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HYDROIDS (HYDROZOA: ANTHOATHECATA) FROM THE BEAGLE GULF AND DARWIN HARBOUR, NORTHERN AUSTRALIA

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ABSTRACT

Nine species of athecate hydroids collected in two surveys in the Northern Territory of Australia include a new species of *Ralpharia* Watson, 1980, and a new record of *Corydendrium parasiticum* (Linnaeus, 1767) from Australia. Other species in the collection are known from warm temperate to tropical world regions including Western Australia and Queensland, the Timor Sea and Torres Strait.

KEYWORDS: Hydroids, Anthoathecata, Beagle Gulf, Darwin Harbour, northern Australia.

INTRODUCTION

This paper reports upon athecate hydroids collected in two surveys conducted in the Beagle Gulf of the Northern Territory of Australia.

The Beagle Gulf is a large, open embayment of the Australian mainland on the Timor Sea between Melville Island and Bathurst Island (Fig. 1). A survey of the invertebrate fauna of the western side of Anson Bay (13° 29.64' S, 129° 51.00' E) to the eastern side of Cape Hotham (12° 12.36' S, 131° 23.22' E) in Beagle Gulf was undertaken in October 1993 by the Northern Territory Conservation Commission. The survey included 162 stations sampled by dredging in water depths of 4-39 m. The Port of Darwin (12° 28' S, 130° 51' E) is situated in Darwin Harbour, an extensive inlet in Beagle Gulf. The hydroid fauna living on port structures, natural reef and soft bed was intensively collected by the author using SCUBA in August, 1998.

The physical regime of Beagle Gulf is tropical with a water temperature range of 23°-33° C. Water depths are relatively shallow throughout the region, lithology of the seabed varying from sandstone reefs, isolated coral outcrops, loose shale, coarse sand, silt and mud. Strong tidal currents of 50-100 cm/sec (1-2 knots), rising to 4 knots in narrow passages, carry fine sediment throughout the gulf region, resulting in high water turbidity.

Both the wide-ranging Beagle Gulf survey and the more intensive Darwin Harbour survey recovered a rich hydroid fauna. This paper reports upon the anthoathecate species in the collection. Leptothecate hydroids will be reported upon in a later paper.

Other than brief reports on some hydroids collected at Cape Jaubert, Western Australia (Jäderholm 1916) and Torres Strait (Busk 1852, Kirkpatrick 1890), little is known of the north-western and northern Australian hydroid fauna ranging from the warm temperate-tropical water confluence at Shark Bay in Western Australia to Torres Strait in the north (Watson 1996), a distance of some 7,000 km.

The athecate hydroids in the two collections include eight known species and one species of *Ralpharia* Watson, 1980, described here as new. The finding of *Corydendrium parasiticum* (Linnaeus, 1767) is a new record for Australia; three species (*Eudendrium kirkpatricki* Watson, 1985, *Eudendrium infundibuliforme* Kirkpatrick,

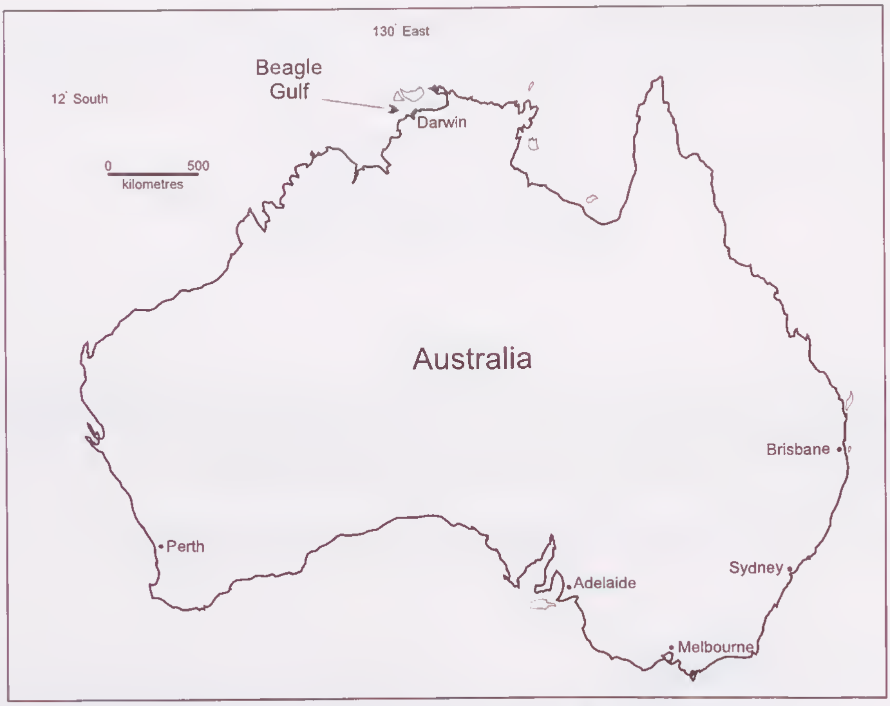

Fig. 1. Map of mainland Australia showing location of Beagle Gulf and Darwin.

1890, *Cladocoryne floccosa* Rotch, 1871) are previously known from the Timor Sea and Torres Strait region, four species (*Bougainvillia ?balei* Stechow, 1924, *Eudendrium glomeratum* Picard, 1951, *Cladocoryne floccosa, Pennaria disticha* Goldfuss, 1820) have been previously recorded from the central western coast of Western Australia, and two species (*Eudendrium kirkpatricki, Solanderia secunda* (Inaba, 1892)) from warm temperate to tropical Queensland. *Corydendrium parasiticum, Cladocoryne floccosa* and *Pennaria disticha* are widely distributed in warm temperate to tropical seas; the latter two also being known from New Zealand, and *Eudendrium glomeratum* is known from the Mediterranean Sea and the British Isles.

MATERIAL AND METHODS

Material collected by the Beagle Gulf survey was fixed in a 10% formaldehyde solution in seawater on board boat and later sorted by staff at the Museum and Art Gallery of the Northern Territory, Darwin. Specimens collected by the author in Darwin Harbour were sealed in containers *in situ*, and (depending on species) immediately preserved on board boat in a 10% solution of formaldehyde in seawater or 70% ethanol.

Descriptions are from preserved material. Type and voucher specimens are lodged in the Museum and Art Gallery of the Northern Territory, Darwin (NTM C) and voucher specimens are lodged in the Museum of Victoria, Melbourne, Australia (MVF).

SYSTEMATICS

Order Filifera

Family Clavidae McCrady, 1859

Genus *Corydendrium* P.J. van Beneden, 1844

Corydendrium parasiticum (Linnaeus, 1767)

(Fig. 2A-E)

Sertularia parasitica Linnaeus, 1767: 1315.

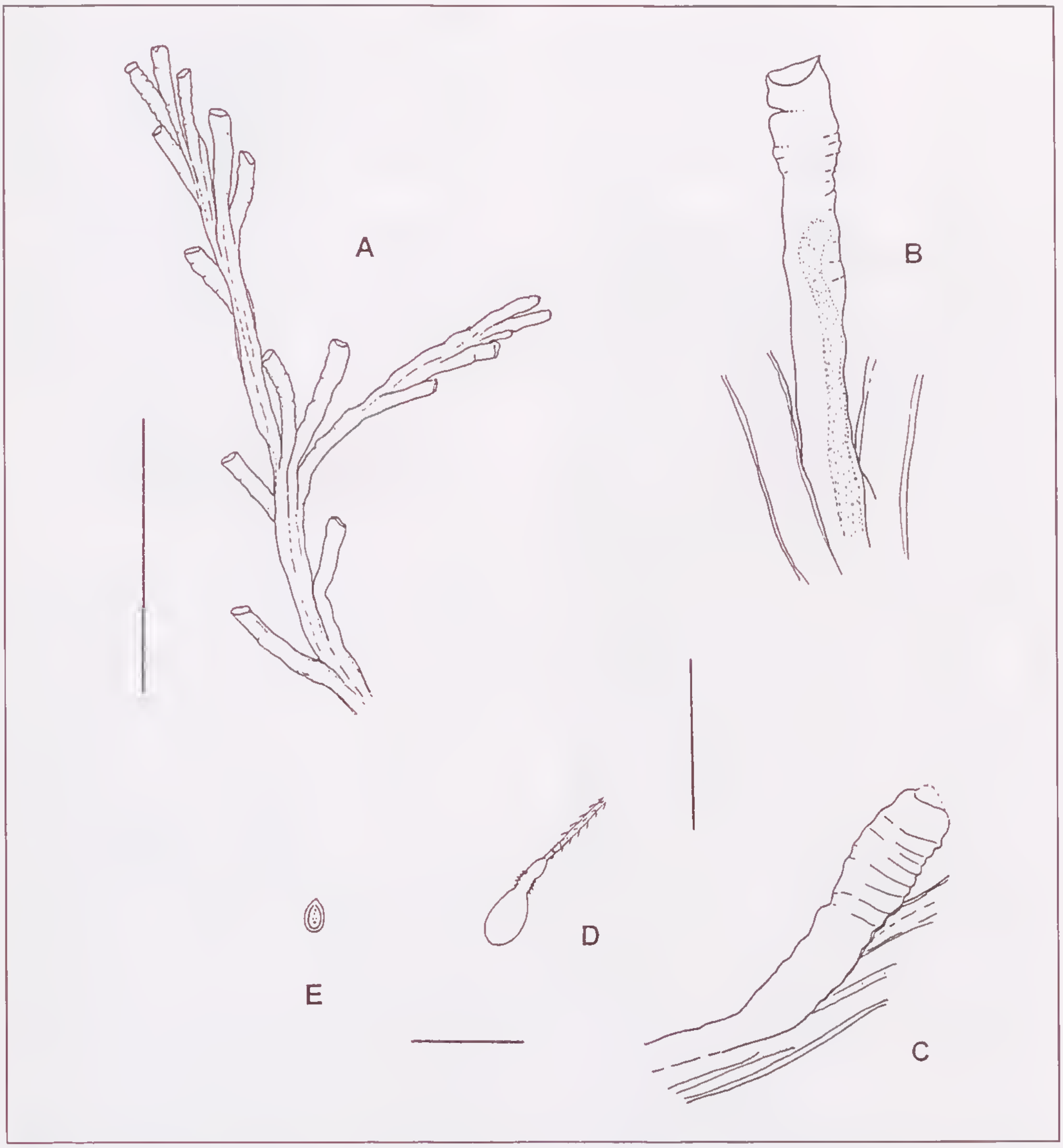

Fig. 2. *Corydendrium parasiticum*: **A**, distal branches of colony; **B**, **C**, distal ends of branches; **D**, microbasic eurytele; **E**, ?desmoneme. Scale bar: A, 5 mm, B, C, 1 mm; D, E, 20 µm.

Soleniopsis dendriformis Ritchie, 1907: 495.

Corydendrium parasiticum - Vervoort 1946: 292; - Millard 1959: 301; - Hirohito 1969: 1; - Millard and Bouillon 1973: 27; - Millard 1975: 72; - Hirohito 1983: 9; - Rees; and Vervoort 1987: 12; - Calder 1988: 6; - Hirohito 1988: 66; - Ramil and Vervoort 1992: 16; - Migotto 1996: 11.

Records and material. NTM C12586, Anson Bay, 13° 25.02' S, 129° 55.98' E, 16 m, 1/10/1993; bottom, fine silt; one colony of three infertile stems, the longest 80 mm high, detached from substrate. NTM C12587; outer Charles Point, 12° 16.08' S, 130° 40.98' E, 28 m, 13/10/1993; bottom, sandy mud; two small, infertile colonies on worm tubes.

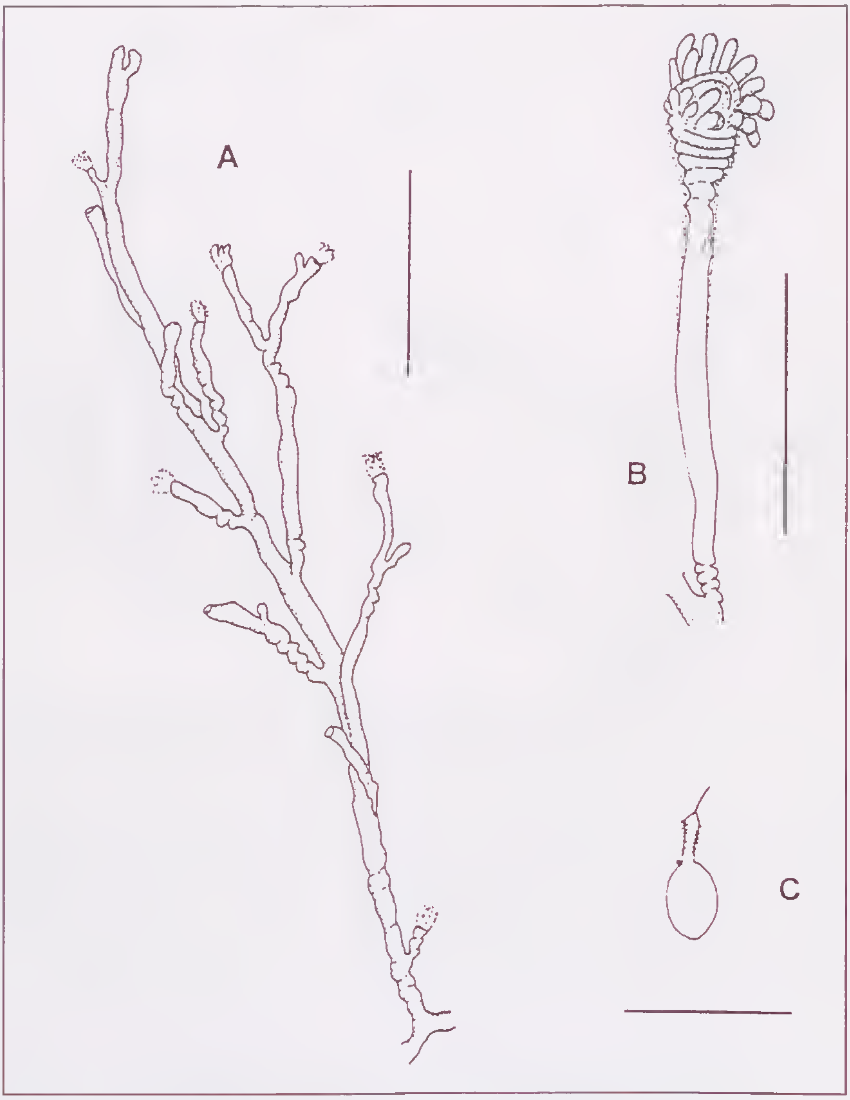

Fig. 3. *Bougainvillia ?balei*: **A**, branched colony; **B**, hydranth; **C**, eurytele. Scale bar: A, 1 mm, B, 0.5 mm, C, 20 µm.

Description. Stems consisting of a bundle of fascicled, irregularly branched hydrocauli; branching of three orders more or less in same plane by forking of perisarc tubes. Adnate tubes proximally narrow, free part diverging at an acute angle to stem; perisarc thick, wrinkled, corrugated to almost smooth. Hydranths with approximately 20 long tentacles scattered over body.

Cnidome. 1) microbasic euryteles in tentacles, capsule 9.5-10.5 x 4.5-6.5 µm, shaft 7 µm, tubule proximally thick with spirals of fine spines; few discharged, not common (Fig. 2D).

2) ?desmonemes, capsule ovoid, 5 x 4.5 µm; rare, none discharged, not common (Fig. 2E).

Colour. Pale honey brown.

Measurements (mm).

Perisarc tube, free length	1.25 - 1.75
Diameter at tube rim	0.3 - 0.6

Remarks. The colonies are covered by adventitious material, chiefly sponge spicules, and some epizooites. Marginal rims of most tubes are crushed but were probably circular. Remnants of a thin opercular flap are visible within some tubes. The hydranths are too poorly preserved for detailed description. The cnidome generally agrees with that of *Corydendrium parasiticum* from Bermuda (Calder 1988).

Distribution. *Corydendrium parasiticum* is widely distributed in temperate and tropical seas (Rees and Vervoort 1987). Although recorded from the Indo-Pacific it has not previously been reported from the Australian coast.

Family Bougainvilliidae Lesson, 1830
Bougainvillia Lesson, 1830
Bougainvillia ?balei Stechow, 1924
(Fig. 3A-C)

Bougainvillia balei Stechow, 1924: 58. - Stechow 1925: 199, fig. B; - Watson 1996: 78.

Record and material. NTM C12588; outer Charles Point, 12° 25.84' S, 130° 37.86' E, 27 m, 13/10/1993; bottom, sandy mud; one infertile colony of many short, branched and simple stems on *Thyroscyphus*; hydrorhiza intergrown with that of *Synthecium* colony.

Description. Main stems slender, unfascicled, arising from a creeping ramified hydrorhiza. Branching irregularly alternate, secondary branching common, branches usually arising at an acute angle to stem; diameter of stem and branches almost the same but branches widening a little distally to base of hydranth. Perisarc of stems and branches thick, wrinkled to almost smooth, bases of stems and most branches with up to four irregular annulations; perisarc invested in a gelatinous sheath, thinner on main stem and lower region of branches, becoming thicker distally, continuing over hydranth to base of tentacles as a thick pseudohydrotheca. Hydranth terminal on branch, with 14-18 tentacles, hypostome conical.

Cnidome. Nematocysts all microbasic euryteles, capsule ovoid, no size classes distinguishable; capsules ranging from 5.5-11 x 4.5-8 µm long, shaft of larger nematocysts 5 µm (none fully discharged). Larger nematocysts concentrated in tips of tentacles; others scattered throughout hydranth.

Colour. Pale brown.

Measurements (mm).

Branched stem, height	8
diameter at base	0.08
maximum length branch	0.50 - 2.25
diameter at origin of branch	0.05 - 0.08
Hydranth	
diameter below tentacles	0.12 - 0.25

Remarks. On colony morphology alone the species could well be referred to *Bougainvillia macloviana* (Lesson, 1830). However, the cnidome is different from the desmonemes and microbasic euryteles of *B. macloviana* described by Millard (1975). No desmonemes were found in the present material and no distinct size classes of euryteles could be identified, the only size difference being that the larger ones tended to be concentrated in the tips of the tentacles.

I have examined alcohol-preserved material, assumed to be type, labelled "*Bougainvillia* (?) *balei* Stechow *auf Lytoscyphus fruticosus* (Esper) von Heirisson Prong, Sharks Bai, Westaustralien, 11 - 12 m tief. 18.vi.1905. det. E. Stechow", kindly loaned by the Zoologische Staatssammlung, Munich, Germany. The two small stem fragments of *Thyroscyphus fruticosus* bear no *Bougainvillia* so the existence of any type material of *B. balei* is in doubt. Hence conspecificity of the Beagle Gulf specimen with *B. balei* cannot be firmly established. However, on the basis of trophosomal similarities with Stechow's figure and its association with *Thyroscyphus*, the Beagle Gulf specimen is doubtfully referred to *B. balei*.

Distribution. Previously known from the type locality of Shark Bay, Western Australia.

Family Eudendriidae L. Agassiz, 1862
Eudendrium Ehrenberg, 1834
Eudendrium kirkpatricki Watson, 1985
(Fig. 4A-D)

Eudendrium kirkpatricki Watson, 1985: 194.

Records and material. NTM C12589; outer Shoal Bay, 12° 6.90' S, 130° 49.92' E, 18 m, 12/10/1993; sponge bed; one infertile colony of several stems 4-19 mm high on

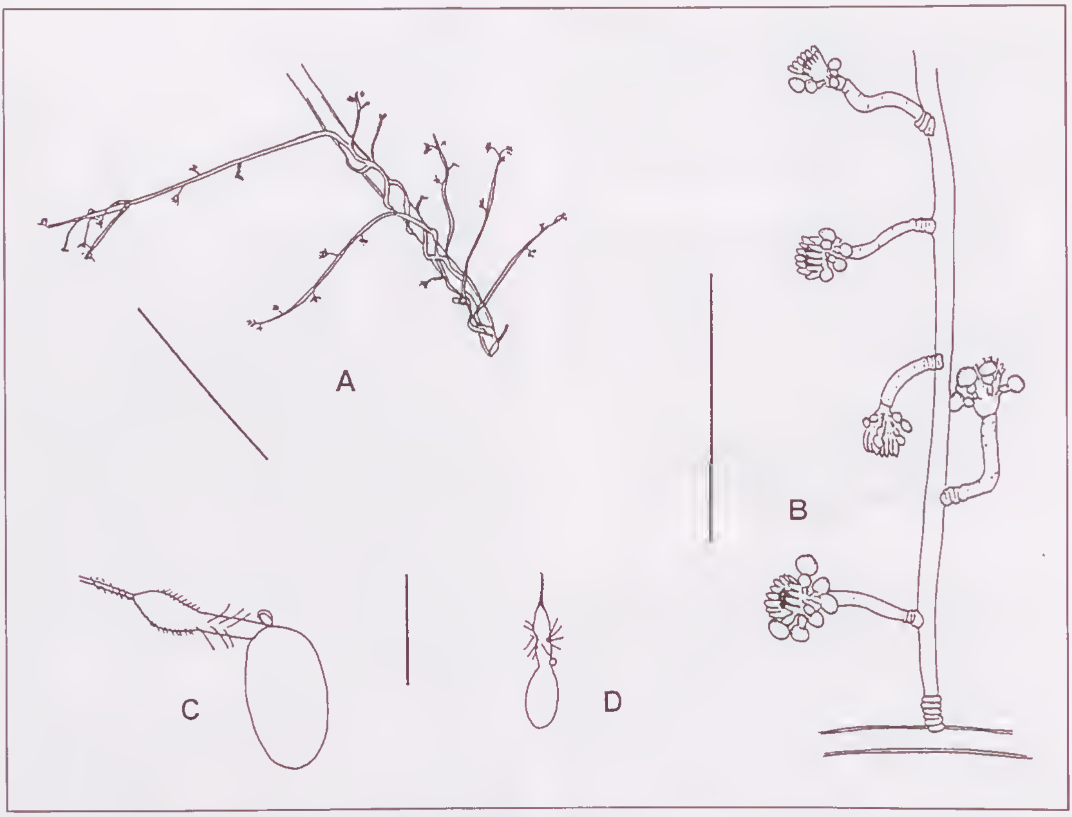

Fig. 4. *Eudendrium kirkpatricki*: **A**, simple colony from Shoal Bay; **B**, part of branched stem from Darwin Harbour; **C**, microbasic eurytele size class 1 from hydranth body; **D**, microbasic eurytele size class 2 from tentacles. Scale bar: A, 1 cm, B, 3 mm, C, D, 10 µm.

dead alcyonarian. NTM C12591, W of Quail Island, 12° 16.08' S, 130° 22.92' E, 9 m, 6/10/1993; bottom coarse sand and gravel; one infertile stem 12 mm high with several hydranths, detached from substrate. NTM C12592, Darwin, offshore reefs, East Point, 4-6 m, coll: J. E. Watson, 19/8/1998; abundant colonies to 50 mm long on alcyonarians, octocorals and sponge. NTM C12590, NNE of North Peron Island, 13° 0.96' S, 130° 4.96' E, 13 m, 4/10/1993; bottom, mud, shale and sand; one infertile stem 10 mm high with two hydranths, detached from substrate.

Description. Colonies from Darwin consisting of tangled, hand-sized tufts of stems arising from ramified hydrorhizae. Hydrocauli of same diameter as hydrorhiza, junction with hydrorhiza marked by several annulations, hydrocauli sometimes lightly fascicled by stolons creeping up stems; stems sparingly branched, origins of branches annulated, perisarc smooth and shining, hydranth pedicels given off at various angles around stem, indistinctly ridged, diameter increasing imperceptibly to base of hydranth; hydranth with 26-28 tentacles.

Male and female gonophores on separate colonies, male two-chambered, bead-shaped, borne on a short peduncle on a blastostyle with fully formed hydranth; female subspherical, borne on blastostyle below hydranth.

Colony from Shoal Bay straggling, monosiphonic, stems arising from a creeping hydrorhiza; tallest stem sparingly branched; most simple, the few remaining hydranths too poorly preserved for description.

Cnidome. 1) large microbasic euryteles, capsule bean-shaped, 28-33 x 13-15 µm, shaft 20 µm, discharges sideways; on body of hydranth, not numerous (Fig. 4C).

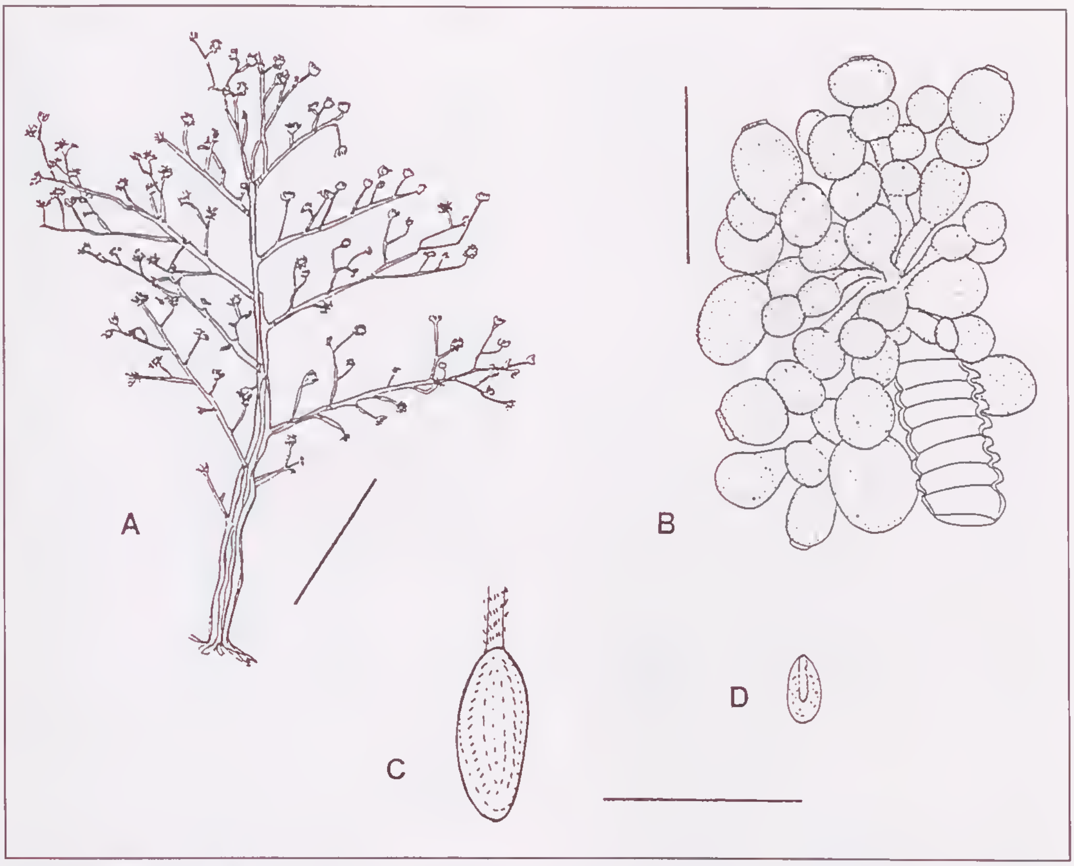

Fig. 5. *Eudendrium glomeratum*: **A**, colony from Chambers Bay; **B**, male gonophores; **C**, ?macrobasic eurytele from hydranth; **D**, microbasic eurytele from tentacles. Scale bar: A, 1 cm, B, 1 mm, C, D, 20 µm.

2) small microbasic euryteles, capsule ovoid, 10-11 x 5-6 µm, shaft about same length as capsule, armed with numerous spines; discharges in axis of capsule, tubule at least 60 µm long; numerous, arranged in circlets around tentacles (Fig. 4D).

Colour. Hydrorhiza and stems shining brown, living hydranths and gonophores creamy-white.

Measurements (mm). (Darwin Harbour specimens)

Stem, width at base	0.30 - 0.35
Hydranth pedicel	
length	0.5 - 2.4
proximal width	0.15 - 0.20
distal width	0.2 - 0.3
Male gonophore	
width across cluster	1.0 - 1.4
length of chain	0.50 - 0.58

Remarks. The luxuriant, fascicled mature colonies from Darwin, occurring on a wide variety of substrates, bear little resemblance to the small, straggling, monosiphonic colonies in the Beagle Gulf collection. The male gonophore has not previously been figured.

The microbasic euryteles are a little larger than previously described for *E. kirkpatricki* by Watson (1985).

Distribution. *Eudendrium kirkpatricki* is one of the most widely distributed species of *Eudendrium* in tropical Australia (Watson 1985).

Eudendrium glomeratum Picard, 1951
(Fig. 5A-D)

Eudendrium glomeratum Picard, 1951:

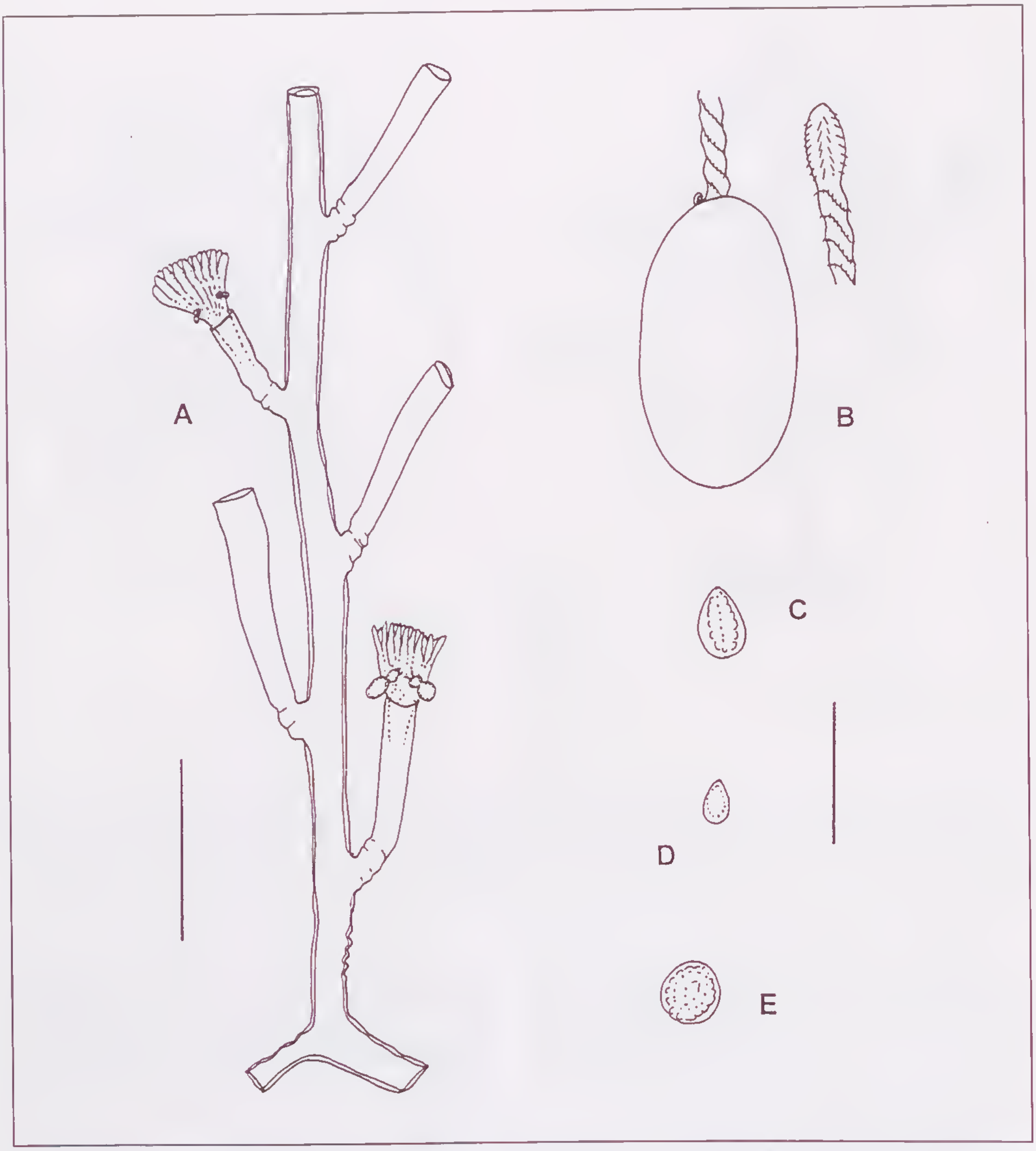

Fig. 6. *Eudendrium infundibuliforme*: **A**, part of small stem with hydrorhiza; **B**, large macrobasic euytele from body of hydranth; **C**, **D**, ?microbasic euryteles, size classes 2 and 3 respectively; **E**, unidentified nematocyst. Scale bar: A, 1 mm, B-E, 20 µm.

338. - Picard 1955: 183; - Rossi 1961: 73. - Teissier 1965: 14; - Fey 1969: 391; - Watson 1985: 213; - Boero *et al*., 1986: 81; - Boero and Cornelius 1987: 244; - Medel and López-Gonzälez 1996: 194; - Watson 1996: 78.

Eudendrium generalis von Lendenfeld, 1885, 351. - Thornely 1904: 110; - Jäderholm 1916: 3.

Eudendrium indopacificum Stechow, 1924: 59.

Records and material. NTM C12593, W of Ruby Island, Chambers Bay, 12° 7.08' S, 131° 20.04' E, 22 m, 9/10/1993; bottom, shale and coral rubble; large male colony of about 20 stems to 6 cm high on calcareous bryozoan. NTM C12594; outer Shoal Bay, 12° 6.90' S, 130° 49.92' E, 18 m, 12/10/1993; sponge bed; one stem 35 mm high, detached from substrate.

Description. Hydrorhiza a ramified stolon entwining substrate. Hydrocaulus straight, tubular, fascicled proximally, polysiphonic tubes running about halfway up main stem and for a short distance along some branches. Branching alternate, almost planar, one order of rebranching frequent, three to five indistinct annulations at origin of each branch. Hydranths borne on pedicels of varying length, perisarc annulated, thin and transparent, base of hydranth frequently with a distinct groove just above junction with pedicel, several nematocyst pads distributed around body of most hydranths.

Male gonophores clustered on blastostyle, hydranth completely resorbed; gonophore of three linear bead-shaped chambers on a short peduncle.

Cnidome. 1) large ?macrobasic euryteles, capsule bean-shaped, 34-36 x 11-12 µm, grouped in pads around hydranth body above groove and on gonophores; none fully discharged (Fig. 5C).

2) microbasic euryteles, capsule ovoid, 11.5 - 15 x 4.5 - 7 µm, abundant in tentacles; none discharged (Fig. 5D).

Colour. Main stems dark shining brown, branches paler brown, hydranths and gonophores pale cream.

Measurements (mm).

Stem, width at base	2
Pedicel length	1.0 - 3.5
Gonophores	
width across cluster	2.8 - 3.1
length of chain	1.0 - 1.3

Remarks. The material generally conforms with the description of *E. glomeratum* from north-western Australia by Watson (1985). However, the nematocysts of the present material are considerably larger than previously reported.

Being similar in size and habit, infertile colonies of *Eudendrium kirkpatricki* and *E. glomeratum* are easily confused. In fertile material the distinction between male colonies is simple as the mature blastostyle of *E. kirkpatricki* retains a fully developed hydranth whereas that of *E. glomeratum* is completely resorbed. This is the first record of a male colony from Australia.

Distribution. *Eudendrium glomeratum* is a common hydroid in the Mediterranean Sea and has been recorded from the British Isles (Boero and Cornelius 1987). The only previous Australian record of the species is from Cape Jaubert in Western Australia (Jäderholm 1916; Watson 1985, 1996).

Eudendrium infundibuliforme Kirkpatrick, 1890
(Fig. 6A-E)

Eudendrium infundibuliforme Kirkpatrick 1890: 606. - Pennycuik 1959: 167; - Watson 1985: 211.

Records and material. NTM C12595, NW of Blaze Reef, Fog Bay, 12° 52.02' S, 130° 11.10' E, 6 m, 4/10/1993; bottom coarse sand and shale; one large male colony 70 mm high, detached from substrate. NTM C12596, Bynoe Harbour, 12° 40.92' S, 130° 33.12' E, 9 m, 7/10/1993; young infertile branched colony 30 mm high, hydranths well preserved, on calcareous bryozoan. NTM C12597, south of Fish Reef, Grose Islands, 12° 27.90' S, 130° 26.70' E, 6 m, 6/10/1993; bottom coarse sand; one infertile colony 18 mm high with one branch, no hydranths, attached to shell grit. NTM C12598, outer Charles Point, 12° 15.84' S, 130° 37.86' E, 27 m, 13/10/1993; bottom sandy mud; one small, unbranched stem 45 mm high, with several developing gonophores.

Description. Largest colony arborescently branched but not in one plane; up to four orders of branching, proximal stems of most colonies polysiphonic, the largest colony strongly fascicled with many tubes, some tubes running onto proximal region of branches.

Hydrorhiza a ramified tubular stolon; simple hydrocauli and polysiphonic tubes of fascicled stems of same diameter as hydrorhiza. Stems and branches straight; obscurely annulated at intervals, hydrothecal pedicels alternate, usually directed upwards, pedicel with up to five indistinct proximal annulations, funnel-shaped, widening distally to hydranth. Hydranths too poorly preserved for description.

Male gonophores two-chambered, borne in a circlet on blastostyle with unreduced hydranth; poorly preserved.

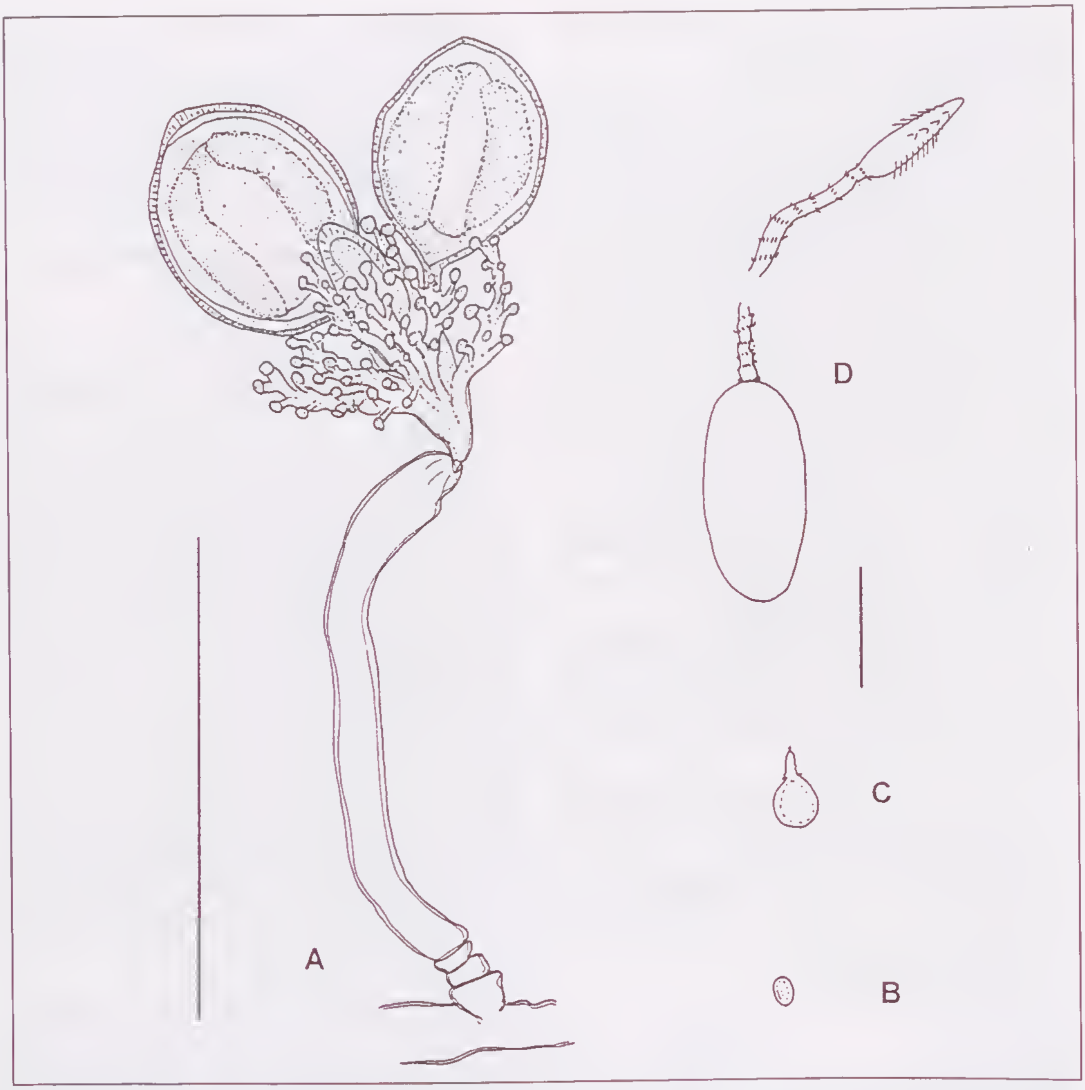

Fig. 7. *Cladocoryne floccosa*: **A**, fertile hydranth; **B**, **C**, ?stenoteles; **D**, macrobasic eurytele from capitate tentacles. Scale bar: A, 1 mm, B-D, 20 µm.

Cnidome. Four types of nematocysts, all poorly preserved.

1) macrobasic euryteles, capsule bean-shaped 37-42 x 21-22 µm, tubule at least 300 µm long, armed with spirals of bristles along length, head slightly inflated, spinous; several on body of hydranth (Fig. 6B).

2) ?microbasic euryteles, capsule ovoid, 7-9 x 4.5-7 µm, in tentacles, none discharged (Fig. 6C).

3) very small ?microbasic euryteles, 5-6 x 3.5 µm, rare in tentacles, none discharged (Fig. 6D).

4) unidentifiable bodies - ?nematocysts, capsule subspherical, none clearly seen, 9-12 x 7 - 10 µm; none discharged, common in tentacles (Fig. 6E).

Colour. Perisarc brown, hydranths white.

Measurements (mm).

Stem, branch diameter	0.2 - 0.3
Pedicel	
length	0.5 - 3.1
proximal diameter	0.12 - 0.19
distal diameter	0.19 - 0.33

Remarks. The specimens conform to the description of *Eudendrium infundibuliforme* by Watson (1985). The distally expanding hydranth pedicels are diagnostic of the species. Other than confirming Watson's (1985) suggestion that the male gonophores are two-chambered, their poor state of preservation precludes further description. Only a few of the very large euryteles from the hydranth body are discharged and the remainder of the cnidome is too poorly preserved for adequate description. Both size classes of euryteles are larger than previously reported by Watson (1985) for *E. infundibuliforme*. There is no previously recorded counterpart for the putative tentacular nematocysts (4) in the Beagle Gulf specimens.

Distribution. Torres Strait (Kirkpatrick 1890), Papua New Guinea, Great Barrier Reef, Australia (Watson 1985).

Order Capitata

Family Cladocorynidae Allman, 1872

Cladocoryne Rotch, 1871

Cladocoryne floccosa Rotch, 1871

(Fig. 7A-D)

Cladocoryne floccosa Rotch 1871: 228. - Vervoort 1941: 190; - Pennycuik 1959: 159; - Millard and Bouillon 1974: 11; - Bouillon 1974: 145; - Millard 1975: 65; - Watson 1996: 95; - Schuchert 1996: 97.

Cladocoryne haddoni Kirkpatrick, 1890: 605.

Cladocoryne pelagica Allman 1876: 255. - Stechow and Müller 1923: 459; - Stechow 1925: 193.

Record and material. NTM C12599, E of Blaze Reef, Fog Bay, 12° 51.96' S, 130° 14.10' E, 7 m, 4/10/1993; bottom mud and shale; one colony of many sparingly fertile stems on the hydroid *Idiellana pristis*.

Description. Stems simple, up to 2 mm high, perisarc with a few proximal annulations, smooth thereafter, thinning a little and tapering below hydranth. Hydranth with several whorls of branched tentacles bearing many globular capitula armed with nematocysts; hypostome clavate. Gonophores large, globular, borne among oral tentacles.

Cnidome. 1) ?stenoteles, capsule subspherical, diameter 5-7 µm, very abundant, none discharged (Fig. 7B).

2) ?stenoteles, capsule subspherical, 11-12 x 10-12 µm, shaft 8 µm, indistinct, abundant (Fig. 7C).

3) macrobasic euryteles, capsule 66-75 x 25-30 µm, tubule long, thick, unarmed proximally, with distal spirals of spines and spear-shaped tip armed with spines; in capitate tentacles (Fig. 7D).

Colour. Preserved material white.

Remarks. The material conforms to descriptions of this distinctive species. The smaller nematocysts in the cnidome correspond with measurements given by Millard (1975); however, the macrobasic euryteles are much larger and the distal end of the tubule differs from the thread-like end shown in Milliard's figure.

