum oblitum Kott, 2001
Didemnum ossium Kott, 2001
Didemnum parancium Kott, 2001
Didemnum pecten Kott, 2001
Didemnum pellucidum Kott, 2001
Didemnum perplexum Kott, 2001
Didemnum precocinum Kott, 2001
Didemnum scopi Kott, 2001
Didemnum sordidum Kott, 2001
Didemnum spadix Kott, 2001
Didemnum stragulum Kott, 2001
Didemnum sucosum Kott, 2001
Didemnum ternerratum Kott, 2001
Didemnum theca Kott, 2001
Didemnum verdantum Kott, 2001
Didemnum via Kott, 2001
Didemnum vulgare Kott, 2001
Diplosoma velatum Kott, 2001
Leptoclinides aciculus Kott, 2001
Leptoclinides albamaculatus Kott, 2001
Leptoclinides brandi Kott, 2001
Leptoclinides caelestis Kott, 2001
Leptoclinides carduus Kott, 2001
Leptoclinides cavernosus Kott, 2001
Leptoclinides comitus Kott, 2001
Leptoclinides compactus Kott, 2001
Leptoclinides confirmatus Kott, 2001
Leptoclinides constellatus Kott, 2001
Leptoclinides durus Kott, 2001
Leptoclinides echinus Kott, 2001
Leptoclinides erinaceus Kott, 2001
Leptoclinides exiguus Kott, 2001
Leptoclinides levitatus Kott, 2001
Leptoclinides longicollis Kott, 2001
Leptoclinides maculatus Kott, 2001
Leptoclinides magnistellus Kott, 2001
Leptoclinides placidus Kott, 2001
Leptoclinides rigidus Kott, 2001
Leptoclinides seminudus Kott, 2001
Leptoclinides umbrosus Kott, 2001
Leptoclinides variegatus Kott, 2001
Lissoclinum caliginosum Kott, 2001
Lissoclinum concavum Kott, 2001
Lissoclinum conchylidium Kott, 2001
Lissoclinum durable Kott, 2001
Lissoclinum levitum Kott, 2001
Lissoclinum limosum Kott, 2001
Lissoclinum maculatum Kott, 2001
Lissoclinum reginum Kott, 2001
Lissoclinum roseum Kott, 2001
Lissoclinum sente Kott, 2001
Lissoclinum spongium Kott, 2001
Lissoclinum variable Kott, 2001
Polysyncraton dentatum Kott, 2001
Polysyncraton dromide Kott, 2001
Polysyncraton flammeum Kott, 2001
Polysyncraton glaucum Kott, 2001
Polysyncraton infundibulum Kott, 2001
Polysyncraton lodix Kott, 2001
Polysyncraton multiforme Kott, 2001
Polysyncraton oceanium Kott, 2001
Polysyncraton palliolum Kott, 2001
Polysyncraton papyrus Kott, 2001
Polysyncraton pedunculatum Kott, 2001
Polysyncraton pulchrum Kott, 2001
Polysyncraton regulum Kott, 2001
Polysyncraton rica Kott, 2001
Polysyncraton robustum Kott, 2001
Polysyncraton rubitupum Kott, 2001
Polysyncraton scobinum Kott, 2001
Polysyncraton scorteum Kott, 2001
Polysyncraton sideris Kott, 2001
Polysyncraton tasmanense Kott, 2001
Polysyncraton tegetum Kott, 2001
Polysyncraton tenuicutis Kott, 2001

- Trididemnum amiculum* Kott, 2001
Trididemnum caelatum Kott, 2001
Trididemnum cristatum Kott, 2001
Trididemnum crystallinum Kott, 2001
Trididemnum lapidosum Kott, 2001
Trididemnum nobile Kott, 2001
Trididemnum pigmentatum Kott, 2001
Trididemnum spumosum Kott, 2001
Trididemnum tectum Kott, 2001
Trididemnum vermiforme Kott, 2001
Clavelina amplexa Kott, 2002
Didemnum vexillum Kott, 2002
Distaplia cuspidis Kott, 2002
Herdmania fimbriae Kott, 2002
Herdmania mentula Kott, 2002
Leptoclinides complexus Kott, 2002
Botrylloides saccus Kott, 2003
Peroplora longicaulis Kott, 2003
Polyclinum corbis Kott, 2003
Sigillina pulvinus Kott, 2003
Stolonica brevigastra Kott, 2003
Didemnum aratore Kott, 2004
Didemnum asterix Kott, 2004
Didemnum congregatum Kott, 2004
Didemnum coralliforme Kott, 2004
Didemnum diversum Kott, 2004
Didemnum domesticum Kott, 2004
Didemnum farrago Kott, 2004
Didemnum fibriae Kott, 2004
Didemnum lillipution Kott, 2004
Didemnum nanibucciensis Kott, 2004
Didemnum rota Kott, 2004
Didemnum spumante Kott, 2004
Didemnum spumosum Kott, 2004
Didemnum tunulatum Kott, 2004
Didemnum usitatum Kott, 2004
Didemnum vesperi Kott, 2004
Didemnum vestum Kott, 2004
Diplosoma secundum Kott, 2004
Distaplia turboensis Kott, 2004
Leptoclinides cucurbitus Kott, 2004
Leptoclinides decoratus Kott, 2004
Leptoclinides grandistellus Kott, 2004
Leptoclinides prunus Kott, 2004
Leptoclinides tuberculatus Kott, 2004
Lissoclinum coactum Kott, 2004
Lissoclinum diversum Kott, 2004
Lissoclinum lanenum Kott, 2004
Lissoclinum scopulosum Kott, 2004
Lissoclinum stellatum Kott, 2004
Polysyncraton alinguum Kott, 2004
Polysyncraton aruum Kott, 2004
Polysyncraton catillum Kott, 2004
Polysyncraton galaxum Kott, 2004
Polysyncraton linere Kott, 2004
Polysyncraton longitubis Kott, 2004
Polysyncraton luteum Kott, 2004
Polysyncraton miniastrum Kott, 2004
Polysyncraton montanum Kott, 2004
Polysyncraton niveum Kott, 2004
Polysyncraton peristroma Kott, 2004
Polysyncraton pseudomagnetae Kott, 2004
Polysyncraton reticulum Kott, 2004
Polysyncraton rostrum Kott, 2004
Polysyncraton textus Kott, 2004
Polysyncraton turris Kott, 2004
Symplegma teruakii Kott, 2004
Trididemnum farrago Kott, 2004
Trididemnum pusillum Kott, 2004
Trididemnum reticulatum Kott, 2004
Didemnum cilicium Kott, 2005
Didemnum corium Kott, 2005
Didemnum leopardus Kott, 2005
Didemnum plebeium Kott, 2005
Leptoclinides frustus Kott, 2005
Leptoclinides minus Kott, 2005
Leptoclinides pulvinus Kott, 2005
Lissoclinum agriculum Kott, 2005
Lissoclinum clavatum Kott, 2005
Lissoclinum karenae Kott, 2005
Polysyncraton polysystema Kott, 2005
Pycnoclavella filamentosa Kott, 2005

Pycnoclavella inflorescens Kott, 2005
Pycnoclavella narcissus Kott, 2005
Stolonica vermiculata Kott, 2005
Trididemnum mellitum Kott, 2005
Aplidium abditum Kott, 2006
Aplidium formosum Kott, 2006
Aplidium laticum Kott, 2006
Ascidia saccula Kott, 2006
Clavelina simplex Kott, 2006
Rhopalaea meridionalis Kott, 2006
Sigillina exigua Kott, 2006
Synoicum splinctorum Kott, 2006
Synoicum syrtis Kott, 2006
Didemnum vesica Kott, 2007
Didemnum velum Kott, 2008
Leptoclinides vesica Kott, 2008
Synoicum implicatum Kott, 2008
Synoicum rapum Kott, 2008
Synoicum vesicum Kott, 2008
Polycarpa seges Kott, 2009

PUBLICATIONS (1951–2011)