Distribution. Widely distributed in tropical and subtropical waters, sometimes extending into cooler seas, e.g. New Zealand (Schuchert 1996), Port Phillip Bay, southern Australia (Watson, pers. obs.). In the Australian region it is known from Queensland (Pennycuik 1959) to Shark Bay on the western side of the continent (Stechow 1925) and from the Timor Sea (Stechow and Müller 1923).

Family Tubulariidae Fleming, 1828

Ralpharia Watson, 1980

Ralpharia rosetta sp. nov.

(Fig.8A-G)

Records and material. HOLOTYPE, NTM C12606, East Point, Darwin, reef 700 m from shore, 6 m, coll: J. E. Watson 17/8/1998; one fertile colony on worm tube growing on coral rock.

Description. Hydrorhiza entwining substrate, tubular, contorted, perisarc very thick, some stolons attached to lower regions of hydrocauli.

Hydrocaulus tubular, of greater diameter than hydrorhiza, straight or curved, circular in section, hollow, increasing in diameter distally from base, 10-12 narrow longitudinal internal canals all of similar diameter, visible through perisarc; perisarc thinning over length of stem, merging into an indistinctly transversely wrinkled transparent sheath beneath hydranth, a groove separating distal end of hydrocaulus from base of hydranth.

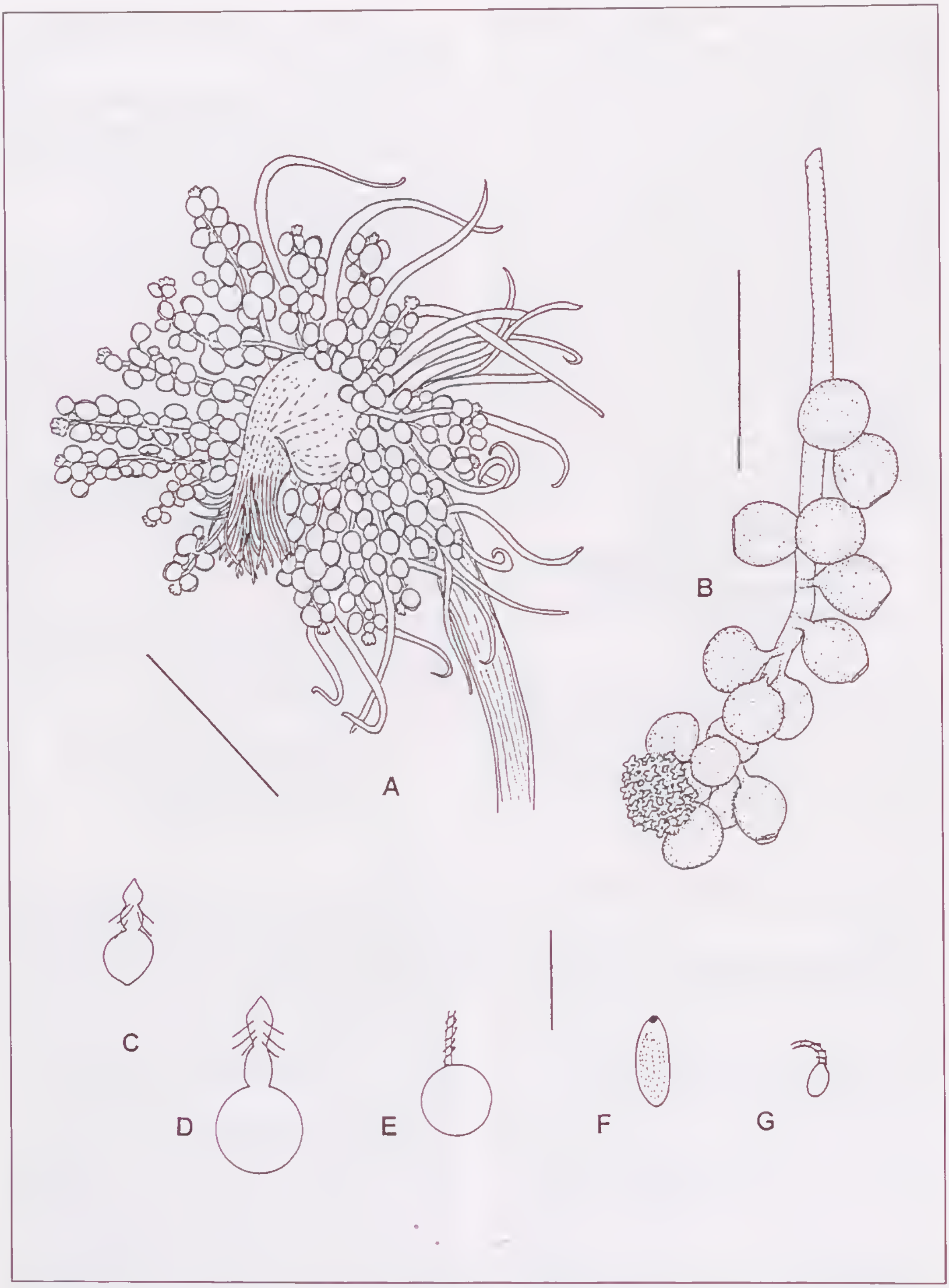

Fig. 8. *Ralpharia rosetta*, sp. nov.: **A**, fertile hydranth; **B**, blastostyle with male gonophores; **C**, **D**, stenoteles, size classes 1 and 2 respectively; E, anisorhiza from apical cluster of gonophore; **F**, ?isorhiza from base of aboral tentacles; **G**, desmoneme. Scale bar: A, 5 mm, B, 2 mm, C-F, 20 µm.

Hydranth pyriform, base broad with a whorl of about 40 long aboral tentacles and 20 tightly clustered short oral tentacles; aboral tentacles well separated from orals by a long coelenteric region.

Gonophores male, up to 20 on a long, slender, unbranched blastostyle: gonophores spherical, some flattened apically. Distal end of blastostyle a tight rosette of small, quadrate nematophores richly armed with nematocysts.

Cnidome. 1) stenoteles, capsule subspherical 7.5-12 x 8-11 µm, shaft 15 µm long with large spines, abundant in oral and aboral tentacles and in apical cluster (Fig. 8C).

2) stenoteles, capsule spherical, diameter 15-17 µm, shaft 20-22 µm, with large spines; scattered abundantly in oral tentacles and apical cluster (Fig. 8D).

3) large anisorhizas, capsule spherical, 15-16 µm diameter, tubule thick and ropy, at least 45 µm long, heavily armed with small spines; very abundant, in nematophore cluster, few discharged (Fig. 8E).

4) ?isorhizas, capsule elongate ovoid, anterior end slightly pointed, 14-19 x 1-7 µm, in base of aboral tentacles, none discharged (Fig. 8F).

5) desmonemes, capsule 8-9 x 3-4 µm, partially discharged, rare, site unknown (Fig. 8G).

Colour. In life, hydrocaulus pale green, body of hydranth deep orange to gold, aboral tentacles clear white to pale gold, oral tentacles pale gold; gonophores scarlet. Preserved material uniformly white.

Measurements (mm).

Hydrorhiza, diameter	0.5	-	0.75
Hydrocaulus			
length	17	-	30
proximal diameter	0.75	-	1.00
distal diameter	1.0	-	2.0
Hydranth			
width across extended tentacles			15.0
length of aboral tentacles			5.0
length of oral tentacles			3.0
Gonophore			
length of blastostyle	5	-	7
diameter of gonophore	0.5	-	0.6

Remarks. The class (1) stenoteles exhibit such a large range in size that the extremes could well be assigned to two different size classes.

The hydranths are fertile even when quite young. In life, the aboral tentacles are strongly recurved backward, exposing the gonophores. The function of the distal nematophore cluster mus be defence of the underlying gonophores. Some previously broken hydrocauli show regeneration of stems and regrowth of hydranths.

Petersen's (1990) redefinition of *Ralpharia* Watson, 1980 now encompasses those species with 10-20 canals in the parenchymatic endoderm, one canal being larger than the others, and branched or unbranched blastostyles with or without distal a nematophore cluster. Inclusion of a nematophore now greatly widens the original definition of *Ralpharia* to the extent that critical review of the scope of the genus may be nesessary.

I therefore refer the present species with some hesitation to *Ralpharia*. While *Ralpharia rosetta* is in some respects similar to *Ralpharia neira* Petersen, 1990, from Indonesia, there are fewer endodermal canals and no obvious central canal in the hydrocaulus, nor are the medusa buds borne on dichotomously branched blastostyles as in *R. neira*.

Etymology. Named for the distal rosette-shaped nematophore cluster of the blastostyle.

Family Solanderiidae Marshall, 1892

Solanderia Duchassaing and Michelin, 1846

Solanderia secunda (Inaba, 1892)

(Fig. 9A-F)

Dendrocoryne secunda Inaba, 1892: 98. - Goto 1897: 93; - Stechow 1909: 40; - Stechow 1913: 7; - Bedot 1918: 116; - Stechow 1923: 2; - Bedot 1925: 165; - Prévot 1959: 100, 125; - Yamada 1959: 14.

Solanderia secunda - Vervoort 1962: 526. - Millard 1966: 446; - Vervoort 1966: 387, 389; - Vervoort 1967: 23 -25; - Mergner and Wedler 1977: 11; - Vervoort and Vasseur 1977: 10, 11-15; - Ho 1984: 23, 24, 41, 44; - Hirohito 1988: 49. - Bouillon *et al.*, 1992: 12.

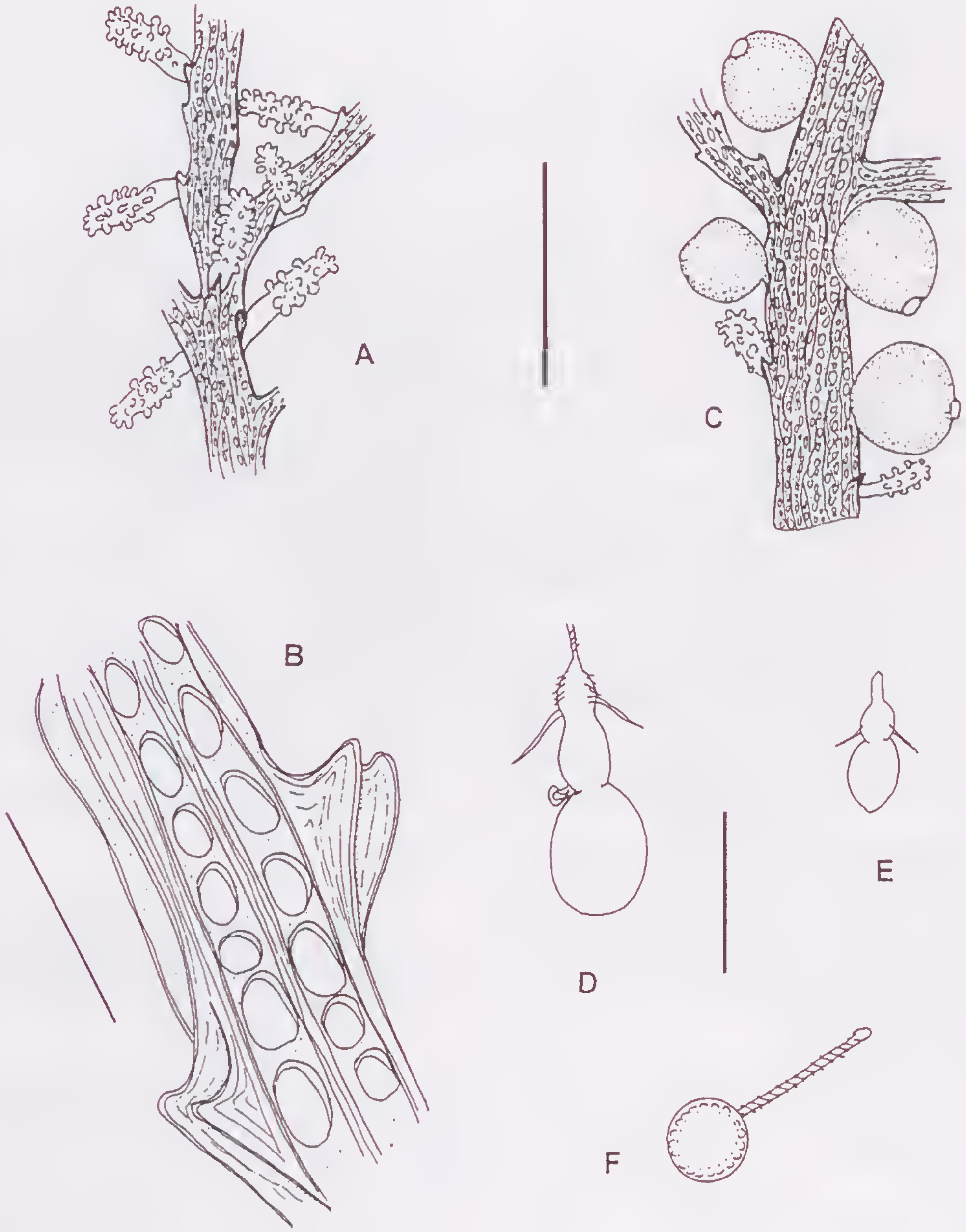

Fig. 9. *Solanderia secunda*: **A**, part of upper branch with hydranths; **B**, young branch with perforations and bracket-like spines; **C**, gonophores; **D**, stenotele of size class 1 from capitala of tentacles; **E**, stenotele size class 2; **F**, ?isorhiza. Scale bar: A, C, 2 mm, B, 0.25 mm, C-F, 20 μm.

Solanderia rufescens Jäderholm, 1896: 5.

Ceratella minima Hickson, 1903: 114. - Thornely, 1908: 85.

Solanderia minima - Stechow 1909: 41. - Bedot 1925: 413; - Vervoort 1962: 531; - Vervoort 1967: 25, 26; - Millard and Bouillon 1973: 16; - Millard and Bouillon 1974: 3; - Millard 1975: 59; - Mergner and Wedler 1977: 11; - Vervoort 1977: 10; - Bouillon and Gravier-Bonnet 1987: 768.

Ceratella crosslandi Thornely, 1908: 85.

Solanderia crosslandi - Stechow 1909: 41. - Bedot 1925: 412; - Kramp 1947: 6; - Vervoort 1962: 531; - Vervoort 1967: 20,23,24,26; - Vervoort 1977: 11.

Records and material. NTM C12600, SW of Marsh Shoals; outer Shoal Bay, 12° 7.02' S, 130° 52.92' E, 20 m, 12/10/1993; sponge bed; one infertile colony 30 mm high, on shell. NTM C12601, South Shell Island, Darwin; reef in channel bed, 6 m, coll: J. E. Watson, 21/8/1998; two fertile colonies, the tallest 18 cm high, on worm tubes and coral rock. MVF 83436, East Arm Port breakwater, 3-4 m, coll: J. E. Watson, 20/8/1998; one infertile colony 10 cm high.

Description. Hydrorhiza a cluster of stolons strongly entwined around substrate. Colonies arborescently branched in one plane, several main branches arising from a thick, short trunk; trunk of largest colony 4 mm thick near base; in older colonies many orders of branching, the branches thinning to growing tips. Skeletal meshwork on younger branches penetrated by lines of oval to quadrangular perforations aligned parallel to axis of branch, this pattern often obscured in older branches and stem.

Darwin material with a mean of 50 hydranths per cm along length of branch; in life, hydranths large, cylindrical, supported on prominent bicuspid skeletal spines; all tentacles capitate, four oral and 15-20 others scattered over body. Beagle Gulf specimen with no remaining hydranths.

Gonophores male, eumedusoid, large, globular, with four radial canals (not visible in preserved material) and a small raised apical cap; peduncle very short; no nematocysts.

Cnidome. Nematocysts in capitala of tentacles, few discharged:

1) large stenoteles, capsule subspherical, 17-17.5 x 13-14 µm, shaft 25 µm long with several long spines, tubule thick; moderately abundant (Fig. 9D).

2) smaller stenoteles, capsule ovoid, 8.5-9 x 6.5-7 µm shaft (partially discharged) about same length as capsule; tubule not seen; abundant (Fig. 9E).

3) ?isorhizas, capsule subspherical, 10 x 9 µm, tubule 25 µm (partially discharged) finely spinous; rare in some hydranths, absent from others (Fig. 9F).

Colour. Darwin colonies black in situ, under stereo-microscope deep purple, fading to mauve on tips of branches; hydranths white, gonophores scarlet (leaching to white in alcohol), radial canals white. Beagle Gulf colony brown, yellowish on growing tips.

Measurements (mm).

	Darwin	Beagle Gulf
Skeleton		
length of foramen	0.060 - 0.135	0.065 - 0.115
height of spines	0.06 - 0.22	0.08 - 0.15
Hydranth length	0.75 - 1.25	
Gonophore diameter	0.7 - 1.2	

Remarks. The specimens conform with the concept of *Solanderia secunda* of Bouillon *et al.* (1992) who united two previously separate species (*Solanderia minima* and *Solanderia crosslandi*) with prominent bicuspid hydrophores into forms of *Solanderia secunda*. Their concept encompasses a large morphological range and wide geographical distribution, the f. *typica* being widely known from the Indo-Pacific region while the others have a circumtropical distribution. The present material resembles both f. *crosslandi* from Madagascar and f. *typica* from Papua New Guinea (Bouillon *et al.* 1992).

There is no information available for comparison of the cnidome of *S. secunda* throughout its geographical range. While stenoteles of two sizes are the major components of the cnidome (Bouillon *et al.* 1992 and present material) the larger size class (1) in the Darwin specimens is larger than dimensions given by Bouillon *et al.* for the largest stenoteles (11.2-14.4 x 9-11.2 µm).

The smaller Darwin stenoteles are almost within the same size range as the small stenoteles (6.0-8.6 x 4.0-7.2 µm) given by these authors. Bouillon *et al.* also list unidentified globular nematocysts of 6 x 7 µm which may match the putative isorhizas found in the present material; if so, the Darwin nematocysts are considerably larger. The significance of size ranges of nematocysts in identification of hydroid species is a vexed problem which is not yet properly explored.

Bouillon *et al.* (1992) described the colour of *S. secunda* as varying from purple fading to mauve, or shades of brown fading to yellow-brown on younger branches. The present specimens fall within this colour range, with purple-black colonies up to 25 cm high being abundant on natural reef on the bed of the East Arm Port channel. The small yellow-brown specimen from Beagle Gulf may possibly be the juvenile colour of colonies. The scarlet colour of the Darwin gonophores is distinctive.

Colonies observed on the rock breakwater at East Arm Port, emplaced in March, 1997 were, after 15 months, already up to 10 cm high; indicating a fast rate of growth of the species.

Living hydranths of the Darwin specimens were heavily invested by colonies of the protozoan *Vorticella*.

Distribution. Tropical and subtropical Pacific and Indian Oceans (Bouillon *et al.* 1992).

Family Pennariidae McCrady, 1859

Pennaria Goldfuss, 1820

Pennaria disticha Goldfuss, 1820

(Fig.10A-I)

Pennaria disticha Goldfuss 1820: 89. - Brinckmann-Voss 1970: 40; - Gibbons and Ryland 1989: 387; - Schuchert 1996: 142.

Halocordyle disticha - Pennycuik 1959: 160. - Millard 1975: 41; - Garcüa Corrales and Aguirre 1985: 85; - Calder 1988: 56 (cum. syn.); - Hirohito 1988: 28.

Halocordyle disticha var. *australis* - Stechow 1925: 194; - Vervoort 1941: 192; - Vervoort 1946: 290.

Pennaria australis Bale, 1884: 45; - Trebilcock 1928: 1; - Ralph 1953: 70.

Records and material. NTM C12602, W of Finniss River, Fog Bay, 12° 51.96' S, 130° 16.98' E, 7 m, 4/10/1993; bottom fine mud; one infertile colony of 12 stems to 30 mm high, poorly preserved, detached from substrate. NTM C12603, South Shell Island, Darwin, coll: J. E. Watson, 6 m, 19/8/1998; three stems 50 mm high on shell fragments in channel bed.

Description. Stems plumose, arising from a ramified hydrorhiza; stolons tubular, perisarc very thick, internally longitudinally striated. Hydrocaulus tubular, becoming narrower distally, divided into internodes of variable length by 4-5 deeply indented transverse nodes; hydrocladia distal on internodes, gracefully recurved from stem, up to eight annulations at junction with stem; internodes same as those on stem, one hydranth given off on a short expanding pedicel on upper, distal side of each internode; pedicel indistinctly ringed at base, perisarc thinner than on hydrocladium.

Hydranths clavate to pyriform, terminal hydranth on each hydrocladium usually larger than others, all hydranths with a whorl of 10-14 semi-filiform aboral tentacles and 14-16 scattered pedunculate capitate tentacles on upper body, aboral tentacles with a longitudinal band of nematocysts on outward facing side, peduncle of oral tentacles long, transversely wrinkled, capitilum richly armed with nematocysts. Developing gonophores on young hydranths; too small for description.

Cnidome. 1) stenoteles, capsule ovoid, 45 -46 x 27-30 µm, shaft 58-60 µm, 10 µm wide armed with four or five curved spines 30 µm long spines and spirals of fine bristles, tubule at least 180 µm long; abundant in capitate tentacles (Fig. 10B).

2) stenoteles, capsule ovoid, 37 x 25 µm, shaft 60 µm, tubule at least 60 µm, in capitate tentacles; none discharged, not common (Fig. 10C).

3) stenoteles, capsule ovoid, 15-18 x 13-17 µm, shaft 15-20 µm; in capitate tentacles (Fig. 10D).

4) stenoteles, capsule ovoid, 6.5-10 x 4-7 µm shaft 8 µm, very abundant; in aboral and capitate tentacles, few discharged (Fig. 10E).

5) desmonemes ovoid to pyriform capsules, 6-8 x 4-4.5 µm, in aboral tentacles,

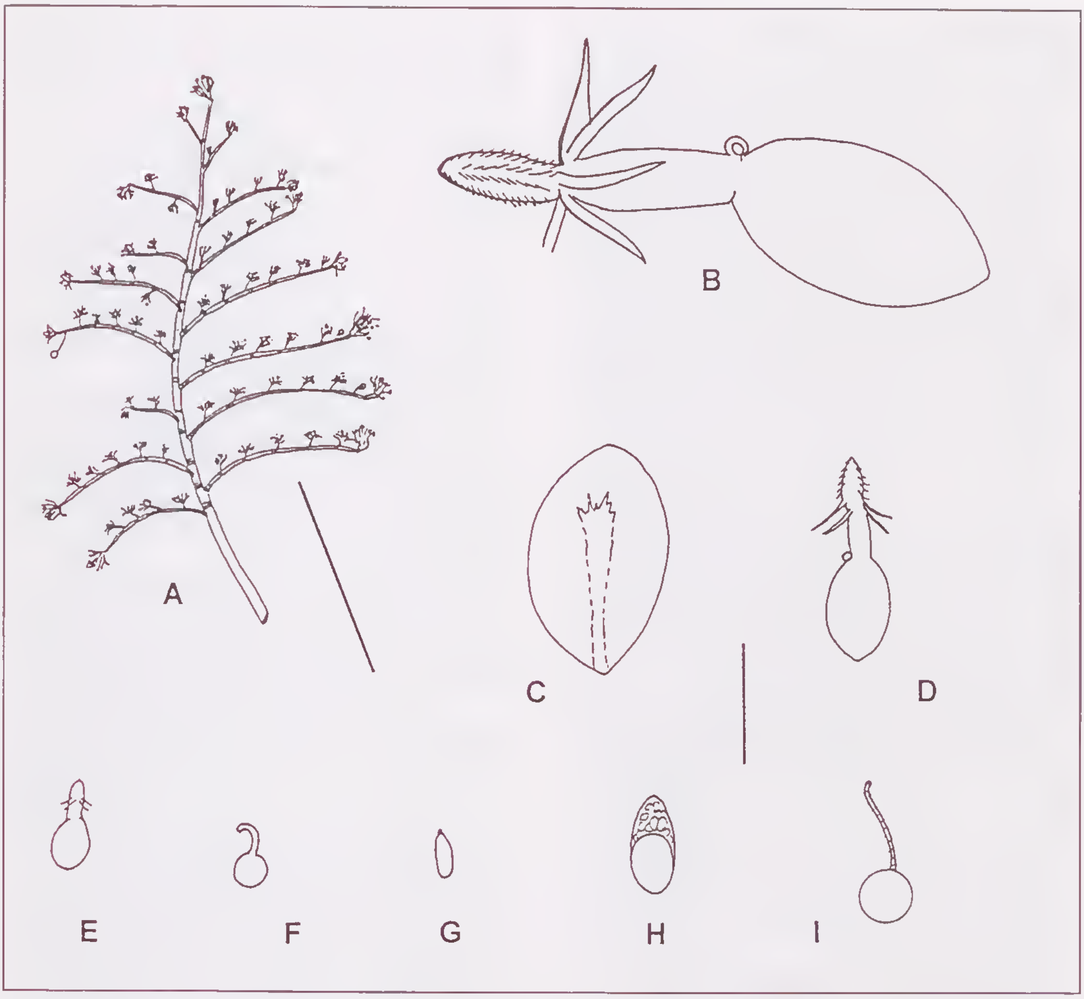

Fig. 10. *Pennaria disticha*: **A**, colony from Darwin Harbour; **B**, **C**, stenoteles size classes 1 and 2 from capitate tentacles; **D**, **E**, stenoteles size classes 3 and 4 from tentacles; **F**, desmoneme; **G**, ?haploneme from aboral tentacles; **H**, nematocyst with inclusion body; **I**, ?isorhiza. Scale bar: A, 1 cm, B-H, 20 µm.

only one seen discharged (Fig. 10F).

6) ?haploneme, capsules small bean-shaped, 9-12 x 3-6 µm; abundant in aboral tentacles, none discharged (Fig. 10 G).

7) capsule ovoid narrower at anterior end, 12.5-15 x 6.5-7 µm with inclusion body; in aboral tentacles, none discharged (Fig. 10H).

8) ?isorhiza capsule almost spherical 10 x 7 µm, site unknown, several partially discharged, tubule with very fine spines (Fig. 10I).

Colour. Stems of Darwin Harbour specimens shining dark brown, hydrocladia lighter brown, hydranths white; Beagle Gulf stems pale brown, hydranths white.

Measurements (mm).

Stem	
internode length	0.55 - 2.00
width at node	0.33 - 0.43
Hydrocladium	
length	1.0 - 12
internode length	1.5 - 2.13
width at node	0.18 - 0.23
Hydranth pedicel	
length	0.23 - 0.48
distal width	0.13 - 0.15

Remarks. Four size classes of stenoteles present in *Pennaria disticha* from Darwin and Beagle Gulf are also recognised in the species from New Zealand (Schuchert 1996), Bermuda (Calder 1988) and the

Mediterranean Sea (Östman *et al*. 1991). However, the actual size ranges within the classes differ between various accounts as well as among the Australian material; for example size class (1) from Darwin is considerably larger than reported from elsewhere. Other than the desmonemes which are invariably present and are of similar size throughout the species' range, haplonemes and heteronemes, including microbasic euryteles, have also been reported by the above authors. In the present material, nematocyst (6), although larger, appears to correspond with haploneme (b) of Calder. While nematocyst (7) conforms with microbasic eurytele (c) of Calder, this type of nematocyst has not been reported by other authors but may correspond with the microbasic b mastigophores with inclusion reported by Östman *et al*. (1991). Isorhiza? (8), although quite common in some hydranths of the present material, has not been recorded by other authors.

The lack of agreement in the type and size of components of the cnidome from four global localities (tropical Australia, New Zealand, Bermuda, Mediterranean Sea) brings into question how much reliance can be placed upon the cnidome in identification of species and the possible disparate response of nematocysts to geographical and environmental factors.

Distribution. Circumglobal tropical to temperate waters; in Australia, southern Queensland (Pennycuik 1959) and Great Barrier Reef (J. E. Watson, pers. obs.)

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A REVIEW OF THE MANGROVE GOBY GENUS *HEMIGOBIUS* (GOBIOIDEI, GOBIIDAE, GOBIONELLINAE)

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ABSTRACT

The gobiid fish genus *Hemigobius* is reviewed and found to comprise two species, which are redescribed. The genus is considered to belong to the subfamily Gobionellinae, is closely related to the genera *Mugilogobius* and *Pseudogobius*, and can be distinguished from them by a combination of characters. *Hemigobius* is restricted to mangrove habitats in northern Australia and South-east Asia.

KEYWORDS: Gobioidei, Gobiidae, Gobionellinae, *Hemigobius*, mangroves, northern Australia, South-east Asia.

INTRODUCTION

The gobiid fish genus *Hemigobius* Bleeker, 1874, consists of six nominal species, which have been variously placed in *Hemigobius*, *Mugilogobius* or *Pseudogobius*. The generic name apparently has not been used other than in Koumans (1931, 1953), Miller (1987), Kottelat *et al.* (1993) and Larson (1995; in press).

Bleeker (1874) placed his new genus *Hemigobius* in the group Subphalanx Eugobii, in which he put most of the gobiid genera comprising his Phalanx Gobiini. He characterised *Hemigobius* by the truncate teeth of its type species, *Gobius melanurus* Bleeker.

Koumans (1931: 101) erected the genus *Microgobius* (non Poey), based on Bleeker's "museum name" written on the bottles of two species at Leiden museum (RMNH), and listed it as a junior synonym of *Stigmatogobius* Bleeker (along with *Pseudogobius*, given as another Bleeker museum name). Koumans included under *Microgobius non* Poey: *Gobius hoevenii* Bleeker, 1851, and *Gobius tambujon* Bleeker, 1854, based on Bleeker's jar labels. Koumans indicated that the latter two species were probably *Stigmatogobius*, but were "... too badly preserved to decide it with certainty" (1931: 102). The holotype of *Gobius hoevenii* (RMNH 4457) is a valid species of *Hemigobius*, redescribed below. Three probable syntypes of *Gobius tambujon* (RMNH 4458) are *Redigobius* species (Larson. in prep.).

Fowler (1940) erected the genus *Sphenentogobius*, for his new species *vanderbilti*. He remarked upon the elevated rear ramus of the mandible, and the etymology of his genus *Sphenentogobius* reflects this: "σφην wedge + εντοζ within + Gobius". He considered *Sphenentogobius* to be "apparently related to *Redigobius*".

During revision of the gobiid fish genus *Mugilogobius* Smitt and its nominal relatives in the subfamily Gobionellinae (Larson 1995; Larson in press), *Hemigobius* Bleeker was found to be most closely related to *Pseudogobius*.

Hemigobius and *Pseudogobius* group together due to their derived fifth ceratobranchial, lip and gut morphology, mouth position and abbreviate headpore patterns (they both lack preopercular pores and the rear part of oculoscapular canal, but headpores are always present) (Larson in prep.). Each genus has an autapomorphic long gut coiling pattern, differing from most of the *Mugilogobius* group of genera. *Hemigobius* has a long coiled gut reminiscent of *Chlamydogobius* (Larson 1995; in press). The gut morphology of *Pseudogobius* resembles a short version of that in *Awaous* (Geevarghese 1983; Larson in press). Other related genera have short, typically "carnivorous goby" gut forms. *Hemigobius* has 17 segmented caudal rays, while *Pseudogobius* has 16. *Pseudogobius* has two *s* papillae rows on the snout, and *Hemigobius* has three, as in *Mugilogobius*. *Hemigobius* has the fine villi on the head characteristic of *Mugilogobius*, while *Pseudogobius* does not possess them.

Miller (1987) was in error when he stated that *Hemigobius* lacked head canals. The author assumes that Miller made this statement on the basis of his examination of the type of *Gobius melanurus* Bleeker, 1849 (which is also the type of *Hemigobius bleekeri* Koumans, 1953), the only material of this genus referred to in his paper (Miller 1987). This specimen (RMNH 4501) has badly abraded skin covering the very short canals, so that the headpores appear to be absent. However, the cheek scales, characteristically shaped dentary and flattened teeth are present. Examination of fresh specimens of this species revealed the canal and headpore arrangement characteristic of this genus. Miller apparently was not aware of the identity of *Gobius hoevenii* Bleeker, 1851, as he refers to *Hemigobius* as being monotypic (based on Koumans 1953). In the same paper, Miller erroneously included *Sphenentogobius* Fowler as a synonym of *Redigobius* (no reasons are given, although it is likely that he did so in agreement with Fowler's statement, in the original description of the genus, that it was related to *Redigobius*).

METHODS

Measurements were taken using electronic callipers and dissecting microscope. Counts and methods generally follow Hubbs and Lagler (1970), except as indicated below. Papillae pattern terminology is based on that of Sanzo (1911), due to its use in previous literature on this group of gobionellines by Aurich (1938) and Miller (1987, 1989). Pterygiophore formula follows Birdsong *et al*. (1988). Transverse scale counts are taken by counting the number of scale rows from the anal fin origin diagonally upward and back toward the second dorsal fin base. Head length is taken to the upper attachment of the opercular membrane. Interorbital width is least fleshy width (not least bony width). In the descriptions, an asterisk indicates counts of the holotype. Numbers in parentheses after counts indicate the number of specimens with that count, or the range of counts. Vertebral counts and other osteological information was obtained by radiography and clearing and double-staining.

Synonymies are not complete, as it was not always possible to determine from descriptions or illustrations what species was referred to in various publications (for example, *Stigmatogobius hoevenii* could be *Hemigobius hoevenii* or *Mugilogobius chulae*). Synonymies are given where the identity was verified by examination of specimens or the description was unequivocal.

Abbreviations for institutions referred to are: AMS - The Australian Museum, Sydney; ANSP - Academy of Natural Sciences, Philadelphia; BMNH - The Natural History Museum, London; CAS - California Academy of Sciences, San Francisco; CMK - Collection Maurice Kottelat, Cornol, Switzerland; KUMF - Kasetsart University Museum of Fisheries, Bangkok; NIFI - National Inland Fisheries Institute, Bangkok; RMNH - Nationaal Naturhistorisches Museum, Leiden; NTM - Museum and Art Gallery of the Northern Territory, Darwin; URM - University of the Ryukyus, Naha; USNM - National Museum of Natural History, Washington; WAM - Western Australian Museum, Perth; ZMH - Zoologische Museum, Hamburg; ZRC - Zoological Reference Collection, University of Singapore; ZSM - Zoologische Staatsammlung, München.

Other abbreviations used: HL - head length; SL - standard length; TRB - transverse scale rows backward.

SYSTEMATICS

Hemigobius Bleeker, 1874

Hemigobius Bleeker, 1874 (*Gobius melanurus* Bleeker, 1849: 31, Java; = *Hemigobius bleekeri* Koumans, 1953: 191, replacement name for *Gobius melanurus* Bleeker, by original designation and monotypy).

Microgobius Koumans, 1931 (listed as synonym of *Stigmatogobius*). Preoccupied by *Microgobius* Poey.

Sphenentogobius Fowler, 1940 (*S. vanderbilti* Fowler, 1940: 396, figs 8-11, Sumatra, by original designation and monotypy).

Diagnosis. Distinguished by following combination of characters. Second dorsal rays I,6-8, modally I,7; anal rays I,6-9, modally I,7; pectoral rays 13-17; 17 segmented caudal rays in 9/8 pattern; some headpores present with no lateral canal over preoperculum, no preopercular pores, no nasal pores, and pairs of interorbital pores not connecting across interorbital space; 25-34 lateral scales; circumpeduncular scales strongly modally 12; predorsal scales 7-12, extending close up to behind eyes, margins of anteriormost scales scalloped; preopercle at least partly scaled; interorbital and top of snout with fine villi; gill rakers without spines; papillose flaps or pads present at insertion of first gill arch onto roof of mouth; jaws small, lower jaw symphysis usually raised; thin, folded lower lip; teeth small and flattened in females (at least), usually conical in males; anterior nostril in short tube oriented down and forward over upper lip, preorbital usually curved outward slightly around base of nostril; genital papilla slender, flattened and pointed in males, conical and blunt-tipped in females; intestine very long and tightly coiled.

Dorsal pterygiophore formula 3-12210; two epurals, rarely one; one to three anal pterygiophores before haemal spine of first caudal vertebra; neural spine on first vertebra usually short and broad. Palatine and pterygoid short, with broad, T-shaped heads; palatine larger and more robust than pterygoid. Metapterygoid deep, well separated from quadrate, anterior process extends upward and forward, well above quadrate. Mandibular ramus elevated and curved anteriorly in *H. mingi*, elevated but angled backward in *H. hoevenii*. Fifth ceratobranchials triangular, very open and lattice-like in structure.

Found in mangroves in Indo-west Pacific.

Key to species of *Hemigobius*

1. Pectoral rays 13-17, usually 15-16; body relatively slender, depth at anus about 4-5.5 times in SL; about six distinct diagonal bars along sides; first dorsal fin with two broad dark bands, not forming spot.................... *H. hoevenii* (Bleeker, 1851) (Thailand, Hong Kong, Malaysia, Singapore, Philippines, Borneo, New Guinea, northern Australia)

1A. Pectoral rays 13-15, usually 14; body relatively deep, depth at anus about 3.5-4.5 in SL; scale margins outlined, forming reticulated pattern, with four or five indistinct dorsal saddles sometimes present; very distinct black spot posteriorly on first dorsal........................ *H. mingi* (Herre, 1936) (Thailand, Singapore, Sumatra, Java)

Hemigobius hoevenii (Bleeker, 1851)

(Figs 1-6, Tables 1-4)

Gobius hoevenii Bleeker, 1851: 426-427 (Sambas, in river, Borneo).

Vaimosa crassa Herre, 1945: 403 (brook near Un Long, Hong Kong).

Stigmatogobius hoevenii - Koumans 1953: 125 (in part).

Microgobius hoevenii - Bleeker 1983: pl. 438, fig. 17.

Mugilogobius obliquifasciata Wu and Ni, 1985: 93-95 (Haikou, Hainan Island, China). - Anon. 1986: 272-273.

Mugilogobius obliquifasciatus - Zhu 1988: fig. 162.

Hemigobius crassa - Davis 1988: 164.

Pseudogobius hoevenii - Murphy 1990: 155.

Mugilogobius latifrons - Nguyen 1991: 334-335, fig. 143.

Hemigobius hoevenii - Kottelat *et al.* 1993: 146.

Material examined. 80 specimens (8.5-37). THAILAND: URM P.12662, 2(28-28), mangrove swamp at Phuket, H. Senou and V. Chavalit, 2 November 1983; ex URM P.6677, 3(22.5-25.5), Ranong, 9 March 1982. MALAYSIA: ZSM 27559, 4(23-26.5), mangrove at Bamgangan, SW of Sandakan, Sabah, Kettner, Krumenacher and Witte, 13 March 1988. SINGAPORE: Paratype of *Vaimosa fusca*, CAS 32987, 25.5 mm SL male, mangrove swamp, Kranji River, A. Herre, March 1937. NTM S.14235-004, 11(8.5-27), Sungei Buloh mangroves, K. Lim, 30 January 1991. BRUNEI: NTM S.12812-002, 2(18-24), Kedalayan River, from *Nypa* leaf axils, R. Hanley and S. Choy, 7 April 1989. INDONESIA: Holotype of *Gobius hoevenii*, RMNH 4457, 32 mm SL female, in river, Sambas, Borneo. BMNH 1935.5.27.28, 1(36), (possibly from Sulawesi), Arnold. HONG KONG: Holotype of *Vaimosa crassa*, 35 mm SL female, CAS/SU 39848, Un Long, New Territories, A.W. Herre, 23 February 1941. PHILIPPINES: CAS 38636, 30(19-33), Coron, Busuanga, 22-30 June 1940, A.W. Herre. PAPUA NEW GUINEA: WAM P.26751-006, 2(21.5-37), Tureture village, Binaturi, G. Allen, 29 September 1979. AUSTRALIA: QUEENSLAND: AMS I.23262-001, 8(18-32), The Esplanade, Cairns, D. Hoese and D. Rennis, 2 October 1982. AUSTRALIA, NORTHERN TERRITORY: NTM S.11065-002, 13(13-21.5), Leanyer Swamp, Darwin, T. Davis, 5 March 1980. WESTERN AUSTRALIA: AMS I.25521-009, 1(27.5), Crab Creek, Broome, D. Hoese, D. Rennis, 20 September 1985.

Other material examined (but not used in description). 275 specimens from the following localities. HONG KONG: Paratype of *Vaimosa crassa*, CAS/SU 39849, 1, 35 mm SL. THAILAND: URM P.13336, 1, Khung Kraben Bay; NTM S.13953-014, 6, Klong Bang Sai, Phuket; URM P.13344, 2, Khung Kraben Bay; NTM S.14288-002, 6, Ta-Chalab. MALAYSIA: CAS 33168, 3, Kabili River, North Borneo. SINGAPORE: ZRC 20635-40, 6, Sungei Punggol; ZRC 20238-45, 8, Sungei Punggol; ZRC 27450, 1, Siglap Canal; ZRC 21084-91, 8, Sungei Seletar; ZRC 21872-906, 35, Mandai Kecil; ZRC 20476-78, 3, Mandai mangroves; NTM S.13957-009, 35, Sungei Pandan; CMK 8223, 6, Kranji mangrove; CAS 40136, 8, Serangoon; ZRC 29185, 1, Sungei Buloh; NTM S.13968-008, 13, Sungei Pandan; NTM S.13959-012, 10, Sungei Buloh; NTM S.13961-007, 27, Mandai Kecil. BRUNEI: NTM S.13052-002, 1, Pulau Berambang. NTM S.13053-004, 2, Pulau Berambang. PHILIPPINES: USNM 99613, 1, Port Dupon; CAS 38637, 46, Panay, Capiz; CAS 26381, 1, Lake Buhi. INDONESIA: CMK 7265, 6, Tanjung Mayong, Padang, Sumatra. PAPUA NEW GUINEA: USNM 316170, 1, Daru. AUSTRALIA, NORTHERN TERRITORY: NTM S.10419-006, 2, Elizabeth River, Darwin Harbour; NTM S.10420-002, 1, Elizabeth River, Darwin Harbour; NTM S.11845-004, 1, Leanyer Swamp; NTM S.14289-001, 12, Leader's Creek, Gunn Point; NTM S.14290-002, 20, Leader's Creek, Gunn Point. NO DATA: RMNH 14049, 1.

Diagnosis. *Hemigobius* with body robust, compressed, with rounded, somewhat depressed head, snout rounded and overhanging upper lip; second dorsal rays I,6-8 (modally I,7); anal rays I,6-7 (modally I,7); pectoral rays 13-16; longitudinal scales 27-32; TRB 7-12; anteriormost predorsal scale largest, 8-10 scales, extending close up behind eyes; mouth enlarged in males; scales on body ctenoid; first dorsal fin low, rounded, with no filamentous spines; body greyish to brownish with six diagonal blackish bars across sides, marbled to ocellate black spot on caudal base, roughly vertical black line on opercle extending to underneath head; known from mangrove areas of the Indo-Malayan Archipelago, Papua New Guinea and northern Australia.

Description. Based on 40 specimens, 15-37 mm SL. Counts of holotype of *Gobius hoevenii* indicated by asterisk.

First dorsal VI*; second dorsal I,7-8 (mean I,7*); anal I,7-9 (mean I,7*), pectoral rays 13-16* (mean 16), segmented caudal rays always 17*; caudal ray pattern 6/6 to 9/8 (modally 8/7*); branched caudal rays 12-

Table 1. Frequency distribution of fin ray counts in *Hemigobius* species.

	Second dorsal rays			Anal rays				Pectoral rays				
Species	**6**	**7**	**8**	**6**	**7**	**8**	**9**	**13**	**14**	**15**	**16**	**17**
hoevenii	-	25	15	-	27	12	1	1	2	17	19	1
mingi	1	34	1	1	35	-	-	2	29	5	-	-

Table 2. Frequency distribution of longitudinal counts in *Hemigobius* species.

Species	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
hoevenii	2	3	10	4	2	6	5	6	1	1
mingi	-	-	4	4	17	9	1	1	-	-

Table 3. Frequency distribution of transverse backward scale counts in *Hemigobius* species.

Species	**7**	**8**	**9**	**10**	**11**	**12**
hoevenii	1	11	10	10	7	1
mingi	-	-	11	19	5	1

17 (modally 15, broken in holotype); unsegmented (procurrent) caudal rays 6/7 to 8/8 (modally 7/7); longitudinal scale count 25-32 (mean 29; 27 in holotype); TRB 7*-12 (mean 10); predorsal scale count 8-10 (mean 9*); circumpeduncular scales 12 (13 in one). Gill rakers on outer face of first arch 2+8 to 4+9 (modally 2+8). Dorsal pterygiophore formula 3-12210 (in 12). Vertebrae 10+16 (in nine), 10+17 (in one), 11+15 (in one), 11+16 (in one). Neural spine of first vertebra very short and broad, sharply bent posteriorly at halfway point (in 11). Two epurals (in 10) or one very broad epural (in two). Two (in two) or three (in 10) anal pterygiophores before haemal spine of first caudal vertebra. Lachrymal not enlarged, relatively slender.

Body approximately rounded anteriorly; compressed posteriorly. Head depressed, especially in mature males, width always greater than depth, cheeks may be inflated in males; profile blunt to rounded; nape often convex behind flattened broad interorbital, HL 3.2-4.1 (mean 3.6) in SL. Depth at posterior preopercular margin 1.5-1.9 (mean 1.7) in HL. Width at posterior preopercular margin 1.2-1.5 (mean 1.3) in HL. Mouth terminal to subterminal, almost horizontal, with rounded snout overhanging upper lip; jaws forming angle of about 7-15° with body axis; jaws generally reaching at least to below anterior half of eye, and to rear edge of eye in large (sexually mature) males. Upper jaw 1.7-3.6 (mean 2.8) in HL; in males, 1.7-3.5 (mean 2.6); in females, 2.1-3.6 (mean 2.9) in SL. Upper lip narrow, smooth, without fleshy fimbriae; lower lip thin, reduced to narrow (mugilid-like) fold, free along posterior half of jaw, anterior half of lip fused to underside of head, lower lip fold often thicker and extending further forward in mature males; lower jaw slightly curved upward, in large specimens low ridge at symphysis sometimes present. Eyes large, dorsolateral, high on head, sometimes forming part of dorsal profile, 3.1-4.2 (mean 3.5) in HL. Snout rounded, inflated over top lip, 2.8-4.1 (mean 3.3) in HL. Interorbital broad, flat, 2.3-5.3 (mean 3.0) in HL. Top of head, from just behind eyes up to snout tip, often with fine villi, these sometimes relatively sparse on anteriormost nape scales (villi may only be visible in specimens with well-preserved mucous coat). Body often quite round in abdominal region in females, depth at anal origin 4.2-5.6 (mean 4.9) in SL. Caudal peduncle compressed, length 3.3-4.1 (mean 3.7) in SL. Caudal peduncle depth 5.5-7.9 (mean 6.9) in SL.

First dorsal fin low, rounded, tips of second to fourth spines free, second or third spines longest or subequal; spines always falling short of second dorsal fin origin when depressed. First dorsal spine always shorter than next three. Third dorsal spine length 5.1-13.2 (mean 7.6) in SL. Fourth dorsal spine length 6.3-10.0 (mean 7.8) in SL. Second dorsal and anal fins low, posteriormost rays usually longer than anteriormost, rays reaching more than halfway to caudal fin base when depressed. Pectoral fin short and rounded, central rays longest, 4.4-5.5 (mean 4.9) in SL; rays usually all branched but for uppermost. Pelvic fins short, rounded, reaching half (or less) distance to anus, 4.9-6.8 (mean 5.7) in SL. Caudal fin round, 3.5-4.9 (mean 3.9) in SL.

No mental fraenum, chin smooth. Anterior nostril in short tube, placed just behind upper lip, tube oriented forward and down; preorbital straight, not curved to accommodate nostril. Posterior nostril oval, with or without low rim, placed about halfway between anterior margin of eye and edge of preorbital (usually slightly closer to eye). Gill opening narrow, usually extending from just beyond lower pectoral base forward to just under opercle. Inner edge of shoulder girdle smooth with no ridge or flange (in 16) or with low bony ridge or flange formed by partly exposed cleithrum (in 10), which may be bent laterally. Gill rakers on outer face of first arch very short, pointed and without spines, longest raker at angle of arch; several thin lobes or flaps on fleshy pads on roof of mouth just above first arch; rakers on inner face of first arch long and slender; outer rakers on second arch similar to, but smaller than, those on first arch; outer rakers on third and fourth arches very tiny or absent; inner rakers on second and third arches progressively longer and finer than first arch inner rakers; inner rakers of fourth arch small, fine and closely spaced. Tongue tip usually rounded, somewhat bilobed in northern Australian and Papua New Guinea specimens. Teeth in two rows in each jaw; tooth form differing between males and females. In males, teeth in outer row of upper jaw enlarged, conical and curved (Fig. 1), row present across front of jaw only; inner row teeth small, conical, stout, blunt or pointed, extending whole length of jaw, inner teeth more widely spaced along sides of jaw than those crowded together across front. Lower jaw teeth in males stout, conical, slightly curved and pointed; teeth in both rows about equal in size but anteriormost two to four teeth in inner row usually enlarged and pointing backward; usually no teeth present on rear third to half of jaw. In females, both rows of upper jaw teeth very small, flattened, with blunt tips, teeth with tips bent to one side along side of jaw; both rows of teeth extending along entire length of jaw. Lower jaw teeth in females very small, curved and pointed; teeth slightly larger near median symphysis, teeth at side of jaw slightly increasing in size posteriorly, with posteriormost tooth considerably larger, stout and strongly curved.

Predorsal scales medium, largest scales anteriormost, scales reaching forward to close behind eyes; edge of first few predorsal scales often crenulate or scalloped (most conspicuous in larger specimens). Operculum covered with cycloid scales. Cheek below eye naked, often one to three scales on upper preopercle close behind eye. Pectoral base covered with cycloid scales. Prepelvic area covered with small cycloid

Table 4. Measurements (mm) of *Hemigobius hoevenii* (Bleeker, 1851).

Character	Holotype	Males Minimum	Males Maximum	Males Mean n = 18	Females Minimum	Females Maximum	Females Mean n = 22
Head Length	7.9	4.1	10.0	7.3	4.2	9.5	6.5
Head Depth	5.3	2.3	6.3	4.4	2.3	5.4	3.8
Head Width	6.3	3.1	8.0	5.7	3.1	7.2	5.0
Body Depth	7.0	2.7	8.6	5.4	3.1	7.4	4.8
Body Width	-	1.5	5.3	3.2	1.8	5.7	2.9
Caud. Ped. Length	8.6	4.5	10.6	7.1	3.8	9.3	6.3
Caud. Ped. Depth	5.4	1.9	6.5	3.9	2.0	5.4	3.4
Snout	-	1.1	3.3	2.3	1.2	3.1	1.9
Eye	2.5	1.2	3.0	2.1	1.3	2.9	1.9
Jaw	-	1.2	5.5	3.2	1.2	3.7	2.3
Interorbit	1.5	1.2	4.1	2.6	1.2	3.7	2.3
Pectoral	-	2.8	7.6	5.3	3.0	6.7	4.7
Pelvic	4.7	2.5	6.9	4.6	2.6	5.7	4.1
Caudal	-	3.8	10.2	6.7	4.1	7.7	5.8
Longest D1 spine	-	1.7	5.1	4.1	1.8	4.4	3.2

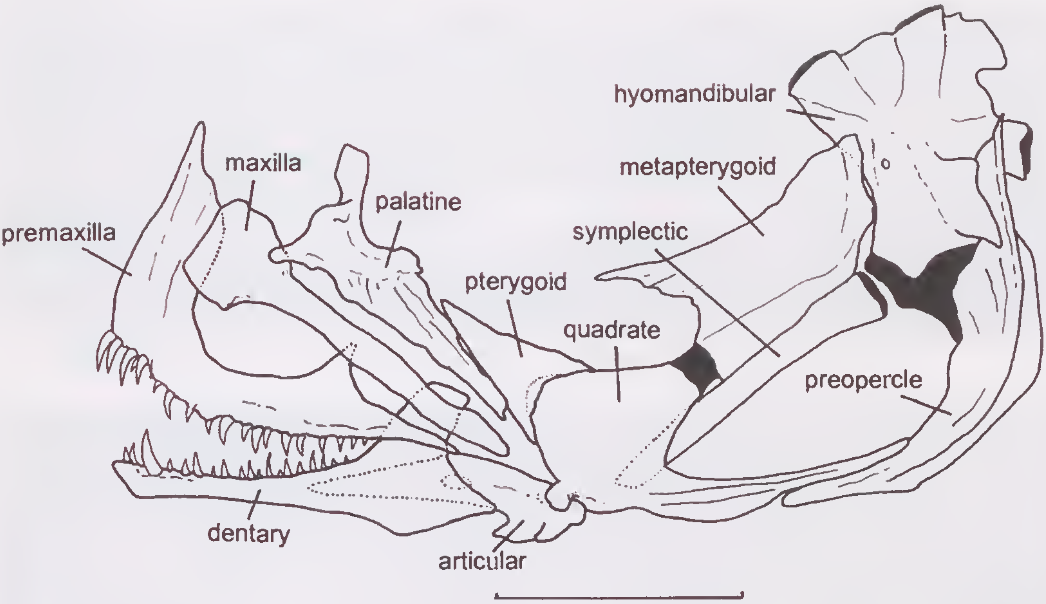

Fig. 1. Jaws and suspensorium of *Hemigobius hoevenii*, male, ex NTM S.11065-002, Leanyer Swamp, Northern Territory. Scale bar = 1 mm. Black areas are cartilage.

scales. Belly scales mostly cycloid, anterior half to third ctenoid. Body scales ctenoid up to pectoral base, ctenoid scales sometimes extending above posterior part of opercle.

Genital papilla in female short, rounded, slightly flattened toward blunt tip; papilla in male slender, elongate and flattened, narrowing toward pointed tip; small finger-like protrusion at tip may be present.

Head pores present, in reduced pattern (Fig. 2). Anterior and posterior interorbital pores paired; latter pair never joined by canal, always separate. Postorbital and infraorbital pores present. No preopercular pores. No lateral canal over preoperculum.

Sensory papillae pattern longitudinal, as in Figure 2. Papilla row *p* consisting of widely spaced papillae; row largely replaced by interorbital canal. Cheek papillae rows short; papillae rows rather broken-up, scattered, rows *a, cp* and *c* composed of few large papillae; rows *b* and *d* short, composed of small, close-set papillae. Preopercular margin papilla row *e* often broken up into short sections or pairs of papillae following margin. Three *s* rows present on snout, of one papilla each. Single *f* row papilla on each side of mandibular symphysis, behind lip (sometimes row *i* extending up behind symphysis, so that four papillae appear to be present).

Coloration of fresh material. An illustration is given in Bleeker (1983: pl. 438, fig. 17; as *Microgobius hoevenii*) of this species. It shows the bands on the first dorsal fin, and the oblique blackish bars over lighter background (rather pinkish, with lower half of head yellow).

From colour photograph in Zhu (1988: fig. 162), identified as *Mugilogobius obliquifasciatus* Wu and Ni, of two *H. hoevenii* in an aquarium. Head and body greyish yellow to greyish pink, with dark brown oblique bars and other markings, edges of oblique bars quite black, darker than colour in bars' centres. Greyish pink streak, with brown streak on either side, extending from front of eye to upper jaw. Iris very dark brown. Ocellate black caudal spot surrounded by almost pinkish colour. Both dorsals translucent yellowish grey with blackish brown markings; second dorsal with broad transparent margin. Caudal fin translucent, with few brownish streaks along fin ray bases. Pectoral base with distinct black line near upper edge, and indistinct pinkish band along bases of fin rays.

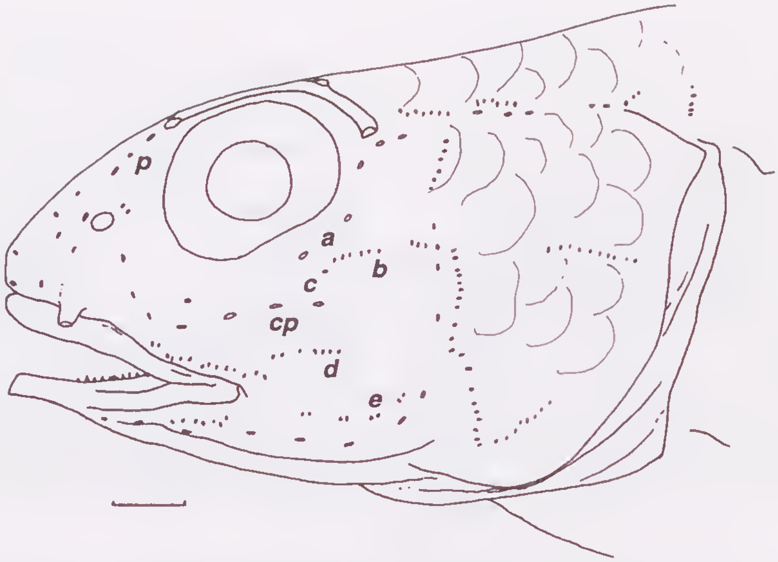

Fig. 2. *Hemigobius hoevenii* papillae pattern. CAS/SU 38636, Coron, Busuanga, Philippines. Scale bar = 1 mm.

Live specimens from Singapore mangroves noted (by author) as being mostly pinkish with dark brown bars and other markings. Lower half of body pale pinkish to pinkish brown, upper half light brown to pinkish. Pectoral fins yellowish with gold mark on ventral half of fin base. Chrome yellow area just above and anterior to black caudal base spot.

Live juveniles from mangroves near Darwin, Northern Territory, with dull whitish yellow body with brownish black markings. Peritoneum silvery blue, dorsally blotched with dark brown. Light iridescent patch present on each side of chest, and similar blue pigment on lower pectoral fin rays and scattered across branchiostegal rays. First dorsal fin mainly black, translucent anteroventrally, with bright orange stripe through centre.

Coloration of preserved material. Head and body grey to light brown, lighter ventrally and sometimes posteriorly (Figs 3-4). Top and side of head indistinctly mottled with brown to greyish brown; usually most distinct markings being two brown streaks from front edge of eye to upper lip, areas between and on either side of streaks usually paler than surroundings. Black to dark brown line running along anteriormost edge of opercle down and across branchiostegal membranes, becoming diffuse at isthmus; black line may be almost indistinguishable from brown mottling on head in heavily-pigmented specimens.

Six broad blackish to brown oblique bars crossing back and side, bars oriented anteriorly; first bar crossing nape in front of first dorsal fin and extending (diffusely) onto opercle, last bar beginning below uppermost few rays of caudal fin. Posteriormost bars often more distinct, due to contrasting lighter background. Bars sometimes pointed ventrally or partly broken up and interconnecting with interspersed mottled dark blotches or spots. At upper base of caudal fin, distinct round black spot present, surrounded by light brown or whitish; spot partly ocellate in many specimens. Below this spot, variably shaped blackish oblique blotch present; blotch forming spot, streak or ocellate curved black line. Belly and ventral part of body whitish or mottled with brown. Pectoral base with small black spot or short horizontal stripe near upper edge. Peritoneum dark brown, fading at lower sides toward belly.

First dorsal fin divided into three nearly equal bands: lowermost band dark grey to brown, central band narrowest, clear to

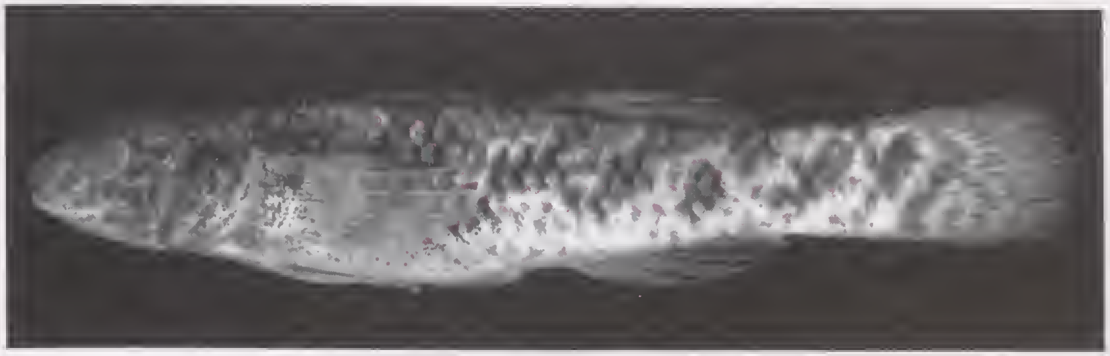

Fig. 3. *Hemigobius hoevenii,* female, 29 mm SL, ZRC 21872-21906, Singapore.

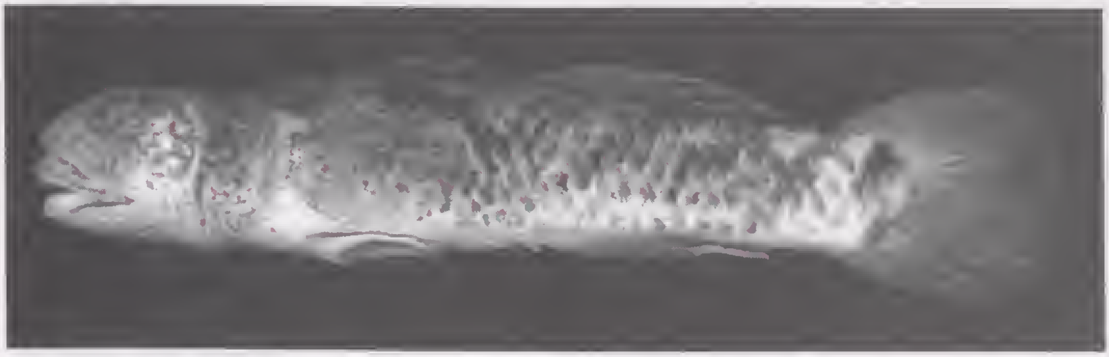

Fig. 4. *Hemigobius hoevenii,* male, 31 mm SL, NTM S.13968-008, Singapore.

whitish, outermost band usually dusky brownish, with tips of fin spines darkest. Lowermost band usually with black spot between fourth and sixth spines; sometimes second, poorly developed, black spot present near base of third spine. Second dorsal fin dusky, with broad white to translucent margin, and about three indistinct rows of short dark vertical blotches (blotches oriented along fin rays); uppermost row of blotches usually forming continuous dark edge just below white marginal band; blotches in lowermost row sometimes coalescing and forming three dark patches evenly spaced along fin base. Anal fin plain dark grey to brown, with broad white to translucent margin. Pectoral fin translucent to dusky, with blackish pigment along fin rays. Pelvics pale to dusky grey with broad whitish margin, fraenum whitish. Caudal fin mostly plain greyish, with two to three vertical curving dark bands behind ocellate black spot, irregular dark spots and streaks sometimes present; posteriormost edge of fin often whitish.

Comparisons. This species can be distinguished from the other known species in the genus, *H. mingi*, by having more pectoral rays (usually 15-16 versus 14 in *H. mingi*), the cheek below the eye being naked (versus two or three rows of scales below the eye), two dark bands, not forming a black spot, on the first dorsal fin (versus distinct black spot posteriorly), body shape (rather flat-headed and slender-bodied versus square-headed and deep-bodied) and in live colour.

This species superficially resembles a *Mugilogobius* (in its size, having a somewhat depressed head with rounded snout, similar body form and preference for shallow mangrove habitat), but can be distinguished by possessing headpores, 17 segmented caudal rays, a long coiled gut and a relatively small mouth with reduced lips.

Distribution. Specimens are known from Hong Kong, Borneo, Brunei, Sabah, Thailand, Singapore, the Philippines, Papua New Guinea and Northern Australia (Fig. 5).

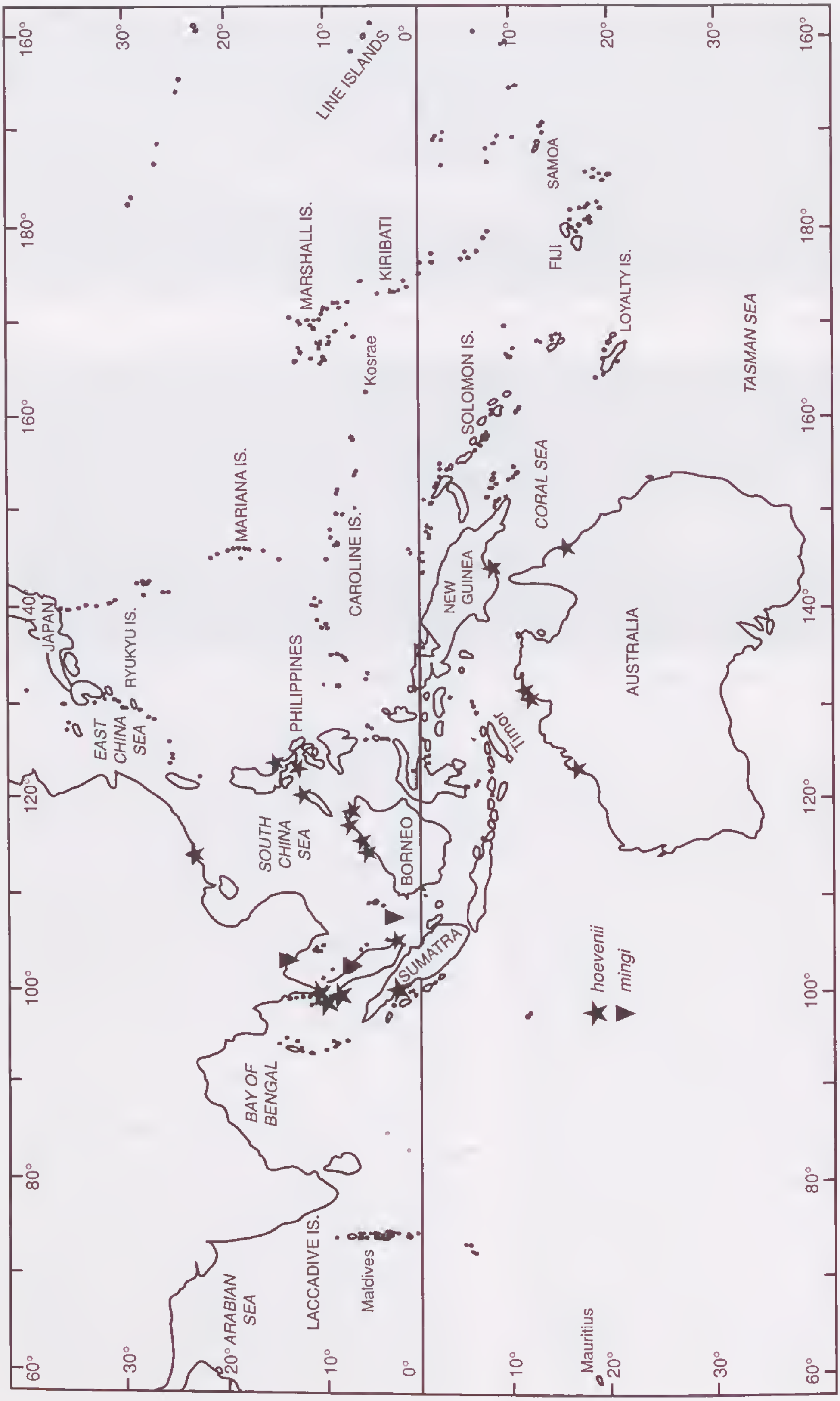

Fig. 5. Distribution of *Hemigobius* species.

Fig. 6. *Microgobius hoevenii* (= *Hemigobius hoevenii*), from Bleeker 1983: pl. 438, fig. 17. Courtesy of the Smithsonian Institution Press.

Zhu (1988: English Appendix, unpaginated) stated that this species "...is found in brackish water in the estuary of the Nandu River [China] and in freshwater of the Hainan Island". A colour slide sent by I-Shiung Chen (Bristol University) of a specimen he collected from Taiwan, confirms the species' occurrence at that island.

Ecology. *Hemigobius hoevenii* can be quite abundant in mangrove estuaries and streams. It is most easily observed in the shallows and in small isolated pools, where they lie concealed under leaf litter and detritus. Two specimens have been collected from *Nypa* palm leaf axils; the palms were fringing a flowing estuarine river.

Murphy (1990) reports that this species (as *Pseudogobius hoevenii*) feeds very close to the water's edge at low tide in Singapore mangroves and that he has observed a specimen captured by a large wolf-spider of the genus *Thalassius* (the goby was actually twice the body length of the spider).

Remarks. Bleeker's female holotype of *G. hoevenii* (RMNH 4457) is in very poor condition: the tail is broken, the jaws are missing and the skin from the top of the head and upper cheeks is missing. The bony grooves of the interorbital canals can be observed, and the counts and proportions agree with those of more recently-collected specimens. The small interorbital width given here for the holotype probably reflects the condition of the specimen, therefore the interorbital width given is closer to the least bony interorbital width, not least fleshy width. Both Doug Hoese (AMS) and the author independently examined the holotype and obtained similar measurements.

RMNH 4457 is a little small (32 mm SL) for agreement with the type specimen in Bleeker's description. The type was given as 45 mm TL by Bleeker. The greatest caudal fin length obtained for a female was 7.7 mm, which would only bring the type to about 40 mm TL. The longest caudal fin was recorded for a 36 mm SL male (10.2 mm CL). Allowance should be made, however, for the missing jaws and damaged head of the type and the specimen is here accepted as being the holotype.

Bleeker's (1983) figure of *Microgobius hoevenii* (Fig. 6) shows the oblique dark bars of the species. Bleeker (1851) considered that *Gobius hoevenii* was related to *G. poicilosoma* (= *Pseudogobius poicilosomus*).

Koumans (1953: 125) confused this species with *Mugilogobius chulae*, placing species belonging to *M. chulae* in synonymy with *Stigmatogobius hoevenii* (= *Hemigobius hoevenii*). In his 1953 work, he describes the interorbital pores of *Hemigobius* but the colour pattern of *M. chulae* (Koumans 1953: 125-126).

Type specimens of *Mugilogobius obliquifasciatus* Wu and Ni, 1985, were unavailable for study. However, the senior author of this species, Dr Wu of Shanghai University, confirmed via correspondence

Table 5. Measurements (mm) of *Hemigobius mingi* (Herre, 1936).

Character	Holotype	Males Minimum	Males Maximum	Males Mean n = 18	Females Minimum	Females Maximum	Females Mean n = 18
Head Length	10.6	4.3	11.5	8.2	4.6	12.0	9.7
Head Depth	6.9	2.7	8.9	5.6	3.0	8.6	6.5
Head Width	7.3	3.3	8.3	5.9	3.4	8.9	7.0
Body Depth	10.8	3.3	13.1	7.7	3.7	12.1	9.3
Body Width	-	1.7	6.8	4.1	3.6	7.8	5.6
Caud. Ped. Length	12.8	3.9	12.8	8.7	4.5	15.1	10.1
Caud. Ped. Depth	7.1	1.9	8.3	4.9	2.1	9.0	5.7
Snout	3.3	1.2	3.7	2.6	1.3	4.1	3.1
Eye	3.5	1.4	3.6	2.7	1.6	3.7	3.0
Jaw	3.0	1.3	3.7	2.6	1.6	3.8	3.0
Interorbit	4.9	1.9	5.2	3.8	2.3	6.1	4.4
Pectoral	7.8	2.8	8 .0	5.7	4.5	9.7	6.8
Pelvic	6.7	2.5	8.1	5.2	2.8	7.8	5.9
Caudal	11.0	3.9	12.0	8.3	6.5	11.9	9.8
Longest D1 spine	6.2	2.2	6.7	5.5	3.5	6.9	5.9

and photographs that the species was the same as *H. hoevenii*.

Herre's (1939) record of *Vaimosa hoeveni* (sic) from Middle Andaman Island probably refers to *M. chulae*. *Hemigobius hoevenii* has no more than 10 predorsal scales (Herre gives 13 predorsal scales for his Andaman specimen), while *M. chulae* has 11-15 scales.

Munro (1967), in a key, refers to a record of *Stigmatogobius hoeveni* from West New Guinea, which could be of *Hemigobius hoevenii*, *Mugilogobius chulae* or a currently undescribed *Mugilogobius* (Larson in press) (location of Munro's specimens unknown).

Chatterjee's (1980) record of *Stigmatogobius hoevenii* from West Bengal is probably not a *Hemigobius hoevenii* or a *Mugilogobius* species, but possibly a *Drombus*, as he illustrates the fish as having two transverse papillae rows on the cheek. Also, his predorsal scale count of 10-11 is little high for *H. hoevenii*. Unfortunately, Chatterjee did not give sufficient information to allow the reader to confidently identify the species from the text and drawings. It is unclear what he meant by the "nasal sensory canal-pores" illustrated in Figure 1B; they may be the large sensory papillae belonging to the nasal *c* series.

Nguyen's (1991) record of *Mugilogobius latifrons* from Ha Nam Ninh in Vietnam is accompanied by a drawing that is clearly of *H. hoevenii*.

Hemigobius mingi (Herre, 1936)

(Figs 5, 7-12; Tables 1-3, 5)

Gobius melanurus Bleeker, 1849: 31 (Java) [not *Gobius melanurus* Gmelin]. - Günther 1961: 33.

Hemigobius melanurus - Koumans 1931: 78; - Bleeker 1983: pl. 433, fig. 9.

Gnatholepis mingi Herre, 1936: 8-9, pl. IV (Pulau Ubin, Singapore). - Fowler 1938: 266; - Koumans 1940: 151.

Sphenentogobius vanderbilti Fowler, 1940: 396-397, figs 8-11 (Medan, Sumatra). - Böhlke 1984: 111.

Stigmatogobius mingi - Koumans 1953: 118-119.

Hemigobius bleekeri Koumans, 1953: 191-192, fig. 47 (replacement name for *Gobius melanurus* Bleeker, 1849, not *Gobius melanurus* Bloch and Schneider, 1801). - Kottelat *et al*. 1993: 146, pl. 67.

Material examined. 68 specimens (11.3-55). INDONESIA: Lectotype of *Gobius melanurus* and *Hemigobius bleekeri*, RMNH 4501, 55 mm SL female, Java, in sea (Sunda Archipelago on jar label). Paralectotypes of *Gobius melanurus* and *Hemigobius bleekeri*, ex RMNH 4501, 2 (40.5-55), same data as lectotype. Holotype of *Sphenentogobius vanderbilti*, ANSP 68714, 40.5 mm female, Medan, Sumatra, Vanderbilt Expedition, 23 May 1939. SINGAPORE: Holotype of *Gnatholepis mingi*, CAS 30960, 43 mm SL male, Pulau Ubin, A.W. Herre, 1934. ZRC 20263-72, 10(28-47), Sungai Punggol, 22 March 1966; ZRC 20192-37, 46(11.3-41.2), Sungei Punggol, C.K. Quek and M. Dali, 19 October 1965; CMK 8322, 2(39-41), Kranji mangroves near Sungei Buloh, M. Kottelat and D. Murphy, 8 April 1992; NTM S.14235-003, 4(14.5-22), Sungei Buloh mangroves, K. Lim, 30 January 1992; ZMH 19308, 2(26.5-35), aquarium import, Reichelt, 1 December 1090. THAILAND: URM P.6677, 4(33-40), Ranong, 9 March 1982; NTM S.14288-001, 1(46), in ponds within research station, Ta-Chaluab, Chantaburi Province, *Mahidolia* Project, NIFI, Chulalongkorn University and Mahidol University parties, 2 June 1990; KUMF uncatalogued, 1(40.5), Tak Bai canal, Narathiwat Province, D. Tanwilai, 25 September 1984; CMK 5419, 1(32.5), Ban Pliu, near Chantaburi, M. Kottelat, 21 March 1980. NO LOCALITY: RMNH 12580, 2(28-35.5).

Other material examined (but not used in description). 28 specimens, from the following localities. SINGAPORE: ZRC 30165-70, 6, Sungei Buloh East mangroves; NTM S.13961-006, 12, Mandai Kecil; NTM S.13957-008, 9, Sungei Pandan. THAILAND: USNM 316180, 1, Cheh Bilang, Satul, Satul Province.

Diagnosis. Deep bodied *Hemigobius*, with blunt head and compressed body; second dorsal rays I,6-8 (modally I,7); anal rays I,6-7 (modally I,7); pectoral rays 13-15; longitudinal scales 27-32; TRB 9-12; predorsal scales large, 8-10, edges often scalloped, extending close up behind eyes; body scales ctenoid; side of lower jaw strongly curved upward, forming ridge at symphysis; first dorsal fin low, rounded, with no filamentous spines; body greyish to brownish, scales often with blackish centres and five to six white diagonal bars (very prominent in life), marbled or somewhat ocellate blackish spot on caudal base, eyes blue when live; known only from mangrove areas in Thailand, Singapore and Indonesia.

Description. Based on 36 specimens, 13.5-34 mm SL. Counts of holotype of *Gobius melanurus* indicated by asterisk.

First dorsal VI*; second dorsal I,6-I,8 (mean I,7*); anal I,6-7 (mean I,7*); pectoral rays 13-15 (mean 14; holotype with 15 on right, 14 on left); segmented caudal rays always 17*; caudal ray pattern 6/6 to 9/8 (modally 8/7*); branched caudal rays 12-17 (mean 15*); unsegmented (procurrent) caudal rays 6/7 to 8/8; longitudinal scale count 27-32* (mean 29); TRB 9*-12 (mean 10); predorsal scale count 8-10* (mean 9); circumpeduncular scales 12* or 13 (in one). Gill rakers on outer face of first arch 5+12 to 6+12 (modally 5+12). Dorsal pterygiophore formula 3-12210 (in 12). Vertebrae 10+16 (in nine), 10+17 (in one), 11+15 (in one), 11+16 (in one). Neural spine of first vertebra very short and broad, sharply bent posteriorly at halfway point (in 11). Two epurals (in 10) or one very broad epural (in two). Two (in two) or three (in 10) anal pterygiophores before haemal spine of first caudal vertebra. Lachrymal enlarged, almost square.

Body rounded anteriorly (especially in females); belly rounded and body compressed posteriorly in both sexes. Head square in cross-section, depth about equalling width; profile blunt to rounded; nape profile often curving behind flattened broad interorbital, HL 3.1-4.7 (mean 3.7) in SL. Depth at posterior preopercular margin 1.3-1.6 (mean 1.5) in HL. Width at posterior preopercular margin 1.3-1.6 (mean 1.4) in HL. Mouth small, subterminal, slightly oblique, with rounded snout overhanging upper lip; jaws forming angle of about 15-20° with body axis; jaws generally reaching to below anterior margin of eye in both sexes. Upper lip narrow, smooth, without fleshy fimbriae; lower lip reduced, narrow lip fold free at lower corner of jaw, rest of lip smoothly fused to underside of head; lower jaw curving upward and forming ridge at symphysis (resembling jaw of mugilid). Upper jaw 2.8-3.5 (mean 3.2) in HL. Eyes large, lateral, high on head, sometimes forming part of dorsal profile, 2.7-3.6 (mean 3.2) in HL. Snout bluntly rounded, and inflated over top lip, 2.8-3.6 (mean 3.2) in HL. Interorbital broad, flat, 1.8-4.1 (mean 2.3) in HL. Top of head above preopercular margin up to close behind posterior nostril often with fine villi, these relatively sparse on scales when compared with naked skin (villi often only visible in specimens with well-preserved mucous coat; visible in holotype). Body usually quite round in abdominal region, especially in females, depth at anal origin 3.5-4.6 (mean 4.0) in SL. Caudal peduncle long, compressed, length 3.3-4.5 (mean 3.6) in SL. Caudal peduncle depth 5.5-7.3 (mean 6.4) in SL.

First dorsal fin low, rounded, tips of second to fourth spines free, second or third spines longest or subequal; spines always falling short of second dorsal origin when depressed. First dorsal spine usually shorter than next three. Second dorsal spine length 3.5-6.7 (mean 4.5) in SL. Third dorsal spine length 2.2-6.4 (mean 4.9) in SL. Fourth dorsal spine length 4.5-6.8 (mean 5.5) in SL. Second dorsal and anal fins low, posteriormost rays usually longer than anteriormost, rays only extending about half length of caudal peduncle when depressed. Pectoral fin small, short and rounded, central rays longest, 4.7-6.1 (mean 5.4) in SL; in adults, rays all branched but for lower and uppermost rays (uppermost ray or two usually unbranched). Pelvic fins short, rounded, reaching half (or less) distance to anus, 5.2-8.0 (mean 6.0) in SL. Caudal fin rounded, 3.4-5.0 (mean 3.8) in SL.

No mental fraenum, chin smooth. Anterior nostril in very short tube, placed just behind upper lip, tube oriented forward. Posterior nostril oval, with low rim, placed halfway between anterior margin of eye and edge of preorbital. Gill opening usually extending forward to just under opercle. Inner edge of shoulder girdle smooth with no ridge or flange (in 21) or with low bony ridge or flange (in 10). Gill rakers on outer face of first arch very short, pointed and without spines, longest two rakers on either side of angle of arch; tiny papillose flaps on pads above first arch; rakers on inner face of first arch more slender; outer rakers on other arches similar to those on first arch; inner rakers on other arches twice length of first arch inner rakers. Tongue tip usually blunt, or with tip concave in centre (almost bilobed in few specimens). Outer teeth in upper jaw very small, flattened, slightly curved, with pointed or somewhat spatulate tips (Fig. 7); behind this row, one or two rows of very small sharp teeth often partly concealed by flesh of mouth. Lower jaw with band of three to five rows of very small pointed teeth, tooth band widest toward rear of jaw; teeth covering raised mandibular symphysis. No difference in teeth between males and females.

Predorsal scales medium to large, with largest scales anteriormost, scales reaching forward to close behind eyes; edge of predorsal scales usually crenulate or scalloped, most conspicuous in larger specimens. Operculum covered with cycloid scales. Cheek with two or three rows of cycloid scales: single row of scales below eye always present in adults, may be absent in specimens about 14 mm SL or less; often one or two scales on upper preopercle close behind eye. Pectoral base covered with cycloid scales. Prepelvic area covered with small cycloid scales. Belly scales ctenoid; few small cycloid scales around anus sometimes present. Body scales ctenoid up to pectoral base, ctenoid scales sometimes extending above posterior part of opercle.

Genital papilla in female short, conical and rather pointed, slightly flattened toward tip; papilla in male slender, flattened and pointed to slightly rounded at tip; may be short or elongate (up to half length of anal fin spine).

Head pores present, in reduced pattern (Fig. 8). Anterior and posterior interorbital pores paired; latter pair of pores never joined by canal, always separate. Postorbital and infraorbital pores present. No preopercular pores. No oculoscapular canal over preoperculum. In small (juvenile) specimens, anterior interorbital pores may be absent.

Sensory papillae pattern longitudinal, as in Figure 8. Papilla row *p* consisting of widely spaced papillae; row largely replaced by interorbital canal. Cheek papillae rows short, interrupted by scale rows on cheek; papillae rows rather broken-up, scattered, rows *a*, *cp* and *c* composed of few large papillae; rows *b* and *d* short, composed of small, close-set papillae. Three *s* rows present on snout, consisting of one or two papillae each. Single *f* row papilla on each side of mandibular symphysis, behind lip.

Coloration of fresh material. A dead specimen is shown in Kottelat *et al.* (1993: 146, pl. 67), and a coloured illustration in

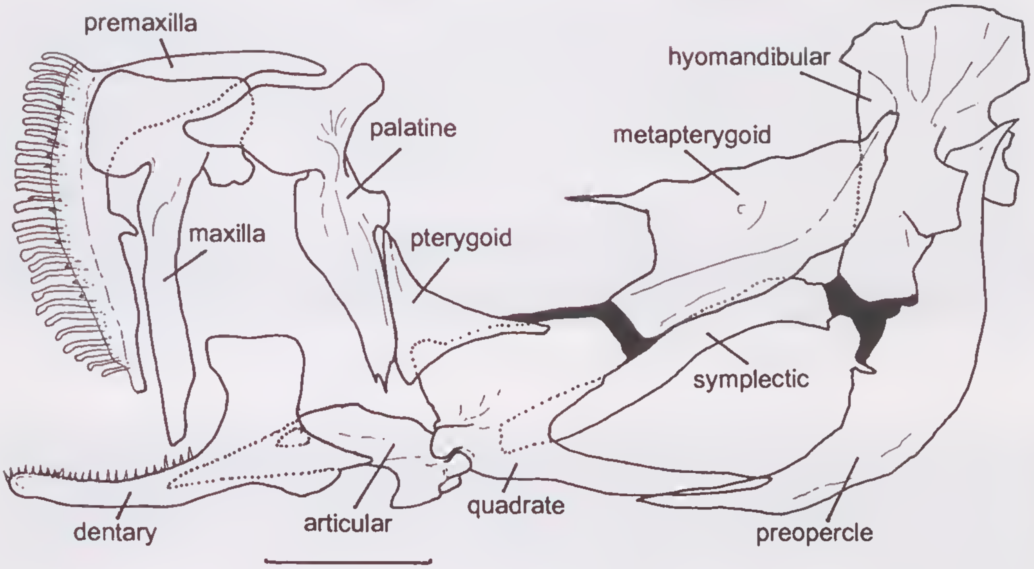

Fig. 7. Jaws and suspensorium of *Hemigobius mingi*, female, ex URM P.6677, Ranong, Thailand. Scale bar = 1 mm. Black areas are cartilage.

Bleeker (1983: pl. 433, fig. 9). The living fish are considerably more conspicuous. Notes taken by the author, from living Singapore specimens, follow.

Head and body yellowish brown with pale yellowish to whitish yellow bars alternating with dark brownish bars on side of body. Body bars most clearly defined in young fish; pale bars appear wider in young. Area around dark spot at base of caudal slightly more intensely yellow than yellowish (pale) body bars. Juveniles and specimens up to about 25 mm with three bright blue-white to whitish yellow or white bars across top of nape, beginning not far behind eyes, bars can be irregular or asymmetric in shape; anteriormost bar often rounded, forming conspicuous blotch or spot. Underside of head silver, silvery blue or deep blue; blue sometimes extending up onto cheek, opercle and pectoral base. All fish with distinctive pale blue eyes; blue visible when viewed from above. Inside of lips and mouth golden yellow to brownish yellow.

First dorsal fin with dense black spot occupying rear half of fin; anterior half of fin bright orange. Second dorsal and anal fins pinkish to yellow with darker brownish markings. Caudal fin greyish to pinkish with grey vertical banding and spotting. Juveniles with most intense fin colours.

Coloration of preserved material. Head and body dark grey to light brown, usually paler on lower abdomen and belly. Most scales with darker spot near centre; often giving appearance of indistinct thin lines midlaterally. Six variably oblique white bars present, crossing dorsal midline (most distinct in well-preserved fresh specimens): first bar crossing above opercle, second bar below first dorsal fin, third at gap between dorsals, fourth at midpoint of second dorsal, fifth across caudal peduncle and sixth (vertical) crossing caudal base (Figs 9-11). Bars breaking up laterally, with anteriormost bar often absent in larger specimens. At caudal base behind white bar, black spot on upper half of base or vertically paired black spots usually visible; spot diffuse in large adults, intense black in juveniles. Top and sides of head dark grey, sometimes mottled, but without any distinct pattern. Juvenile specimens often with one or more white spots on anteriormost predorsal scale. Peritoneum dull brownish, darkest dorsally, fading toward pale belly.

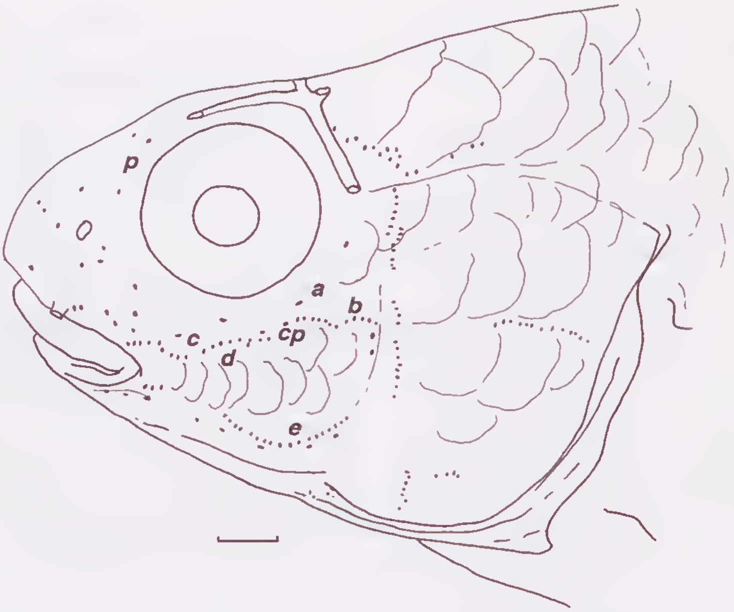

Fig. 8. *Hemigobius mingi*, headpores and papillae pattern. ZRC 20263-72, Sungei Punggol, Singapore. Scale bar = 1 mm.

First dorsal fin with distal half whitish to translucent, with narrow black to brown margin; proximal half dusky to brown with large black spot posteriorly, occupying space between third or fourth spines and rear of fin. Second dorsal fin translucent whitish, with three indistinct dusky stripes; stripes often broken up into series of vertically aligned oval brown to blackish spots, although uppermost stripe usually present as continuous stripe; fin margin translucent whitish. Anal fin dusky, translucent proximally and at anterior base of first few fin rays. Caudal fin dark grey to brown, with about six or seven vertical rows of small spots and short streaks. Pectorals clear to whitish, fin rays with very narrow blackish edges. Pelvics plain light brown to whitish.

Comparisons. Characters distinguishing this species from the only other known species in the genus, *H. hoevenii*, are given under Comparisons for that species. *Hemigobius mingi* has an autapomorphy in the shape of the lachrymal, which is quite large for this group of fishes, and almost square.

Distribution. Specimens are known from Singapore, Thailand, Sumatra and Java (Fig. 5). The species has recently been collected by the author from Brunei (Bandar Seri Begawan, Tutong, Kuala Belait), but the material was not available to include in this study.