Publishing as Patricia Kott

- 1951 Nereidae and Eunicidae of south western Australia; also notes on the ecology of Western Australian limestone reefs. *Proceedings of the Royal Society of Western Australia* **35**: 85–130.
- 1952a. Observations on compound ascidians of the Plymouth area, with descriptions of two new species. *Journal of the Marine Biological Association of the United Kingdom* **31**(1): 65–83.
- 1952b. *Corella halli* n.sp. A new ascidian from the English Channel. *Journal of the Marine Biological Association of the United Kingdom* **31**(1): 33–36.
- 1952c. Ascidians of Australia. 1. Stolidobranchiata and Phlebobranchiata *Australian Journal of Marine and Freshwater Research* **3**(3): 206–333.
1953. Modified whirling apparatus for the subsampling of plankton. *Australian Journal of Marine and Freshwater Research* **4**(2): 387–393.
- 1954a. Tunicata. *British, Australian and New Zealand Antarctic Research Expedition, 1929–1931, Reports Series B (Zoology and Botany)* **1**(4): 121–82.
- 1954b. Further onshore plantological investigations in eastern Australia 1945–54. *Oceanographical Station List* No. 22. Division of Fisheries C.S.I.R.O.
- 1954c. Planktological investigation made by the F.R.V. Derwent Hunter in eastern Australian waters 1952–54. *Oceanographical Station List* No. 23. Division of Fisheries C.S.I.R.O.
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Larva and deutonymph of *Promegistus armstrongi* Womersley (Acari: Mesostigmata: Trigynaspida: Promegistidae)

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Citation: Seeman, O.D. 2012 02 17. Larva and deutonymph of *Promegistus armstrongi* Womersley (Acari: Mesostigmata: Trigynaspida: Promegistidae). *Memoirs of the Queensland Museum – Nature* 56(1): 255-269. Brisbane. ISSN 0079-8835. Accepted: 6 May 2011.

ABSTRACT

Larvae and deutonymphs of *Promegistus armstrongi* Womersley are described from new material collected from south-east Queensland. Leg chaetotaxy is provided. Unlike other known trigynaspid larvae, those of *P. armstrongi* are extremely hypotrichous, especially on the opisthosoma, and possess a long trochantal process. Likewise, the deutonymph is unique with poorly defined dorsal and ventral shields, small bare sternal shield, and forked trochantal process. The morphology of the immature stages of *P. armstrongi* is compared with other immature stages of trigynaspid mites, including the unplaced species *Derrickia setosa* Womersley (unplaced), which it resembles most. Diagnoses are provided for the immature life stages of Celaenopsoidea, Fedrizzioidea and Megisthanoidea.

□ Taxonomy, ontogeny, classification, Antennophorina, Parantennuloidea.

Promegistus armstrongi Womersley is the sole member of the Promegistidae. Womersley (1958) originally placed this unusual mite in the Paramegistidae, which it resembles in the smooth dorsum fringed with setae, fragmented sternal shield and hypertrichous ventrianal shield. Later, the unique arrangement of sternal and genital shields coupled with unique leg chaetotaxy led Kethley (1977a) to form a new family to accommodate this species, within the Fedrizzioidea. Later, Kim (2004) moved the family from the Fedrizzioidea and into the Parantennuloidea, mostly on the basis of the pseudosternogynum: a bare pregenital shield present only in parantennuloid mites.

Like most trigynaspid mites, adult life stages of *P. armstrongi* are associated with insects (Hunter 1993; Seeman 2001). Womersley's (1958) original collections were from a carabid and a passalid beetle (plus several other specimens with poor collection data), suggesting both may serve

as hosts. However an extensive survey of log inhabiting arthropods by Seeman (2001, 2002), in addition to further collection records presented here, indicate this species is almost exclusively associated with large carabid beetles. Records from passalid beetles represent accidental associations resulting from carabid and passalid beetles co-habiting beneath rotting logs.

Few immature life stages are described for trigynaspid mites (Seeman 2000), yet their morphology could help place problematic species such as *P. armstrongi*. The paucity of information on immature trigynaspids is probably due the obscurity of these mites and the dissociated juvenile and adult habitats. While most adult trigynaspid mites live on insects, with few exceptions the immature life stages are free living. In situations in which the host insect lives in a long-lasting habitat, the immature mites roam freely in the habitat, for example within the tunnels of passalid beetles (e.g., Butler & Hunter 1968; Seeman 2000) or

scolytid beetles (e.g. Kinn 1966, 1967). However when the host insect is not sedentary, such as many carabid beetles, the immature life stages are harder to find.

During the IBISCA (Investigating the Biodiversity of Soil and Canopy Arthropods)-Queensland Project (see Kitching *et al.* this volume), samples of soil revealed the hitherto unknown deutonymph of *P. armstrongi*. This spurred further attempts to rear the mites in an effort to obtain all life stages.

MATERIAL AND METHODS

Leaf litter was placed in a Tullgren funnel, extracted into 75% ethanol, and a single deutonymph of *P. armstrongi* removed. This specimen was cleared in Nesbitt's fluid, mounted in Hoyer's medium and the slide ringed with insulating varnish. All specimens were examined with a Nikon Eclipse 80i microscope equipped with DIC and a drawing tube. Illustrations were prepared by Michelle Baker. Leg chaetotaxy follows Evans (1963). Body chaetotaxy follows Lindquist & Evans (1965).

Previous attempts at rearing *P. armstrongi* involved removing adult mites from carabid beetles and placing them into containers with a moistened plaster of Paris - charcoal substrate, as in Seeman (2000), using nematodes as food. However, all attempts failed as the adult mites did not feed on nematodes.

The first successful attempt at obtaining larvae of *P. armstrongi* used the same method, with mites taken from a *Pamborus alternans* Latreille (Carabidae) collected from Mt Glorious. A small amount of woody debris was added to the container to provide habitat. As nematodes were not available, the adult mites received no food. From this, two dead larvae were found. These were mounted in Dimethyl Hydantoin Formaldehyde (Steedman 1958). This mounting medium has good optical properties and slides can be dried at room temperature and do not require ringing.

However, these slides and another series mounted at the same time (Cheyletidae, Phytoseiidae, Tenuipalpidae, Tydeidae) demonstrated two limitations. First, this medium does not clear specimens after mounting, so incompletely cleared specimens are poor. Second, the cuticle of soft-bodied specimens crumpled. Consequently, the two damaged larval specimens could only be used for comparison with the larval specimens obtained later and mounted in Hoyer's medium.

The subsequent rearing attempt involved keeping a *Pa. alternans* beetle, infested with *P. armstrongi*, alive in a small plastic tub with woody debris. The container and beetle were examined every few days for the presence of immature mites, from which a larva was recovered. Two weeks after the death of the beetle, the contents of the tub were placed into 75% ethanol and searched. From this material two live deutonymphs were recovered. Both specimens were much smaller than the specimen captured from litter extraction, suggesting the rearing conditions were not ideal. These specimens were cleared in Nesbitt's Fluid, mounted in Hoyer's medium, and ringed with insulating varnish.

SYSTEMATICS

Promegistidae Kethley, 1977a

Diagnosis. *All life stages:* palp tibia and tarsus fused. *Adults:* Round mites with minute dorsal setae and marginal fringe of spine-like setae; palp genu with 6 setae; moveable digit of chelicerae with filamentous excrescence; fixed digit with membranous distal excrescence; both digits with fine fringes; membranous lobe between digits; gnathotectum with weak median keel. *Female:* Sternal shield fragmented: *st1-3* on sternal shield; *st4* on metasternal shields that are fused to the endopodal shields; posteromedial pseudosternogynum present. Latigynal shields free, bearing nine or ten setae. Bare mesogynal shield fused to hypertrichous ventrianal shield. *Deutonymph:* Dorsum with reticulated prodorsal,

paired mesonotal and pygidial shield; palp trochanter with blunt forked process. *Larva*: Dorsum with six pairs of prodorsal setae on weak shield, one pair of opisthodorsal setae, one pair of opisthogastric setae, one pair of paranal setae and unpaired anal seta; anal shield placed terminally; anteriormost prodorsal setae elongate, the longest dorsal seta; palp trochanter with blunt process.

Type species. *Promegistus armstrongi* Womersley.

Promegistus armstrongi Womersley, 1958

Material. 1 deutonymph, Lamington National Park IBISCA, SE Qld, Australia, Plot # IQ-1100-C, 1106 m alt., 28.260°S 153.167°E, 5-7 Oct 2006, rainforest, K. Staunton, ex litter extraction. Sampcode 20013 (a pitfall trap site where an opportunistic litter sample was taken). 2 deutonymphs, 1 larva, reared in captivity, original adult *P. armstrongi* record: 2♀♀, 3♂♂, Lamington National Park IBISCA, SE Qld, Australia, Plot# IQ-500-B, 514 m alt., 28.212°S 153°141'E, 23 Oct 2006, rainforest, C. Burwell, day hand collecting, 1210-1310 hrs, ex. *Pamborus alternans* (Coleoptera: Carabidae). 2 larvae, reared in captivity (collected dead), original adult *P. armstrongi* from Mt Glorious National Park, C. Burwell, hand collection, Aug. 2006, ex. *Pamborus alternans*. All slides in Queensland Museum.

Description. Larva (n = 1; Figs 1-7). *Dorsal idiosoma* (Fig. 1). Round, length 247, width 278, with incompletely formed prodorsal shield (folded medially in specimen) and setae *j1* on small weakly formed anterior plate. Prodorsum with six pairs of setae tentatively assigned as *j1*, *j3*, *j5*, *j6*, *z4* and *s4* (*j1* and *z4* off shield). Setae *j1* 225 long, barbed; other prodorsal setae short (9 – 20 long), smooth. One pair of pores laterad *s4*. Opisthodorsum with one pair of *J* setae 38 long. Soft cuticle striate.

Ventral idiosoma. (Fig. 2) Tritosternal base 16 wide, 31 long, lacinae separate, 53 long. Sternal setae barbed, *s11-3* 63-75. Sternal shield delineated by a poorly defined area of smooth cuticle between sternal setae. Opisthogastric with one pair of setae, barbed, 90 long, probably *JV1* or *JV2* based on its medial position. Anal valves with alveoli of paired euanal setae. Small terminal postanal shield bearing paranal setae 133 long, barbed, and postanal seta broken, at least 250 long, barbed.

Two pairs of pores between anus and anal setae. Soft cuticle striate, weakly so between anus and postanal shield.

Gnathosoma. (Fig. 3) Hypostomal setae *h1* barbed, 83 long, *h2* barbed, 104 long. Deutosternum with four rows of denticles. Corniculi blunt, 25 long. Gnathotectum multi-tined, without keel. Palp trochanter with narrow non-setigerous process on adaxial margin, 50 long (homologous with forked process in deutonymph). Palp setal count (trochanter – tibiotarsus) 0-4-5-22; apotele two-tined; pre-apotele (tibia) with seven setae, post-apotele (tarsus) with 15 setae. Palp tarsal tip with two blunt setae.

Chelicerae. (Fig. 4) Large, moveable digit 125, fixed digit 178. Moveable digit with one row of five-six large and eight-nine small teeth and two seta-like cheliceral excrescences, 17 long. Fixed digit with blade-like cheliceral seta, 19 long, and two rows of teeth: five-six large and eight-nine small teeth in inner row, and 27 small teeth in outer row. Pilus dentilus not obvious, however a small cavity 22 from cheliceral tip may represent a rudimentary pilus dentilus.

Legs. (Figs 5-7) Coxae of all legs (I-III) and trochanters and femora II-III with rows of fine denticles. Tarsus I without claws, but with long thick terminal seta 206 long; six elongate setae with a wavy form. Tibia I with two elongate setae. Setal counts for coxa to tarsus: leg I 2-4-9-6-8-26; leg II 1-4-7-6-7-16; leg III 1-4-5-6-6-16. Leg chaetotaxy for trochanters to tibiae presented in figures 5-7.

Deutonymph. (n = 3; Figs 8-16) *Dorsal idiosoma* (Fig. 8). Oval, length 950-1550, width 810-1240, with small reticulate prodorsal shield with irregular margins, 350-370 long, 430-450 wide. Prodorsal setae tentatively designated as *j1-6*, *z3-6*, *s4-6* and two-three setae lateral to series *s*; series *r* hypertrichous. Setae *j1* 315 long, with few barbs. Prodorsal shield with setae *j5* (27-30 long, smooth) medially and setae *j4*, *j6*, *z3*, *z4* and *z5* captured on the shield's margin. Medial opisthodorsum mildly hypertrichous.

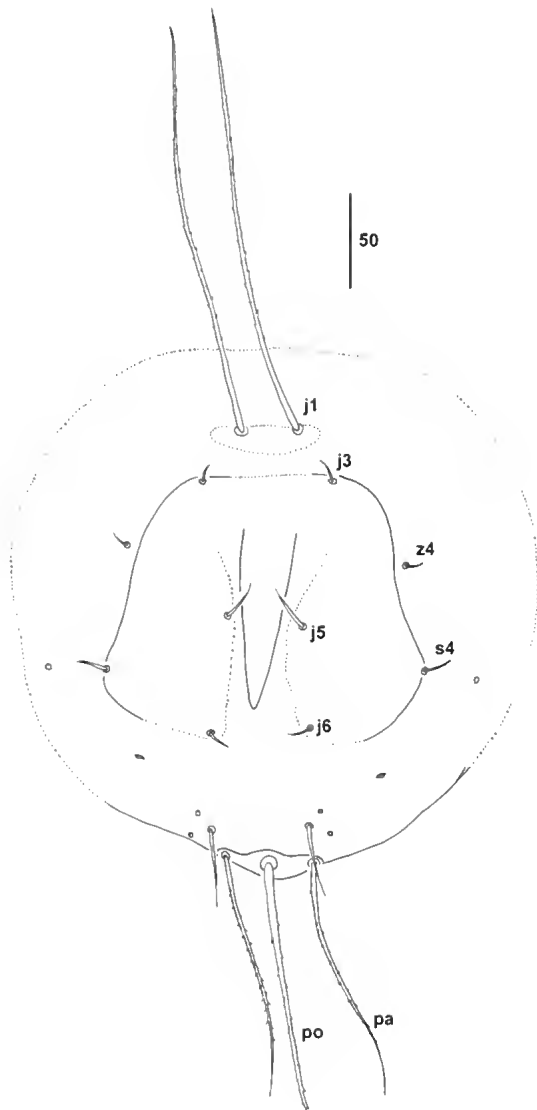


FIG. 1. Dorsum of the larva of *Promegistus armstrongi* Womersley with tentative setal designations.

All mediiodorsal setae relatively short, smooth, 22-47 long. Paired mesonotal plates small, reticulate, with irregular margins, 100-105 long, 135-150 wide; without setae. Pygidial shield similar, 100 long, 200-213 wide, bearing

seta tentatively named *j3* and an unpaired medial seta on anterior margin. Marginal setae smooth with few barbs anteriorly, ca. 150 long, becoming longer and barbed posteriorly. Many posterior marginal setae barbed for ca. 250, then attenuate for another 200-250 (truncated in illustration). Soft cuticle strongly striate.

Ventral idiosoma. (Fig. 9) Tritosternal base 42 wide, 124 long. Laciniae separate, 130 long. Sternal shield small, reticulate, with irregular margins, 175 long, 138 wide. Setae *st1-5* barbed, 150-175 long. Opisthogastric setae tentatively designated as *JV1-5*, *ZV1-5*, *UR1-2* and paranal setae. Postanal seta absent. Five paired patches of reticulate cuticle posterior to *st5*: anterior-most associated with pair of pores (just posteromedad *st5*); two patches associated with *JV1* and *ZV1*; one patch laterad *JV3*; and with rudimentary endopodal plates around coxa IV. Peritreme very short, 26-30 long. Anus 45 long, bearing alveoli of paired euanal setae, surrounded by small ring of smooth cuticle, bearing one pair of pores posteriorly.

Gnathosoma. (Figs 10-11) Hypostomal setae *h1-4* barbed, 175-225 long. Deutosternum with four rows of small denticles. Corniculi strong, with blunt bifid tips, 51-55 long. Membranous gnathosomal collar with spiculate cuticle. Gnathotectum (Fig. 11) multi-tined, branched, without keel; with long broad medial tine (95-102 long) and paired multi-branched tines either side. Palp trochanter with forked non-setigerous process on adaxial margin. Palp setal count (trochanter - tibiotarsus) 2-5-6-31; apotele two-tined; pre-apotele (tibia) with eight setae; post-apotele (tarsus) with 23 setae. Palp tarsal tip with at least four blunt setae.