Ecology. In Singapore, this species is common in muddy mangrove pools back from the main tidal flow, especially among *Rhizophora* thickets. The behaviour of *Hemigobius mingi* is interesting in that the fish hover above the substrate in an almost vertical posture, in small groups, with the bright silvery-white bars across the dorsal surface making the fish quite conspicuous against the dark background. This behaviour is unusual in that many mangrove gobies conceal themselves under leaf litter or in holes, with the conspicuously marked *Brachygobius* and *Pandaka* being exceptions. The anteriormost spot (or bar) in this species is reminiscent of that visible in the ricefishes (*Oryzias*) which are syntopic with *Hemigobius* in the Indo-Malayan Archipelago.

It is apparently fairly tolerant of poor conditions, as some specimens collected in Singapore (Mandai Kecil) came from pools in which the substrate consisted mostly of

Fig. 9. *Hemigobius mingi.* Holotype of *Gnatholepis mingi* Herre, 44 mm SL, CAS 30960, Pulau Ubin, Singapore.

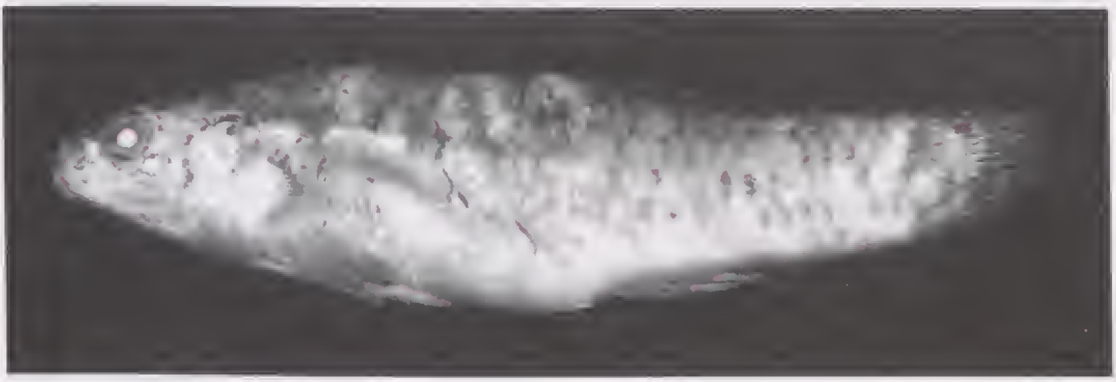

Fig. 10. *Hemigobius mingi.* Holotype of *Sphenentogobius vanderbilti* Fowler, 42.5 mm SL, ANSP 68714, Medan, Sumatra.

Fig. 11. *Hemigobius mingi*, male, 40 mm SL, one of ZRC 20263-20272, Sungai Punggol, Singapore.

mud and rotting garbage (although it must be admitted that the *Hemigobius* and other gobies present appeared temporarily stunned by the gases released from beneath the substrate as the author moved about the pools dipnetting fish).

Remarks. Koumans (1953) created the name *bleekeri* as a replacement name for *Gobius melaurus* Bleeker "not *Gobius melanurus* Broussonet – not *Gobius melanuros* Gmelin in Linnaeus ... not *Gobius melanurus* Bl. Schn. ...". This was an

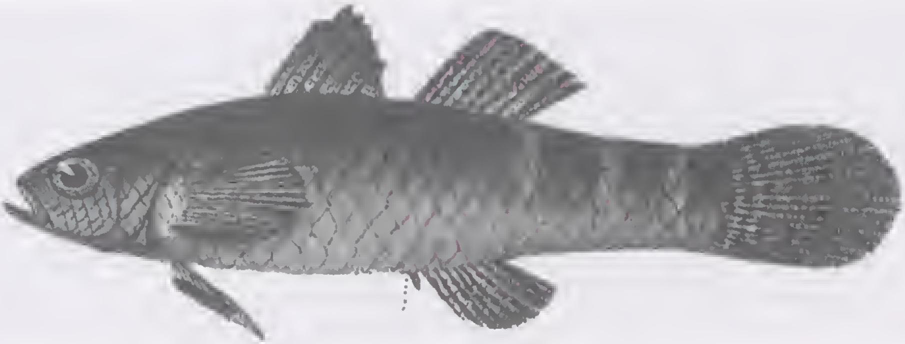

Fig. 12. *Hemigobius mingi*, from Bleeker 1983 (pl. 433, fig. 9). Courtesy of the Smithsonian Institution Press.

unnecessary replacement, as is outlined below.

Broussonet (1782), at the end of his description of *Gobius ocellaris*, listed four sets of gobioid groups and a character distinguishing each group from *Gobius ocellaris*. Here he gave the name *Gobiis melanuro* and a character "*pinnis dorsalibus duabus*". The character of "two dorsal fins"was provided to distinguish *G. ocellaris* from *Gobiis anguillaris* and *Gobiis melanuro* by its possessing two dorsal fins, implying that the latter two species have one fin. *Gobiis anguillaris* and *G. melanuros* are not distinguished from each other by any statement. Therefore the name *melanuro* Broussonet is not available as no description exists. Eschmeyer (1998) stated the name *Gobiis melanuro* Broussonet, 1782, as not available (no distinguishing features).

Gmelin's (1789) use of the name *Gobius melanuros* constitutes a description, as he lists two characters (single dorsal fin, black caudal fin), therefore that name is available. Lacepède (1800) correctly latinized the Greek *-os* to *-us* when he used the emended name *melanurus*, and he placed the species in the genus *Gobioides* (along with three other species). Bloch and Schneider (1801) also referred to Gmelin's name and corrected the spelling to *Gobius melanurus*.

Bleeker (1849) created the name *Gobius melanurus* for his species from Java, without reference to Broussonet or Gmelin. Bleeker's name is thus a primary homonym of Gmelin's emended *Gobius melanurus*, the first available name. The next available name for the taxon is *Gnatholepis mingi* Herre, 1936.

It is uncertain as to what the species *melanurus* of Gmelin and Lacepède actually is (described as "*pinna dorsali unica, cauda nigra*" by Gmelin). Richardson (1846) referred to specimens from Canton, China, as *Gobioides melanurus* (after Broussonet manuscript and figure). No specimens are known, and Richardson's description is based on a drawing and notes, which indicate that the fish had a pointed tail, a black spot on the base of the fin and one dorsal fin (Richardson 1846). It is possible that *Gobioides melanurus* is an amblyopine, or even a channid.

Miller (1987) referred to the holotype of *Hemigobius bleekeri* Koumans as being RMNH 4501, a 40 mm SL ("40+8") female. Koumans (1953) stated "Types seen", but did not designate a type of *H. bleekeri*, nor is there any indication in the specimen jar as to which specimens he considered to be types. In 1988, RMNH 4501 consisted of three possible syntype specimens, 40.5-55.0 mm SL, of which the largest and smallest are female. In the original description, Bleeker (1849) wrote "33 millimetr", that is, 33 mm TL, which would make these types of *melanurus* (and *bleekeri*) rather larger than he described (he did not indicate how many specimens he had). The description may have been based on a male, as Bleeker wrote: ". . *appendice anali conica acuta*. ."; however, this description could equally apply to some female specimens. The figure given in Bleeker of *Hemigobius melanurus*

(1988: pl. 433, fig. 9) (Fig. 12), drawn life-sized, is of a 55 mm SL fish, probably the large female in RMNH 4501. In the interests of stability, this 55 mm SL female specimen (RMNH 4501) is here designated as lectotype of *Gobius melanurus* Bleeker and *Hemigobius bleekeri* Koumans.

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Short communication

EMERGENT AGGREGATIONS IN SEMON'S ROCK-CLIMBING GOBY *STIPHODON SEMONI*

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The gobiid genus *Stiphodon* comprises a small group of tiny, usually brightly coloured fishes which are widely distributed through Indonesia, New Guinea and various Pacific islands (Allen 1991; Kottelat *et al.* 1993). They are diadromous, spending their adult lives in the upper freshwater reaches of small coastal streams. Breeding takes place during the wet season in freshwaters, after which the larvae are flushed into the river mouths and the sea (Parenti and Thomas 1998). The post-larval fish must then travel back upstream to the rocky, torrent habitats they favour, up an elevation of 350 m (Watson 1996).

In southwestern Sumbawa, Indonesia, development of a gold/copper resource has prompted an ecological monitoring program for the local freshwater streams. Fish populations have been sampled at several sites in each of four streams on a semi-annual basis since 1996. The largest stream sampled is the Tatarloka River, with a catchment size of about 200 sq km.

During the course of regular monitoring surveys on the upper Tatarloka River on 14th April, 1999, large aggregations of Semon's Rock-climbing Goby (*Stiphodon semoni*) were observed (Figs 1-2). At numerous points along the river within a narrow gorge, thousands of individuals of this species were found to have climbed right out of the water and were clinging on to vertical, wet rock faces. Massive schools were also observed in the water, and many individuals were observed to climb out to join the emergent fish. The fish climbed the rock faces as high as the wash line, which was up to 40 cm in some areas. There, they were observed to cling to the rocks and slowly crawl in the direction of any wash current. When still, they appeared to be feeding, by scraping the wet rock surface. Fukui (1979) described in detail the manner in which the related *Sicyopterus japonicus* climbed vertical surfaces in Japanese rivers, using the pelvic disk and fleshy jaws as "suction cups".

Densities of the *Stiphodon* aggregations were recorded by counting the number of individuals occupying 10 x 10 centimetre areas at several sites. From these data, the average densities of individuals on the rock faces were calculated at about 4,000 per m^2, to a maximum of 10,000 per m^2. The largest area covered was over 2 m^2 on one rock face.

The timing of this occurrence is significant. Early April is usually the beginning of the dry season in Sumbawa, but in 1999, the wet season was prolonged and for several days before and following the observations, storms and heavy rain were experienced in the catchment. Only one hour after the above observations were made, a storm event occurred and the water level at the site rose by two metres in half an hour.

It is suggested that these aggregations consisted of post-larval fish in the process of an annual, post wet season migration upstream from the estuary, which is some 10 km away. Disrupted by flooding events in a constricted section of the river, and unable to swim upstream against the strong current, the fish were forced to escape by climbing out of the water. All individuals were noted to be smaller than the regular adult size (up to 45 mm standard length) for this species, and all were dull brown in appearance. These observations suggest that the fish

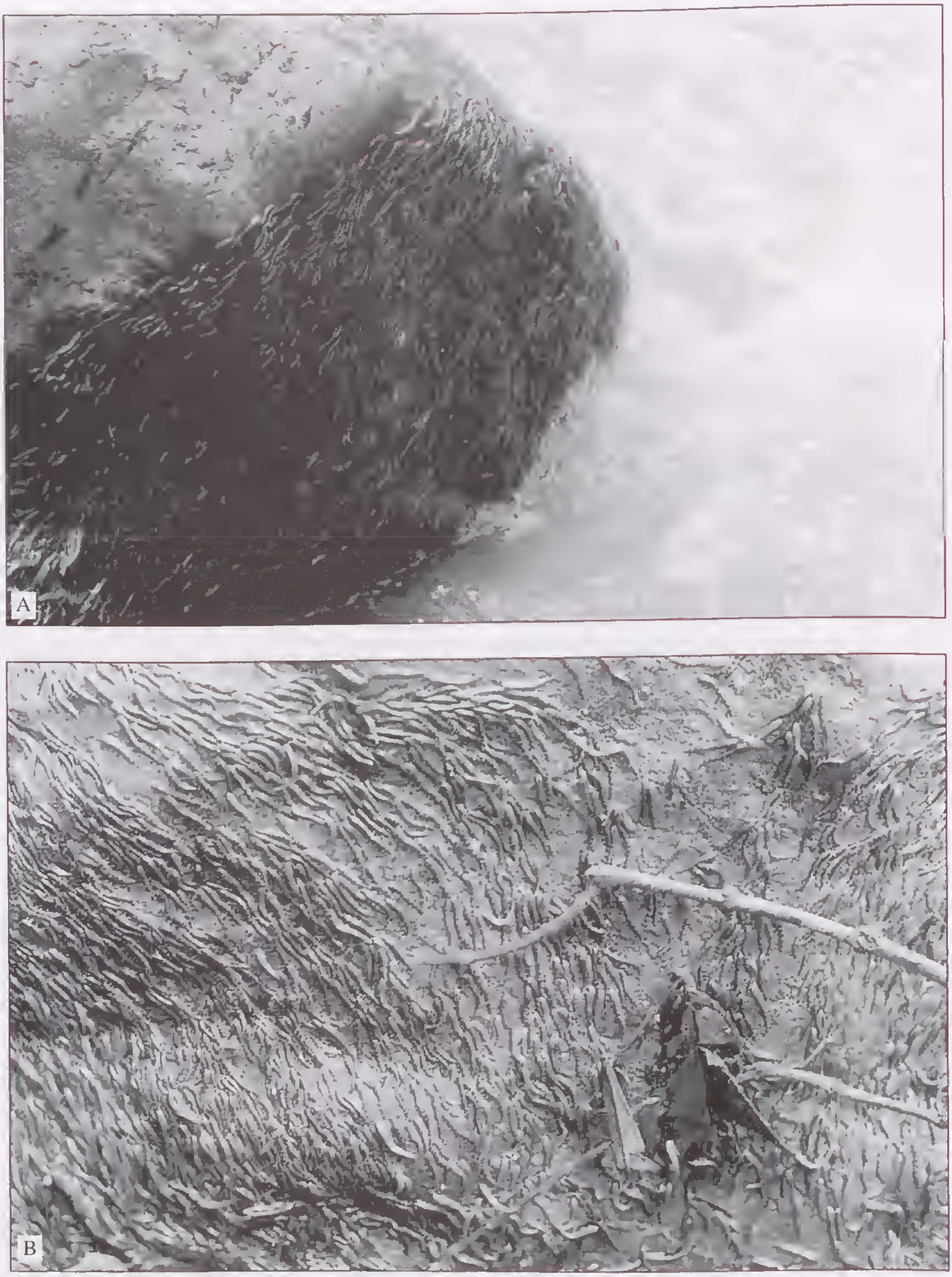

Fig. 1. A, aggregation of *Stiphodon semoni* gobies on an exposed rock face; **B**, detail.

were immature, as adult fish, especially the males, are brightly coloured with iridescent green or blue stripes (Watson 1996).

Stiphodon semoni is an abundant species throughout the study area, and instream mass migrations have been observed on one other occasion during the monitoring surveys, also in April but in a different river system. "Rock-climbing" gobies of the genera *Stiphodon, Sicyopterus, Sicopus* and *Rhyacichthys* dominate these upstream torrent habitats. These small fishes are especially adapted to life in the steep, boulder strewn coastal streams of the study area.

During normal dry season conditions in the study area, *Stiphodon* gobies prefer relatively level, shallow (<0.5 m), rocky or gravelly sections of the stream with a moderate flow. Density studies on these gobies under normal conditions indicate average abundances of 7-18 fish per m^2 of substrate, with over one hundred per m^2 observed on some plots. Goby densities were found to be significantly correlated to open, sunny locations, boulder or cobble substrates, and areas of moderate leaf litter cover. Water quality in the Tatarloka River is high and there is no human habitation or disturbance in the area. Generally, upstream sites along the river have a high pH (7.5-8.3), high dissolved oxygen (typically 80-90%), and a low conductivity (usually <300 (µs). The waters are generally very clear and warm (25°-30° C).

The observed emergent aggregating behaviour illustrates the amazing ability and resilience of these tiny fishes to cope with extreme natural conditions. It demonstrates that these fish, like most diadromous species in the area, have a regular requirement to undertake long and sometimes difficult migrations up and down these streams at certain times of the year.

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The aquatic monitoring program is one of a number of environmental studies being undertaken by PT. Newmont Nusa Tenggara in southwestern Sumbawa. The aggregation photographs were taken by Muhamad Yani. Helen Larson reviewed the draft and provided comments and additional references.

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CHECKLIST OF THE SCLERACTINIAN CORAL SPECIES FROM THE WATERS OF PADANG (WEST SUMATRA, INDONESIA) HELD IN THE CORAL COLLECTION OF BUNG HATTA UNIVERSITY

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ABSTRACT

The coral collection project at Bung Hatta University, Padang, Indonesia, was initiated during March 1996, to fulfill an urgent need to document the coral fauna in the waters of West Sumatra. Before this time an extensive survey of the coral species of the area had not been performed and at the time of writing, the Bung Hatta University collection is the only substantial collection of scleractinian corals in Indonesia. This paper documents the reasons for which a coral collection was required, the development of the coral collection and the infrastructure required to support it. In addition, the 163 scleractinian coral species from 58 hermatypic and ahermatypic genera represented in the Bung Hatta University collection are listed.

KEYWORDS: Scleratinia, coral, checklist, Padang, Sumatra, Indonesia.

INTRODUCTION

The Indonesian Archipelago consists of 17,000 islands with over 81,000 km of coastline. Both the Indian and Pacific Oceans wash these islands, with Indonesian territorial waters being approximately 3,650,000 km^2 (World Resources Institute 1996). This vast aquatic environment contains a kaleidoscope of habitats including coral reefs, mangrove forests and sea grass beds. In fact, the coral reefs of Indonesia and the neighbouring Philippines are renowned as a global center of coral reef diversity. The reefs themselves are made up of as many as 70 genera of corals (Veron 1986), the highest generic diversity of anywhere in the world. In spite of the diversity and extent of the coral reefs of Indonesia, many of the areas are poorly known in a taxonomic sense and there was no substantial taxonomic reference collection of scleractinian corals held in any institution in Indonesia that documented the species present in the archipelago.

Prior to 1996, the Fisheries Research and Development Centre (PPPP) of Bung Hatta University had worked collaboratively with overseas coral taxonomists from the Museum of Tropical Queensland, Australia and the Rijksmuseum van Naturlijke Historie, Leiden, Netherlands. This work, along with opportunistic coral collecting performed by members of the PPPP, indicated that there was an urgent requirement to document the coral fauna of the territorial waters of West Sumatra. The reasons for the urgency to establish this coral collection were twofold. Firstly, due to the lack of research which has been performed in the waters of West Sumatra, the coral species which can be found in the area are poorly known and further investigations would improve knowledge of genus and species distributions (Jonker and Johan 1998). This in turn would provide information for subsequent coral biodiversity and biogeographical studies for this area, whose coral fauna is influenced by both the Indian and Pacific Ocean faunas.

Secondly, the coral reefs in West Sumatra are under threat from anthropogenic sources, which include untreated waste from Padang's population of 700,000, pollution from industry, sedimentation and heavy metals from logging and mining operations, and fertiliser runoff from intensive agriculture activities. As well as these disturbances, coral and shell collecting and destructive fishing techniques (trawling, poison and explosives) are still used (Kunzmann 1997). Obviously there was a need to document the coral diversity in West Sumatra before it was destroyed and to assist in the implementation of marine protection programs to conserve what is left (Jonker and Johan 1998).

The importance of this second reason was realised with the onset of more recent and dramatic disturbances to the reefs which consisted of two consecutive events. From August till December 1998, West Sumatra, along with many other provinces of Indonesia, was blanketed by thick smoke, which was the direct result of uncontrolled forest fires. This smoke obscured the sun and thus resulted in a dramatic drop in water temperature of 5-6° C (from an average of 29° C). It is already clear that sudden and major deviations from an acclimated temperature regime may trigger bleaching in corals (Tomascik *et al.* 1997) and thus the drop in temperature caused by the predominating smoke conditions undoubtedly resulted in physiological stress to the corals, and minor localised bleaching events were noted. When the smoke cleared with the onset of delayed rain, the reefs were then subjected to a red tide event from late December 1997 to early January 1998. This proved to be catastrophic to the reefs in these waters, resulting in widespread coral death. In areas which, prior to the smoke and red tide events had a percentage live coral cover of up to 83% (Kunzmann and Efendi 1994), the live coral cover has been reduced to almost 0% (Efendi and Indrawadi 1998).

In response to the need to document the coral diversity of the waters of West Sumatra, it was decided that a coral collection would be developed at Bung Hatta University in Padang. Technical assistance on taxonomy and collection management practices was requested from Australia and in March 1996, the project to establish coral collections at the University commenced. This paper describes the development of the scleractinan coral collection at Bung Hatta University, Padang, Indonesia with a checklist of the species collected.

STUDY AREA

The province of West Sumatra (capital Padang), Indonesia has a shoreline of approximately 450 km. Nearly 50% of the province's total area (20,000 km^2) is sea, and encompasses 86 inshore islands and reefs as well as the offshore Mentawai Island group. The inshore islands and reefs are in two chains, running parallel to the coast at distances of 13 and 22 km from the coast. They can be categorised in a north-south direction, with those islands in the north being sandy, flat coral cays, while islands towards the south have their basis in volcanic rock and are generally higher and more heavily vegetated than those found in the north (Kunzmann 1997). This north-south demarcation emulates the geography of the mainland.

Due to prevailing weather and wave conditions most islands are elongated north to south and are kidney shaped. Reefs on the west side are exposed to powerful wave action, reefs on the southerly aspect of the island can be exposed to strong winds for at least three months of the year, while the reefs on the east sides of the islands are on the protected leeward side (Kunzmann 1997). These differences in wind and wave regime, plus the differing geology of the islands and the differences in distance from the coast have resulted in a high diversity of coral habitats and coral species. Reefs in these waters can usually be described as submerged patch reefs and fringing reefs that surround islands. These fringing reefs generally have steep slopes with well-developed spur and groove formations at some sites (Kunzmann 1997). Reefs in nearshore areas are exposed to turbid waters and large sediment loads from mainland rivers, especially during the rainy season, while offshore, visibility is often in excess of 30 m. Reefs are found adjacent to both seagrass and mangrove areas.

The study area is presented in Figure 1.

METHODOLOGY AND PROJECT DEVELOPMENT

Identification and literature used. At the time of the project's commencement (1996), there was a small collection of approximately 150 scleractinian specimens, including a comprehensive series of *Acropora* (Family: Acroporidae) species, and representatives of the family Fungiidae which had been collected and identified by Dr Carden Wallace (Museum of Tropical Queensland) and Dr Bert Hoeksema (Rijksmuseum van Naturlijke Historie) respectively. The first phase of the project involved verification of the identification of

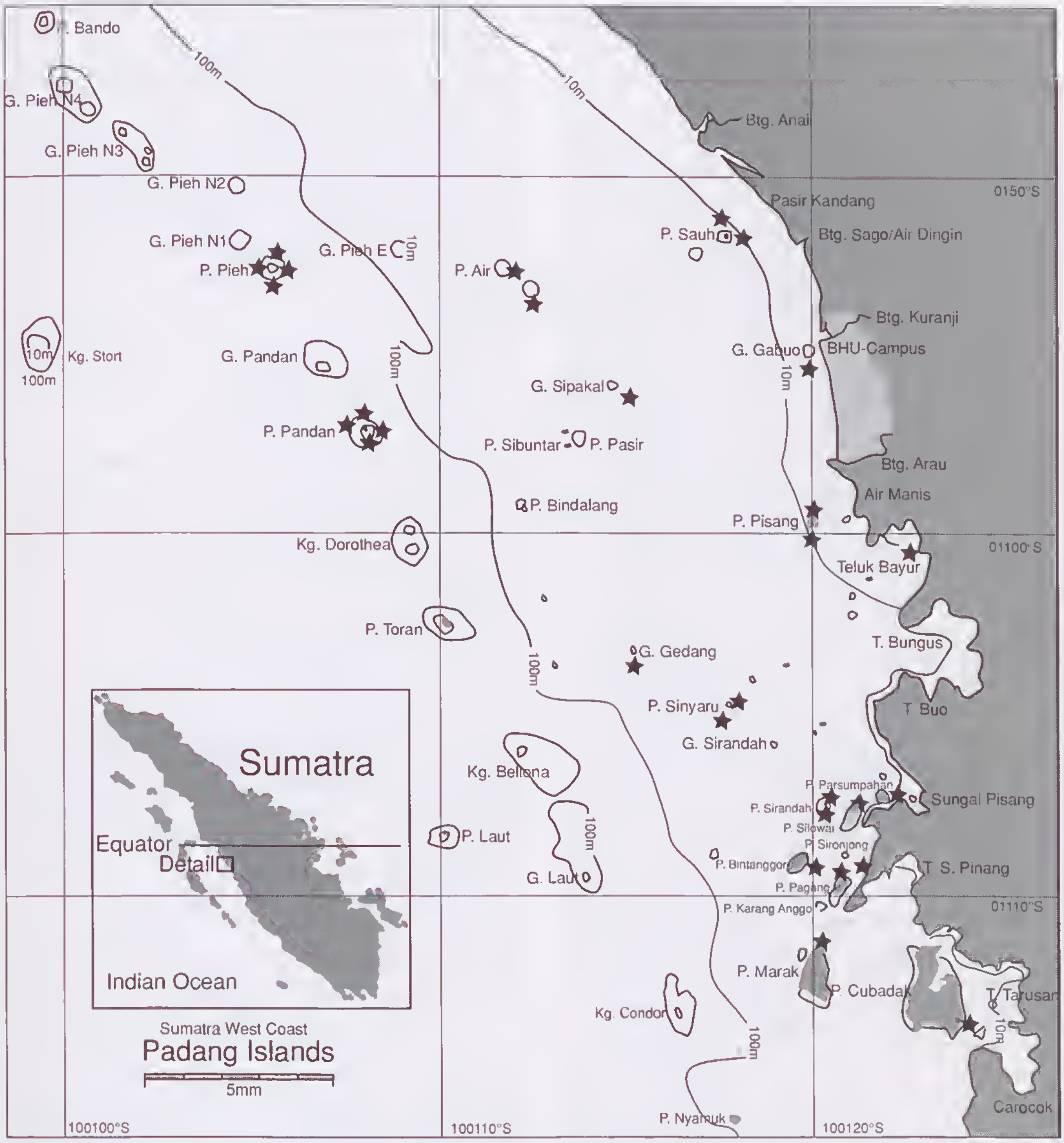

Fig 1. Locality map of Padang and surrounding waters. Stars indicate sites from which corals were collected. (Adapted from Kunzmann, 1997).

the corals that had already been collected. Identification of these and samples subsequently collected was based on the following taxonomic literature: Hoeksema (1989), Veron (1986), Veron and Pichon (1976), Veron and Pichon (1980), Veron and Pichon (1982), Veron, Pichon and Wijsman-Best (1977), Veron and Wallace (1984), Wallace (1994), Wallace (1997) and Wallace and Wolstenholme (1997). Identification was based on growth form and corallite structure, the latter being examined with the aid of a stereomicroscope. Comparison with examples in the literature and specimens positively identified in the collection was extensive.

Specimen collection and preparation. The majority of the specimens in the collection have been collected from the reef flat and reef slope to depths of approximately 25-30 m with an extensive coverage of the inshore islands both to the north and south of Padang. In addition, fieldwork has been performed at the offshore Mentawai Islands group. Collecting was carried out by SCUBA divers, at depths to 30 m, who used hammers and chisels to collect specimens or representative samples of larger colonies. Notes were taken on depth, colour of the colony, and the substrate on which the colony was found. The sites at which corals were collected are shown on Figure 1.

Upon arrival at the laboratory, specimens were immediately immersed in a solution of bleach (sodium hypochlorite), rinsed in fresh water and then dried in the sun until the corallum was white. Upon identification the sample was registered into the specimen database, labelled and stored in the collection.

Database system. A database was developed using the FoxPro database software package and all specimens were registered in this database. Foxpro allows search and reporting based on any field in the database. Consistent with standard collection management practice, each specimen was given a unique reference number and various taxonomic and habitat parameters were recorded.

Infrastructure. As coral collecting continued it soon became apparent that a laboratory and storage facility was required, which could be used both for specimen preparation and to house the collection safely. Plans were prepared and the 144 m^2 collections laboratory was completed during June 1997. This air-conditioned laboratory encompasses a wet area with a fumehood, bench space and desk space and an area for storage of the collection in custom made wood and glass cupboards. In addition, a secure outside coral preparation room was designed to facilitate the preparation of coral specimens. This tiled area has a perspex roof to allow the sun to penetrate and walls made from metal trellis to allow air circulation, both of which assist in the drying and bleaching of the specimens. Trellis foldaway shelves on each of the walls, are used for cleaning the coral and provide excellent air circulation for the subsequent drying of the specimens.

NEW GENUS AND DISTRIBUTION RECORDS

Hoeksema (1997) has previously reported on the genera of corals found in the waters of West Sumatra. In addition to the genera reported in Hoeksema's (1997) list, the coral collection at Bung Hatta University also holds specimens of the following eleven coral genera, which are previously unreported from this area: *Palauastrea* (Family: Pocilloporidae), *Coscinarea, Pseudosiderastrea* (Family: Siderastreidae), *Achrelia* (Family: Oculinidae), *Halomitra* (Family: Fungiidae), *Cynarina* (Family: Mussidae) *Caulastrea, Oulastrea, Plesiastrea* (Family: Faviidae) *Astrangia* and *Culicia* (Family: Rhizangiidae).

Due to the previously unexplored nature of the waters of West Sumatra, it is inevitable that range extensions for generic distribution would be encountered. Veron (1986, 1993) gives a thorough coverage of coral genus distribution from research results and literature searches. Based on the computer generated distribution maps prepared from these results which predict the range of each genus (Veron 1986), the following genera which are held in the Bung Hatta University collection represent range extensions to previously known distribution patterns: *Palauastrea* (Fam: Pocilloporidae). *Pseudosiderastrea* (Fam: Siderastreidae). *Coeloseris* (Fam: Agariciidae). Acrhelia (Fam: Oculinidae), *Australomussa* (Fam: Mussidae) and *Oulastrea* (Fam: Faviidae).

NEW SPECIES RECORDS

In addition to the range extensions for genera, several new species of coral have been discovered in the waters of West Sumatra, these being representatives of the families Acroporidae and Fungiidae. According to Wallace's (1997) research on the *Acropora* species found in the waters of Indonesia, the paratype specimens of two newly described species, *Acropora (Acropora) sukarnoi* and *Acropora (Acropora) indonesia* were found on West Sumatran reefs. In addition, the recently described *Acropora kosurini* (Wallace 1994) can be found in West Sumatra (Wallace and Wolstenholme 1998). As a result of Hoeksema's research in the area, a new *Podabacia* (Fam: Fungiidae) species was discovered and will be described.

CHECKLIST OF CORALS IN THE BUNG HATTA UNIVERSITY COLLECTION

The coral collection held at Bung Hatta University contains almost 900 specimens. Of the 58 genera (163 species) which are represented in the collection, 55 genera are hermatypic and 3 genera are ahermatypic. This represents an extensive coverage of the coral fauna which would be expected to be found in this area, as Veron (1993) predicted 70 genera of coral from this region of Indonesia.

Up till now, limited sampling has taken place in the intertidal zone, in areas of high turbidity, or in deep water, and it is envisaged that further collecting efforts which could be centered on these habitats will undoubtedly result in the discovery of further genera.

The species of coral which are represented in the Bung Hatta University coral collection are presented in Table 1.

ACKNOWLEDGMENTS

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Table 1. Checklist of scleractinian coral species found in the waters of West Sumatra, represented in the coral collection of Bung Hatta University, Padang, West Sumatra, Indonesia.

Family Astrocoeniidae

Stylocoeniella armata (Ehrenberg, 1834)
Stylocoeniella guentheri Bassett-Smith, 1890

Family Pocilloporidae

Palauastrea ramosa Yabe and Sugiyama, 1941(1,2)
Pocillopora damicornis (Linnaeus, 1758)
Pocillopora eydouxi Milne Edwards and Haime, 1860
Pocillopora verrucosa (Ellis and Solander, 1786)
Seriatopora caliendrum Ehrenberg, 1834
Seriatopora hystrix Dana, 1846
Stylophora mordax (Dana, 1846)
Stylophora pistillata Esper, 1797

Family Acroporidae (3)

Acropora austera (Dana, 1846)
Acropora brueggemanni (Brook, 1893)
Acropora cerealis (Dana, 1846)
Acropora clathrata (Brook, 1891)
Acropora cytherea (Dana, 1846)
Acropora divaricata (Dana, 1846)
Acropora donei Veron and Wallace, 1984
Acropora echinata (Dana, 1846)
Acropora elseyi (Brook, 1892)
Acropora florida (Dana, 1846)
Acropora formosa (Dana, 1846)
Acropora gemmifera (Brook, 1892)
Acropora humilis (Dana, 1846)
Acropora hyacinthus (Dana, 1846)
Acropora millepora (Ehrenberg, 1834)
Acropora nasuta (Dana, 1846)
Acropora nobilis (Dana, 1846)
Acropora palifera (Lamarck, 1816)
Acropora palmerae Wells, 1954
Acropora samoensis (Brook, 1891)
Acropora sarmentosa (Brook, 1892)
Acropora secale (Studer, 1878)

Table 1 cont. Checklist of scleractinian coral species found in the waters of West Sumatra, represented in the coral collection of Bung Hatta University, Padang, West Sumatra, Indonesia.

Acropora spicifera (Dana, 1846)
Acropora tenuis (Dana, 1846)
Acropora valenciennesi (Milne Edwards and Haime, 1860)
Acropora valida (Dana, 1846)
Astreopora myriophthalma (Lamarck, 1816)
Astreopora ocellata Bernard, 1896
Montipora aequituberculata Bernard, 1897
Montipora danae (Milne Edwards and Haime, 1851)
Montipora digitata (Dana, 1846)
Montipora foliosa (Pallas, 1766)
Montipora hispida (Dana, 1846)

Family Poritidae
Goniopora columna Dana, 1846
Goniopora lobata Milne Edwards and Haime, 1860
Goniopora pandoraensis Veron and Pichon, 1982
Goniopora stokesi Milne Edwards and Haime, 1851
Porites cylindrica Dana, 1846
Porites lichen Dana, 1846
Porites lutea Milne Edwards and Haime, 1860
Porites nigrescens Dana, 1848
Porites (Synaraea) rus (Forsskål, 1775)
Porites solida (Forsskål, 1775)

Family Siderastreidae
Coscinaraea exesa (Dana, 1846)(2)
Psammocora contigna (Esper, 1797)
Psammocora digitata Milne Edwards and Haime, 1851
Psammocora explanulata Van Der Horst, 1922
Psammocora haimeana Milne Edwards and Haime, 1851
Pseudosiderastrea tayami Yabe and Sugiyami, 1935(1,2)

Family Agariciidae
Coeloseris mayeri Vaughan, 1918(1)
Gardineroseris planulata (Dana, 1846)
Leptoseris gardineri Van Der Horst, 1921
Leptoseris hawaiiensis Vaughan, 1907
Leptoseris mycetoseroides Wells, 1954
Leptoseris scabra Vaughan, 1907
Leptoseris yabei Pillai and Scheer, 1976
Pachyseris rugosa (Lamarck, 1801)
Pachyseris speciosa (Dana, 1846)
Pavona cactus (Forsskål, 1775)
Pavona clavus (Dana, 1846)
Pavona decussata (Dana, 1846)
Pavona explanulata (Lamarck, 1816)
Pavona minuta Wells, 1956
Pavona varians Verrill, 1864
Pavona venosa (Ehrenberg, 1834)

Family Pectiniidae
Echinophyllia aspera (Ellis and Solander, 1788)
Echinophyllia echinata (Saville-Kent, 1871)
Echinophyllia echinoporoides Veron and Pichon, 1980
Mycedium elephantotus (Pallas, 1766)
Oxypora lacera (Verrill, 1864)
Pectinia alcicornis (Saville-Kent, 1871)
Pectinia elongata Rehberg
Pectinia lactuca (Pallas, 1766)
Pectinia paeonia (Dana, 1846)

Family Oculinidae
Achrelia horrescens (Dana, 1846)(1,2)
Galaxea astreata (Lamarck, 1816)
Galaxea fascicularis (Linnaeus, 1767)

Family Fungiidae
Ctenactis albitentaculata Hoeksema, 1989
Ctenactis crassa (Dana, 1846)
Ctenactis echinata (Pallas, 1766)
Fungia (Cycloseris) costulata Ortmann, 1889
Fungia (Cycloseris) tenuis Dana, 1846
Fungia (Danafungia) horrida Dana, 1846
Fungia (Danafungia) scruposa Klunzinger, 1879
Fungia (Fungia) fungites (Linnaeus, 1758)
Fungia (Lobactis) scutaria Lamarck, 1801
Fungia (Pleuractis) moluccensis Van der Horst, 1919
Fungia (Pleuractis) paumotensis Stutchbury, 1833
Fungia (Verrillofungia) concinna Verrill, 1864
Fungia (Verrillofungia) repanda Dana, 1846
Fungia (Wellsofungia) granulosa Klunzinger, 1879
Halomitra pileus (Linnaeus, 1758)(2)
Herpolitha limax (Esper, 1797)
Lithophyllon mokai Hoeksema, 1989
Podabacia crustacea (Pallas, 1766)
Podabacia sp. nov. Hoeksema, in press
Polyphyllia talpina (Lamarck, 1801)
Sandalolitha dentata Quelch, 1884

Family Mussidae
Australomussa rowleyensis Veron, 1985(1)
Cynarina lacrymalis (Milne Edwards and Haime, 1848)(2)

Table 1 cont. Checklist of scleractinian coral species found in the waters of West Sumatra, represented in the coral collection of Bung Hatta University, Padang, West Sumatra, Indonesia.

Lobophyllia corymbosa (Forsskål, 1775)
Lobophyllia hataii Yabe, Sugiyama and Eguchi, 1936
Lobophyllia hemprichii (Ehrenberg, 1834)
Lobophyllia pachysepta Chevalier, 1975
Symphyllia agaricia Milne Edwards and Haime, 1849
Symphyllia radians Milne Edwards and Haime, 1849
Symphyllia recta (Dana, 1846)

Family Faviidae
Caulastrea curvata Wijsman-Best, 1972 (2)
Cyphastrea chalcidicum (Forsskål, 1775)
Cyphastrea microphthalma (Lamarck, 1816)
Cyphastrea serailia (Forsskål, 1775)
Diploastrea heliopora (Lamarck, 1816)
Echinopora horrida Dana, 1846
Echinopora lamellosa (Esper, 1795)
Favia laxa (Klunzinger, 1879)
Favia matthaii Vaughan, 1918
Favia pallida (Dana, 1846)
Favia rotumana (Gardiner, 1899)
Favia speciosa (Dana, 1846)
Favia stelligera (Dana, 1846)
Favites complanata (Ehrenberg, 1834)
Favites halicora (Ehrenberg, 1834)
Favites pentagona (Esper, 1794)
Favites russelli (Wells, 1954)
Goniastrea edwardsi Chevalier, 1971
Goniastrea favulus (Dana, 1846)
Goniastrea pectinata (Ehrenberg, 1834)
Goniastrea retiformis (Lamarck, 1816)
Leptastrea purpurea (Dana, 1846)
Leptastrea transversa Klunzinger, 1879
Leptoria phrygia (Ellis and Solander, 1786)
Montastrea annuligera (Milne Edwards and Haime, 1849)
Montastrea curta (Dana, 1846)
Oulastrea crispata (Lamarck, 1816)(1,2)
Platygyra daedalea (Ellis and Solander, 1786)
Platygyra lamellina (Ehrenberg, 1834)
Platygyra pini Chevalier, 1975
Platygyra sinensis (Milne Edwards and Haime, 1849)
Platygyra verweyi Wijsman-Best, 1976
Plesiastrea versipora (Lamarck, 1816)(2)

Family Merulinidae
Hydnophora exesa (Pallas, 1766)
Hydnophora microconos (Lamarck, 1816)
Hydnophora rigida (Dana, 1846)
Merulina ampliata (Ellis and Solander, 1786)
Merulina scabricula Dana, 1846
Hydnophora rigida (Dana, 1846)
Merulina ampliata (Ellis and Solander, 1786)
Merulina scabricula Dana, 1846

Family Caryophylliidae
Euphyllia glabrescens (Chamisso and Eysenhardt, 1821)
Physogyra lichtensteini (Milne Edwards and Haime, 1851)
Plerogyra sinuosa (Dana, 1846)

Family Dendrophylliidae
Tubastraea micrantha Ehrenberg, 1834
Turbinaria peltata (Esper, 1794)
Turbinaria reniformis Bernard, 1896

Family Rhizangiidae
Astrangia sp. Milne Edwards and Haime, 1848(2)
Culicia sp. Dana, 1846(2)

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(1) indicates an extension of distribution range for the genera according to Veron (1986).
(2) indicates first record of the genus from West Sumatra.
(3) note that Tomascik *et al.* (1997) lists an additional 12 *Acropora* species from Padang which are not represented in the collection.

The Beagle, Records of the Museums and Art Galleries of the Northern Territory, 1999 **15**: 55-74

TYPE SPECIMENS OF TERRESTRIAL VERTEBRATES IN THE MUSEUM AND ART GALLERY OF THE NORTHERN TERRITORY - 1973 TO 1999

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ABSTRACT

Details of type specimens deposited in the Terrestrial Vertebrates Collection of the Museum and Art Gallery of the Northern Territory, Darwin, Northern Territory, Australia, are given. Material whose descriptions were published prior to 1 November 1999 is covered and includes 49 holotypes and 507 paratypes. Discrepancies between original descriptions and MAGNT catalogue entries are commented on. Tables give a summary of type material and show both new and superseded catalogue numbers.

KEYWORDS: Type specimens, terrestrial vertebrates, Amphibia, Reptilia, Mammalia, Northern Territory Museum, Northern Territory, Australia.

INTRODUCTION

With origins dating only from 1969, the Museum and Art Gallery of the Northern Territory (MAGNT) is the youngest major Australian museum. The first natural history specimen (a terrestrial vertebrate) was catalogued in September 1973 and, since that time, more than 37,000 individual terrestrial vertebrates have been accessioned. Composed of amphibian, reptile, bird and mammal material, the Terrestrial Vertebrates Collection is primarily focused on the Northern Territory (87% of specimens), but does contain significant comparative material from other Australian States and some material from other countries. At the time of writing the Collection contains 6,391 amphibians, 22,540 reptiles, 3,587 birds and 4,746 mammals. Among these are 555 type specimens (49 holotypes and 507 paratypes), which represent 67 species and 16 subspecies.

Wells and Wellington (1985) who, in a controversial publication, re-classified the Amphibia and Reptilia of Australia, designated a percentage of type material in the Terrestrial Vertebrates Collection. In this work the taxonomic status of Wells and Wellington types in the collection is addressed.

HISTORICAL BACKGROUND

As reflected by the Terrestrial Vertebrates Collection's composition, curatorial interests have been principally herpetological. The inaugural terrestrial vertebrates curator was Mr G.F. Gow, who accessioned the first specimens and managed the Collection till March 1985. His curatorship was followed by that of Dr M.E. King, who developed the Collection until October 1993 when he retired. Following Dr King's retirement, the author was appointed as curator.

Prior to the establishment of the MAGNT, the (now) Parks and Wildlife Commission of the Northern Territory initiated a wildlife reference collection intended as the nucleus of a "future" museum collection. This collection's original specimen catalogue is titled "Northern Territory Museum specimen register" and indicates that K.R. Slater and A. Newsome were mainly responsible for curatorial activities. Accessioning of specimens into this collection began in October 1965, and included specimens which had been collected up to fourteen years earlier. As this collection was located in Alice Springs and MAGNT was becoming established in Darwin, the titles of the collection and its building were changed in 1980 to the Central Australia Wildlife

Collection (CAWC) and the "Central Australian Museum". The latter was an unfortunate title as the current Central Australian Museum is a branch of MAGNT and an entirely separate institution.

For a period prior to 1980, the CAWC was inadequately curated and managed. Located at the Arid Zone Research Institute, Alice Springs, it was housed in a non air-conditioned shed and many catalogued specimens were lost through misuse or discarded due to desiccation. As no attempt was made to distinguish types from ordinary specimens, this period resulted in the disappearance or loss of some type material.

The CAWC had several series of numbers implemented, and often poor quality, easily detached, paper tags were used as labels. The first series of specimens were accessioned with an NTM prefix and were given catalogue numbers 0001 to 6000. This series included all macrofauna types (amphibians, reptiles, fish, birds and mammals), and also often included animal products such as scats, gut contents and skeletal fragments as catalogued specimens. A second series was begun in November 1974, again with the prefix NTM but divided into the major fauna types. Catalogue numbers for this series were NTM A.0001 to A.0149 (amphibians), NTM B.0001 to B.0215 (birds), NTM F.0001 to F.0072 (fish), NTM R.0001 to R.0799 (reptiles), and NTM M.0001 to M.0272 (mammals). This series was altered in February 1981, when the NTM prefix was changed to CAM (Central Australian Museum). Accessioning of specimens into the CAWC ceased in May 1985, when the collection was transferred to the MAGNT.

At the time of transfer the CAWC was composed of about 9,700 catalogued specimens, of which 8,090 have been accessioned into the MAGNT Terrestrial Vertebrates Collection. The remaining 1,600 specimens had been either lost, discarded or were deemed of little scientific value. As the numbering system of the CAWC was inconsistent and duplicated the MAGNT herpetological numbering system, its terrestrial vertebrate content has been re-catalogued and allocated new MAGNT registration numbers. Animal products such as scats and gut contents were not allocated new numbers but, where appropriate, were cross referenced to the relevant catalogued specimen.