Chelicerae. (Fig. 12) Large, moveable digit 255-275 long, fixed digit 362-380 long. Moveable digit with single row of 21-27 teeth, large teeth interspersed with small teeth; with three seta-like cheliceral excrescences, 60-70 long; distal hook with numerous fine rasp-like teeth. Fixed digit with cheliceral seta (45-51 long) and 27-28 teeth in two rows: inner row with 12-14 large teeth

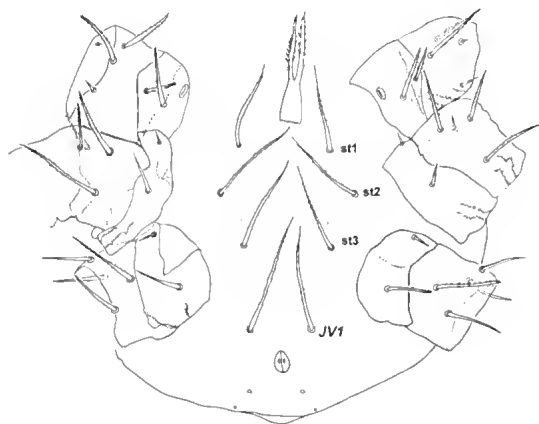


FIG. 2. Venter of the larva of *Promegistus armstrongi* Womersley.

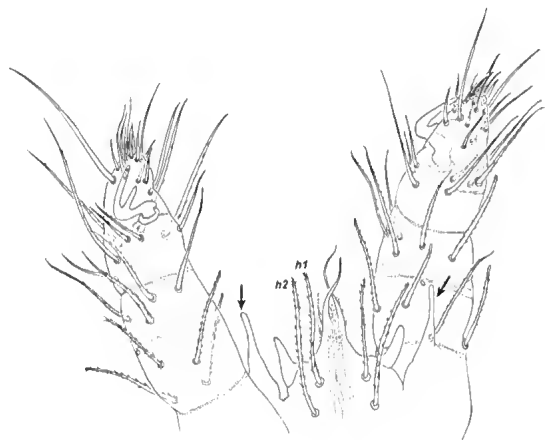


FIG. 3. Hypostome and palps of the larva of *Promegistus armstrongi* Womersley. The right palp is a ventral view. On the left palp, the trochanter has twisted clockwise and the femur to tarsus has twisted anticlockwise. Arrows indicate the trochanteral process.

interspersed with small teeth; outer row with 24-26 tiny teeth, from pilus dentilus (eight long) to a cluster of teeth on distal hook.

Legs. (Figs 13-16) Coxae of legs I with 26-33 sclerotised pore-like structures. Denticles absent

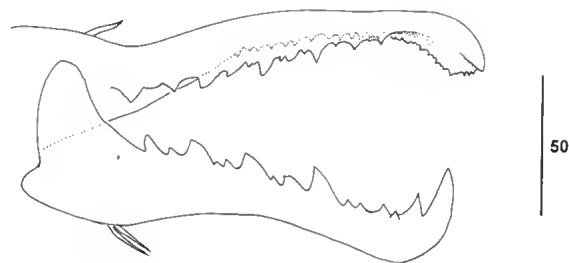


FIG. 4. Chelicera of the larva of *Promegistus armstrongi* Womersley.

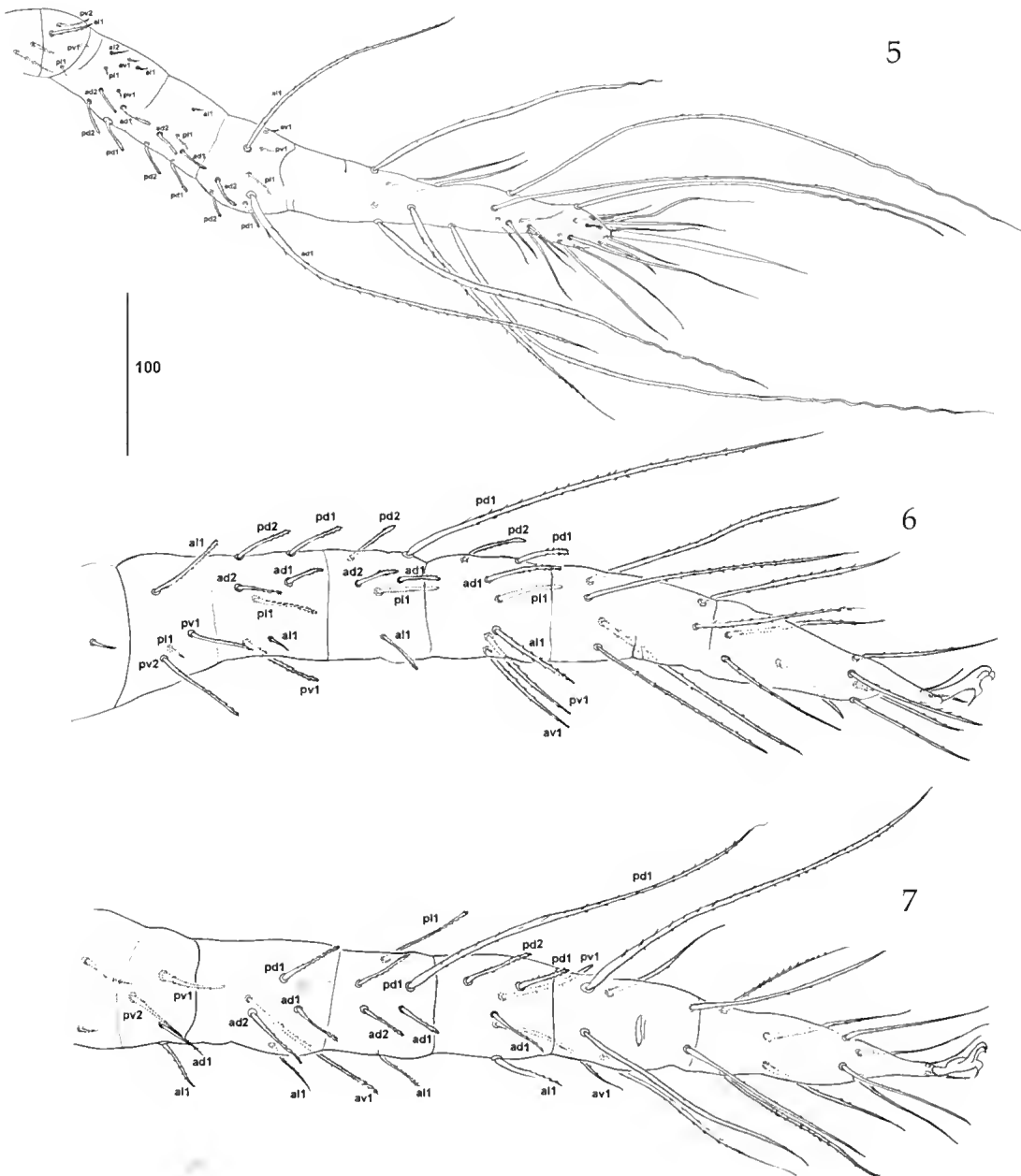
on all segments. Tarsus I without claws, wavy setae absent. Setal counts for coxa to tarsus: leg I 2-6-11-6-10-33 (min.); leg II 1-5-10-8-9-19; leg III 1-5-7-8-8-19; leg IV 1-5-8-7-8-21. Tarsus IV with av4 and pv4 small, placed on ventral intercalary sclerite between basitarsus and telotarsus. Leg chaetotaxy for trochanters to tibiae presented in figures 13 to 16.

Remarks. With the exception of fedrizziid and davacarid mites (Seeman 2000; Walter 2004), larvae of Trigynaspida lack the full setal complement of the Gamasina (Lindquist & Evans 1965; Seeman & Walter 1997). This hypotrachy is usually mild, but in *P. armstrongi* it is extreme. Gamasina larvae possess up to 20 pairs of dorsal setae and four pairs of opisthogastric setae. *Promegistus armstrongi* has just seven pairs of dorsal setae and one pair of opisthogastric setae.

Similar prodorsal hypotrachy occurs on the prodorsum of *Choriarchus reginus* Kinn, 1966, (Schizogyniidae) which also possesses just six pairs of prodorsal setae and their positions suggest these setae are homologous.

DISCUSSION

The Trigynaspida is currently split in two cohorts, Cercomegistina and Antennophorina, with one and seven superfamilies, respectively (Kim 2004). This follows Kethley's (1977a)



FIGS 5-7. Legs of the larva of *Promegistus armstrongi* Womersley with setal designations for trochanters to tibiae.

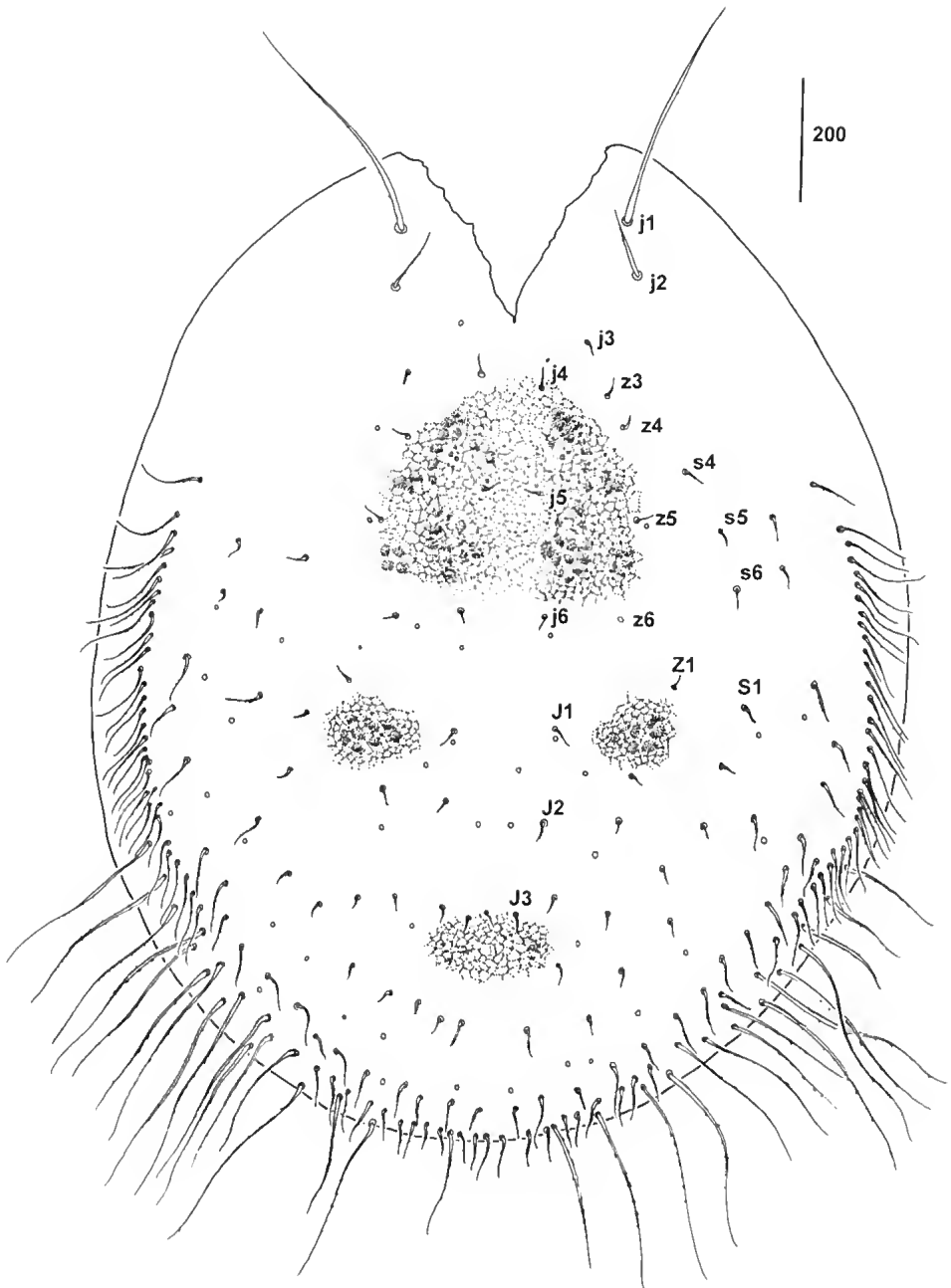


FIG. 8. Dorsum of the deutonymph of *Promegistus armstrongi* Womersley with tentative setal designations for some podosomal setae.

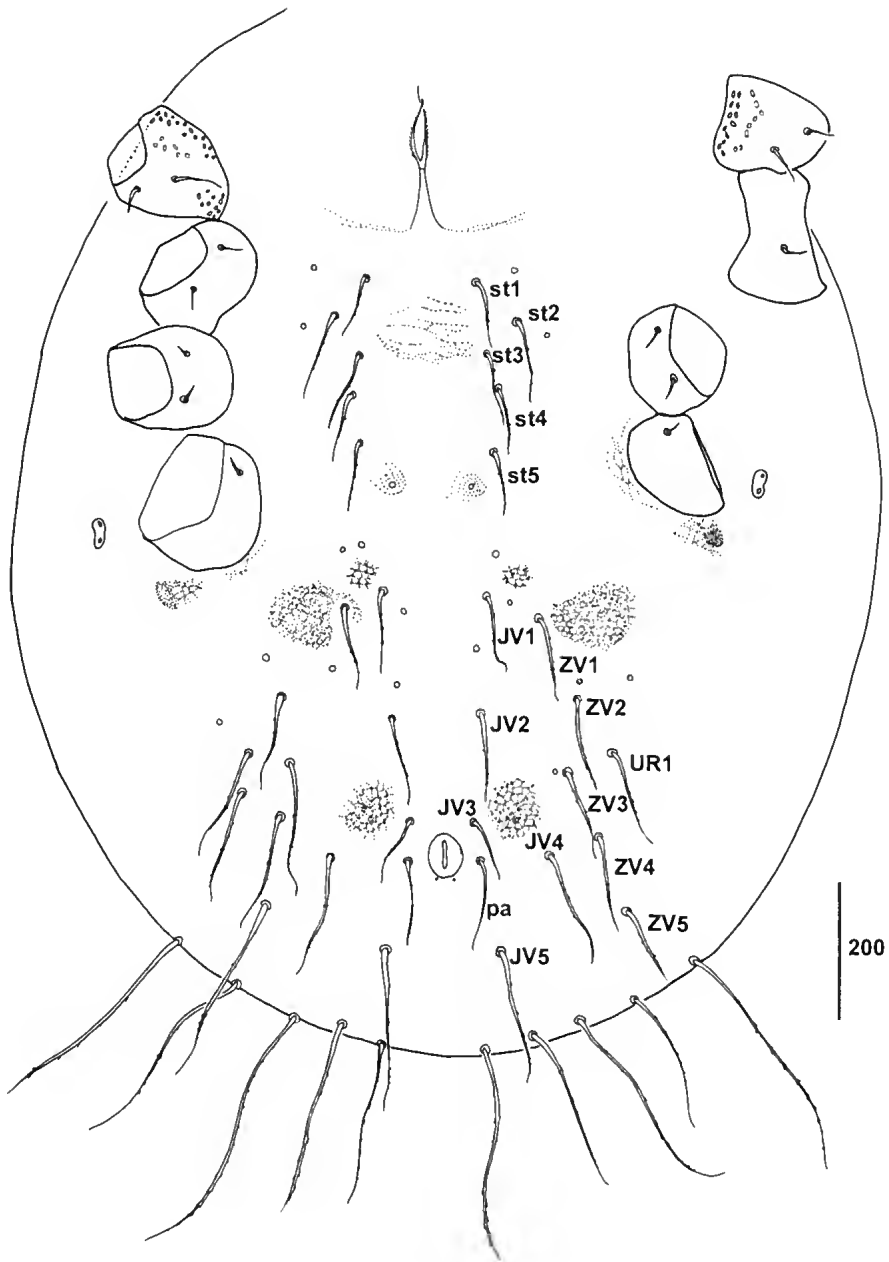


FIG. 9. Venter of the deutonymph of *Promegistus armstrongi* Womersley with tentative setal designations for opisthogastric setae.