LIST OF TYPE SPECIMENS

Explanatory notes. Where CAWC specimens are listed as type material, their original catalogue number is shown in parentheses after their MAGNT number. A summary of MAGNT holotypes and paratypes is given in Appendices 1 and 2. Note that the prefix NTM can relate to catalogue numbers from both the MAGNT collection and to superseded catalogue numbers from the CAWC.

Only type material from descriptions published prior to 1 November 1999 are included. Unless noted otherwise, all type localities listed are from within the Northern Territory and type specimens are spirit preserves.

Class AMPHIBIA
Order SALIENTIA
Family HYLIDAE

Cyclorana maculosus Tyler and Martin, 1976: 269

Paratype. R.30093 (NTM3178), Tennant Creek, 19°04'S 134°12'E, 30 January 1966.

Cyclorana maini Tyler and Martin, 1976: 273.

Paratypes (5). R.30034-30037 (NTM2309-2311, NTM2316), Arid Zone Research Institute, 5 km south of Alice Springs, 23°46'S 133°53'E, 21 October 1964; R.30079 (NTM3177), Mount Doreen Station, 22°02'S 131°18'E, 23 January 1966.

Litoria pallida Davies, Martin and Watson, 1983: 101

Paratypes (2). R.10098-10099, Cannon Hill, 12°23'S 132°57'E, 28 November 1977.

Litoria personata Tyler, Davies and Martin, 1978: 151

Paratypes (3). R.30804-30806 (CAMA-

123-125), Cannon Hill, 12°23'S 132°57'E, 01 February 1977.

Family MYOBATRACHIDAE

Megistolotis lignarius Tyler, Martin and Davies, 1979: 137

Paratypes (7). R.578-579, R642, 1 km west of Oenpelli, 12°21'S 132°59'E, 21-22 May 1975; R.2143, 8 miles north of Humbert River Crossing, 16°28'S 130°30'E, 22 April 1976; R.5035, no data; R.31043 (CAMA121), Marlipur Creek, Wellington Range, 11°51'S 133°08'E, January 1977; R.31044 (CAMA122), Remusatia Gorge, Mount Brockman, 12°45'S 132°56'E, 31 October 1974.

Ranidella bilingua Martin, Tyler and Davies, 1980: 94

Paratypes (2). WESTERN AUSTRALIA - R.5838, 1.5 km north of Lake Argyle Tourist Village, 16°15'S 128°45'E, 19 February 1977; R.5839, Mining campsite, Mitchell Plateau, 14°50'S 125°50'E, 29 January 1978.

= *Crinia bilingua* after Heyer *et al.* (1982).

Uperoleia arenicola Tyler, Davies and Martin, 1981a: 26

Paratype. R.6276, Birrndu, 12°28'S 132°56'E, 30 November 1978.

Uperoleia inundata Tyler, Davies and Martin, 1981a: 39

Paratypes (2). R.6934-6935, Leanyer Swamp, Darwin, 12°22'S 130°55'E, 31 May 1979.

Uperoleia lithomoda Tyler, Davies and Martin, 1981a: 43

Paratype. R.6936, Arnhem Highway at Fogg Dam turnoff, 12°38'S 131°18'E, 31 May 1979.

Uperoleia micromeles Tyler, Davies and Martin, 1981a: 46

Paratype. R.31199 (CAMA140), Tanami Desert, 20°38'S 130°25'E, 18 January 1978.

Uperoleia trachyderma Tyler, Davies and Martin, 1981b: 149

Paratype. R.9865, George Redman Causeway, 37 km north of Elliot, 17°14'S 133°28'E, 16 December 1980.

Class REPTILIA

Order CROCODILIA

Family CROCODYLIDAE

Crocodylus pethericki Wells and Wellington, 1985: 7

Holotype. R.24821, male, Sweet's Lookout Billabong, Finniss River, 12°54'S 130°35'E, D.A. Lindner and party, 19 July 1979. Total length 5.1 metres.

Comments. Holotype is a skin, dry mounted on an artificial body. Skeletal elements, apart from the skull, jaws, digits and osteoderms, have been removed from the skin (heart and stomach contents are held by Crocodylus Park, Darwin, N.T.). The articulated, post-cranial skeleton is mounted separately, being completed by the addition of the skull, jaws, digits and osteoderms from a similarly sized *C. porosus*. Both mounts are on public display in the Natural Sciences Gallery of the MAGNT. At the time of publication the holotype had not been allocated an NTM catalogue number. The diagnosis differentiated the taxon from *C. porosus* by unsubstantiated aspects of scalation, colour and pattern, hatchling colour and behaviour, "eyeshine" and habitat preferences. Until a more detailed analysis of diagnostic characters and comparison with congeners is made, the taxon is synonymised with *C. porosus*.

= *Crocodylus porosus* Schneider, 1801. Synonymy of this paper.

Order TESTUDINES

Family CHELIDAE

Emydura tanybaraga Cann, 1997: 24

Paratype. R.20416, male, Daly River, crossing near Police Station, 13°45'S 130°41'E, M. Casey, 4 June 1994.

Comments. First published in the "Monitor", Journal of the Victorian Herpetological Society, where the paper's title differs from that given in the table of contents. The author is also only named in the contents. The paper is repeated almost verbatim in Cann (1998), leading to some confusion as to the date of publication. In the description the Daly River type locality is referred to as "Policeman's Crossing", this is an old name which is not in common usage today and could lead to confusion with "Policeman's Crossing" on the Rose River.

Order SQUAMATA
Suborder SAURIA
Family AGAMIDAE

Amphibolurus caudicinctus slateri Storr, 1967b: 52

Paratypes (36). R.31252-31255 (NTM1472-1475), Hermannsburg, 23°57'S 132°46'E, 11 March 1964; R.31257 (NTM1943), Reedy Creek, 24°18'S 131°36'E, 15 August 1964; R.31258-31259 (NTM2018-2019), Kathleen Creek, 24°02'S 131°40'E, 15 August 1964; R.31260 (NTM2378), Palm Valley, 24°03'S 132°43'E, 25 November 1964; R.31261-31278 (NTM2379-2396), Hermannsburg, 23°57'S 132°46'E, 25 November 1964; R31280-31289 (NTM2670-2679), Reedy Creek, 24°18'S 131°36'E, 19-21 February 1965.

= *Ctenophorus caudicinctus slateri* after Storr (1982).

Family GEKKONIDAE

Gehyra borroloola King, 1983: 160

Holotype. R.10726, male, 4 km south of Balbirini Station turnoff on the Tablelands Highway, 16°46'S 135°44'E, M.E. King, 23 June 1976.

Comments. King erroneously published the type locality as four kilometres south of the Balbirini Station turnoff on the Barkly Highway. The Balbirini Station turnoff is on the Tablelands Highway, approximately seven kilometres south of its junction with the Carpentaria Highway.

Paratypes (9). R.10717-23, 37.3 km northwest of the Balbirini Road junction, 16°43'S 135°23'E, 19 April 1979; R.10724-10725, 37.3 km northwest of the Balbirini Road junction, 16°43'S 135°23'E, 24 April 1979.

Comments. In the type description King lists a series of 10 paratypes as being lodged in the NTM collection. One of these is cited under the same catalogue number as the holotype. Though the collection data for this paratype differs (37 km north of Mimets Camp, McArthur River), it cannot be found and its location is unknown.

Gehyra membranacruralis King and Horner, 1989: 174

Holotype. R.13746, male, Port Moresby, Papua New Guinea, 09°30'S 147°07'E, D. Black, 1982.

Paratypes (2). PAPUA NEW GUINEA - R.13744-13745, Port Moresby, 09°30'S 147°07'E, 1982.

Gehyra minuta King, 1982a: 155

Holotype. R.9878, 78.5 km south of Renner Springs, 18°55'S 134°06'E, M.E. King, 17 June 1973.

Paratypes (8). R.9879-9882, same data as holotype; R.9883-9886, 17.9 km north of Renner Springs, 18°12'S 133°43'E, 17 June 1973.

Gehyra pamela King, 1982b: 97

Holotype. R.8656, Nourlangie Rock, 12°43'S 132°33'E, M.E. King, 7 July 1980.

Paratypes (4). R.8657, Lightning Dreaming, 12°54'S 132°51'E, 9 August 1979; R.8658, Cannon Hill, 12°23'S 132°57'E, 30 July 1979; R.8659, Nourlangie Rock, 12°43'S 132°33'E, 7 July 1980; R.8660, Birrndu, 12°28'S 132°56'E, 3 September 1979.

Nephrurus amyae Couper (in Couper and Gregson, 1994: 60)

Paratypes (21). R.441, Barrow Creek, 21°32'S 133°53'E, 26 November 1974; R.2458, Emily Gap, Alice Springs, 23°45'S 133°57'E, 15 March 1976; R.5383, Alice Springs Power House, 23°42'S 133°55'E, 22 February 1977; R.5466, Mount Gillen, Alice Springs, 23°43'S 133°48'E, 17 October 1976; R.5586, Alice Springs, 12°42'S 133°52'E, 1978; R.5969, Alice Springs, 12°42'S 133°52'E, 9 April 1978; R.12377, 16 km north of Alice Springs, 23°34'S 133°53'E, 11 March 1984; R.12380, 9 km north of Alice Springs, 23°37'S 133°53'E, 19 March 1984; R.14096, Mount Riddock Station, Dulcie Ranges, 22°30'S 135°25'E, 23 October 1987; R.14991, Alice Springs, 23°42'S 133°52'E, 23 October 1988; R.33715 (CAMR1039), Krichauff Range, 23°59'S 132°38'E,8 May 1983; R.33716 (CAMR1193), Bond Springs Station, 23°34'S 133°52'E, 18 October 1982; R.33717 (CAMR537), Winnecke Goldfields, 23°02'S 134°23'E, 1976; R.33719 (NTM2355), Hermannsburg, Finke

River Crossing, 23°58'S 132°46'E, 25 November 1964; R.33720 (NTM2759), 19 Mile Bore, Alice Springs Hills, 23°35'S 133°52'E, 8 March 1965; R.33721 (NTM3084), Charles River, Alice Springs, 23°39'S 133°51'E, 7 October 1965; R.33722-33723 (NTM4222-4223), Wigley's turnoff, Alice Springs, 23°36'S 133°53'E, 22 December 1968; R.33724, R.33726 (NTM5, NTM6), Alice Springs, 23°42'S 133°53'E, February 1959; R.33728 (NTM8), no data.

Nephrurus sheai Couper (in Couper and Gregson, 1994: 63)

Holotype. R.11470, Bowerbird Camp, Magela Creek, Northern Territory, 12°47'S 133°07'E, I. Archibald and J. Bywater, 1 September 1983.

Paratypes (15). R.267, Katherine, 14°28'S 132°16'E, 28 November 1973; R.297, Katherine, 14°28'S 132°16'E, 15 December 1973; R.387, 4.7 miles north of Katherine, 14°27'S 132°15'E, 22 October 1974; R.2377, Katherine, Lower Farms Road, 14°35'S 132°12'E, 4 April 1976; R.3759-3761, 4 km north of Katherine, 14°27'S 132°15'E, 1977; R.4027, R.4272, Jim Jim Falls, 13°17'S 132°50'E, 13 August 1977; R.11464, R.12493, Bowerbird Camp, Magela Creek, 12°47'S 133°07'E, 31 August 1983; R.12605, Nabalek, 12°19'S 133°19'E, October 1982; R.13485, Bullita area, Gregory National Park, 16°07'S 130°26'E, 06 August 1986; R.17822, 10 km southeast of Oenpelli, 12°22'S 133°07'E, 21 July 1992; R.33718 (CAMR552), Wickham River, Victoria River District, 16°05'S 130°35'E, 7 June 1978.

Oedura attenboroughi Wells and Wellington, 1985: 13

Paratype. R.4816, 2 km east of Anakie, Queensland, 23°33'S 147°45'E, G.F. Gow, 10 December 1977.

= *Oedura marmorata* Gray, 1842, after Kluge (1991).

Oedura derelicta Wells and Wellington, 1985: 14

Holotype. R.11413, female, Jessie Gap, 17 km east of Alice Springs, 23°45'S 134°01'E, I. Archibald, 11 November 1983.

Comments. The diagnosis differentiated the taxon from *O. marmorata* Gray on the basis of "lack of transverse banding in mature *Oedura marmorata*."

= *Oedura marmorata* Gray, 1842, after Kluge (1991).

Oedura gemmata King and Gow, 1983: 446

Holotype. R.9877, rock outcrop by Kakadu Highway, 5 km west of the South Alligator River crossing, Northern Territory, 13°20'S 132°17'E, M.E. King and P. King, 22 May 1981.

Comments. King and Gow erroneously published the holotype as R.9817. The correct catalogue number is R.9877. R.9817 is allocated to a *Gehyra australis* Gray, 1845.

Paratypes (5). R.2506, Mount Brockman, 12°45'S 132°56'E, 22 June 1976; R.8880, Waterfall Creek, above falls, 13°58'S 132°31'E, 12 September 1980; R.9862-9863, Radon Creek, 12°45'S 132°56'E, 6 August 1975; R.9864, Buffalo Camp, Boroalba Creek, 12°50'S 132°50'E, 18 October 1974.

Family PYGOPODIDAE

Delma borea Kluge, 1974: 81

Paratypes (5). R.32293 (NTM1680), Darwin 12°25'S 13053'E, May 1964; R.32295 (NTM3080), Darwin 12°25'S 13053'E, 4 September 1965; R.32296 (NTM4582), Darwin 12°25'S 13053'E, 14 March 1969; R.32298 (NTM4950), Angurugu Mission, Groote Eylandt, 13°59'S 136°27'E, 29 September 1969; R.32300 (NTM9), Darwin 12°25'S 13053'E, 9 April 1959.

Family SCINCIDAE

Calyptotis ruficauda Greer, 1983: 30

Paratypes (7). NEW SOUTH WALES - R.4797-803, Dongdingalong Estate, South Kempsey, 31°05'S 152°50'E, 13 December 1977.

Comments. Greer erroneously published these paratypes as R.4697-703. The correct catalogue numbers are R.4797-803.

Carlia amax Storr, 1974: 160

Paratypes (11). R.31718 (NTM3891),

Nicholson River, 17°49'S 137°13'E, 31 August 1967; R.31719 (NTM3892), Springvale, 18°32'S 137°36'E, 22 August 1967; R.31720, R.31722 (NTM4550, NTM4552); Mount Borradaile, 12°03'S 132°55'E, 6 November 1968; R.31721 (NTM4551), Cooper Creek, 12°05'S 132°57'E, 3 November 1968; R.31723 (NTM5011), Deaf Adder Creek, 13°02'S 132°56'E, 28 September 1969; R.31724 (NTM5013), Muirella Park, 12°51'S 132°46'E, 1 October 1969; R.31726-31728 (NTM5738, NTM5742, NTM5747), Maria Island, 14°53'S 135°43'E, 14-18 July 1972; R.31732 (NTM5045), Deaf Adder Creek, 13°02'S 132°56'E, 19 September 1969.

Carlia gracilis Storr, 1974: 158

Paratypes (9). R.31748-31750 (NTM 1603-1605), Beatrice Hill, 12°39'S 131° 19'E, 08 July 1964; R.31752-31754 (NTM4599-4601), Marrakai-Woolner Road, 12°58'S 131°18'E, 5 December 1968; R.31755-31756 (NTM4603-4604), Marrakai-Woolner Road, 12°58'S 131°18'E, 10 December 1968; R.31761 (NTM5477), Marrakai Station, 12°36'S 131°37'E, 7 June 1970.

Comments. Storr erroneously cited NTM4602 as one of the paratype series. This number is allocated to a *Pseudonaja nuchalis* Günther, 1858, and should be excluded from the type series.

Cryptoblepharus horneri Wells and Wellington, 1985: 27

Holotype. R.7762, Rimbija Island, Cape Wessel, 11°01'S 136°45'E, P.G. Horner, 16 October 1979.

Comments. The diagnosis simply referred to previously published data and illustrations (Horner 1984) comparing the taxon to *C. litoralis*. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *C. litoralis*.

= *Cryptoblepharus litoralis* (Mertens, 1958). Synonymy of this paper.

Cryptoblepharus swansoni Wells and Wellington, 1985: 27

Holotype. R.2915, Smith Street, Darwin, 12°27'S 130°50'E, R. Pengilley, 17 January 1977.

Paratypes (46). R.3005-50, Smith Street, Darwin, 12°27'S 130°50'E, 1-2 February January 1977.

Comments. This name is a *nomen nudum*. The diagnosis did not "state in words characters that are purported to differentiate the taxon" or supply "bibliographic reference to such a published statement" (International Commission on Zoological Nomenclature 1999, Article 13 (13.1.1-13.1.2)), but simply gave an unsubstantiated statement of habitat and distribution.

= *Cryptoblepharus plagiocephalus* (Cocteau, 1836). Synonymy of this paper.

Ctenotus alacer Storr, 1970: 104

Paratypes (2). R.31867 (NTM3945), Alice Springs, 23°42'S 133°53'E, 25 November 1967; R.31868 (NTM4105), Alice Springs, 23°46'S 133°53'E, January, 1968.

Ctenotus astictus Horner, 1995: 76

Holotype. R.11252, 14 km west of Numbulwar, on Ngukurr Road, 14°14'S 135°36'E, I. Archibald, 7 June 1983.

Paratypes (15). R.11250-11251, same data as holotype; R.14183, Lake Eames, Vanderlin Island, 15°41'S 137°02'E, 21 July 1988; R.16113, R.16134-16135, R.16140-16144, Cadell River crossing, Arnhem Land, 12°15'S 134°26'E, 12-13 July 1989; R.16177, Liverpool River crossing, Arnhem Land, 12°22'S 134°07'E, 18 July 1989; R.19151, R.19153, Red Point, Marchinbar Island, 11°16.7'S 136°35, 15 July 1993; R.20252, Bumaga Island, Wessel Islands, 11°46'S 136°05'E, 12 October 1993.

Ctenotus borealis Horner and King, 1985: 143

Holotype. R.3177, male, Ban Ban Springs, 13°23'S 131°30'E, D.C. Metcalfe, 14 February 1977.

Paratypes (9). R.2664, Border Store, 17 km southwest of Oenpelli,, 12°23'S 132°57'E, 27 December 1976; R.2710, Berry Springs Reserve, 12°42'S 130°59'E, 02 January 1977; R.3186-3187, same data as holotype, except 15 February 1977; R.7044, El Sharana, 13°31'S 132°31'E, May 1979; R.7884, R.7965, R.8019, Cape Fourcroy, Bathurst Island, 11°47'S 130°01'E, 26, 29 October 1979, 1 November 1979; R.8825, 7 miles south of Adelaide River Town, 13°20'S 131°07'E, 10 August 1980.

Ctenotus brooksi aranda Storr, 1970: 108

Holotype. R.34520 (NTM2931), Ringwood, 24°12'S 135°05'E, D.A. Lindner, 14 June 1965.

Ctenotus pantherinus calx Storr, 1970: 99

Paratypes (2). R.32111 (NTM1632), Larrimah, 16°03'S 133°25'E, 05 July 1964; R.32123 (NTM3860), Nicholson River, 18°05'S 137°15'E, 4 September 1967.

Ctenotus regius Storr, 1971: 7

Paratype. SOUTH AUSTRALIA - R.32177 (NTM1552), Lambina Station, 26°56'S 134°06'E, 6 April 1964.

Ctenotus rimacola camptris Horner and Fisher, 1998: 194

Paratype. R.22936, Spirit Hills, Keep River, 15°23.52'S 129°05.33'E, 12 October 1996.

Ctenotus rimacola rimacola Horner and Fisher, 1998: 191

Holotype. R.22905, male, Lindermans Bore, Limbunya Station, 17°33'S 130°05'E, A. Fisher, 6 October1996.

Paratypes (10). R.18344, R.18346, Kidman Springs Station, 16°08'S 130°, 25 May 1997; R.20444, near Waterbag Bore, Victoria River Downs Station, 16°23'S 131°26'E, 14 May 1994; R.21537, Kirkimbie Station, 17°52.79'S 129°08.04'E, 08 June 1995; R.22803-22805, Kirkimbie Station, 17°44'S 129°14'E, 1-4 October 1996; R.23242-23244, near No.5 Bore, Mount Sanford Station, 17°10'S 130°54'E, 6 December 1996.

Ctenotus saxatilis Storr, 1970: 101

Paratypes (2). R.32218 (NTM1485), Alice Springs, 23°38'S 133°53'E, 12 March 1964; R.32219 (NTM2015), Ooraminna, 24°31'S 134°01'E, 18 September 1964.

Ctenotus septenarius King, Horner and Fyfe, 1988: 148

Holotype. R.13704, female, Bacon Range, near Henbury meteorite craters, 24°35'S 133°08'E, G. Fyfe, 17 September 1986.

Paratypes (11). R.13705-12, same data as holotype; R.13713, Valley of the Winds, Mount Olga, 25°18'S 130°44'E, 20 August 1986; R.15089-15090, southeast side of Mount Olga, 25°17'S 130°43'E, 5 March 1988.

Ctenotus strauchii varius Storr, 1981: 139

Paratype. SOUTH AUSTRALIA - R.32270 (NTM1548), Lambina Station, 26°56'S 134°06'E, 21 May 1964.

Ctenotus stuarti Horner, 1995: 79

Holotype. R.13723, Swim Creek, Point Stuart Station, 12°34.5'S 131°49.5'E, P.G. Horner, 24 April 1988.

Paratypes (8). R.13086-13087, R.13722, R.13724-27, same data as holotype; R.17453, Kapalga, 12°40'S 132°22E, 12 October 1992.

Ctenotus tanamiensis Storr, 1970: 103

Holotype. R.32274 (NTM2079), The Granites, 20°34'S 130°21'E, K.R. Slater, D.R. Stephens and D.A. Lindner, 9 September 1964.

Paratypes (6). R.32275, R.32277-80 (NTM2080,NTM2218-21), same data as holotype; R.32276 (NTM2203), Tanami Desert, 20°32'S 130°56'E, 12 September 1964.

Ctenotus vertebralis Rankin and Gillam, 1979: 501

Holotype. R.34521 (NTMR410), Arnold River, Cox River Station, 15°43'S 134°32'E, M.W. Gillam, 5 July 1977.

Paratype. R.34522 (NTMR411), Cox River headwaters, Cox River Station, 15°54'S 134°41'E, 7 July 1977.

Egernia arnhemensis Sadlier, 1990: 30

Holotype. R.0809, 6.1 km southwest of Oenpelli, 12°21'S 132°59'E, G.F. Gow and B. Jukes, 21 May 1975.

Paratypes (7). R.1190, 2 km southwest of Oenpelli, 12°23'S 133°01'E, 28 July 1975; R.8032-8034, R.8181, Nourlangie Rock, 12°52'S 132°, 26 November 1979; R.8387-8388, Little Nourlangie Rock, 12°52'S 132°47'E, 15 January 1980.

Comments. This name is a synonym of *Egernia obiri* (Wells and Wellington, 1985).

R.0809 and R.1190 are also types of *Hortonia obiri* Wells and Wellington, 1985.

= *Egernia obiri* (Wells and Wellington, 1985). Synonymy of this paper.

Egernia margaretae margaretae Storr, 1968: 53

Paratypes (17). R.32775, R.32777 (NTM1881, NTM1883), Reedy Creek, George Gill Range, 24°16'S 131°36'E, 14 August 1964); R.32776 (NTM1882), Kathleen Creek, George Gill Range, 24°02íS 131∞40'E, 14 August 1964; R.32778-32779 (NTM2665-2666), Reedy Creek, George Gill Range, 24°18'S 131°36'E, 19-20 August 1964; R.32780 (NTM2667), Palm Valley, 24°03'S 132°42'E, 20 February 1965; R.32781-32782 (NTM2668-2669), Reedy Creek, George Gill Range, 24°18'S 131°36'E, 21 February 1964; R.32783-32784, R.32786-32788 (NTM2765-2766,TM2768-2770), Reedy Creek, George Gill Range, 24°18'S 131°36'E, 25 March 1965; R.32789-32792 (NTM2815-2818), Palm Valley, 24°03'S 132°, 18 April 1965.

Comments. Storr erroneously published NTM2284-85 as part of the paratype series. NTM2284-85 are allocated to two specimens of *Eremiascincus fasciolatus* Günther, 1867, and are cited as such by Storr in an earlier publication (Storr 1967a). NTM2284-85 should be excluded from the type series.

Egernia slateri slateri Storr, 1968: 53

Paratypes (57). R.32799-32809, R.32811 (NTM2052-2053, NTM2055-2062, NTM-2169, NTM2171), R.32815-32817, R.32819, R.32821, R.32823, R.32829 (NTM2191-2193, NTM2195, NTM2198, NTM2200, NTM2269), R.32824-32828 (NTM2227-2231), R.32830-32832 (NTM2272-2274), R.32833-32844, R.32846-32847, R.32878 (NTM2286-2297, NTM2299-2300, NTM-2605), Alice Springs, 23°46'S 133°53'E, September/October 1964; R.32881-32885, R.32888 (NTM2683-2686, NTM2757, NTM2883), R.32887 (NTM2853), Alice Springs, 23°46'S 133°53'E, March/April 1965; R.32848-32850 (NTM2348-2350), 10 miles northeast of Hermannsburg, 23°54'S 132°57'E, 26 November 1964; R.32851, R.32877, R.32879, R32880 (NTM2578, NTM2604, NTM2606, NTM2634), near Ellery Creek, 23°55'S 132°56'E, 16-17 December 1964; R.32886 (NTM2771), Tempe Downs Station, 24°28'S 131°35'E, 29 March 1965.

Comments. The type description lists a series of 58 paratypes as being lodged in the NTM collection. Of these, NTM2197 cannot be found and its location is unknown.

Glaphyromorphus harwoodi Wells and Wellington, 1985: 30

Holotype. R.3465, Brunette Downs Station, 18°39'S 135°57'E, H.P. Van Dyke, 8 June 1977.

Comments. The diagnosis differentiated the taxon from congeners on the unsubstantiated basis of "almost uniform brown colouration and its much longer tail (about 3 times SVL)". Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *G. isolepis*.

= *Glaphyromorphus isolepis* (Boulenger, 1887). Synonymy of this paper.

Hortonia obiri Wells and Wellington, 1985: 30

Holotype. R.1190, 2 km southwest of Oenpelli, 12°23'S 133°01'E, B. Jukes, 28 July 1975.

Paratype. R.0809, 6.1 km west of Oenpelli, 12°21'S 132°59'E, 21 May 1975.

Comments. The diagnosis of this taxon was based on unsubstantiated aspects of colour, body pattern and distribution. Sadlier (1990) firmly established the distinctiveness of the taxon when he described it as *Egernia arnhemensis* (at this time the scientific status of Wells and Wellington (1985) was in question). R.1190 and R.0809 are also types of *E. arnhemensis* Sadlier, 1990.

= *Egernia obiri* (Wells and Wellington, 1985). Nomenclature of this paper.

Lerista aericeps aericeps Storr, 1986: 145

Holotype. R.34506 (CAMR1568), 25 km south of Alice Springs, 23°57'S 133°56'E, A. Kerle, 5 November 1985.

Comments. Storr erroneously published the holotype as CAMR.1565. The correct catalogue number is CAMR.1568, which is now re-catalogued as R.34506. CAMR.1565 is a paratype of *Lerista aericeps taeniata* Storr, 1986.

Paratypes (4). R.33363 (CAMR1140), Kurundi Station, 20°37'S 134°05'E, 25 September 1983; R.33365 (CAMR379), Andado Station, 25°25'S 135°17'E, 09 September 1977; R.33369 (CAMR1573), one km north of Ewaninga, 23°58'S 133°55'E, 06 September 1985; R.34507 (NTM50), 16 miles north of Alice Springs, 23°30'S 133°50'E, 25 May 1955.

Comments. Greer (1990) synonymised *Lerista aericeps aericeps* Storr, 1986 with *Lerista xanthura* Storr, 1976. This taxonomy has been challenged by Storr (1991) who recognises the taxon as *Lerista aericeps* Storr, 1986.

= *Lerista xanthura* after Greer (1990).

Lerista aericeps taeniata Storr, 1986: 148

Holotype. R.33367 (CAMR1566), 20 km east of the Granites, 20°34'S 130°38'E, S.R. Morton, 15 November 1985.

Paratypes (11). R.33362 (CAMR1043), Tanami Desert, 20°15'S 131°, 14 June 1983; R.33364 (CAMR1314), Sangster's Bore, 20°53'S 130°24'E, 11 December 1984; R.33366, R.33368 (CAMR1565, CAMR1567), R.33462 (CAMR1574), R.34508-34511 (CAMR1569-1572), R.34512-34513 (CAMR1575-1576), Tanami Desert, 20°34'S 130°38'E, April/November 1985.

Comments. Storr erroneously published R.33366 (CAMR.1565) as the holotype of *Lerista aericeps aericeps* Storr 1986: 145. See comments under *L. a. aericeps*.

= *Lerista taeniata* after Greer (1990).

Menetia alanae Rankin, 1979: 492

Paratypes (2). R.2739, 32.5 km southeast of Noonamah, 12°54'S 131°, 02 January 1977; R.4733, Nakara, suburb of Darwin, 12°23'S 130°53'E, 06 November 1977.

Menetia concinna Sadlier, 1984: 46

Paratype. R.2665, 34.5 km southwest of Oenpelli, 12°30'S 132°55'E, 28 December 1976).

Morethia storri Greer, 1980: 89

Holotype. R.1815, 4.5 km south of Noonamah, 12°40.5'S 131°05'E, G.F. Gow and R.W. Wells, 10 November 1975.

Paratypes (4). R.2715, Berry Springs Reserve, 12°42'S 130°, 02 January 1977; R.2731-2732, 32.5 km southeast of Noonamah, 12°54'S 131°12'E, 2 January 1977; R.2864, Millner, suburb of Darwin, 12°23'S 130°50'E, August 1976.

Proablepharus barklyensis Wells and Wellington, 1985: 36

Holotype. R.3673, Brunette Downs Station homestead, 18°39'S 135°57'E, H.P. Van Dyke, 18 January 1977.

Comments. The diagnosis differentiated the taxon from *P. kinghorni* on the unsubstantiated basis of indistinct body pattern and a larger maximum size. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. kinghorni*.

= *Proablepharus kinghorni* (Copland, 1947). Synonymy of this paper.

Sphenomorphus isolepis douglasi Storr, 1967a: 16

Paratype. NTM1602, Beatrice Hill, 12°39'S 131°20'E, 8 July 1964.

Comments. NTM1602 cannot be found. A note in the CAWC catalogue indicates this specimen had become desiccated and was discarded.

= *Glaphyromorphus douglasi* after Greer (1989).

Family VARANIDAE

Varanus baritji King and Horner, 1987: 74

Holotype. R.13192, female, Mirrngadja, Arnhem Swamp, Arnhem Land, 12°39'S 135°12'E, N. White, 5 June 1985.

Paratypes (9). R.3107, 8 km north of Pine Creek, 13°47'S 131°47'E, 20 February 1977; R.6531, Katherine, 14°28'S 132°16'E, 1 December 1978; R.8346-8348, 7 miles south of Adelaide River Town, 13°21'S 131°, 22 January 1980; R.8364, 7 miles west of Stuart Highway, on Daly River road, 13°30'S 131°03'E, 05 February 1980; R.8931, 20 km south of Adelaide River Town, 13°27'S 131°11'E, 10 August 1980; R.13150- 13151, Donydji, Arnhem Land, 12°55'S 135°19'E, 01 September 1985.

Varanus kingorum Storr, 1980: 268

Paratypes (2). WESTERN AUSTRALIA - R.6681, R.6954, Turkey Creek, 16°54'S 128°19'E, 14 April 1979.

Order SQUAMATA
Suborder SERPENTES
Family BOIDAE

Liasis stimsoni orientalis Smith, 1985: 270

Paratypes (38). R.0434, 6 miles east of the Granites, 20°06'S 130°25'E, 17 November 1974; R.0543, Alice Springs, 23°42'S 133°52'E, 2 August 1975; R.0711, 6 km north of Alice Springs, 23°36'S 133°52'E, 2 November 1974; R.0712, 14.5 km north of Alice Springs, 23°34'S 133°50'E, 14 April 1975; R.0713, 12.2 km north of Alice Springs, 23°35'S 133°51'E, 3 June 1975; R.0756, 14 km north of Alice Springs, 23°34'S 133°50'E, 7 June 1975; R.2455, Alice Springs, 23°42'S 133°52'E, 2 March 1976; R.3637, R.3669, Anthony Lagoon Station, 17°59'S 135°36'E, 19-21 May 1977; R.3643, R.3649, R.3660, Brunette Downs Station racecourse, 18°39'S 135°57'E, 22 May 1977; R.3683, Barkly Highway, 19°18'S 135°00'E, 23 May 1977; R.3807, Alice Springs, 23°42'S 133°52'E, 1977; R.5219, one km east of Brunette Downs Station homestead, 18°39'S 135°57'E, 8 April 1978; R.5233-5234, Brunette Downs Station racecourse, 18°39'S 135°57'E, 6 April 1978; R.5361, 35 km east of Three Ways, on Barkly Highway, 19°23'S 134°, 27 May 1978; R.5844-5845, Anthony Lagoon Station, 17°59'S 135°, 26 May 1978; R.8438-8439, No.3A Bore, Rockhampton Downs Station, 19°22'S 135°18'E, 25 February 1980; R.8440, No.6 Bore, Rockhampton Downs Station, 19°23'S 135°24'E, 25 February 1980; R.8553, Alroy Downs Station, 19°18'S 136°04'E, 5 March 1980; R.31639 (CAMR145), Muckaty Station, 18°38'S 133°52'E, 26 12 1975; R.31644, R.31649 (NTM1391, NTM1437), Simpsons Gap, 23°04'S 133°43'E, 1-2 January 1964; R.31645 (NTM1392), Alice Springs, 23°04'S 133°, 13 January 1964; R.31648 (NTM1395), Todd River Station, 23°58.05'S 134°, 31 January 1964; R.31652 (NTM1647), Todd River Station, 23°48'S 134°, 12 February 1964; R.31684 (NTM2336), Alice Springs, 23°46'S 133°53'E, 5 November 1964; R.31685 (NTM2337), Alice Springs, 23°46'S 133°53'E, 10 November 1964; R.31687 (NTM3214), Stuart Highway, 21°00'S 134°12'E, 27 January 1966; R.31688 (NTM3215), Attack Creek, 19°02'S 134°08'E, 29 January 1966; R.31689 (NTM3216), Stuart Highway, 20°48'S 134°14'E, 21 January 1966; R.31690 (NTM3270), Petermann Ranges, 24°52'S 129°03'E, 28 March 1966; R.31692 (NTM4032), Alice Springs, 23°42'S 133°53'E, 1967; R.31693 (NTM5349), Elkedra Station, 21°01'S 135°27 E, 23 March 1970.

Comments. In a typographical error, Smith published R.8440 as R.0844. The correct catalogue number is R.8440. R.0844 is allocated to a *Pseudonaja nuchalis* Günther, 1858.

Python bredli Gow, 1981: 29

Holotype. R.4535, Pitchie Ritchie Park, Alice Springs, 23°42'S 133°55'E, K. Roth, 12 January 1977.

Paratypes (10). R.0328, Harts Range, 23°06'S 134°55'E, 17 July 1974; R.0430, 12 miles east of the Granites, 20°43'S 130°27'E, 17 November 1974; R.0709-0710, born in captivity, parent from Harts Range, 23°06'S 134°55'E, 27 April 1974; R.1974, Mount Gillen, Alice Springs, 23°43'S 133°48'E, 12 November 1975; R.2995, no data; R.2996, Garden Station, 23°17'S 134°25'E, 10 October 1976); R.4635-4637, Harts Range, 23°06'S 134°55'E, 1975.

Comments. Kluge (1993) treated this taxon as a subspecies of *M. spilota* (Lacépéde, 1804).

= *Morelia bredli* after Kluge (1993).

Python oenpelliensis Gow, 1977: 133

Holotype. R.0840, male, 6.5 km west of Oenpelli,, 12°21'S 132°59'E, B. Jukes, 27 June 1975.

= *Morelia oenpelliensis* after Kluge (1993).

Family COLUBRIDAE

Cerberus montgomeryi Wells and Wellington, 1985: 43

Holotype. R.5114, Edward River, western Cape York Peninsula, Queensland, 14°39'S 142°03'E, J. Bredl, 1975.

Comments. The diagnosis of this taxon is based solely on a previously published illustration and description of *C. rynchops novaeguineae* in Gow (1983) Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *C. rynchops novaeguineae*.

= *Cerberus rynchops novaeguineae* Loveridge, 1948. Synonymy of this paper.

Family ELAPIDAE

Acanthophis hawkei Wells and Wellington, 1985: 43

Holotype. R.3677, 1.5 miles southwest of Brunette Downs Station homestead, Barkly Tablelands, 18°40'S 135°55'E, H.P. Van Dyke, 20 April 1977.

Comments. This name is almost certainly a *nomen nudum*. The diagnosis did not "state in words characters that are purported to differentiate the taxon" or supply "bibliographic reference to such a published statement" " (International Commission on Zoological Nomenclature 1999, Article 13 (13.1.1-13.1.2)), but simply gave unsubstantiated statements on distribution, maximum size, juvenile colouration and a reference to unpublished ecological and morphological data and an illustration.

= *Acanthophis antarcticus* (Shaw and Nodder, 1802). Synonymy of this paper.

Brachyurophis murrayi Wells and Wellington, 1985: 44

Holotype. R.3451. Casuarina, suburb of Darwin, 12°21'S 130°52'E, L. Miels, 19 June 1977.

Comments. The relatively detailed diagnosis is based on a description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *B. roperi.*

= *Brachyurophis roperi* (Kinghorn, 1931). Synonymy of this paper.

Denisonia ordensis Storr, 1984a: 254

Paratypes (3). WESTERN AUSTRALIA - R.0314, Gordon Downs Station, 18°45'S 128°35'E, August 1973; NORTHERN TERRITORY - R.32406-32407 (CAMR561-562); Wave Hill Station, 17°35'S 130°05'E, 9 June 1978.

= *Suta ordensis* after Cogger (1986).

Pseudonaja imperitor Wells and Wellington, 1985: 48

Holotype. R.3352, Angurugu, Groote Eylandt, 13°58'S 136°26'E, J. Waddy, 2 September 1976.

Comments. The holotype comprises the head and neck of an adult specimen. The diagnosis is based on a description of the partial holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. nuchalis.*

= *Pseudonaja nuchalis* Günther, 1858. Synonymy of this paper.

Pseudonaja jukesi Wells and Wellington, 1985: 48

Holotype. R.1186, Oenpelli, 12°20'S 133°02'E, B. Jukes, 15 April 1975.

Comments. The diagnosis is based on a description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. nuchalis.*

= *Pseudonaja nuchalis* Günther, 1858. Synonymy of this paper.

Pseudonaja kellyi Wells and Wellington, 1985: 48

Holotype. R.1689, Stuart Highway, 160 km north of Ayres Rock turnoff, 24°00'S 133°40'E, P.G. Horner, 22 October 1975.

Comments. The diagnosis is based on a description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. nuchalis.*

= *Pseudonaja nuchalis* Günther, 1858. Synonymy of this paper.

Pseudonaja mengdeni Wells and Wellington, 1985: 48

Holotype. R.1989, 2 km east of Maryvale, 24°04'S 134°05'E, B. Jukes, 16 November 1975.

Comments. The diagnosis is based on a description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. nuchalis.*

= *Pseudonaja nuchalis* Günther, 1858. Synonymy of this paper.

Pseudonaja ohnoi Wells and Wellington, 1985: 48

Holotype. R.1970, Mount Gillen, Alice Springs, 23°43'S 133°48'E, K. Roth, 10 November 1975.

Comments. The diagnosis is based on a

description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. textilis*.

= *Pseudonaja textilis* (Duméril, Bibron and Duméril, 1854). Synonymy of this paper.

Pseudonaja vanderstraateni Wells and Wellington, 1985: 49

Holotype. R.0371, Stuart Highway, 100 miles north of Katherine, 15°20'S 133°08'E, G.F. Gow, 22 October 1974).

Comments. The diagnosis is based on a description of the holotype only. Until a more detailed comparison with congeners is made, the taxon is placed as a synonym of *P. nuchalis*.

= *Pseudonaja nuchalis* Günther, 1858. Synonymy of this paper.

Simoselaps morrisi Horner, 1998: 64

Holotype. R.22951, male, Elcho Island, 12°03'S 135°34'E, K. Aland and A. Yumbulul, 10 October 1996.

Paratype. R.17740, Arnhem Land, 20 km east of the Goomadeer River crossing, 12°08'S 133°22'E, 04 October 1992.

Vermicella annulata snelli Storr, 1967c: 82

Paratypes (2). R.34479 (NTM2577), Alice Springs, 23°42'S 133°, 21 December 1964; R.34485 (NTM76), Hermannsburg, 23°57'S 132°46'E, 1961.

Comments. In the type description Storr lists a series of three paratypes as being lodged in the NTM collection. NTM75 cannot be found and its location is unknown. R.34479 and R.34485 are also paratypes of *Vermicella vermiformis* Keogh and Smith, 1996.

Vermicella intermedia Keogh and Smith, 1996: 688

Holotype. R.17196, Humpty Doo District, 12°38'S 131°15'E, G. F. Gow, 1985.

Paratypes (21). R.0221, Katherine Gorge road, 14°24'S 132°20'E, 5 January 1974; R.0354, ex Yarrawonga Zoo, Howard Springs, 12°30'S 131°04'E, 20 October 1974; R.1203, Darwin, 12°26'S 130°55'E, 1975; R.1959, Shoal Bay, Darwin, 12°16'S 131°01'E, 30 October 1975; R.2250, Lower Farms Road, Katherine, 14°29'S 132°14'E, 11 March 1976; R.3476, Stuart Highway, 0.4 km north of Arnhem Highway turnoff, 13°50'S 131°49'E, 09 April 1977; R.5178, Stuart Highway, 6.3 km south of Adelaide River Town, 13°19'S 131°09'E, 24 February 1978; R.16642, Jabiru, 22°19'S 145°01'E, 1986; R.16705, Humpty Doo District, 12°38'S 131°15'E, 21 October 1987; R.16773, Second Street, Katherine, 14°28'S 132°16'E, 11 March 1991; R.17187, R.17191-17195, R.17299-17300, same data as holotype; R.20410, McMinns Lagoon, 12°31'S 131°05'E, 7 November 1987; R.34481 (NTM3529), Berrimah, Darwin, 12°27'S 130°, 10 April 1967; R.34486 (NTM1078), Darwin, 12°03'S 130°35'E, 1963.

Vermicella semifasciata incincta Storr, 1967c: 89

Paratypes (3). R.34168-34169 (NTM2262-2263), Mount Denison Station, 22°08'S 132°05'E, 1 October 1964; R.34170 (NTM63) Alice Springs, 23°42'S 133°53'E, 18 December 1960.

= *Simoselaps incinctus* after Cogger (1975).

Vermicella vermiformis Keogh and Smith, 1996: 695

Holotype. R.34484 (NTM5959), Alice Springs, 23°42'S 133°53'E, Anon., 03 June 1972.

Paratypes (7). R.34476 (CAMR240), Alice Springs, 23°46'S 133°, 6 May 1976; R.34477 (CAMR448), Ellery Gorge, MacDonnell Ranges, 23°47'S 133°04'E, February 1978; R.34478 (CAMR640), Jay Creek Settlement, 23°45'S 133°35'E, 23 March 1979; R.34479 (NTM2577), Alice Springs, 23°42'S 133°53'E, 21 December 1964; R.34480 (NTM3411); Alice Springs, 23°46'S 133°53'E, 27 January 1967; R.34483 (NTM5896), Alice Springs, 23°42'S 133°53'E, October 1972; R.34485 (NTM76), Hermannsburg, 23°57'S 132°46'E, 1961.

Comments. The type description cites a series of 10 paratypes as being lodged in the NTM collection. R.34480 is cited twice (once under old number NTM3411). The type description also erroneously cites registration numbers R.34476-34479 as R.33476-33479. R.34485 (NTM76) and R.34479 (NTM2577) are also paratypes of *Vermicella annulata snelli* Storr, 1967.

Family TYPHLOPIDAE

Ramphotyphlops centralis Storr, 1984b: 313

Holotype. R.34490 (CAMR317), male, Alice Springs, Northern Territory, 23°42'S 133°52'E, Anon., October 1976.

Paratypes (5). R.34491 (NTM5888), Pine Gap, 23°48'S 133°44'E, 3 November 1972; R.34492 (NTM5890), Alice Springs, 23°46'S 133°53'E, 2 October 1972; R.34493(NTM5895), Alice Springs, 23°42'S 133°53'E, 18 October 1972; R.34494 (NTM5906), Alice Springs, 23°42'S 133°53'E, 15 December 1972; R.34495 (CAMR138), Alice Springs, 23°42'S 133°53'E, 30 October 1974.

Ramphotyphlops nema Shea and Horner, 1996: 54

Holotype. R.21665, Fannie Bay, suburb of Darwin, 12°26'[S 130°50'E, D. Low Choy, 8 February 1995.