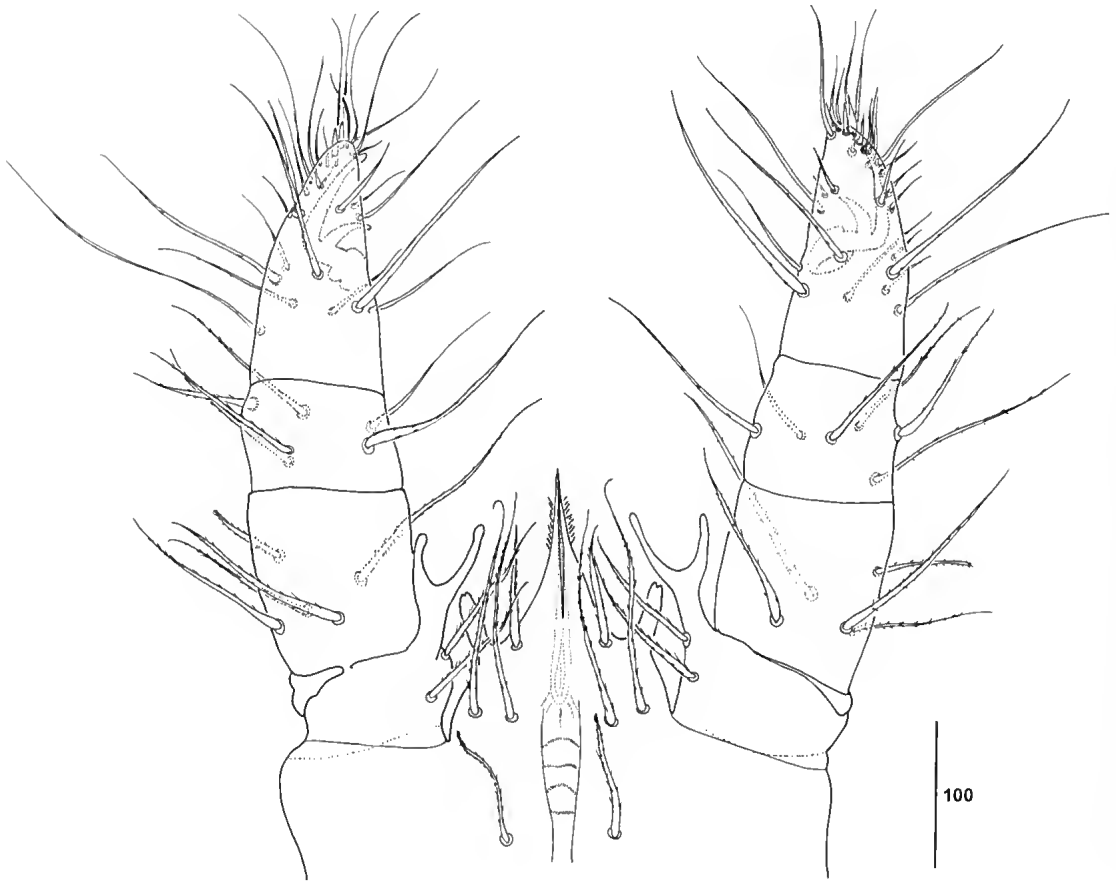


FIG. 10. Hypostome and palps the deutonymph of *Promegistus armstrongi* Womersley.

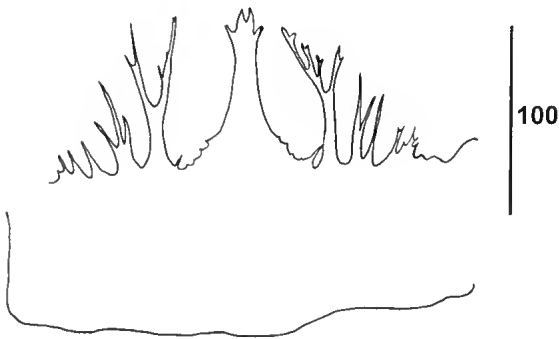


FIG. 11. Gnathotectum of the deutonymph of *Promegistus armstrongi* Womersley.

concept fairly closely, excepting the concept of the Fedrizzioidea. This superfamily was split, with the Promegistidae being moved to a different Superfamily, the Parantennuloidea. This change was supported by a phylogenetic analysis. Nevertheless, *P. armstrongi* does at least bear a superficial resemblance to members of the Paramegistidae. Both families have large rounded adult mites with bare dorsal shields fringed with blade-like setae, fragmented sternal and genital shields, and a large hypertrichous ventrianal shield. Furthermore, Kontschan & Seeman (2011) found a surprising number of leg setal differences between *P. armstrongi* and other members of the

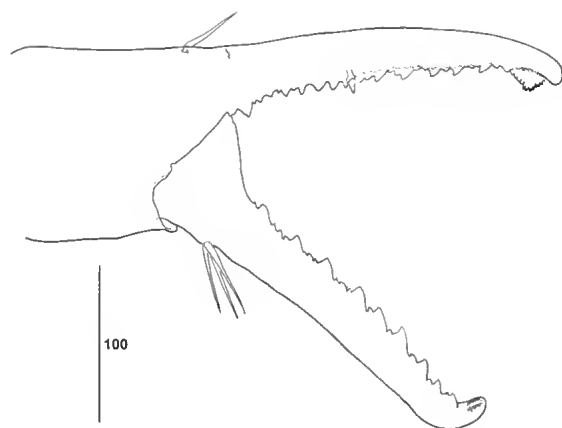


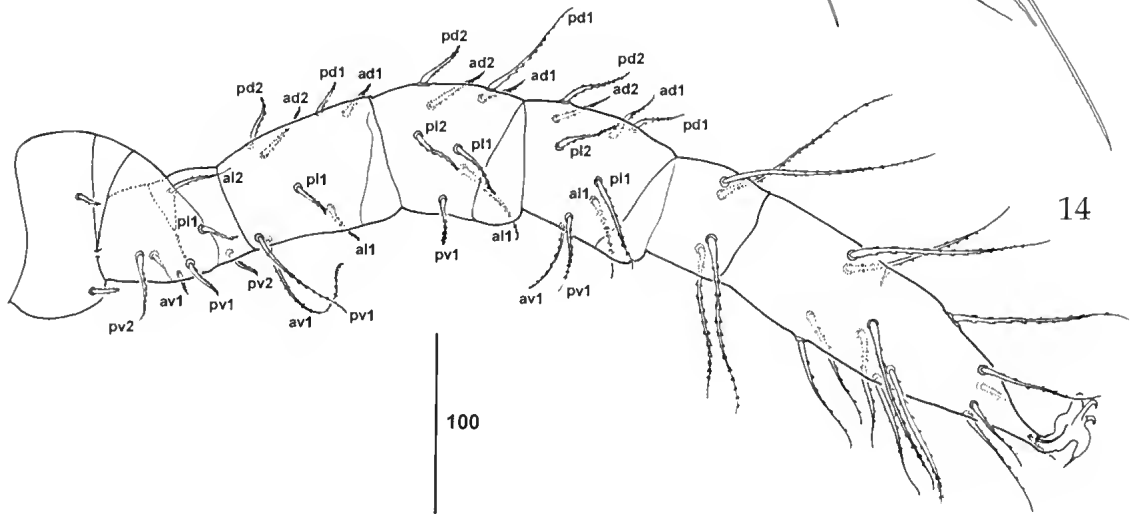
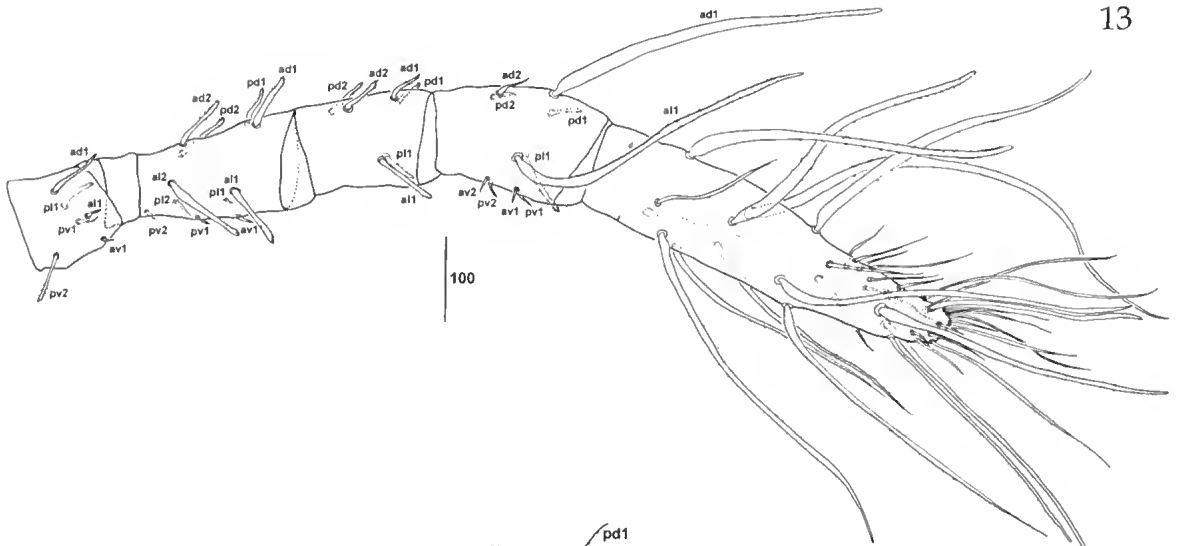
FIG. 12. Chelicera of the deutonymph of *Promegistus armstrongi* Womersley.