Paratypes (2). R.16047, Malak, suburb of Darwin, 12°24'S 130°54'E, 10 April 1990; R.34110 (NTM3236), Darwin, 12°25'S 130°53'E, December 1965.

Class MAMMALIA

Order CHIROPTERA

Family HIPPOSIDERIDAE

Hipposideros diadema inornatus McKean, 1970: 138

Holotype. U.2379 (NTM4696), Deaf Adder Creek, Arnhem Land escarpment, 13°06'S 132°56'E, W. Bolton, D. Howe and S.A. Parker, 12 September 1969.

Comments. The holotype consists of a study skin and separate skull.

Paratypes (6). U.2376 (NTM4689), U.2377-78 (NTM4693-94), U.2380-81 (NTM4700-01), U.2382 (NTM4721), same locality as holotype.

Comments. Paratypes are all study skins with separate skulls.

Order DASYUROMORPHIA

Family DASYURIDAE

Sminthopsis bindi Van Dyke, Woinarski and Press, 1994: 312

Holotype. U.0944, Eva Valley Station, 14°30'S 132°45'E, J.C.Z. Woinarski, 22 February 1991.

Comments. The holotype is a spirit preserve with separate dry skull.

Paratypes (5). U.0716, El Sharana Plateau, Kakadu National Park, 13°31'S 132°33'E; U.0943, same data as holotype; U.0945, Stuart Highway, 33 km south of Arnhem Highway turnoff, 12°51'S 131°08'E; U.0946, Arnhem Highway, 77 km east of Stuart Highway, 12°53'S 131°40'E; U.0954, Roper Valley Station, 14°55'S 133°54'E.

Comments. Paratypes are spirit preserves. U.0716 has separate dry skull.

Order RODENTIA

Family MURIDAE

Pseudomys johnsoni Kitchener, 1985: 208

Holotype. U.3486 (CAMM854), Kurundi Station, 20°37'S 135°01'E, M. Hewett, 27 September 1983.

Comments. The holotype is a spirit preserve with separate dry skull.

Paratypes (9). U.3487 (CAMM797), U.3491-95 (CAMM1034, CAMM1036-37, CAMM1039-40), McLaren Creek Station, Murchison Range, 20°29'S 134°27'E; U.3488-90 (CAMM847, CAMM849, CAMM853), Kurundi Station, 20°37'S 134°51'E.

Comments. Paratypes are spirit preserves. U.3487, U.3488-3490, U.3494-3495 have separate dry skulls. Skulls from U.3491 and U.3492 cannot be found and their location is unknown.

Zyzomys maini Kitchener, 1989: 357

Holotype. U.4027 (CAMM1002), Djawamba Massif, 1.5 km east of Ja Ja Billabong, 12°31'S 132°54'E, A. Kerle, 26 August 1979.

Comments. The holotype is a spirit preserve with separate dry skull.

Paratypes (5). U.0505-06, U.4032 (CAMM248), Little Nourlangie Rock, Kakadu National Park, 12°44'S 132°55'E; U.4028 (CAMM1008), Magela Creek, Kakadu National Park, 12°34'S 132°55'E; U.4036 (NTM4287), Mount Borradaile, Arnhem Land, 12°03'S 132°55'E.

Comments. Paratypes U.0505-06 and U.4032 are dry skulls only. U.4028 and U.4036 are spirit preserves with separate dry skulls.

Zyzomys palatalis Kitchener, 1989: 361

Holotype. U.1388, Banyan Gorge, Wollogorang Station, 17°12'S 137°41'E, D.G. Langford, 10 June 1987.

Comments. The holotype is a spirit preserve with separate dry skull.

Paratypes (1). U.1148, Echo Gorge, Wollogorang Station, 17°12'S 137°41'E.

Comments. The paratype is a spirit preserve with separate dry skull.

Class AVES
Order COLUMBIFORMES
Family COLUMBIDAE
Petrophassa albipennis boothi Goodwin, 1969:132.

Holotype. T.3074 (NTM5000), Stokes Range, Victoria River District, 15°36'S 131°06'E, British Museum (Natural History) Harold Hall Expedition, led by Major B. D. McDonald Booth, 11 August 1968.

Comments. The holotype is a study skin, which has attached a label bearing the number: Brit. Mus. Reg. 1969.4.112.

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	Scientific name under which originally described	MAGNT Reg. No. (prefix = NTM)
REPTILIA		
Crocodylidae	*Crocodylus pethericki* Wells and Wellington, 1985	R.24821
Gekkonidae	*Gehyra borroloola* King, 1983	R.10726
Gekkonidae	*Gehyra membranacruralis* King and Horner, 1989	R.13746
Gekkonidae	*Gehyra minuta* King, 1982	R.9878
Gekkonidae	*Gehyra pamela* King, 1982	R.8656
Gekkonidae	*Nephrurus sheai* Couper, 1994	R.11470
Gekkonidae	*Oedura derelicta* Wells and Wellington, 1985	R.11413
Gekkonidae	*Oedura gemmata* King and Gow, 1983	R.9877
Scincidae	*Cryptoblepharus horneri* Wells and Wellington, 198	R.7762
Scincidae	*Cryptoblepharus swansoni* Wells and Wellington, 19	R.2915
Scincidae	*Ctenotus astictus* Horner, 1995	R.11252
Scincidae	*Ctenotus borealis* Horner and King, 1985	R.3177
Scincidae	*Ctenotus brooksi aranda* Storr, 1970	R.34520 (NTM2931)
Scincidae	*Ctenotus rimacola rimacola* Horner and Fisher, 199	R.22905
Scincidae	*Ctenotus septenarius* King, Horner and Fyfe, 1988	R.13704
Scincidae	*Ctenotus stuarti* Horner, 1995	R.13723
Scincidae	*Ctenotus tanamiensis* Storr, 1970	R.32274 (NTM2079)
Scincidae	*Ctenotus vertebralis* Rankin and Gillam, 1979	R.34521 (NTMR410)
Scincidae	*Egernia arnhemensis* Sadlier, 1990	R.0809
Scincidae	*Glaphyromorphus harwoodi* Wells and Wellington, 1985	R.3465
Scincidae	*Hortonia obiri* Wells and Wellington, 1985	R.1190
Scincidae	*Lerista aericeps aericeps* Storr, 1986	R.34506 (CAMR1568)
Scincidae	*Lerista aericeps taeniata* Storr, 1986	R.33367 (CAMR1566)
Scincidae	*Morethia storri Greer,* 1980	R.1815
Scincidae	*Proablepharus barklyensis* Wells and Wellington, 1985	R.3673
Varanidae	*Varanus baritji* King and Horner, 1987	R.13192
Boidae	*Python bredli* Gow, 1981	R.4535
Boidae	*Python oenpelliensis* Gow, 1977	R.0840
Colubridae	*Cerberus montgomeryi* Wells and Wellington, 1985	R.5114
Elapidae	*Acanthophis hawkei* Wells and Wellington, 1985	R.3677
Elapidae	*Brachyurophis murrayi* Wells and Wellington, 1985	R.3451
Elapidae	*Pseudonaja imperitor* Wells and Wellington, 1985	R.3352
Elapidae	*Pseudonaja jukesi* Wells and Wellington, 1985	R.1186
Elapidae	*Pseudonaja kellyi* Wells and Wellington, 1985	R.1689
Elapidae	*Pseudonaja mengdeni* Wells and Wellington, 1985	R.1989
Elapidae	*Pseudonaja ohnoi* Wells and Wellington, 1985	R.1970
Elapidae	*Pseudonaja vanderstraateni* Wells and Wellington, 1985	R.0371
Elapidae	*Simoselaps morrisi* Horner, 1998	R.22951
Elapidae	*Vermicella intermedia* Keogh and Smith, 1996	R.17196
Elapidae	*Vermicella vermiformis* Keogh and Smith, 1996	R.34484 (NTM5959)
Typhlopidae	*Ramphotyphlops centralis* Storr, 1984	R.34490 (CAMR317)
Typhlopidae	*Ramphotyphlops nema* Shea and Horner, 1996	R.21665
MAMMALIA		
Hipposideridae	*Hipposideros diadema inornatus* McKean, 1970	U.2379 (NTM4696)
Dasyuridae	*Sminthopsis bindi* Van Dyke, Woinarski and Press, 1994	U.0944
Muridae	*Pseudomys johnsoni* Kitchener, 1985	U.3486 (CAMM854)
Muridae	*Zyzomys maini* Kitchener, 1989	U.4027 (CAMM1002)
Muridae	*Zyzomys palatalis* Kitchener, 1989	U.1388
AVES		
Columbidae	*Petrophassa albipennis boothi* Goodwin, 1969	T.3074 (NTM5000)

Appendix 2. Paratypes deposited in the Terrestrial Vertebrates Collection, Museum and Art Gallery of the Northern Territory, to November 1999. Superseded catalogue numbers for specimens formerly housed in the Central Australian Wildlife Collection are shown in the parentheses.

	Scientific name under which originally described	No. in series	MAGNT Reg. No. (prefix = NTM) [superseded CAWC number shown in parentheses]
AMPHIBIA			
Hylidae	*Cyclorana maculosus* Tyler and Martin, 1976	1	R30093 (NTM3178)
Hylidae	*Cyclorana maini* Tyler and Martin, 1976	5	R30034-36 (NTM2309-11): R.30037 (NTM2316); R30079 (NTM3177)
Hylidae	*Litoria pallida* Davies, Watson and Martin, 1983	2	R10098-99
Hylidae	*Litoria personata* Tyler, Davies and Martin, 1978	3	R30804-06 (CAMA123-25)
Myobatrachida	*Megistolotis lignarius* Tyler, Davies and Martin	7	R578-79; R642; R2143; R5035; R31043-44 (CAMA121-22)
Myobatrachida	*Ranidella bilingua* Martin, Tyler and Davies, 1980	2	R5838-39
Myobatrachida	*Uperoleia arenicola* Tyler, Davies and Martin, 1981	1	R6276
Myobatrachida	*Uperoleia inundata* Tyler, Davies and Martin, 1981	2	R6934-35
Myobatrachida	*Uperoleia lithomoda* Tyler, Davies and Martin, 1981	1	R6936
Myobatrachida	*Uperoleia micromeles* Tyler, Davies and Martin, 1981	1	R31199 (CAMA140)
Myobatrachida	*Uperoleia trachyderma* Tyler, Davies and Martin, 1981	1	R9865
REPTILIA			
Chelidae	*Emydura tanybaraga* Cann, 1997	1	R.20416
Agamidae	*Amphibolurus caudicinctus slateri* Storr, 1967	36	R31252-55 (NTM1472-75); R31257 (NTM1943): R31258-59 (NTM2018-19); R31260-78 (NTM2378-96); R31280-89 (NTM2670-79)
Gekkonidae	*Gehyra borroloola* King, 1983	9	R10717-25
Gekkonidae	*Gehyra membranacruralis* King and Horner, 1989	2	R13744-45
Gekkonidae	*Gehyra minuta* King, 1982	8	R9879-86
Gekkonidae	*Gehyra pamela* King, 1982	4	R8657-60
Gekkonidae	*Nephrurus amyae* Couper, 1994	21	R441; R2458; R5383; R5466; R5586; R5969; R12377; R12380; R14096; R14991; R33715 (CAMR1039); R33716 (CAMR1193); R33717 (CAMR537); R33719 (NTM2355); R33720 (NTM2759); R33721 (NTM3084); R33722-23 (NTM4222-23); R33724 (NTM5); R33726 (NTM6); R33728 (NTM8)
Gekkonidae	*Nephrurus sheai* Couper, 1994	15	R267; R297; R387; R2377; R3759-61; R4027; R4272; R11464; R12493; R12605; R13485; R17822; R33718 (CAMR552)
Gekkonidae	*Oedura attenboroughi* Wells and Wellington, 1985	1	R4816
Gekkonidae	*Oedura gemmata* King and Gow, 1983	5	R2506; R8880; R9862-64;
Pygopodidae	*Delma borea* Kluge, 1974	5	R32293 (NTM1680); R32295 (NTM3080); R32296 (NTM4582); R32298 (NTM4950); R32300 (NTM9)
Scincidae	*Calyptotis ruficauda* Greer, 1983	7	R4797-803
Scincidae	*Carlia amax* Storr, 1974	11	R31718-19 (NTM3891-92); R31720-22 (NTM4550-52); R31723 (NTM5011); R37124 (NTM5013); R31726 (NTM5738); R31727 (NTM5742); R31728 (NTM5747); R31732 (NTM5045)

Appendix 2 cont. Paratypes deposited in the Terrestrial Vertebrates Collection, Museum and Art Gallery of the Northern Territory, to November 1999. Superseded catalogue numbers for specimens formerly housed in the Central Australian Wildlife Collection are shown in the parentheses.

	Scientific name under which originally described	No. in series	MAGNT Reg. No. (prefix = NTM) [superseded CAWC number shown in parentheses]
Scincidae	*Carlia gracilis* Storr, 1974	9	R31748-50 (NTM1603-05): R31752-54 (NTM4599-601); R31755-56 (NTM4603-04); R31761 (NTM5477)
Scincidae	*Cryptoblepharus swansoni* Wells and Wellington, 1985	46	R3005-50
Scincidae	*Ctenotus alacer* Storr, 1970	2	R31867 (NTM3945); R31868 (NTM4105)
Scincidae	*Ctenotus astictus* Horner, 1995	15	R11250-51; R14183; R16113; R16134-35; R16140-44; R16177; R19151; R19153; R20252
Scincidae	*Ctenotus borealis* Horner and King, 1985	9	R2664; R2710; R3186-87; R7044; R7884; R7965; R8019; R8825
Scincidae	*Ctenotus pantherinus* calx Storr, 1970	2	R32111 (NTM1632); R32123 (NTM3860)
Scincidae	*Ctenotus regius* Storr, 1971	1	R32177 (NTM1552)
Scincidae	*Ctenotus rimacola camptris* Horner and Fisher,	1	R22936
Scincidae	*Ctenotus rimacola rimacola* Horner and Fisher,	10	R18344; R18346; R20444; R21537; R22803-05; R23242-44
Scincidae	*Ctenotus saxatilis* Storr. 1970	2	R32218 (NTM1485); R32219 (NTM2015)
Scincidae	*Ctenotus septenarius* King, Horner and Fyfe, 1981	11	R13705-13; R15089-90
Scincidae	*Ctenotus strauchii varius* Storr. 1981	1	R32270 (NTM1548)
Scincidae	*Ctenotus stuarti* Horner, 1995	8	R13086-87; R13722; R13724-27; R17453
Scincidae	*Ctenotus tanamiensis* Storr, 1970	6	R32275 (NTM2080); R32276 (NTM2203); R32277-80 (NTM2218-21)
Scincidae	*Ctenotus vertebralis* Rankin and Gillam, 1979	1	R34522 (R411)
Scincidae	*Egernia arnhemensis* Sadlier, 1990	7	R.1190; R8032-34; R8181; R 8387-88
Scincidae	*Egernia margaretae margaretae* Storr, 1968	17	R32775-77 (NTM1881-83); R32778-82 (NTM2665-69); R32783-84 (NTM2765-66); R32786-88 (NTM2768-70); R32789-92 (NTM2815-18)
Scincidae	*Egernia slateri slateri* Storr, 1968	57	R32799-800 (NTM2052-53); R32801-08 (NTM2055-62); R32809 (NTM2169); R32811 (NTM2171); R32815-17 (NTM2191-93); R32819 (NTM2195); R32821 (NTM2198); R32823 (NTM2200); R32824-28 (NTM2227-31); R32829 (NTM2269); R32830-32 (NTM2272-74); R32833-44 (NTM2286-97); R32846-47(NTM2299-300); R32848-50(NTM2348-50); R32851 (NTM2578); R32877-79 (NTM2604-06); R32880 (NTM2634); R32881-84 (NTM2683-86); R32885 (NTM2757); R32886 (NTM2771); R32887 (NTM2853); R32888 (NTM2883)
Scincidae	*Hortonia obiri* Wells and Wellington, 1985	1	R.0809
Scincidae	*Lerista aericeps aericeps* Storr, 1986	4	R33363 (CAMR1140); R33365 (CAMR379); R33369 (CAMR1573); R34507 (NTM50)
Scincidae	*Lerista aericeps taeniata* Storr, 1986	11	R33362 (CAMR1043); R33364 (CAMR1314); R33366 (CAMR1565); R33368 (CAMR1567); R33462 (CAMR1574); R34508-11 (CAMR1569-72; R34512-13 (CAMR1575-76)

Appendix 2 cont. Paratypes deposited in the Terrestrial Vertebrates Collection, Museum and Art Gallery of the Northern Territory, to November 1999. Superseded catalogue numbers for specimens formerly housed in the Central Australian Wildlife Collection are shown in the parentheses.

Scientific name under which originally described		No. in series	MAGNT Reg. No. (prefix = NTM) [superseded CAWC number shown in parentheses]
Scincidae	*Menetia alanae* Rankin, 1979	2	R2739; R4733
Scincidae	*Menetia concinna* Sadlier, 1984	1	R2665
Scincidae	*Morethia storri* Greer, 1980	4	R2715; R2731-32; R2864
Scincidae	*Sphenomorphus isolepis* douglasi Storr, 1967a	1	(NTM1602) specimen discarded
Varanidae	*Varanus baritji* King and Horner, 1987	9	R3107; R6531; R8346-48; R8364; R8931; R13150-51
Varanidae	*Varanus kingorum* Storr, 1980	2	R6681; R6954
Boidae	*Liasis stimsoni orientalis* Smith, 1985	38	R434; R543; R711-13; R756; R2455; R3637; R3643; R3649; R3660; R3669; R3683; R3807; R5219; R5233; R5234; R5361; R5844-45; R8438-40; R8553; R31639 (CAMR145); R31644-45 (NTM1391-92); R31648 (NTM1395); R31649 (NTM1437); R31652 (NTM1647); R31684-85 (NTM2336-37); R31687-89 (NTM3214-16); R31690 (NTM3270); R31692 (NTM4032); R31693 (NTM5349)
Boidae	*Python bredli* Gow, 1981	10	R328; R430; R709-10; R1974; R2995-96; R4635-37
Elapidae	*Denisonia ordensis* Storr, 1984	3	R0314; R32406-07 (CAMR561-62)
Elapidae	*Simoselaps morrisi* Horner, 1998	1	R17740
Elapidae	*Vermicella annulata snelli* Storr, 1967c	2	R34479 (NTM2577); R34485 (NTM76)
Elapidae	*Vermicella intermedia* Keogh and Smith, 1996	21	R221; R354; R1203; R1959; R2250; R3476; R5178; R16642; R16705; R16773; R17187; R17191-95; R17299-300; R20410; R34481 (NTM3529); R34486 (NTM1078)
Elapidae	*Vermicella semifasciata incincta* Storr, 1967	3	R34168-69 (NTM2262-63); R34170 (NTM63)
Elapidae	*Vermicella vermiformis* Keogh and Smith, 1996	7	R34476 (CAMR240); R34477 (CAMR448); R34478 (CAMR640); R34479 (NTM2577); R34480 (NTM3411); R34483 (NTM5896); R34485 (NTM76)
Typhlopidae	*Ramphotyphlops centralis* Storr, 1984	5	R34491 (NTM5888); R34492 (NTM5890); R34493 (NTM5895); R34494 (NTM5906); R34495 (CAMR138)
Typhlopidae	*Ramphotyphlops nema* Shea and Horner, 1996	2	R16047; R34110 (NTM3236)
MAMMALIA			
Hipposiderida	*Hipposideros diadema inornatus* McKean, 1970	6	U2376 (NTM4689); U2377-78 (NTM4693-94); U2380-81 (NTM4700-01); R2382 (NTM4721)
Dasyuridae	*Sminthopsis bindi* Van Dyke, Woinarski and Press	5	U0716; U0943; U0945-46; U0954
Muridae	*Pseudomys johnsoni* Kitchener, 1985	9	U3487 (CAMM797); U3488 (CAMM847); U3489 (CAMM849); U3490 (CAMM853); U3491 (CAMM1034); U3492-93 (CAMM1036-37); U3494-95 (CAMM1039-40)
Muridae	*Zyzomys maini* Kitchener, 1989	5	U0505-06; U4028 (CAMM1008); U4032 (CAMM248); U4036 (NTM4287)
Muridae	*Zyzomys palatalis* Kitchener, 1989	1	U1148

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CHELID TURTLES (PLEURODIRA, CHELIDAE) FROM THE MIOCENE CAMFIELD BEDS, NORTHERN TERRITORY OF AUSTRALIA, WITH A DESCRIPTION OF A NEW GENUS AND SPECIES

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ABSTRACT

The Bullock Creek Local Fauna (mid Miocene Camfield Beds, Northern Territory of Australia) contains five or possibly six species of chelid turtles (Pleurodira: Chelidae), though only one form is sufficiently represented to be named. *Birlimarr gaffneyi* gen. et sp. nov. is a small (carapace length: 160 mm), short-necked species represented by a complete skeleton. A phylogenetic analysis of cranial and shell characters resolves the new genus as quite derived amongst Australian short-necked chelids, the plesiomorphic sister taxon to a clade composed of *Emydura* plus an *Elseya dentata* 'generic group'. Three other forms are diagnosed on shell material to genus or suprageneric level: a large (carapace length ca. 440 mm) short-necked form is designated gen. aff. *Emydura/Elseya* sp. indet. and two long-necked forms are designated *Chelodina* sp. A and sp. B. Additional shell material indicates a fifth and possibly a sixth chelid species is present in the assemblage, but the lower level affinities of these forms cannot be determined. The *Emydura/Elseya* form is similar but not identical to previously described *'Emydura'* material from the Miocene of South Australia (Wipajiri and Namba Formations), while a previously described carapace from the Miocene of western Queensland (Carl Creek Limestone) may represent a species of *Birlimarr* gen. nov. The Carl Creek Limestone and Camfield Beds assemblages are similarly diverse, approximating the maximum sympatric diversity recorded in extant assemblages: palaeoenvironmental conditions at these two Miocene localities thus appear to have been optimal for chelid diversity. Many of the Camfield Beds specimens show evidence of predation by crocodiles.

KEYWORDS: Chelidae, Pleurodira, *Birlimarr gaffneyi*, new genus, new species, Miocene, Camfield Beds, Northern Territory, Australia, phylogeny, phylogenetic analysis, palaeoecology.

INTRODUCTION

The Chelidae is a family of pleurodirous ('side-necked') freshwater turtles whose living representatives are today found in South America, Australia and New Guinea (plus some eastern Indonesian islands - Rhodin 1994). The Australasian and South American representatives are generically distinct (Fig. 1). Chelid turtles are relatively common in the Cainozoic vertebrate fossil assemblages of Australia, and the better material has been described or reviewed in Warren (1969), Gaffney (1979a; 1981, 1991), Gaffney *et al.* (1989), Burke *et al.* (1983), White and Archer (1994), White (1997) and Thomson *et al.* (1997).

Chelid turtles comprise a significant component of the Miocene Bullock Creek Local Fauna (LF) from the Camfield Beds of northern Australia (Murray and Megirian 1992), but have not previously been analysed. Most of the material assembled by the Museums and Art Galleries of the Northern Territory (NTM) consists of disassociated carapace and plastron fragments representing numerous individuals, with only a few other post-cranials and even fewer disarticulated cranial bones, though additional isolated cranial and post-cranial bones are expected to be found when the finer residues of acid preparation are more thoroughly sorted. Such representation, together with a very limited

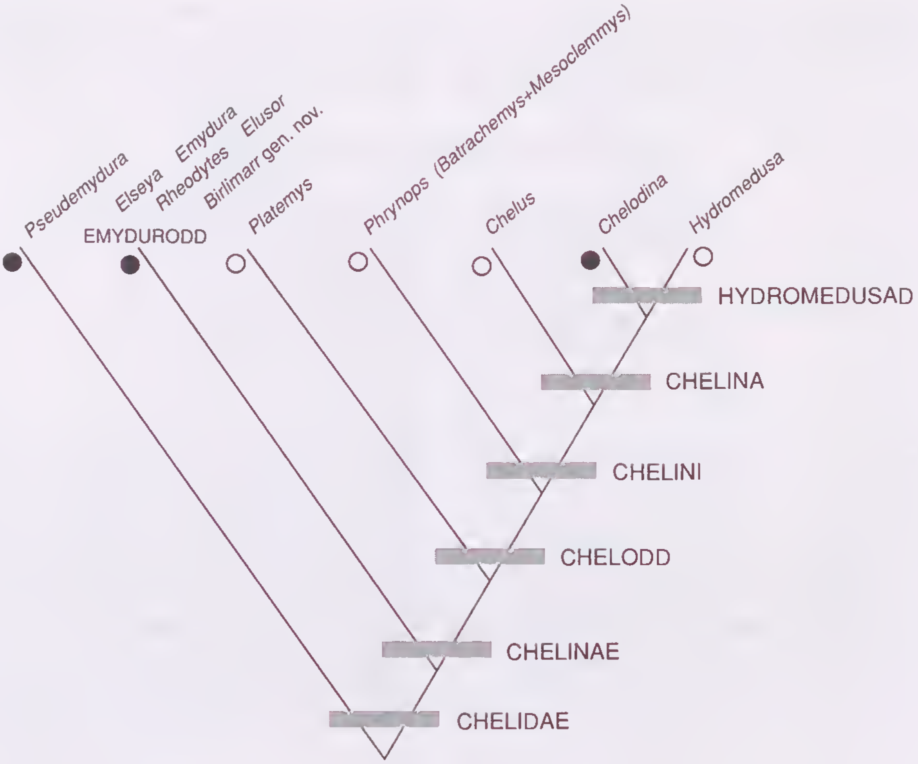


Fig. 1. Theory of relationships within the Chelidae based on shared, derived cranial characters, with the systematic nomenclature of Gaffney (1977). Solid circles indicate Australasian genera, open circles indicate South American genera. (after Gaffney 1977: fig. 10).

literature on the comparative osteology of extant Australian chelid species, inspired no attempt to interpret the affinities of the assemblage until a complete skeleton, the holotype of *Birlimarr gaffneyi* gen. et sp. nov., was collected in 1992 (Fig. 2).

The main objectives of this paper are to describe the Bullock Creek LF chelid fossils, to evaluate how many species may be represented, to investigate what the possible relationships of these may be to extant taxa and previously described Miocene forms, and to comment on the palaeoecological significance of the assemblage.

Only one morphotype, *Birlimarr gaffneyi* gen. et sp. nov., is sufficiently represented at this time to be assigned a binomial. Three other forms, however, can be diagnosed to a genus or suprageneric group on the basis of a selected reference specimen: gen aff. *Elseya/Emydura* sp. indet., *Chelodina* sp. A and *Chelodina* sp. B.

Various additional 'forms' are recognised in the comparative study of individual bones. Within that section, specimens which cannot be referred to the diagnosed taxa are designated 'forms' of some recognised group of chelids, i.e. at whatever taxonomic level can be resolved. These form designations apply only within the set of a particular bone - it should not be understood that, for example, epiplastron 'form 1' represents the same species as entoplastron 'form 1': no hypothetical taxa are proposed on the basis of observations as to which isolated bones seem to conform best to other isolated bones. The comparative analysis is aimed at determining the minimum number of morphospecies and individuals that accounts for the NTM Bullock Creek LF

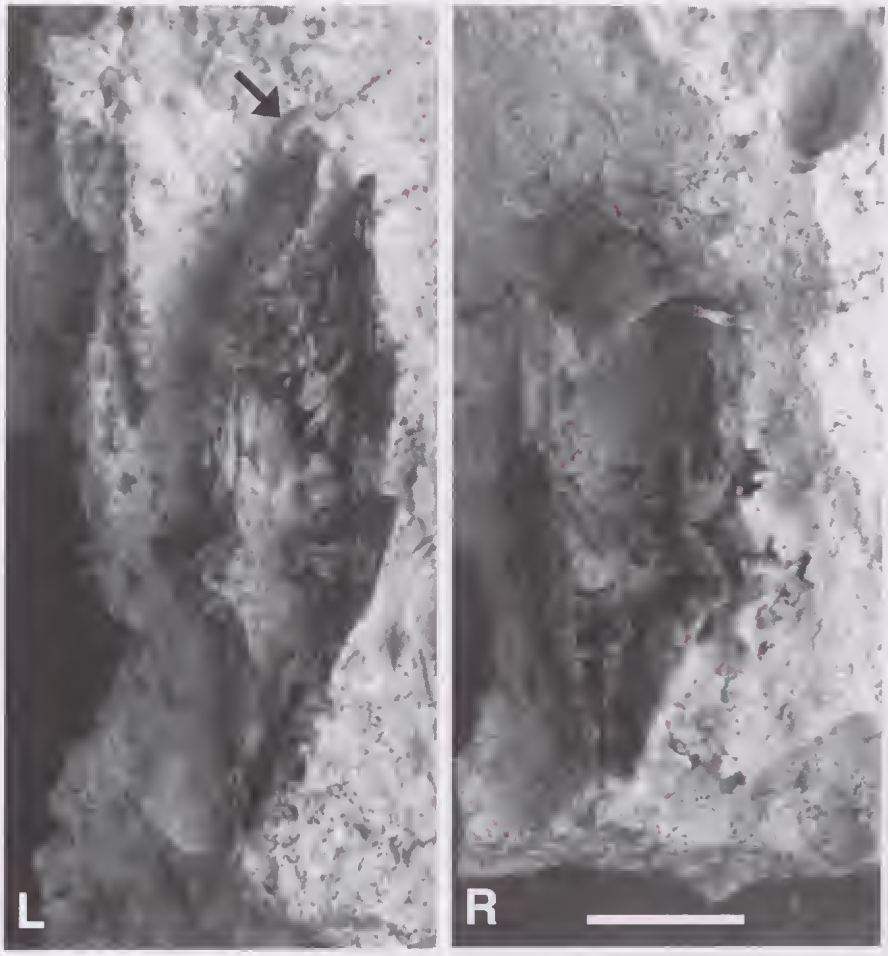


Fig. 2. *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1, left and right halves partially acid etched out of Camfield Beds calcimudstone. Anterior towards the top, skull arrowed. Scale bar: 20 mm.

chelid assemblage as a whole, to investigate the diagnostic potential of certain bones, and to contribute to the comparative osteology of living and extinct Australian chelids.

Materials and methods. The described fossils were extracted from their limestone matrix using dilute (≈10%) acetic acid. All NTM Bullock Creek Local Fauna chelid bones that could be identified as such were examined as part of this study, but only specimens which were found to be informative in terms of the stated objectives are reported here. Representatives of each bone were compared with each other, and sorted into apparently natural groups on the basis of their morphological similarities, using the listed comparative material of extant species and cited literature on chelids as a guide. The contents of each set of bones were examined to see whether fragmented bones could be united into more complete specimens. Next, the contents of each set of carapacial and plastral bones that are in sutural contact in the chelid skeleton were compared in turn with each other, in order to identify more complete individuals wherever possible.

Terminology for the bones of the shell and epidermal scutes follows Zangerl (1969), and cranial anatomy follows Gaffney

(1979b). The combined axillary and inguinal buttresses of the shell are referred to as the bridge. The paired bones and scutes of the turtle shell are not always equal in length at their medial contacts. Where paired structures are referred to, interlaminal measurements, that is the average of left and right sides along their medial contact, should be assumed unless otherwise indicated.

Introductory remarks on chelid systematics and taxonomy. The current classification of Australian chelid species is poorly founded, relying substantially on differential diagnosis rather than on well-tested phylogenetic hypotheses. Manning and Kofron (1996) review and comment on the development and current state of Australian chelid systematics, and the reader is referred to their work for a more comprehensive overview: the histories of various ideas discussed herein are not traced from their origins.

In current classification of Australian chelids (e.g. Cogger 1996), there are five nominal genera of short-necked turtles: *Emydura, Elseya, Elusor, Rheodytes* and *Pseudemydura*, the last three of which are monospecific. 'Long-necked' turtles are all included in *Chelodina*. Georges and Adams (1992) proposed a phylogeny of Australian chelids based on allozyme electrophoresis. That phylogeny, reproduced here as Figure 3, indicates basic generic-level natural groups by which this and other phylogenetic hypotheses can be tested using morphological character states. We follow Thomson *et al.* (1997) in referring to the species (some still undescribed) clustering with *Elseya dentata* and those clustering with *Elseya latisternum* as the *Elseya dentata* and *Elseya latisternum* 'generic groups', that is, generic level clades requiring diagnosis and formal taxonomic revision. On the other hand 'species complexes' are apparently related species that are not sufficiently distinctive to warrant generic level distinction.

Gaffney (1977) presented a generic level cladistic phylogeny of the Chelidae relying primarily on skull characters; his preferred hypothesis and systematic arrangement here reproduced as Figure 1. Gaffney (1977) was obliged to treat *Emydura* and *Elseya* as congeneric because of inadequate documentation of the cranial osteology of the two nominal genera, and also because of the limited amount of objectively identified comparative skeletal material at his disposal. The comparative osteology of Australian chelids remains very incomplete. Legler and Cann's (1980) description of *Rheodytes leukops* and Cann and Legler's (1994) description of *Elusor macrurus* are also useful sources of information on *Emydura* and *Elseya*. The term '*Emydura/Elseya*' is applied here to fossil material where a soundly-based assignment to *Emydura* or one of the two *Elseya* generic groups is not possible. Our '*Emydura/Elseya*' is therefore essentially equivalent to Gaffney's '*Emydura*'.

Higher level systematics follows Gaffney (1977) and Gaffney and Meylan (1988), but attention is drawn to recent work by Georges *et al.* (in press) based in mitochondrial and nuclear gene sequence variation, which leads to some significantly different conclusions about chelid phylogeny (Fig. 4). Taxonomic changes proposed by Georges *et al.* (in press) on the basis of their work are not introduced here. As this study is not concerned with the higher level systematics and taxonomy of the group, nor with the relative merits of biochemical and morphological approaches to phylogeny reconstruction, the selected phylogenies of Georges *et al*. presented here as Figure 4 are simply treated as hypotheses to be tested, insofar as they depict possible relationships amongst chelids.

Gaffney (1977) erected the infrafamily Emydurodd to accommodate the short-necked genera *Emydura* and *Elseya*, observing that placing a species in *Emydura* (or *Elseya*) is akin to stating that it is structurally primitive for a chelid: Emydurodd is a taxon for which no shared, derived morphological character states have been identified. Both *Elusor* and *Rheodytes* are diagnosed by autapomorphies of their type and only species: thus *Rheodytes* was added to Emydurodd by Gaffney *et* al. (1989), and *Elusor macrurus* Cann and Legler, 1994, is clearly also a member. Emydurodd thus comprises all short-necked chelids except *Pseudemydura*. The concept of Emydurodd as a natural group within the Chelidae is supported by the work of Georges and Adams (1992, 1996) and Georges *et al.* (in press) (Figs 3 and 4).

Institutional abbreviations. AM - Australian Museum, Sydney; AMNH - American Museum of Natural History, New York; SMF - Senckenberg Museum, Frankfurt; MUZ - Monash University, Department of Zoology, Victoria; NMV - Museum of Victoria; NTM - Museums and Art Galleries of the Northern Territory (Northern Territory Museum); QM - Queensland Museum; UCMP - University of California Museum of Paleontology; UTG - University of Tasmania, Department of Geology; UU - University of Utah; WAM - Western Australian Museum.

Where no institutional prefix is given, it can be taken that the specimen is from the NTM collection.

Anatomical abbreviations.

Cranium

ang	angular
art	articular
bo	basioccipital
bs	basisphenoid
den	dentary
fr	frontal
ju	jugal
mx	maxilla
na	nasal
pa	parietal
pal	palatine
pf	prefrontal
pm	premaxilla
po	postorbital
pr	prootic
pt	pterygoid
qu	quadrate
so	suproccipital
sq	squamosal
vo	vomer

Shell

BCS	bridge carapace suture
C_{1-5}	costal bones
m_{1-12}	marginal scutes
P_{1-11}	peripheral bones
p_{1-4}	pleural scutes
v_{1-5}	vertebral scutes

Comparative material. *Chelodina longicollis* R.24812, det. S. Thompson, labelled 'UK004', no other data; *Chelodina rugosa* R.24815, Darwin area, Northern Territory, coll. L. Taylor, July 1986; R.24813, ex Parks and Wildlife Commission of the Northern Territory, Darwin area, no other data; R.24814, coll I. Archibald, Humpty Doo, Northern Territory, 1 February 1996; *Chelodina novaeguineae* R.16325, Kalala Station, Northern Territory, coll. R. Kennett, 29 April 1990; *Emydura macquarrii*, R.24816 female, R.24817 male, donated G. Fyfe, ex pet-shop trade from Murray River, South Australia, no other data; *Elseya dentata* R.24818, male, Katherine River, Northern Territory, 14° 21'S, 132° 25'E, coll. I. Archibald, 14 September 1998; *Emydura victoriae* R.24819, Longreach Billabong, Elliott, Northern Territory, coll. G. Fyfe, (species thought to have been introduced to this waterway in historical times); *Emydura* sp. R.24820, sub-adult, no other data.

SYSTEMATICS

Testudines Linnaeus
Pleurodira Cope
Chelidae Gray
Chelinae Gray
Emydurodd Gaffney, 1977
Birlimarr gen. nov.

Type species. *Birlimarr gaffneyi* sp. nov.

Diagnosis. As for *Birlimarr gaffneyi* sp. nov.

Etymology. *Birlimarr* - turtle in the language of the Mudburra Aboriginal people of the Camfield district (*Tjambutjambulani*), Northern Territory (David Nash pers. comm.; Tindale 1974).

Birlimarr gaffneyi sp. nov.

(Figs 2, 5-8, 10-12; Tables 1-3)

Type material. HOLOTYPE NTM P9215-1, virtually complete skeleton.

Type locality, stratigraphy, fauna and age. Calcimudstone facies of the Camfield Beds; 'Top Site' of the Bullock Creek Local

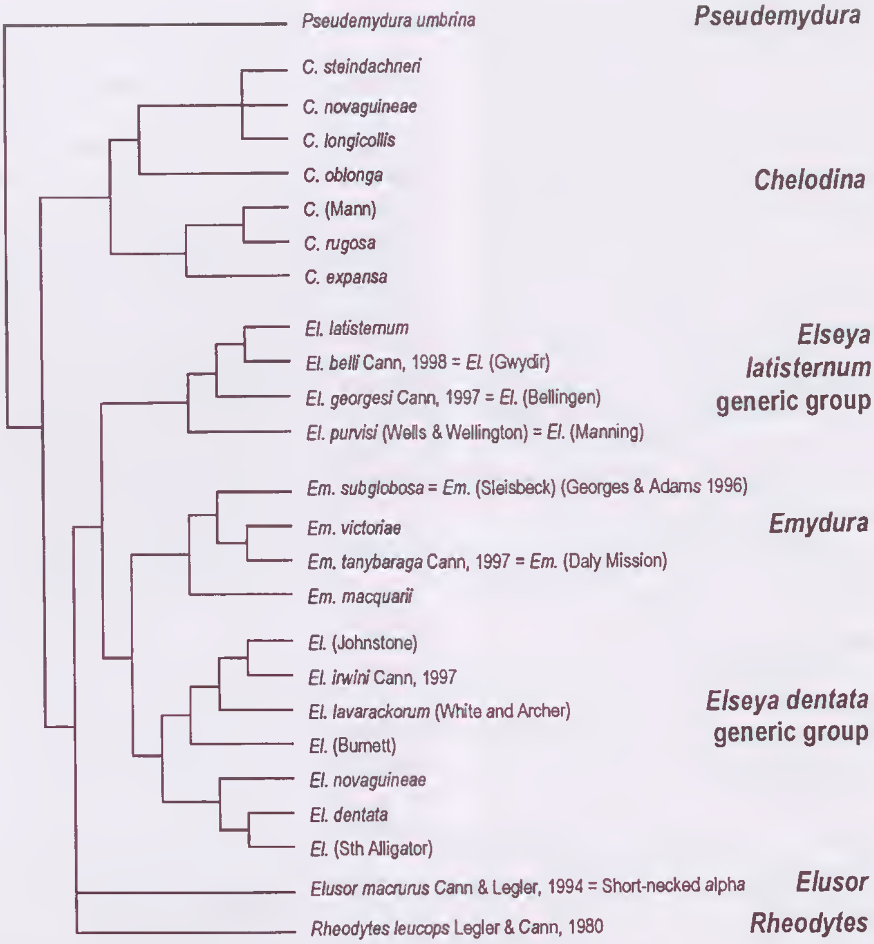


Fig. 3. Phylogenetic hypothesis of Australian freshwater turtles after Georges and Adams (1992: fig. 6), based on allozyme biochemistry of short-necked species excluding *Pseudemydura* (i.e. Emydurodd of Gaffney 1977). *Pseudemydura* and *Chelodina* were not analysed biochemically in that study, but added in on other grounds. New species names added, with an allozyme based phylogeny within the *Elseya dentata* generic group supplied by S. Thomson (written comm.): see also Georges and Adams (1996). Basic generic level taxa recognised in this work added on the right. See Cann (1998) for discussion of *Elseya purvisi* Wells and Wellington, and Thomson *et al.* (1997) for *Elseya lavarackorum* (White and Archer).

Fauna, latitude 17° 07'S, longitude 131° 31'E; mid Miocene on the basis of marsupial stage-of-evolution biochronology. (Plane and Gatehouse 1968; Woodburne *et al.* 1985; Rich 1991; Murray and Megirian 1992; Megirian 1994a; Murray *et al.* in press).

Referred material. All listed sites (quarries) mentioned with referred material are in close proximity to the type locality (i.e. 'Top Site'). Material for which no site name was recorded (i.e. 'unrecorded quarry') is either from the type locality or one of the nearby sites (Murray and Megirian 1992: fig. 2). P9612-2 (Top Site), left epiplastron; P906-22 (Site X), left epiplastron; P9464-157 (Top Site), entoplastron; P9464-156 (Top Site), posterior portion of entoplastron; P9464-149 (Top Site), left hyoplastron; P944-10

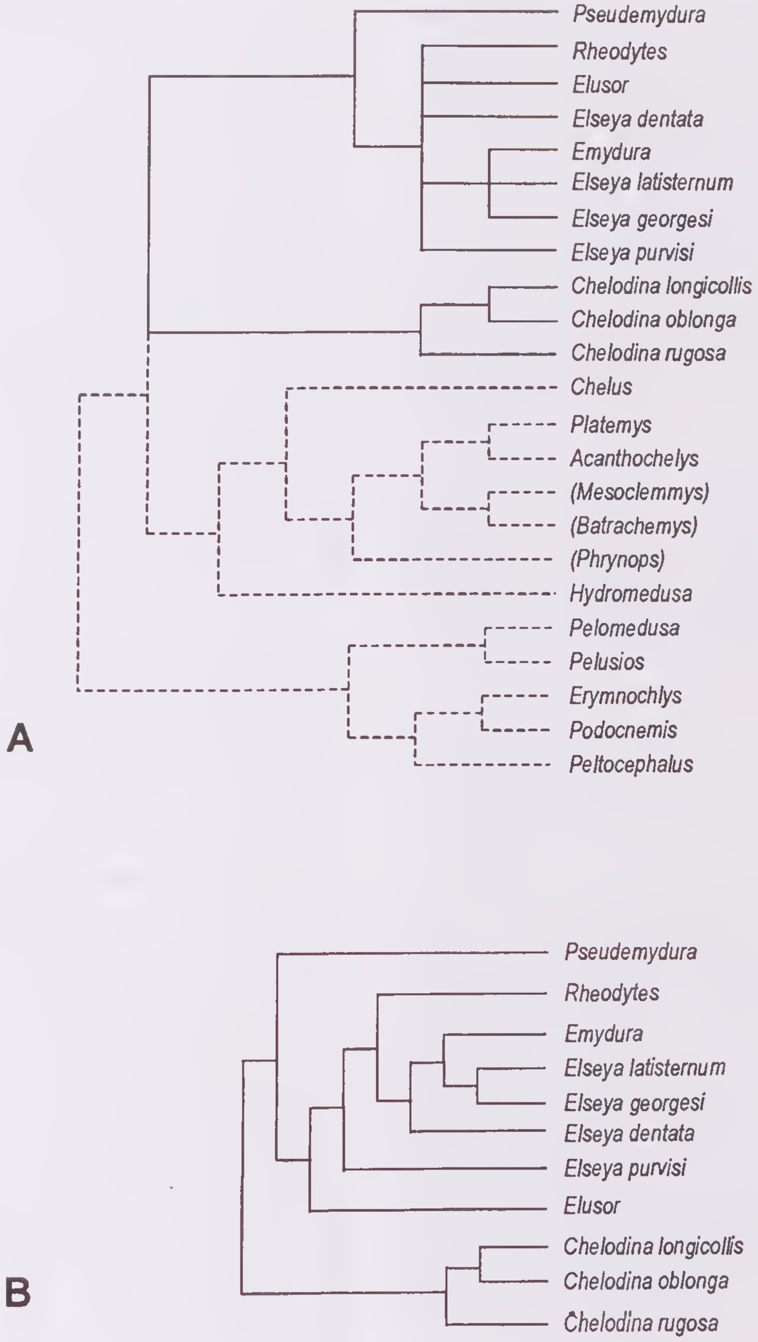


Fig. 4. Phylogenies **A**, of living pleurodires (Australasian taxa connected by solid lines, South American and African taxa connected by dashed lines) and **B**, of Australian chelids, generated from partial sequences of mitochondrial and nuclear genes, after Georges *et al.* (in press: figs 3, 4). Taxa shown in brackets are subgenera of *Phrynops*.

(unrecorded quarry), right hyoplastron; P9464-166 (Top Site), right hypoplastron; P925-5 (Site Y), right hypoplastron; P9464-126 (Top Site), right xiphiplastron; P87105-17 (unrecorded quarry), right costal 1; P9464-137 (Top Site), right costal 1; P9464-138 (Top Site), right costal 1; P9464-139 (Top Site), right costal 1; P9464-140 (Top Site), right costal 1; P9464-142 (Top Site), right costal 1; P9276-6 (Top Site), left costal 1; P9464-135 (Top Site), nuchal; P9464-148 (Top Site), nuchal; P87113-50 (Site Y), right costal 8; P87103-53 (Blast Site), left costal 8.

Diagnosis. Small species of Emydurodd, adult straight line carapace length *ca.* 160 mm. Carapace regularly oval in dorsal view, evenly and quite strongly domed in transverse profile, no indication of axial ridge or depression. Cervical scute present. Vertebral scutes all wider than long. Vertebrals 1 and 5 similar in width, but distinctly narrower than three intervening scutes. Interpleural seams contact marginal scutes 5, 7 and 9. Plastron, excluding bridges, half maximum width of carapace, length 90% of carapace; carapace and plastron with equal anterior projection, carapace overhanging plastron posteriorly. Anterior and posterior lobes of plastron arc gently upwards. In ventral view, margin of the anterior plastral lobe tapers gently forward of the bridge, with blunt, slightly squared-off anterior margin. Femoral scute area of posterior lobe bulges laterally; posterior extremity as covered by anal scutes comparatively small. Intergular about half as wide as long, marginal, completely separating gulars, partially separating humerals. Cranium proportionally low, broad and short, orbits large such that orbital diameter is about 25% of basicondylar length. Supraoccipital spine short, projecting posteriorly to about same extent as occipital condyle. No medial triturating ridge on maxilla. Ventral flanges of frontals vertical and parallel. Pterygoid-palatine suture almost straight, oriented at 45° to axial plane. Pterygoid-quadrate suture long in ventral view, oriented anterolateral to axial plane. Mandible gracile, dentaries fused.

Description. *Taphonomy and stratinomy of the holotype.* The preservation of P9215-1 is unusual for Camfield Beds vertebrates in particular, and for Australian Cainozoic deposits in general, and consequently is described in some detail.

The holotype was found embedded in facing walls of a naturally fractured calcimudstone boulder. Fracturing bisected the skeleton near the axial plane. The shell was crushed dorsoventrally, but not isometrically. On the plane of the fracture, crushing was greatest near the mid and anterior regions, relatively less posteriorly. Partial preparation revealed that some appendicular bones were also broken, and that few bones were in true articulation, but were closely associated with their near anatomical neighbours (Fig. 2).

Removal of limestone matrix by acid etching results in the loss of support of individual bones. Spatial relationships between bones are thus difficult to preserve or record fully with this kind of preparation. On the other hand, acid etching produces undamaged tiny bones, as well as excellent surface-detail, both easily lost in mechanical preparation, especially where the matrix is harder than the fossil. To optimise the taphonomic information that could be recovered during preparation, it was decided to partially restore the shell as it was extracted, and to periodically collect other post-cranials from where they settled, keeping associated pieces together as much as possible. This was achieved by orienting the specimen in the acid tub so that released elements settled more or less *in situ*, rather than in the bottom of the tub. In practice, this method worked for the larger bones, but phalanges, for example, were very difficult to recognise amongst all the other insolubles released. After hand-picking the larger bones, remaining insolubles were screened down to 0.5 mm, and additional bones recovered when the yield was scanned under the microscope.

Re-assembly of the shell (Figs 5-6) resulted in a specimen that is closer to the morphology of the animal in life, rather than a true record of its former arrangement in the matrix, but it remains possible to account for many of the breaks and dislocations. These can be attributed to several mechanisms: the event or events causing anisometric crushing and disarticulation; post-depositional re-arrangement of bones; post-lithification fracture of the host limestone and subsequent weathering; and accidental breakages that occurred during collection and acid preparation.

Wherever possible, accidental breakages, which comprise only a small proportion of the damage visible in the specimen, were repaired as soon as possible after they occurred. The two halves of the shell (plastron + carapace) match exactly at only a couple of points (Fig. 5): elsewhere, weathering resulted in the loss of up to 12 mm of bone. The remaining damage consisted of separations at sutures, many of which were realigned in restoration, and breakages attributable to crushing.

On the carapace, left pleurals 2 to 4 were broken transversely. Two indentations are visible on the break, one on the suture of the first and second pleural, and the other on the suture of the second and third pleural. A possible third indentation lies medial to the fracture on the fourth pleural. On the left plastron, more or less opposing the damage to the carapace just described, are complex fractures radiating from a depressed puncture at the epi-entoplastron suture.

The right carapace preserves another major fracture coursing obliquely from the midline at the third pleural to the margin of the third peripheral. The right plastron is broken in a comparable fashion to the right carapace. However, no punctures or indentations can be distinguished on or near the major fracture on the right side.

The damage on the left hand side is consistent with an attack by a crocodile, of which three species are known to occur in the Bullock Creek Local Fauna (*Baru darrowi* Willis *et al.* 1990; *Harpacochampsa camfieldensis* Megirian *et al.* 1991; and *Quinkana timara* Megirian 1994b). The three species have different dentitions, but the opposing tooth indentations and punctures on the turtle are insufficiently developed to establish which might have been responsible. Although no undoubted tooth punctures are associated with the fractures on the right hand side, they are probably related to the same event.

P9215-1 evidently died from a mortal wound inflicted by a crocodile. Severe crushing resulted in the fracturing of internal bones as well as the plastron and carapace, which also suffered separations at sutures. The turtle was perhaps then released for a second strike, but lost by its attacker. It settled in still water at the bottom of a pond or lake, where decomposition, scavenging and/or bioturbation by small animals resulted in minor dislocations of the remains. Rapid precipitation of the fringing calcite cement that is typically present on bioclasts in fossiliferous facies of the Camfield Beds, followed closely in this case by burial in microdetrital carbonate, ensured its preservation.

Shell (Figs 5-7). In dorsal view, the carpace is an almost regular oval, about one third longer (total length 162 mm) than its maximum width (121 mm) which occurs at about the level of peripheral 7. The carapace is quite strongly domed, with no trace of an axial crest or depression. The lateral edges from peripherals 1-6 are sharply upturned, but only very gently so elsewhere, and there are no marginal serrations posteriorly. Carapacial fenestrae are absent, the pleurals being strongly sutured to the peripherals, and therefore indicating an adult stage of development.

The plastron excluding the bridge is almost exactly half the maximum width of the carapace. The maximum length approaches 90% of that of the carapace. Anterior extent of the upper and lower parts of the shell is equal, the carapace overhanging the plastron posteriorly. In lateral view, the anterior and posterior lobes are gently upwards. In ventral aspect, the laterally edges of anterior lobe taper very gently forwards to the blunt, slightly squared-off anterior margin. The posterior lobe, on the other hand, bulges laterally behind the bridge, with the posterior extremity as covered by the anal scutes small and W-shaped.

The relationships of bones to epidermal scute areas are shown in Figure 5C-D. The vertebral scutes of the dorsal shield are all wider than they are long. Vertebrals 2, 3 and 4 are of about equal width, becoming shorter posteriorly. Vertebrals 1 and 5 are similar in width to each other but distinctly narrower

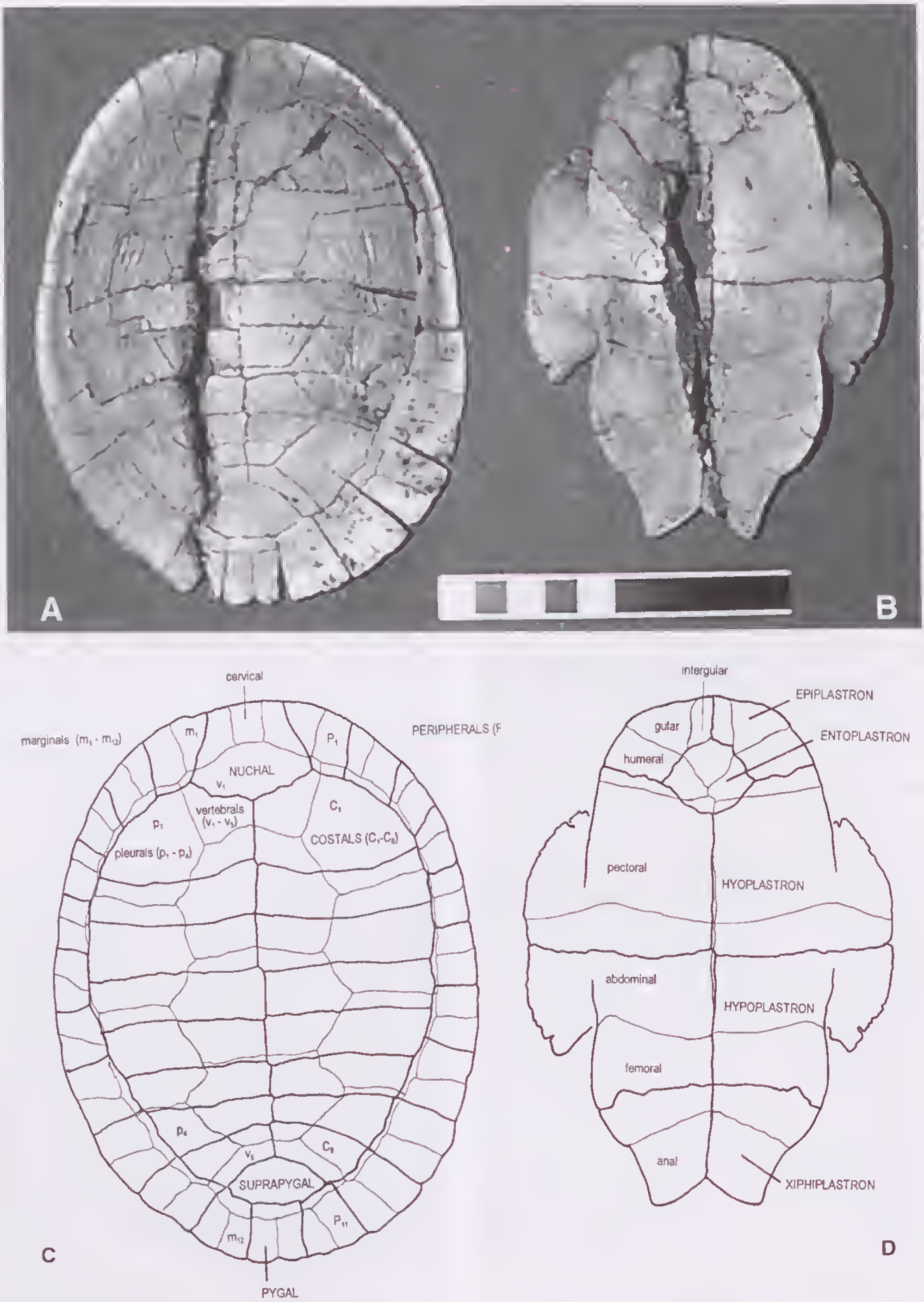


Fig. 5. *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1. **A**, dorsal view of carapace and **B**, ventral view of plastron, with **C** and **D**, restored interpretive diagrams showing the relationships of bones to epidermal scute areas. Bones delimited by heavy lines and labelled in upper case, scutes delimited by fine lines and labelled in lower case.

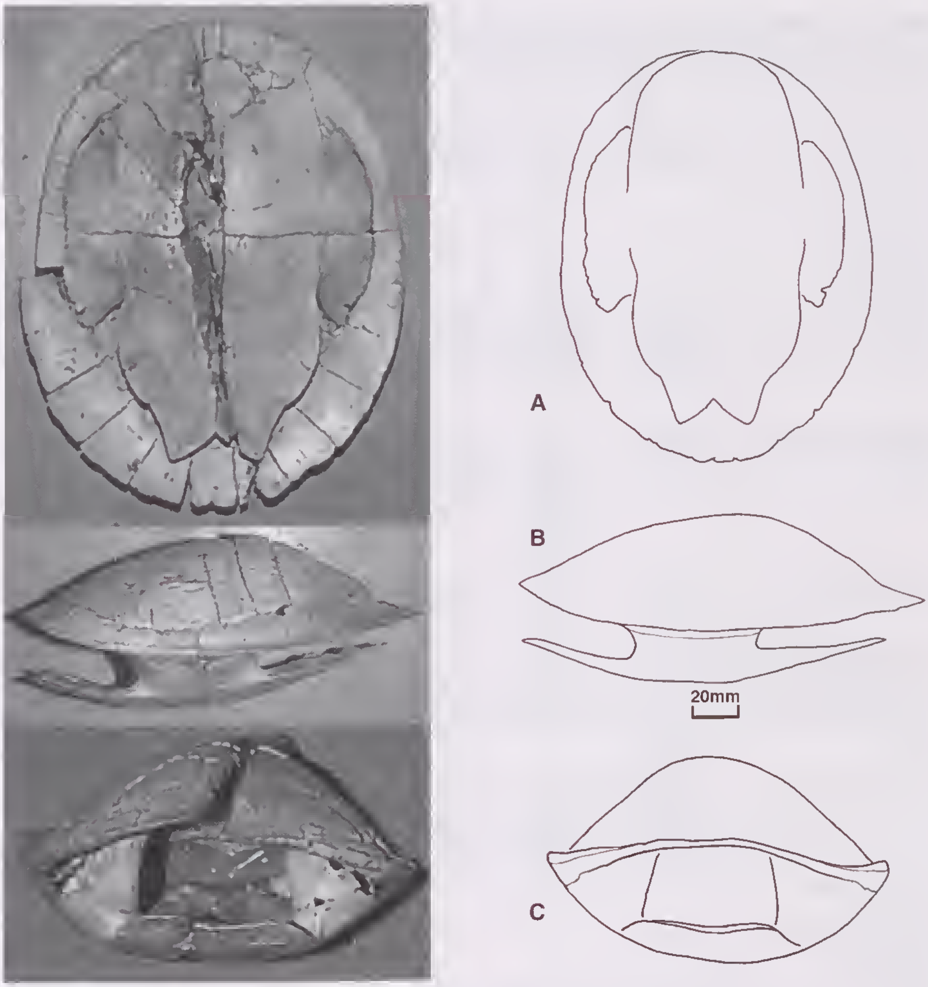


Fig. 6. *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1 in: **A**, ventral; **B**, left lateral; and **C**, anterior views, with restored outlines showing the shape of the shell.

than the three intervening scutes. There is a relatively broad cervical scute on the nuchal bone. The interpleural seams contact marginal scutes 5, 7 and 9 (Table 1). The intergular of the ventral shield completely separates the gulars, but only incompletely separates the humerals, therefore not coming into contact with the pectorals. The intergular scute area is about half as wide as it is long. The modal plastral formula (Table 2), to the extent that preservation allows it to be determined, is pectoral > abdominal > intergular > femoral > anal.

The axillary buttress of the bridge is strongly sutured to the first costal by a broad, deep sutural contact (Fig. 7), which is widest medially, constricting only slightly anterolaterally. The trace of the suture diverges anterolaterally from the trace of the first rib.

Skull. In general terms, the skull of P9215-1 (Fig. 8) has the typical form of Australian short-necked chelids excluding *Pseudemydura*, and also shows some general similarities to the South American *Platemys platycephalus* (Fig. 9). The cranium is slightly flatter in lateral profile than the figured species of *Elseya* and *Emydura*, but not as flat as *P. platycephalus*. The degree of lateral cheek emargination is similar in all these taxa. The supraoccipital has small

Table 1. Comparison of osteological characters of Australian short-necked chelids, abstracted from: (Gaffney 1977: tables 2, 3); Legler and Cann (1980: table 1); Cann and Legler (1994: table 4); Thomson *et al.* (1997: table 1); and this work.

	Pseudemydura umbrina	***Emydura***	***Elseya dentata* (GG)**	***Elseya latisternum* (GG)**	***Rheodytes leucops***	***Elusor macrurus***	***Birlimarr gaffneyi* gen. et sp. nov.**
Anterior process of frontal	absent	present	present	present	present	present	present
Size of postorbital	large	small	small	small	small	small	large
Temporal arch	extensive: formed by parietal, squamosal and supraoccipital	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal
Dorsal (horizontal) portion of parietal	broadly covers adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa
Lateral edges of parietals	sub-parallel but laterally extensive	sub-parallel	tapering anteriorly	tapering anteriorly	tapering anteriorly	tapering anteriorly	parallel
Supraoccipital-parietal contact	present	absent	absent	absent	absent	absent	absent
Quadrate-parietal contact	present	absent	absent	absent	absent	absent	absent
Dorsal (horizontal) portion of supraoccipital	broadly expanded	not expanded	not expanded	not expanded	elongate, but not expanded laterally	not expanded	not expanded
Crista supraoccipitalis	does not extend beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	does not extend beyond occipital condyle
Squamosal expanded anteriorly	yes	no	no	no	no	no	no
Medial maxillary contact dividing premaxillae longitudinally	yes	no	no	no	no	no	?
Mandibles	weak, without symphyseal hook	massive with symphyseal hook	massive with symphyseal hook	massive with symphyseal hook	weak, without symphyseal hook	massive with symphyseal hook	weak, weakly developed hook
Prearticular separates or nearly separates coronoid splenial	yes, when present	no	no	no	splenial absent	no	?

dorsal expression, projecting posteriorly only just as far as the occipital condyle. In this respect, P9215-1 is intermediate between *P. platycephalus*, in which the occipital condyle projects beyond the supraoccipital spine, and *Elseya* and *Emydura* in which the opposite is the case. P9215-1 is broad in relation to its length, compared to *Elseya, Emydura* and *Platemys*. The orbits are proportionally large, having a diameter of about 25% of the basicondylar length. Proportionally large orbits appear to be to some degree an allometric feature of small individuals and species, but not even in the smallest chelid specimens of other chelid species illustrated in Figure 9 does the ratio of orbit diameter to basicondylar length appear to be as high as it is in the fossil form.

The nasals are not represented in P9215-1, but it can be surmised from the continuous sutural surface around the anterior processes of the frontals that nasals were present and that the frontals did not form part of the dorsal anterior margin of the external narial aperture. Neither dorsal flange of the prefrontal is intact, but the nasal suture on

Table 1 cont. Comparison of osteological characters of Australian short-necked chelids, abstracted from: (Gaffney 1977: tables 2, 3); Legler and Cann (1980: table 1); Cann and Legler (1994: table 4); Thomson *et al.* (1997: table 1); and this work.

	Pseudemydura umbrina	*Emydura*	*Elseya dentata* (GG)	*Elseya latisternum* (GG)	*Rheodytes leucops*	*Elusor macrurus*	*Birlimarr gaffneyi* gen. et sp. nov.
Anterior process of frontal	absent	present	present	present	present	present	present
Size of postorbital	large	small	small	small	small	small	large
Temporal arch	extensive: formed by parietal, squamosal and supraoccipital	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal	moderate: formed by squamosal and parietal
Dorsal (horizontal) portion of parietal	broadly covers adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa	covers central, but not lateral, area of adductor fossa
Lateral edges of parietals	sub-parallel but laterally extensive	sub-parallel	tapering anteriorly	tapering anteriorly	tapering anteriorly	tapering anteriorly	parallel
Supraoccipital-parietal contact	present	absent	absent	absent	absent	absent	absent
Quadrate-parietal contact	present	absent	absent	absent	absent	absent	absent
Dorsal (horizontal) portion of supraoccipital	broadly expanded	not expanded	not expanded	not expanded	elongate, but not expanded laterally	not expanded	not expanded
Crista supraoccipitalis	does not extend beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	extends beyond occipital condyle	does not extend beyond occipital condyle
Squamosal expanded anteriorly	yes	no	no	no	no	no	no
Medial maxillary contact dividing premaxillae longitudinally	yes	no	no	no	no	no	?
Mandibles	weak, without symphyseal hook	massive with symphyseal hook	massive with symphyseal hook	massive with symphyseal hook	weak, without symphyseal hook	massive with symphyseal hook	weak, weakly developed hook
Prearticular separates or nearly separates coronoid splenial	yes, when present	no	no	no	splenial absent	no	?

the ascending process of the left maxilla, together with a differentiation of nasal and prefrontal sutural surfaces on the frontal, indicates that both the nasals and prefrontals were similar in form and extent to *Elseya* and *Emydura*. The ventral ridges of the frontal bones are vertical rather than turned inwards into close approximation. No premaxilla or vomer are preserved, and the maxillae are damaged anteriorly and medially. Thus, it is not possible to establish the shape of the premaxillae, whether palatal intermaxillary or else premaxillary-vomer contact occurred, what the shape of the internal narial aperture was, or where the prepalatal foramina were positioned.

The triturating surface of the maxillary palate is bounded by a well-developed labial ridge, but the lingual ridge is weakly expressed, and no medial ridge is present. The lateral ascending processes do not make contact on the dorsal surface of the skull with the frontals. The palatal bones just come into contact with each other

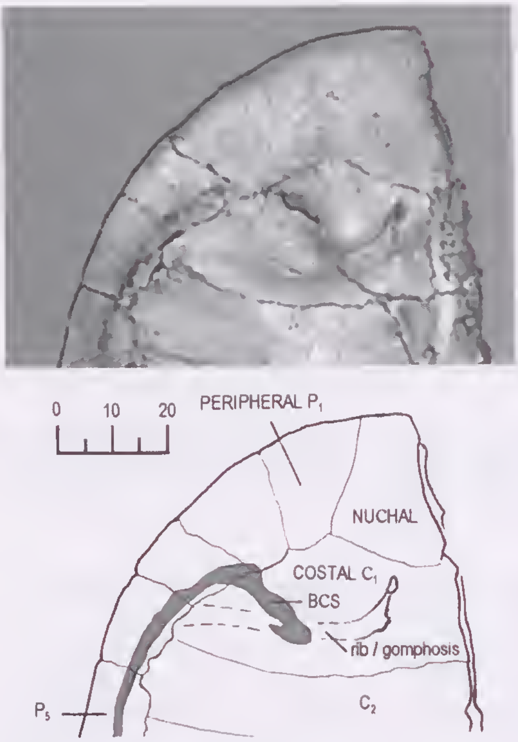


Fig. 7. *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1. Internal view of left side of carapace showing form and position of bridge-carapace suture (BCS).

posteromedially, suggesting that the vomer either stopped short of, or else barely made contact with, the pterygoids. The palatine-pterygoid sutures are oriented posterolaterally at about 45° to the axial plane of the skull, and the interpterygoid suture is long in proportion to the basicondylar length of the cranium. The lateral trochlear processes of the right pterygoid (the left is missing) is quite short. In ventral view, the lateral margin of the processus trochlearis pterygoidei is straight. The ventral trace of the pterygoid-quadrate suture is long and also oriented at about 45° to the axial plane.

The most noteworthy features of the dorsal cranial surface are the sutural relationships between the frontals, postorbitals and parietals. The postorbital is quite large compared to *Elseya* and *Emydura*, but not as large as in *Pseudemydura*, appearing distinctly wider than long in dorsal view. The frontals have a medial posterior process, with the lateral segments of the frontal-parietal contacts diverging anterolaterally.

The mandible is represented by fused dentaries and both articulars and angulars, which is sufficient to give an overall indication of the mandibular shape (Fig. 10). The prearticulars and coronoids are missing, and thus the preservation does not indicate whether or not splenials were present. The mandible is almost as broad as it is long (greatest width/greatest restored length ca. 0.95) and lightly built. The rami are curved in dorsal and ventral views, forming a mandibular angle of about 50° (i.e. the angle between lines drawn from the tip of the symphysis to the articular facets - Legler and Cann 1980). Although the tip is damaged, the tomial profile in lateral view was clearly only moderately upcurved at the tip.

Cervical vertebrae. The Chelidae have the following unique pattern of cervical centrum articulations: (2(, (3(, (4(, (5),)6),)7(, (8) (Williams 1950, Gaffney 1979a). The P9215-1 cervical series includes complete or almost complete vertebrae 2 and 4-7, neural arch 8, and the left half of the axis neural arch with postzygapophyses missing (Fig. 11). There are two poorly preserved fragments with P9215-1 that might represent the centrum and neural arch of cervical 3. The cervicals of the fossil species are very similar to those of *Elseya denata*, though of slightly stockier proportions (Fig. 11). The cervical series has an estimated restored length of about 48 mm, which compares with an estimated length of 82 mm for the dorsal series, using the distance between the anterior- and posterior-most rib heads on the inside of the carapace.

Appendicular elements. The generally stockier proportions of *Birlimarr gaffneyi* gen. et sp. nov. relative to *Elseya dentata* are also evident in the appendicular skeletal elements selected for illustration (Fig. 12). Morphologically, they appear to be typically chelid when compared with the extant species at hand.

Numerous manus and pes elements, though certainly not the complete suite, are present in the type specimen, but no attempt

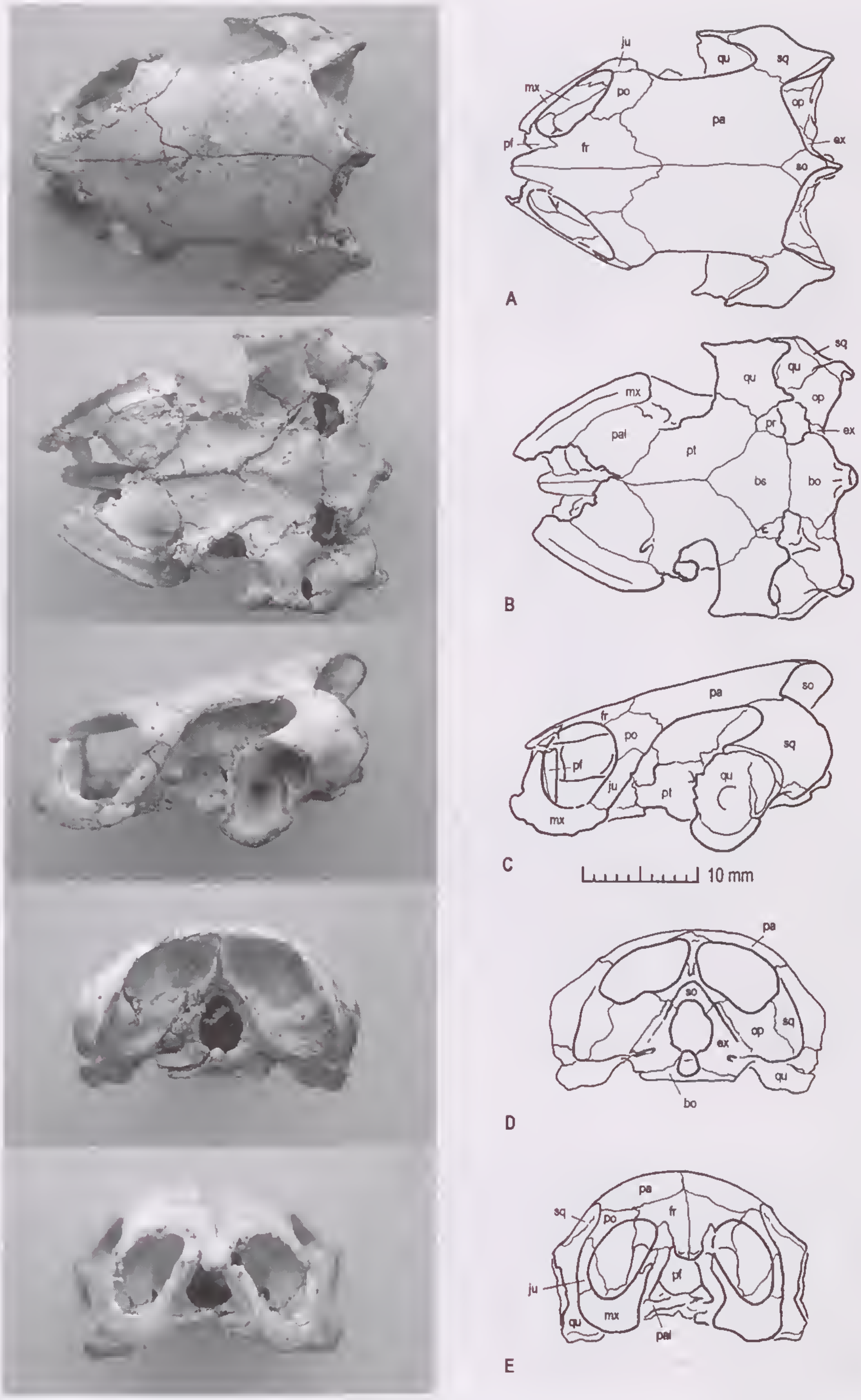
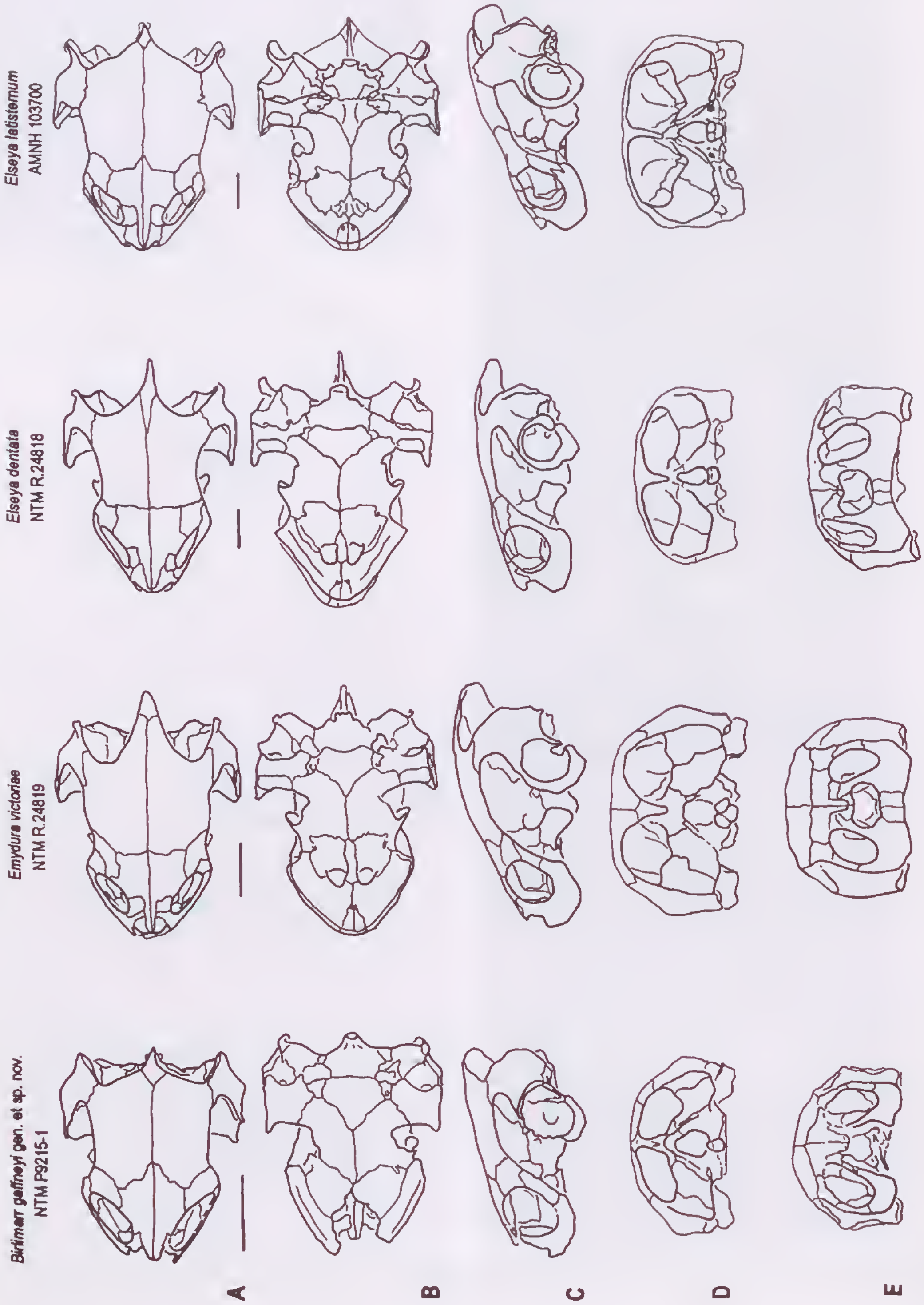


Fig. 8. *Birlimarr gaffneyi* gen. et sp. nov. holotype cranium, P9215-1 in **A**, dorsal; **B**, ventral; **C**, left lateral; **D**, posterior; and **E**, anterior views.


Elseya latisternum
AMNH 103700
Elseya dentata
NTM R.24818
Emydura victoriae
NTM R.24819
Birimarr gaffneyi gen. et sp. nov.
NTM P9215-1
A
B
C
D
E

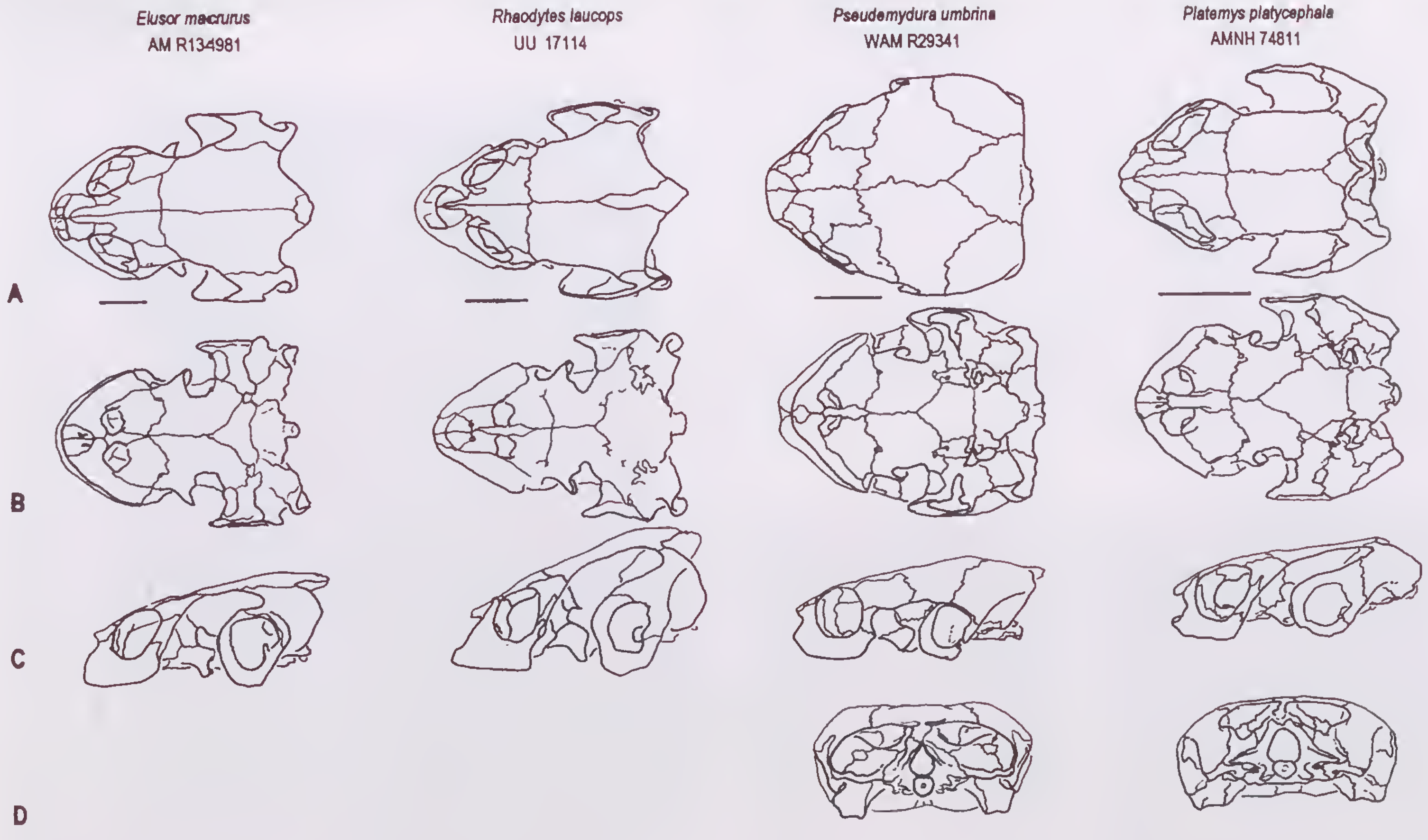


Fig. 9. Comparative cranial morphology of selected chelid species in **A**, dorsal; **B**, ventral; **C**, lateral; **D**, posterior; and **E**, anterior views. Scale bars equal 10 mm. *Elseya latisternum* after Gaffney (1977: fig. 7); *Elusor macrurus* after Cann and Legler (1994: fig. 6); *Rheodytes leucops* after Legler and Cann (1980: fig.2); *Pseudemydura umbrina* after Gaffney (1977: figs 1B,2B, 4B, 6B); and *Platemys platycephala* after Gaffney (1977: figs 1C, 2C, 4C, 6C).

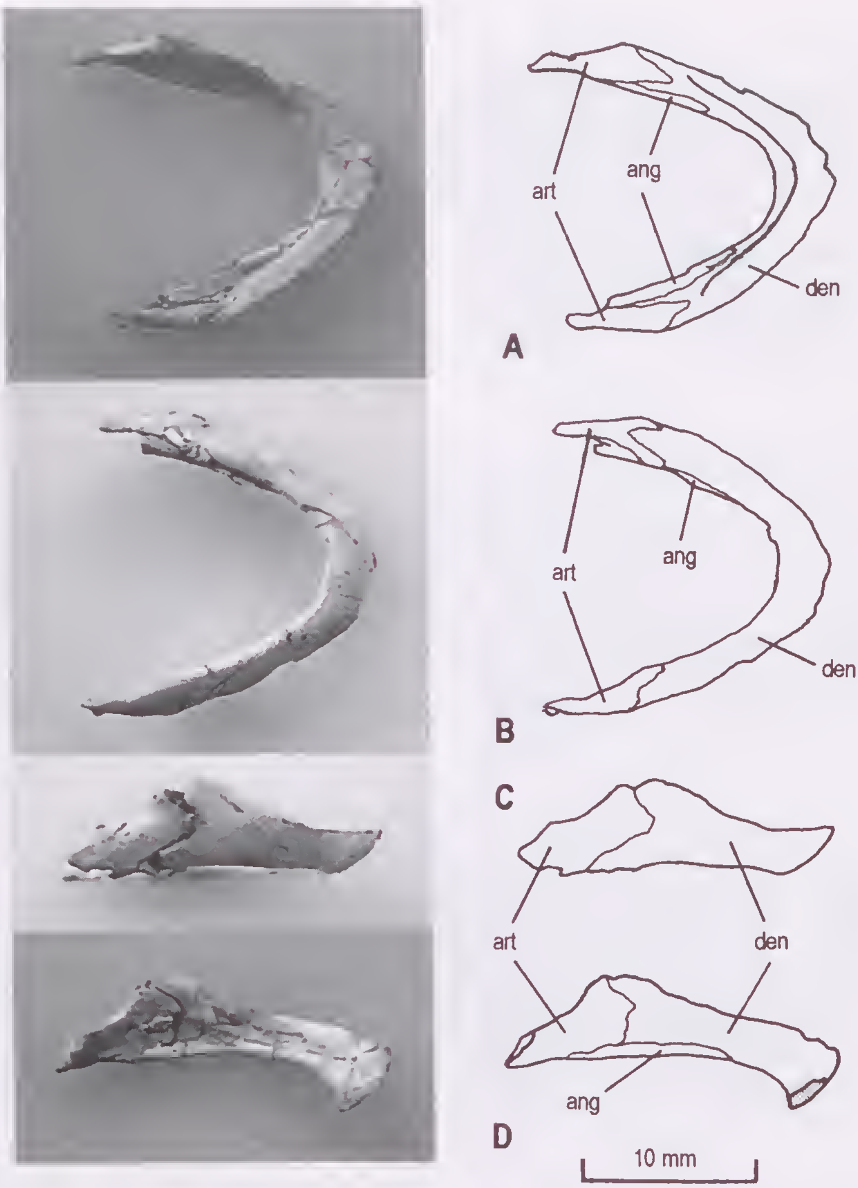


Fig. 10. *Birlimarr gaffneyi* gen. et sp. nov. mandible P9215-1 in: **A**, dorsal view; **B**, ventral view; **C**, right lateral view; and **D**, internal view of left ramus.

was made at reconstruction as they appear at present to be of only minor systematic utility, as outlined in the following section.

Comparative remarks. P9215-1 and referred material represents a small species of short-necked chelid. Lacking the diagnostic characters of *Pseudemydura*, its affinities are clearly with the Emydurodd. *Birlimarr gaffneyi* gen. et sp. nov. lacks the diagnostic shell and/or skull characters of *Rheodytes* and *Elusor*; but a unique suite of skull and carapace character states preclude its inclusion in *Emydura*, the *Elseya dentata* generic group, or the *Elseya latisternum* generic group (Tables 1-3). It is therefore placed in its own genus, *Birlimarr* gen. nov.

The phylogenetic relationships of *Birlimarr* gen. nov. to other short-necked genera are investigated below.

The pterygoid of *Birlimarr gaffneyi* gen. et sp. nov. is not identical in shape to any other chelid examined. The anterior suture with the palatine is almost straight, and oriented at 45° to the axis. In other chelids it is variously straight or concave forward, but perpendicular or sub-perpendicular to the axis (using the chord of the concavity where the suture is not straight). Another distinctive feature of *Birlimarr gaffneyi* gen. et sp. nov. is the length and anterolateral orientation, in ventral view, of the pterygoid-quadrate suture. In other forms, this suture appears to extend laterally from the pro-otic before swinging anteriorly at right angles towards the posterior face of the temporal fossa, medial to the articular surface for the mandible. No phylogenetic significance can be attached to these features at this stage, but they help diagnose the new genus and species.

The only previously described mid Tertiary fossil forms that appear to have any particular similarities to *Birlimarr gaffneyi* gen. et sp. nov. are QM F31304 from Melodies Maze Site, Miocene Carl Creek Limestone of Riversleigh, western Queensland (White 1997), and '*Emydura* sp.' from the Oligocene or Miocene of Taroona, Tasmania described by Warren (1969). The Queensland specimen (White 1997: fig. 2) is accompanied by a highly schematic interpretation of the carapacial scute pattern (White 1997: fig. 3), which at first glance suggests a form quite distinct from *Birlimarr gaffneyi* gen. et sp. nov., partly, as pointed out to us by S. Thomson, because 13 marginal scutes per side are depicted. Thirteen marginal scutes in QM F13304 would seem to be a misinterpretation (Fig. 13), being otherwise only known in the Tribe Carettini of the Cheloniidae, which has both an extra marginal scute and peripheral bone (Zangerl 1969; Gaffney and Meylan 1988).

Amongst the similarities between P9215-1 and QM F31304 (Figs 5, 13, 14) are: small adult size (approximate carapace length: P9215-1, 160 mm; QM F31304, 100 mm); vertebral scute pattern; proportionally large nuchal (as indicated by negative space in QM F31304); regular oval outline with no flare over the hindlimbs; and broad, well-defined, parallel-sided bridge carapace

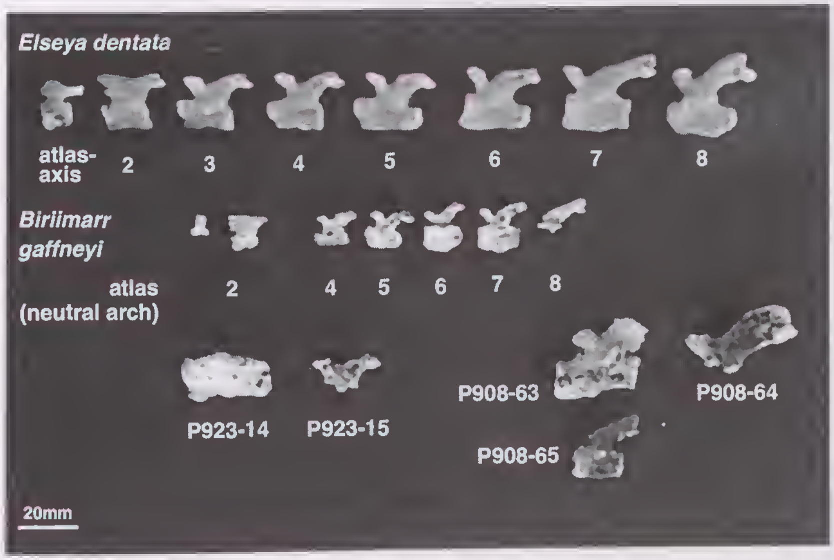


Fig. 11. Cervical vertebrae of *Birlimarr gaffneyi* gen. et sp. nov. (P9215-1) compared with an *Elseya dentata* series (R.24818) and various isolated fossil cervicals. P923-14 (Site X), procoelous centrum, therefore cervical 2, 3 or 4; P923-15 (Site X), neural arch most closely resembling cervical 4 of *E. dentata*; P908-63 and P908-65 (Blast Site), vertebrae with biconcave centra, therefore cervicals 7; P908-64, neural arch most closely resembling cervical 8 of *E. dentata*.