Parantennulidae. Thus, it seems this unusual species may yet be reclassified pending further data, including that of the immature life stages of other trigynaspid mites.

Unfortunately, meaningful comparisons of the immature stages of *P. armstrongi* with other trigynaspid taxa are hampered by lack of data. Immature life stages are known for 18 other species from 13 families of Trigynaspida. Though this sample is scant, some conclusions can be made. First, the protonymph and deutonymph, and generally the larvae, of the Celaenopsoidea seem similar to each other and a tentative diagnosis can be prepared for this group (Table 1). Further to this diagnosis, characters from the adult stage are also evident, such as the large basal cheliceral tooth and the reasonably consistent leg chaetotaxy (Kethley 1977a). Consequently, immature life stages of the Celaenopsoidea are readily identifiable, and *P. armstrongi* is certainly not a celaenopsoid mite.

TABLE 1. Diagnoses for the immature life stages of the Celaenopsoidea. Further characters of the adult body (Kim 2004) and possibly leg chaetotaxy (Kethley 1977a; Seeman 2007b) are complementary to this diagnosis.

<p>Superfamily Celaenopsoidea</p> <p>Taxa: <i>Choriarchus reginus</i> (Schizogyniidae; Kinn 1966), <i>Cryptometasternum derricki</i> (Diplogyniidae; pers. obs.), <i>Euzercon latus</i> (Euzerconidae; Hunter & Davis 1965), <i>Funkotriplogynium iagobadius</i> (Triplogyniidae; Seeman & Walter 1997), <i>Neotenogynium malkini</i> (Neotenogyniidae; Kethley 1974) and <i>Pleuronectocelano barbara</i> (Celaenopsidae; Kinn 1968).</p> <p>Remarks: Absences of features (see below) in the larval stage occur only in <i>P. barbara</i>, which needs to be re-examined to ensure shields are not present but difficult to see. <i>Neotenogynium malkini</i> is unusual in the Celaenopsoidea in having immature life stages associated with their host. Exceptions caused by this species are in italics.</p>
<p>Deutonymphs. Well defined podonotal, mesonotal and pygidial shields; large <i>anal</i> or ventrianal shield; two pairs of well defined metapodal shields, <i>or absent</i>; small platelet posterolateral to ventrianal shield present or absent. Sternal shield well developed, bearing st1-st3 <i>or at margins of shield</i>. Peritremes developed, reaching CxII-III boundary, <i>or very short</i>. If hypertrichous, then hypertrichy mostly restricted to margins and opisthodorsum. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>
<p>Protonymphs. Well defined podonotal, paired mesonotal and pygidial shields; anal or small ventrianal shield present; sternal shield well developed, bearing st1-st3. Peritremes reaching at least to margin of CxIII-IV, <i>or very short</i>. If hypertrichous, then weakly so and only on opisthodorsal margins. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>
<p>Larvae. Podonotal shield present or absent; pygidial shield present. Anal or ventrianal shield present. Euanal setae present, <i>or absent</i>. Sternal shield present or absent; if present then large and bearing st1-st3. Body hypotrichous, but prodorsum with at least six pairs of setae. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>



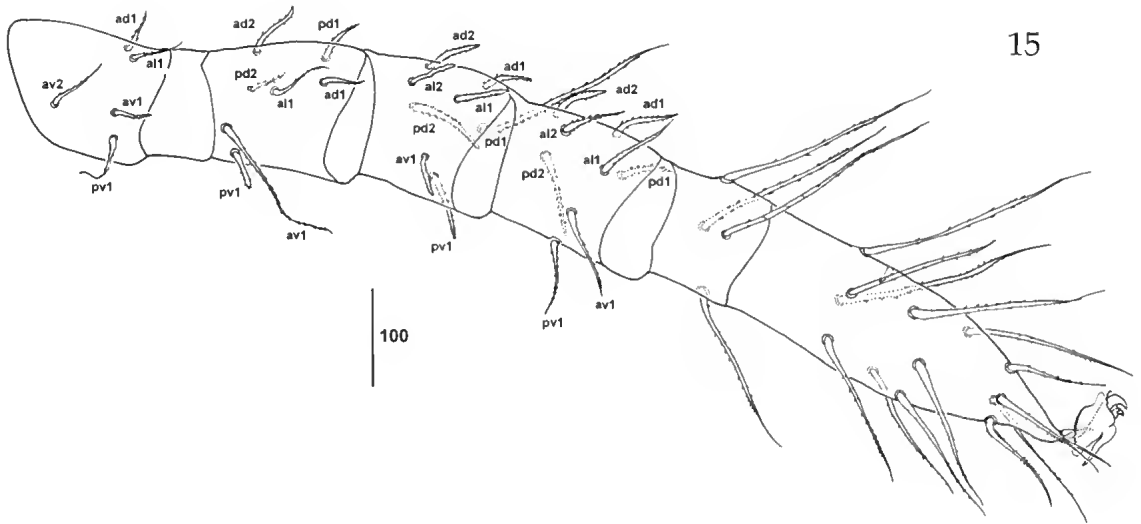
FIGS 13-14. Legs I-II of the deutonymph of *Promegistus armstrongi* Womersley with setal designations for trochanters to tibiae.

Diagnoses for the Fedrizzioidae (Table 2) and Megisthanoidea (Table 3) are tentative, being based on representatives from one of two families in each superfamily. However, the diagnosis for the Fedrizzioidae should be robust, as its two families (Fedrizziidae and Klinckowstroemiidae) are very similar (Seeman 2007a). Note also that the immature stages of *Fedrizzia grossipes* Canestrini

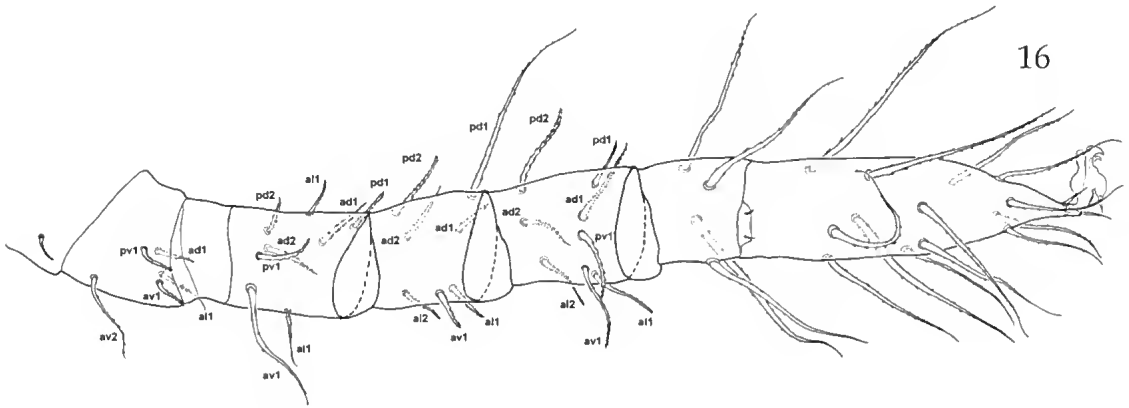
described by Seeman (2000) are now considered to be *Fedrizzia sellnicki* Womersley (Seeman 2007a). The Megisthanidae and Holomegistidae also seem similar, so this diagnosis may also prove useful.

A diagnosis for the Antennophoroidea is premature as immature stages are known only for one species (Wiśniewski & Hirschmann 1992),

15



16



FIGS 15-16. Legs III-IV of the deutonymph of *Promegistus armstrongi* Womersley with setal designations for trochanters to tibiae.

and good diagnoses for the Parantennuloidea and Cercomegistoidea are impossible due to significant variation within known immature stages. For the Parantennuloidea, immature life stages of *Micromegistus* (Parantennulidae: *M. bakeri*, plus two undescribed species from Australia) are virtually identical to each other. *Micromegistus*, *Philodana johnstoni* Kethley (Philodanidae) and *P. armstrongi* share few or no features (Nickel & Elzinga 1970; Kethley 1977b; Table 4). Likewise,

immature life stages of *Cercoleipus coelonotus* Kinn, *Cercomegistus evonicus* Kinn and *Holocercomegistus agelenophilus* Evans (Cercomegistidae; Evans 1958; Kinn 1967, 1970), *Pyrosejus prionotus* Lindquist & Moraza (Pyrosejidae; Lindquist & Moraza 1993), *Acanthodavacarus klompeni* Walter and *Davacarus gressetti* Hunter (Davacaridae; Hunter 1970; Walter 2004) and *Saltiseius lunteri* Walter (Saltiseiidae; Walter 2000) are too variable to make a meaningful diagnosis for the superfamily.

Promegistus armstrongi Womersley

TABLE 2. Tentative diagnoses for the immature life stages of the Fedrizzioidea. Further characters of the adult body (Kim 2004) and leg chaetotaxy (Kethley 1977a; Seeman 2007a) are complementary to this diagnosis.

<p>Superfamily Fedrizzioidea</p> <p>Taxa: <i>Neofedrizzia camini</i> (Fedrizzioidea; Seeman 2000); <i>Fedrizzia sellnicki</i> (Fedrizzioidea; Seeman 2000, 2007a)</p>
<p>Deutonymphs. Well defined podonotal, mesonotal and pygidial shields; large ventrianal shield; 1 pair of well defined metapodal shields; small platelet posterolateral to ventrianal shield present. Sternal shield well developed, bearing st1-st3. Peritremes developed, reaching CxII-III boundary. Hypertrichous, mostly restricted to margins and opisthodorsum. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>
<p>Protonymphs. Well defined podonotal and pygidial shields; mesonotal shields absent; ventrianal shield present, fused with pygidial shield; sternal shield well developed, bearing st1-st3. Peritremes short, barely reaching margin of CxIII-IV. Mild hypertrichy only in J series. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>
<p>Larvae. Well defined podonotal shield; pygidial shield present. Anal shield present, fused with pygidial shield. Euanal setae present. Sternal shield present, bearing only st1. Body hypotrichous, but prodorsum with at least six pairs of setae. Tarsus I not tapering. Macrosetae absent on all leg segments. Hypotrichy absent.</p>

TABLE 3. Tentative diagnoses for the immature life stages of the Megisthanoidea. Further characters of the adult body (Kim 2004) and leg chaetotaxy (Kethley 1977a; Seeman 2007a) are complementary to this diagnosis.

<p>Superfamily Megisthanoidea</p> <p>Taxa: <i>Megisthanus floridanus</i> (Megisthanidae; Hunter & Davis 1965); <i>Megisthanus</i> sp. (pers. obs.)</p>
<p>Deutonymphs. Well defined podonotal and small opisthonotal shields; small ventrianal shield; metapodal shields absent; small platelet posterolateral to ventrianal shield absent. Sternal shield well developed, bearing st1-st3. Peritremes developed, reaching CxII-III boundary. Hypertrichous dorsum and venter, excepting podonotal shield. Tarsus I slightly tapering. Macrosetae absent on all leg segments.</p>
<p>Protonymphs. Well defined small podonotal shields; mesonotal and pygidial shields absent; small ventrianal shield. Sternal shield well developed, bearing st1-st3. Peritremes developed, reaching CxII-III boundary. Mild hypertrichy restricted to opisthodorsum. Tarsus I slightly tapering. Macrosetae absent on all leg segments.</p>
<p>Larvae. Podonotal shield small, medial, bearing 1 pr setae; pygidial shield absent. Small ventrianal shield present. Euanal setae present. Sternal shield present, bearing only st1. Opisthodorsum hypotrichous, prodorsum with usual ten pairs of setae. Tarsus I not tapering. Macrosetae absent on all leg segments.</p>

The immature life stages of *P. armstrongi* have some features found in few, or no other, trigynaspid taxa. In fact, the only trigynaspid mite that immature *P. armstrongi* resembles is *Derrickia setosa* Womersley, 1956 (unplaced family), a species known only from the protonymph and deutonymph collected from "Muminbah" (probably Numinbah) and Brookfield, Queensland (Womersley 1956a, b; Halliday 1990). The species was originally placed in the Podocinidae, but Halliday (1990) recognised this species as a trigynaspid mite, but was unable to further class-

ify the species. This species is not an immature *Promegistus* as it bears some important differences, such as an elaborate brush-like excrescence on the movable digit (versus seta-like in *Promegistus*); an unpaired *j*3 seta (paired in Trigynaspida, except Cercomegistidae); and spiculate soft cuticle on the dorsum (versus striate).

Some features of *D. setosa* allow further speculation on the classification of this mite (Table 4). The fused palp tibia-tarsus indicates that this mite could be a member of the Aenictequoidea (Aenictequidae, Messoracaridae, Physalo-

TABLE 4. Comparison of larvae and deutonymphs of *P. armstrongi* with other trigynaspid taxa.

Character	Taxa sharing character
<u>Larvae</u>	
One pair of opisthodorsal setae.	None
One pair of opisthogastric setae.	None
Setae j1 exceptionally long.	None
Palp trochanter with process.	None
<u>Deutonymphs</u>	
Prodorsal shield reticulate, poorly defined.	<i>Derrickia setosa</i>
Mesonotal shields reticulate, poorly defined.	None
Pygidial shield reticulate, poorly defined.	None
Sternal shield without setae.	None
Peritreme not developed.	None
Paired patches of reticulate cuticle near anus.	None, but metanotal plates in some taxa.
Palp trochanter with forked process.	None
Tarsus I with long (macro) setae. (also character of the larva)	<i>Derrickia setosa</i> , and possibly other taxa with long setae on tarsus I in adults (Messoracaridae, some Paramegistoidea).
Palp tibia-tarsus fused. (also character of the larva)	<i>Derrickia setosa</i> , and presumably other taxa with fused palp tibia-tarsus in adults: Aenictequoidea, Paramegistoidea, Philodanidae.
Tarsus I tapering. (also character of the larva)	<i>Derrickia setosa</i> , and presumably other taxa with elongate tarsi in adults, such as the Aenictequoidea and Paramegistoidea.

zerconidae or Ptochacaridae), Paramegistoidea or Philodanidae (Parantennuloidea). The latter family is unknown in Australia, and the known immature life stages of *Philodana johnstoni* are dissimilar to *D. setosa* (Kethley 1977b), leaving the Aenictequoidea or Paramegistoidea. Unfortunately immature life stages for these superfamilies are unknown. However, comparison of leg chaetotaxy of the deutonymph with adults of these superfamilies should allow a family designation - providing *D. setosa* belongs to a taxon with known adult stages.

ACKNOWLEDGEMENTS

Foremost, I greatly appreciate the fine illustrations of Michelle Baker, without which this work would not have been written up. I also appreciate the keen eye of Kyran Staunton, who first noticed the deutonymph in a litter extraction,

and also for the collections of live adult carabid beetles bearing *Promegistus* by Chris Burwell. Jenny Beard and Bruce Halliday provided useful comments which improved the manuscript.

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