Table 2. Comparison of carapacial seam contacts (following Legler and Cann 1980, after Tinkle 1962). The formula indicates the position at which interlateral scale seams contact marginals scales: seam A = pleural 1 – vertebral 1 seam; seams B,C,D = 3 interpleural seams, anterior to posterior; seam E = pleural 5 – vertebral 5 seam. The letters A (anterior), M (medial), and P (posterior) appended to the marginal scute number indicate the position of seam contact on the marginal. *Rheodytes* is unique (autapomorphous) in having seams C and D contacting scales 6 and 8, in contrast to the usual condition of contact with marginals 7 and 9. * indicates Oligocene or Miocene fossil material.

Taxon / specimen	**Source**	**Carapacial seams**				
		A	**B**	**C**	**D**	**E**
**Birlimarr gaffneyi* gen. et sp. nov. NTM P9215-1	Figs 5, 14	2M	5A	7M	9M	11A
All *Elseya* spp and *Emydura* spp	Cann and Legler 1980	2	5	7	9	11
Rheodytes leucops	Legler and Cann 1980	2M	5A	6P	8P	11A
Elusor macrurus	Cann and Legler 1994: fig. 1	2M	5M	7M	9A	11A
* '*Emydura* sp.' UCMP 77348, Wipajiri Ftn	Fig. 14 (Gaffney 1979: fig. 12)	2M	5M	7M	9M	11A
*'*Emydura* sp.' NMV P159937 Namba Ftn	Fig. 14 (Burke *et al.* 1983: fig. 2)	2M	5M	7M	9M	11A
*'*Emydura* sp.' Tasmania UTG 86978	Fig. 14 (Warren 1969: fig. 1)	2M	5M	7P	9A	11M
*'Genus indet. A' QM F13304 Carl Creek Lst	Figs 13, 14 (White 1997: fig. 2)	2M	5M-	7P	9A	11A

suture on the internal surface of costal 1. However, unlike the P9215-1 carapace, QM F13304 is low and flat, there is an axial depression, peripherals 3, 4, 5 and part of 6 curve ventrally so that the carapace margin is rounded onto the bridge, and there is a prominent, ventrally-projecting crest between the rib head and the medial margin of the bridge carapace suture on pleural 1 (White 1997). White (1997) concluded that QM F31304 could not be placed in any of the extant chelid genera, and consequently designated it 'Genus indet. A'. It is here referred to cf. *Birlimarr* sp. indet., on the basis of the similarities listed above.

Birlimarr gaffneyi gen. et sp. nov. also has some similarities to the chelids described by Warren (1969) from the Oligocene or Miocene of Tasmania, referred to *Emydura* sp., in: small adult size; similar vertebral scale pattern; and apparent lack of flaring over the hind legs (Fig. 14 - note that some distortion of the shell is evident). However, the plastron of the Tasmanian form, of which a composite reconstruction of three individuals is depicted, differs from *Birlimarr gaffneyi* gen. et sp. nov. in having much slimmer proportions and smoothly tapering anterior and posterior lobes. There are insufficient data available to make a new judgement about the generic affinities of Tasmanian fossils.

Other described Miocene carapaces (Fig. 14) differ from *Birlimarr gaffneyi* gen. et sp. nov. in their considerably greater adult size and contrasting vertebral scale pattern, as well as in other osteological details that are discussed below under comparative remarks for gen aff. *Elseya/Emydura* sp. indet. Fragmentary '*Emydura* sp.' skull material

Table 3. Comparison of plastral formulae, after Legler and Cann (1980). The formulae indicate the relative interlaminal lengths of plastral scales. The preservation of *Birlimarr gaffneyi* gen. et sp. nov. (P9215-1) permits only measurements from the left to be taken (Fig. 5). It appears that only in *Birlimarr gaffneyi* gen. et sp. nov. and *Elusor* is the pectoral scale longest, and only in *Birlimarr gaffneyi* gen. et sp. nov. and the *Elseya latisternum* group is the femoral not amongst the three longest scales. * indicates Oligocene or Miocene fossil material.

Taxon / specimen	**Source**	**Plastral formula**
**Birlimarr gaffneyi* gen. et sp. nov. NTM P9215-1	Figs 5, 14	pectoral (33.0 mm) > abdominal (28.8 mm) > intergular (26.5 mm) > femoral (23.3 mm) > anal 21.2 (mm)
Elseya dentata group	Legler & Cann 1980: table 1	femoral > pectoral > abdominal(50%): femoral (79%) or pectoral (21%) longest
Elseya latisternum group	Legler & Cann 1980: table 1	anal > pectoral > intergular (24%): anal (73%), femoral (10%) or pectoral (10%) longest
Emydura spp	Legler & Cann 1980: table 1	pectoral > femoral > abdominal (48%): pectoral (78%) or femoral (21%) longest
Elseya georgesi	Cann 1997	femoral>intergular>anal>humeral
Elseya irwini	Cann 1997	femoral > pectoral > abdominal > anal
Rheodytes leucops	Legler & Cann 1980: table 1	femoral > pectoral > anal (41%): femoral always longest (100%)
Elusor macrurus	Cann & Legler 1994	pectoral > femoral > anal <u>or</u> (pectoral ~= femoral) > anal
*'*Emydura* sp.' Tasmania UTG 86978	Fig. 14 (Warren 1969: fig. 1)	femoral > abdominal > anal ~= humeral ~= pectoral
* '*Emydura* sp.' UCMP 77348, Wipajiri Ftn	Fig. 14 (Gaffney 1979: fig. 13)	femoral > pectoral > intergular > abdominal > anal

associated with the Miocene Etadunna Formation carapaces are very similar to extant *Emydura macquarrii* (Gaffney 1979a: figs 2-10), representing a larger species than *Birlimarr gaffneyi* gen. et sp. nov. The skull of the Etadunna Formation species is proportionally longer and narrower than *Birlimarr gaffneyi* gen. et sp. nov., as evidenced by length to width proportions of, for example, the parietals and basisphenoid. Furthermore, the frontals lack a posteromedial process; the postorbitals are proportionally small and longer than wide in dorsal view; and the supraoccipital extended posteriorly beyond the level of the occipital condyle (Gaffney 1979b: figs 5A, 7A). Thus, to the extent that comparisons are possible, *Birlimarr gaffneyi* gen. et sp. nov. differs from Miocene *Emydura* sp. material from South Australian deposits in the same respects as it does from extant *Emydura* spp.

Birlimarr gaffneyi gen. et sp. nov. shows the typical 'short-necked' condition in which the cervical vertebral series is shorter than the dorsal series. Gaffney (1979a) interprets the condition of the cervical series being longer than the dorsals as a synapomorphy of the subtribe Chelina (Fig. 1). P9215-1 would appear to be one of the few Australian fossil specimens in which this particular character can be assessed. Atlas-axis morphology appears to be of utility and

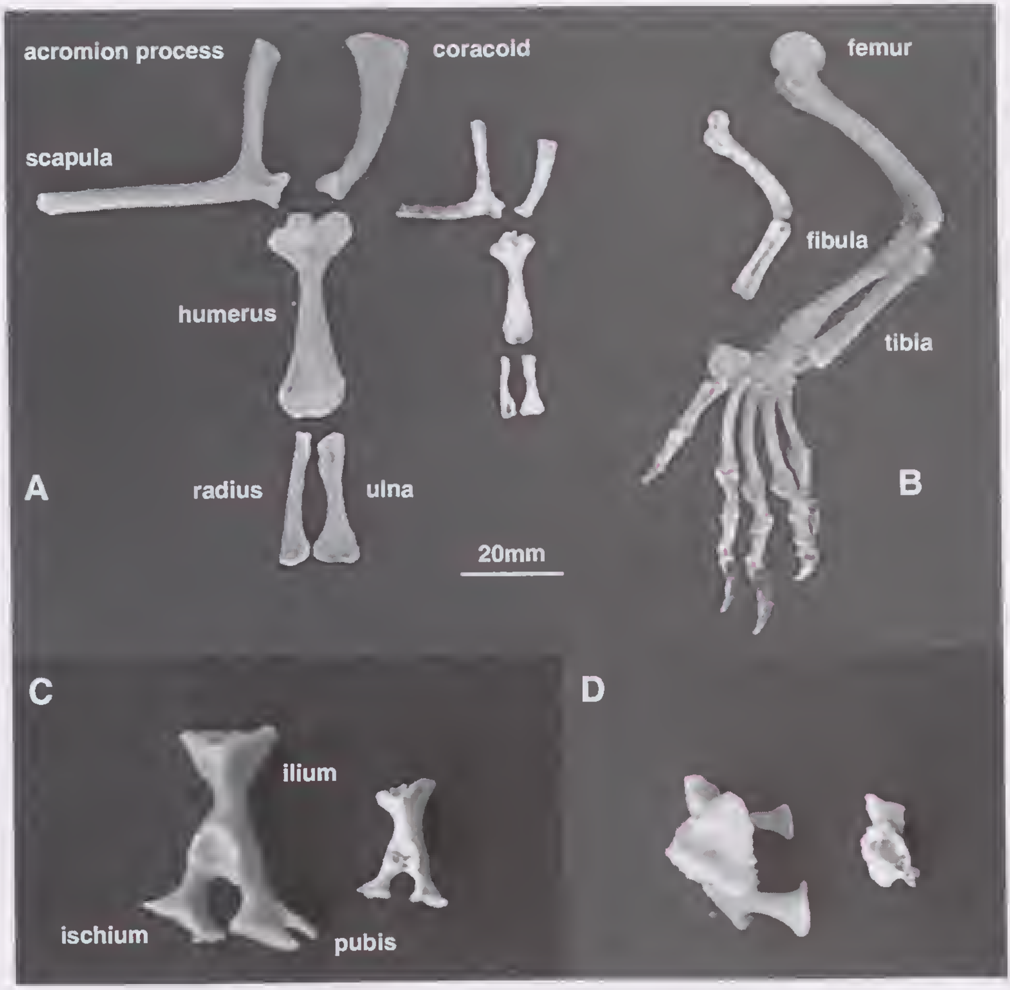


Fig. 12. Appendicular elements of holotype *Birlimarr gaffneyi* gen. et sp. nov. (P9215-1) compared with *Elseya dentata* (R.24818). The fossil is the smaller individual. **A**, disarticulated right forelimbs, in dorsal view (scapula rotated into the plane of the other elements); **B**, articulated left hind limbs in dorsal view; **C**, left innominates in lateral view; **D**, left innominates in dorsal view, anterior to the top.

further potential in the resolution of chelid phylogeny, exhibiting character states that can readily be interpreted as synapomorphies (Gaffney 1979a: 20-21). The atlas-axis complex of P9215-1 is represented only by the incomplete left neural arch of the atlas, and is very similar to that of *Elseya dentata*. The specimen is sufficient to determine two of the suite of primitive states found in *Elseya* plus *Platemys* (? plus *Pseudemydura*), namely that the atlas-axis zygapophyseal articulation is oriented ventrolaterally rather than horizontally; and that the atlantal elements were loosely articulated rather than fused.

At present, and perhaps mostly due to the lack of comparative studies, the appendicular skeleton of chelids is of minor systematic use. Gaffney (1979a) reports that *Chelodina* consistently differs from *Emydura* in having fused distal carpals 5 and 4 and sometimes also 3. No fused carpals were collected with P9215-1.

Etymology. Named *gaffneyi*, in recognition of Eugene Gaffney's (American Museum of Natural History) many

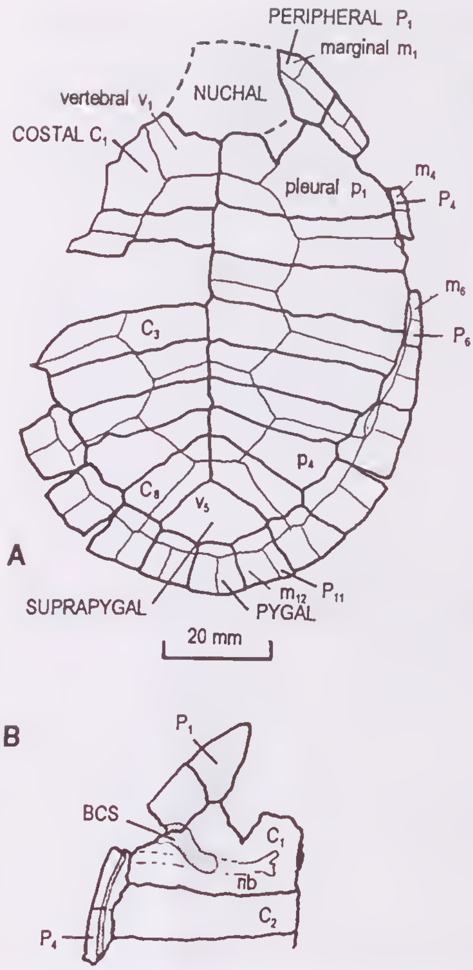


Fig. 13. Interpretative diagram of the osteology and scale pattern of the Miocene Carl Creek Limestone carapace QM F31305. **A**, dorsal view; **B**, internal view of the right anterior portion showing the morphology of the bridge – carapace suture BCS (after White 1997: fig.2).

contributions to Australian vertebrate palaeontology.

Genus aff. *Emydura/Elseya* sp. indet.

(Figs 15-18, Tables 1-3)

Reference specimen. P9464-134 (Top Site), incomplete carapace, and posterior lobe of plastron in which neither xiphiplastron is complete.

Referred material. P895-67 (Blast Site), anterior carapace fragment comprising the nuchal, left pleural 1 and left peripherals 1 to 3; P895-80 (Blast Site), nuchal; P9464-136 (Top Site), nuchal; P9464-155 (Top Site), right hypoplastron with anterior portion of xiphiplastron; P923-8 (Site X), left hypoplastron; P87106-17 + P925-6 (Site Y), right hypoplastron; P8692-23 (Blast Site), left hypoplastron; P923-7 (Site X), left pleural 1; P927-4 (Site Y), right costal 8.

Diagnosis. Large species of Emydurodd (up to 44 cm carapace length) most similar to extant species of *Emydura* and *Elseya*. Carapace evenly domed, lacking axial ridge, depression or flattening; probably evenly oval in outline rather than flared laterally over the hind legs. Posterior lobe of plastron tapering immediately behind the bridge (anterior lobe not known). Proportionally small cervical scute present on nuchal. First vertebral scute as wide as fifth, both wider than vertebrals 2, 3 and 4 which are about equal in width to each other. Vertebral 1 wider than long, vertebrals 2, 3 and 4 longer than wide, vertebral 5 probably about as long as wide. Interpleural seams intersect marginals 5, 7 and 9. Bridge carapace suture on pleural 1 diverges anterolaterally from trace of rib, well-defined sutural surface with sub-parallel anterior and posterior margins. Trace of rib on pleural 1 straight (no distal posterior curvature).

Description. The comparison below of isolated entoplastra suggests that two large species allied to *Emydura/Elseya* are present in the assemblage. Unfortunately the more informative anterior lobe of the plastron of the P9464-134 individual is not represented, and consequently this taxon can at this stage only be diagnosed by the carapace and posterior lobe of the plastron.

Carapace. P9464-134 has most of the paired bones of the carapace represented on one side or the other. Missing completely are peripherals 2, 3 and 10, and the pygal (Fig 15A, B). Peripherals 2 and 3 are, however, represented on referred specimen P895-67 (Fig. 16). The following observations of the general shape and dimensions of P9464-134 are based on the graphical reconstructions shown in Figure 15C. P9464-134 probably

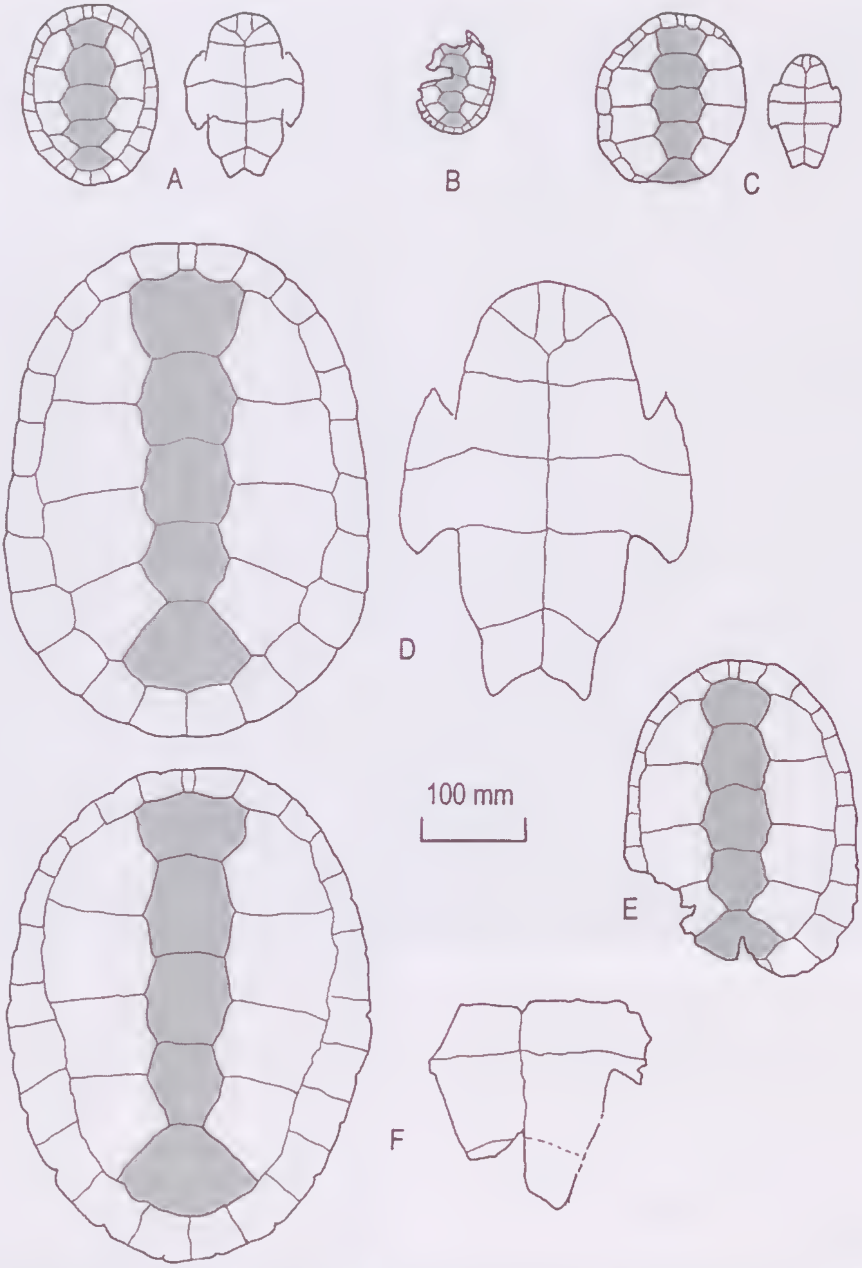


Fig. 14. Comparison of Oligocene and Miocene Emydurodd carapaces and plastra drawn to the same scale, vertebral scutes stippled. **A**, Miocene Camfield Beds of the Northern Territory *Birlimarr gaffneyi* gen. et sp. nov., NTM P9215-1; **B**, Miocene Carl Creek Limestone of Queensland, QM F13305, 'Genus indet A' (after White 1997: fig. 2 – see Figure 13 for details); **C**, Oligocene or Miocene of Taroona, Tasmania '*Emydura* sp.', carapace UTG 86978, plastron composite of MUZ 1204, 1205, and UTG 59374 (after Warren: 1969: fig. 1); **D**, Miocene Wipajiri Formation of South Australia, UCMP 77348, '*Emydura* sp.' (after Gaffney 1979: figs 12, 13); **E**, Miocene Namba Formation of South Australia, NMV P159937, '*Emydura* sp.' (after Burke et al. 1983: fig. 2); **F**, Miocene Camfield Beds of the Northern Territory, gen. aff. *Elseya/Emydura* sp. indet., NTM P9464-134.

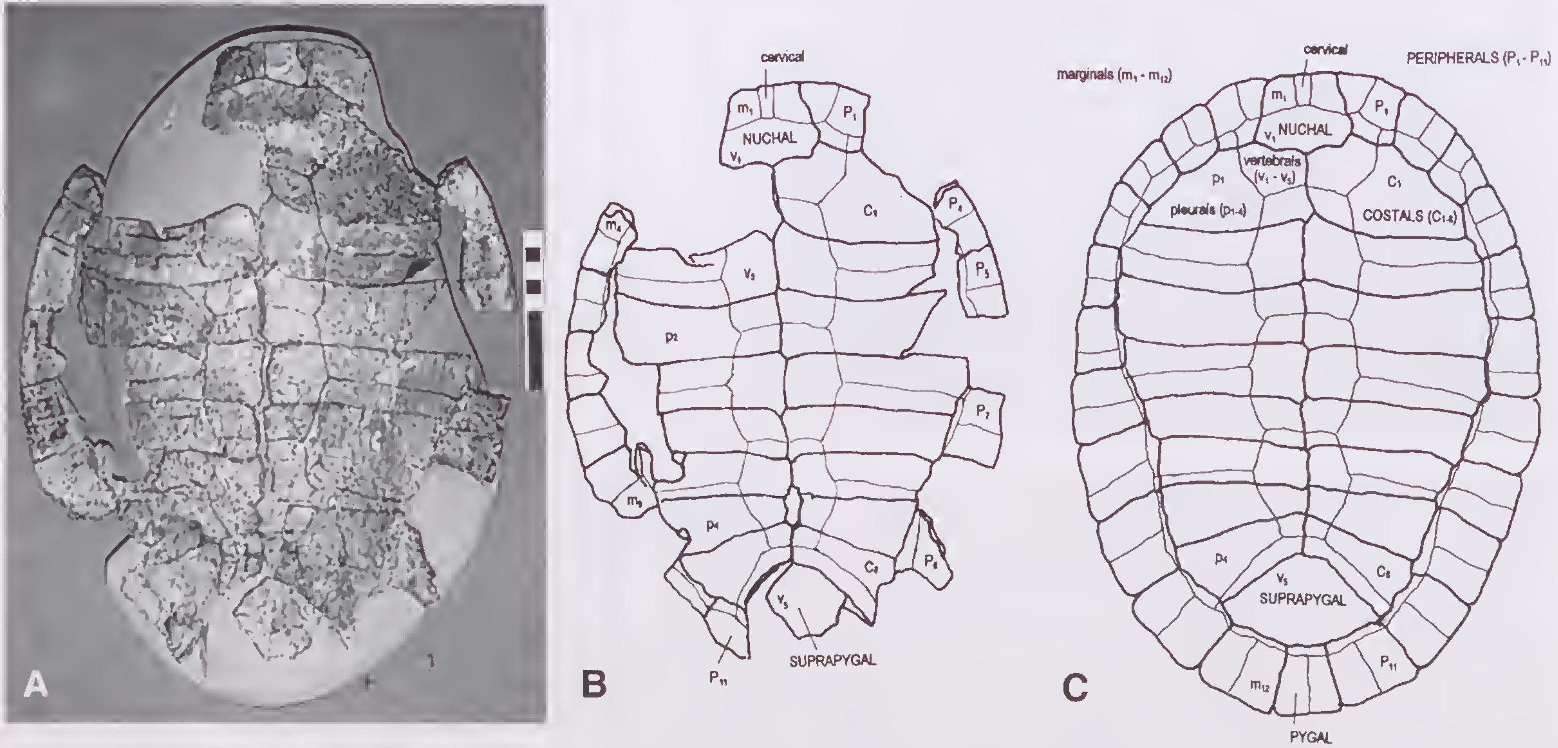


Fig. 15. Gen. aff. *Emydura/Elseya* sp. indet. P9464-134. **A**, dorsal view of carapace. **B**, interpretive diagram. **C**, restoration. Bones delimited by heavy lines and labelled in upper case, scutes delimited by fine lines and labeled in lower case. The two posterior peripherals of the specimen are highly abraded, a quite common feature in aged individuals. The restored outline of the posterior part of the carapace is therefore conjectural, but the outline of the whole carapace was clearly oval rather than flared laterally over the hind legs.

represents an aged individual, as evidenced by the heavily abraded posterior peripherals and extensive pathological modification of the surface of the shell. The effects of abrasion are conservatively compensated for in the graphical reconstruction in order to give an impression of what the likely shape and proportions of a more typical adult specimen of the species might have been.

In restored dorsal view (Fig. 15C), the carapace has a maximum estimated length of 44 cm, and maximum estimated width at about peripheral 7 of 30 cm. Although the posterior outline of restored shell is conjectural, there is little possibility that the carapace flared laterally over the hind legs. Any flaring would require remarkably wide peripherals at the level of the hind legs, and no such indicators are present amongst the many isolated posterior peripherals in the Bullock Creek LF assemblage. A notable feature of P9464-134 is the 'keyhole' outline of the pleurals plus suprapygal. This is a real feature, and definitely not attributable to distortion or displacement. Assuming that P9464-164 is not an aberrant example of the species, the indications are that the shell of this taxon was either regularly oval in outline as shown in Figure 15C, or possibly widest anteriorly and tapering posteriorly if the width of the posterior peripherals was fairly even. The carapace is smoothly domed, with no axial ridge or depression. Peripherals 4 to 7 are slightly upturned, with all other represented marginal bones very gently upswept.

A small cervical scute area is present on the nuchal. The first vertebral scute is wider than it is long. Vertebral 5 is about as long as it is wide, the width closely matching that of vertebral 1. In contrast, the intervening vertebrals are distinctly narrower than 1 and 5, and markedly longer than they are wide. The three intermediate vertebrals show a slight progressive reduction in size from anterior (vertebral 2) to posterior (vertebral 4). The interpleural seams intersect marginal scutes 5, 7 and 9 (Table 2).

The bridge carapace suture on pleural 1 (Figs 16, 17) is deep and well defined, diverging anterolaterally from the trace of the rib. The sutural area is just slightly wider medially than it is laterally.

Plastron. The plastron of the reference specimen, P9464-134, is represented by the hyoplastra and incomplete xiphiplastra (Fig.18). The proportions suggest that the whole plastron was narrow relative to its length. The posterior lobe begins to taper immediately posterior to the bridge, and the profile in ventral view of the femoral and anal scute areas is smoothly confluent, with barely any lateral bulge of the femoral area.

Comparisons made below of isolated hypoplastra support the notion that at least two large chelid species are present, but two or more forms amongst large xiphiplastra could not be discriminated. Larger hypoplastra showing evidence of taper immediately posterior to the bridge are tentatively referred to this taxon: *Chelodina* sp. B grows to at least moderately large size, but its hyoplastron is not known.

A proviso must be attached to the referral of P895-67 (Fig. 16) to this taxon. Associated with the specimen was a large hypoplastron, P895-66 (Fig. 19), which is determined below to represent a form of hypoplastron different from the reference specimen of gen. aff. *Emydura/Elseya* sp. indet., P9464-134. We suspect that P895-67 and P895-66 are the same individual, but cannot demonstrate that this is the case, and therefore have classified them independently.

Comparative remarks. At an estimated 44 cm straight-line carapace length, P9464-134 is amongst the largest recorded short-necked chelids (the referred specimens, P895-67 and P923-7, have larger dimensions than the homologous parts of P9464-134). The Miocene Wipajiri Formation *Emydura* sp. carapace, UCMP 77348, described by Gaffney (1979a) has a straight line carapace length of 44.5 cm. Of the larger extant short-necked turtles, the largest recorded *Elseya dentata* is 40 cm, *Emydura* sp. is 35 cm, and *Elusor* estimated at 40 cm (Cann and Legler 1994: table 2). The holotype of the extant species *Elseya lavarackorum* is a fossil with a restored carapace length estimated at 42 cm (Thomson *et al*. 1997). White (1997) reports that chelids up to 50 cm long are present in the Miocene Carl Creek Limestone, but it is not apparent whether these are short-necked forms or *Chelodina*. The largest *Chelodina* known to Cann and

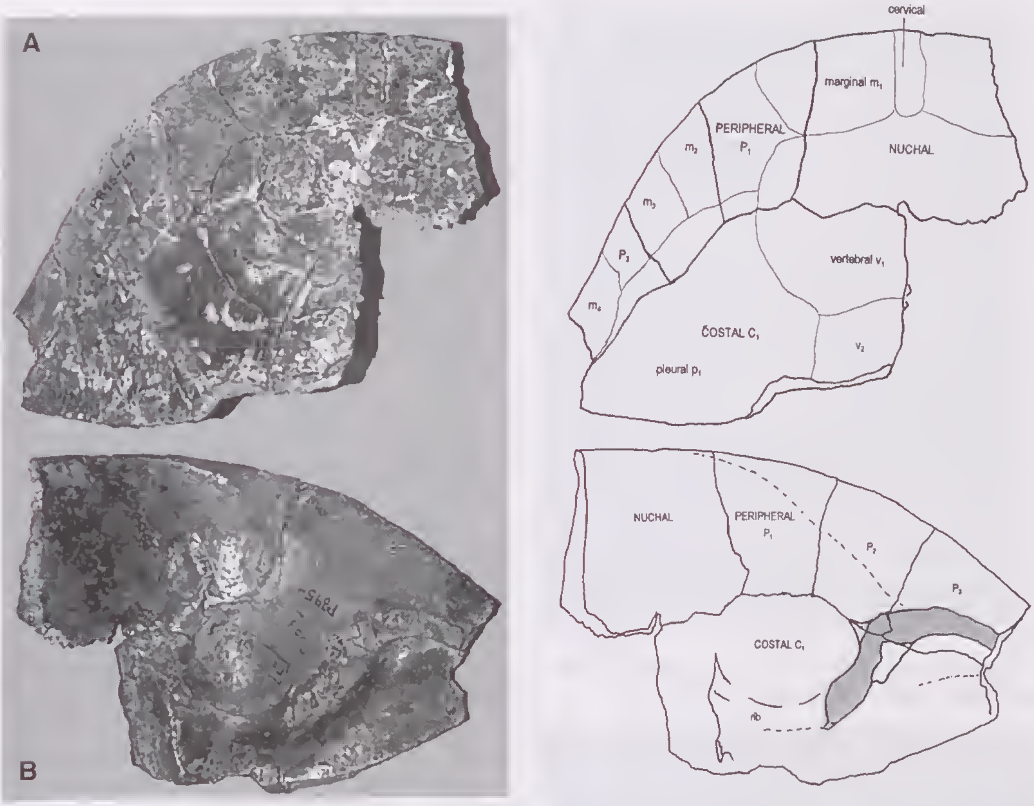


Fig. 16. Gen. aff. *Elseya/Emydura* sp. indet. referred specimen P895-67 in **A**, dorsal view; **B**, internal view showing relationships of scutes (lower case labels) and bones (upper case), and form and extent of the bridge carapace suture (BCS - stipple).

Legler (1994: table 2) is a '*C. (expansa)*' of 48.5 cm carapace length.

P9464-134 is similar to carapaces described from South Australian Miocene deposits (Fig. 14), in particular the Wipajiri Formation carapaces (UCMP 77348 and 72492) described by Gaffney (1979a), and the Namba Formation carapace (NMV P159937) described by Burke *et al.* (1983), in having the first vertebral scute wider than the second, though the difference is more pronounced in P9464-134 (see also referred specimen P895-67 - Fig. 16). Thompson *et al.* (1997) identify a first vertebral wider than the second (and third) as a diagnostic character of the *Elseya dentata* generic group (Fig. 20: character D). In all other short-necked chelids, the first vertebral is equal or sub-equal in width to the second vertebral. The bridge carapace suture on pleural 1 of NMV P159937 (Burke *et al.* 1983: fig. 2B) is of the same morphology as that of P9464-134. Thomson *et al.* (1997) indicate that this morphology is characteristic of *Rheodytes* and the Queensland *Elseya* species complex of the *Elseya dentata* generic group (Fig. 20: character B, state 2). All the Miocene carapaces compared here have the typical interlateral seam formula of short-necked chelids, rather than the unique state of *Rheodytes* (Table 2). While the indications from Thomson *et al.* (1997) are that the Miocene forms listed above may be allied to the *Elseya dentata* generic group, and possibly even to the Queensland *Elseya* species complex, none of the Wipajiri Formation maxillae described by Gaffney (1979) have the medial triturating ridge characteristic of *Elseya dentata*. This observation does not necessarily preclude the Miocene forms from an *Elseya dentata*

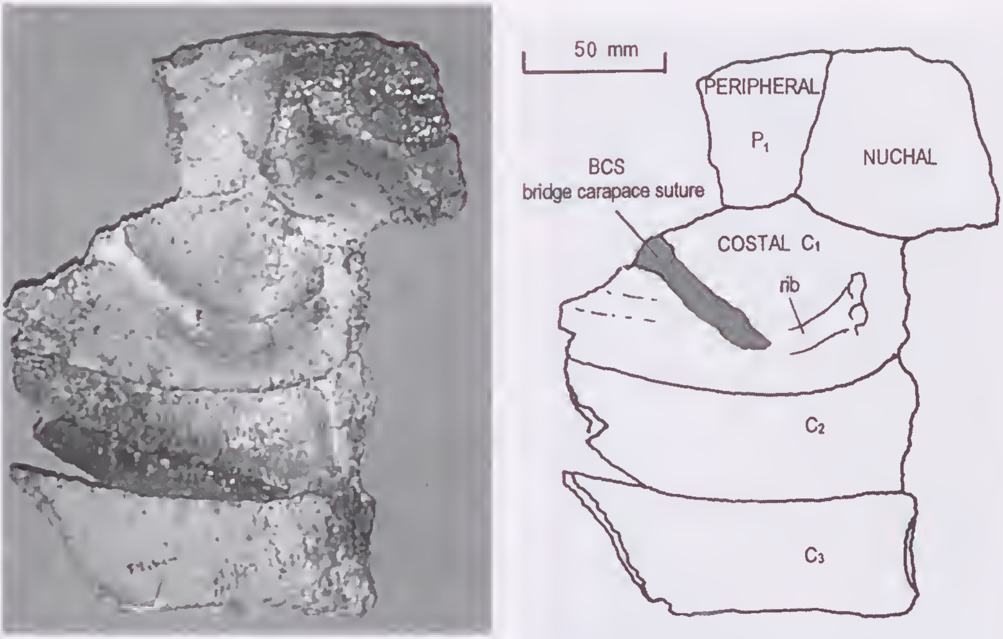


Fig. 17. Gen. aff. *Elseya/Emydura* sp. indet. reference specimen P9464-134, showing the form and shape of the bridge carapace suture on costal 1.

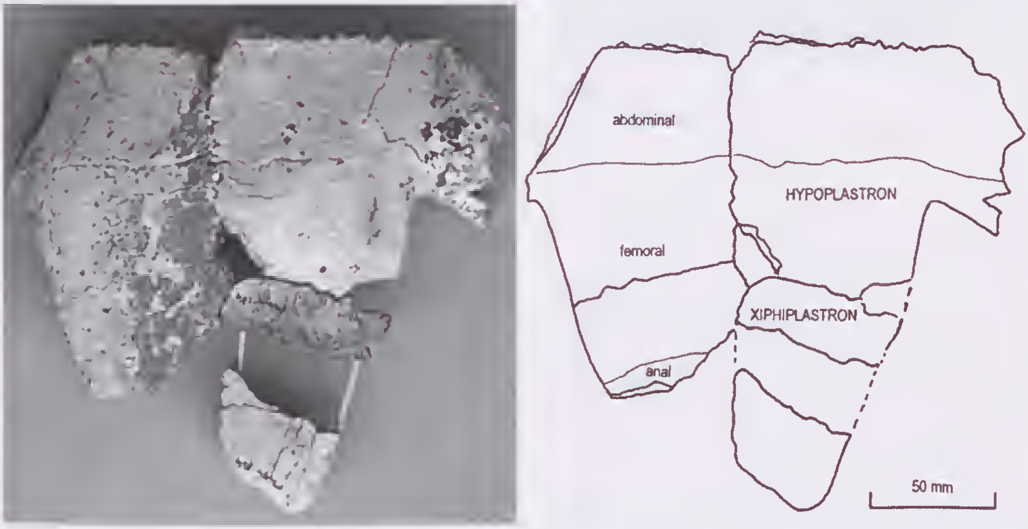


Fig. 18. Gen. aff. *Elseya/Emydura* sp. indet. reference specimen P9464-134, ventral view of the posterior plastral lobe.

generic group, but until the systematic significance of these skull and carapace characters are better understood, we prefer to designate P9464-134 and referred material to gen. aff. *Emydura/Elseya* sp. indet.

Several characters of the kind that are useful for distinguishing extant species suggest that P9464-134 and referred material may not be the same species as the South Australian forms (Fig. 14). In P9464-134 the

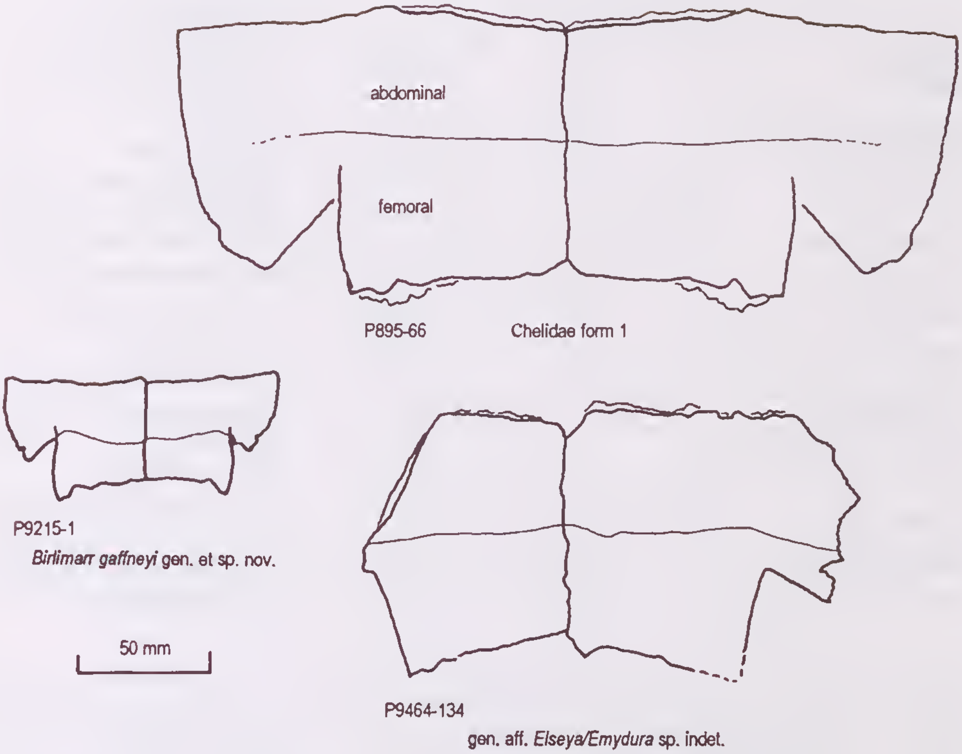


Fig. 19. Hypoplastra. NTM P895-66 (Chelidae form 1) is mirrored.

first vertebral is proportionally shorter, vertebrals 2-4 are narrower, and the trace of the pleurals plus suprapygal is key-hole shaped rather than regularly oval. The South Australian carapaces flare out at about peripheral 8, but as indicated above, a flared margin was probably not a feature of the Bullock Creek form. Finally, the posterior plastral lobe tapers immediately posterior to the bridge, whereas the margins of the proximal posterior lobes of the South Australian examples are parallel.

Chelodd Gaffney, 1977
Chelodina sp. A
(Fig. 21, Table 4)

Reference specimen. NTM P908-49 (Blast Site), right epiplastron.

Referred material. None - other Bullock Creek LF *Chelodina* material described below from isolated bones cannot be assigned to *Chelodina* sp. A until more complete individuals are discovered.

Diagnosis. Diagnosed only by the epiplastron. A species of *Chelodina*, on the grounds that gular scutes are in medial contact anterior to intergular. Anterior margin of plastron describing a segment of a circle; width of intergular scute about one third width of plastron across epi-hyoplastral suture; parallel-sided portion of intergular extends unknown distance onto entoplastron.

Description. Epiplastron P908-49 comes from a relatively small turtle, but it is not possible to ascertain what stage of maturity the individual represented may have attained, and therefore what size the species may have grown to. The following description is based on a mirrored restoration of the specimen (Fig. 21), which gives a more complete impression of the form of the distal portion of the anterior plastral lobe of the species, and facilitates comparison with living species. The anterior margin of the restored plastron

	A	B	C	D	E
Pseudemydura umbrina	0	1	0	1	0
Elseya latisternum generic group	0	1	0	1	0/1
Elusor macrurus	0	1	0	1	0
Rheodytes leucops	1	2	0	1	0
Elseya dentata generic group	1	3	1	2	1
Elseya novaguineae	1	3	1	2	0
Queensland *Elseya* species complex	1	2	1	2	1
Elseya lavarackorum	1	2	1	2	1
Emydura	1	4	1	1	0
***Birlimarr gaffneyi* gen. et sp. nov.**	1	1	1	1	0

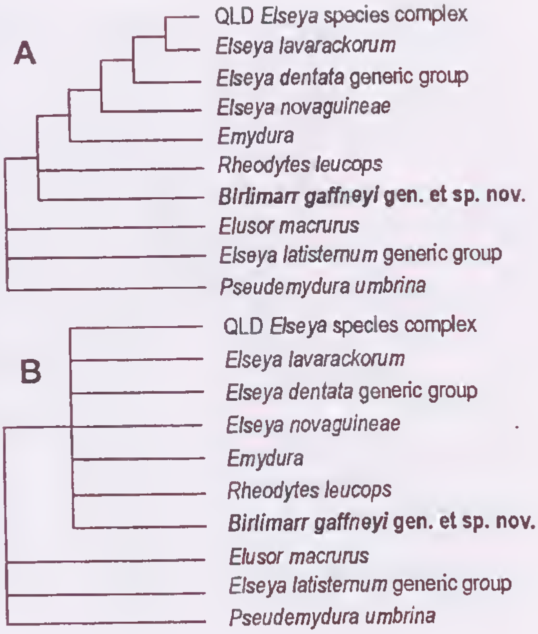


Fig. 20. Post-cranial character matrix after Thomson *et al.* (1997: table 1). Characters A to E are those of Thomson *et al.* but are expressed slightly differently here after clarification was sought from S. Thomsom. **Character A**, relationship of bridge carapace suture BCS to the trace of the rib on pleural 1: 0 = parallel and adjacent, 1 = anterolaterally divergent. **Character B**: BCS shape on pleural 1, ordered multistate: 1 = anterior and posterior edges diverge, widest distal to vertebral column, 2 = anterior and posterior edges essentially parallel, with prominent suture surface between them; 3 = prominent suture surface with marked medial constriction; 4 = sutural surface widest proximal to vetebral column, constricting distally to form a ridge, i.e. essentially no sutural surface distally. **Character C**: rib morphology, pleural: 0 = distal part of rib inflected posteriorly, rib rotated along its axis; 1 = no distal posterior inflection, no axial torsion (axial rotation of the rib may only be apparent if the tip is free of the peripheral gomphosis). **Character D**, relative widths of vertebral scales, unordered: 1 = vertebrals 1 to 3 equal or sub-equal, 2 = vertebral 1 wider than 2 and 3. **Character E**: cervical scute: 0 = usually present, 1 = usually absent. Consensus trees of **A**, two equally short trees, state 1 of Character D set as plesiomorphic; **B**, 24 equally short trees, state 2 of Character D set as plesiomorphic (Hennig86, Version 1.5 – Farris 1988). Identical results obtained whether Character E of *Elseya lavarackorum* generic group set at 0 or 1.

describes an arc of a circle, but not quite a complete semi-circle. Medial contact of the gular scutes anterior to the intergular is diagnostic of *Chelodina*. The intergular occupies less than one third of the posterior width across the combined epiplastra. The parallel lateral margins of this scute extended onto the entoplastron, and no part of its contact with the pectorals is present on the epiplastra. The pectoral scutes are represented on the posteromedial extremities of the epiplastra, the humeral pectoral contacts thereby intersecting the epi-hyoplastral sutural surface.

Comparative remarks are made below under *Chelodina* sp. B.

Chelodina sp. B
(Fig. 21, Table 4)

Reference specimen. NTM P9272-4 (Blast Site), left epiplastron.

Referred material. NTM P9464-147 (Top Site), right epiplastron; P895-72, (Blast Site),

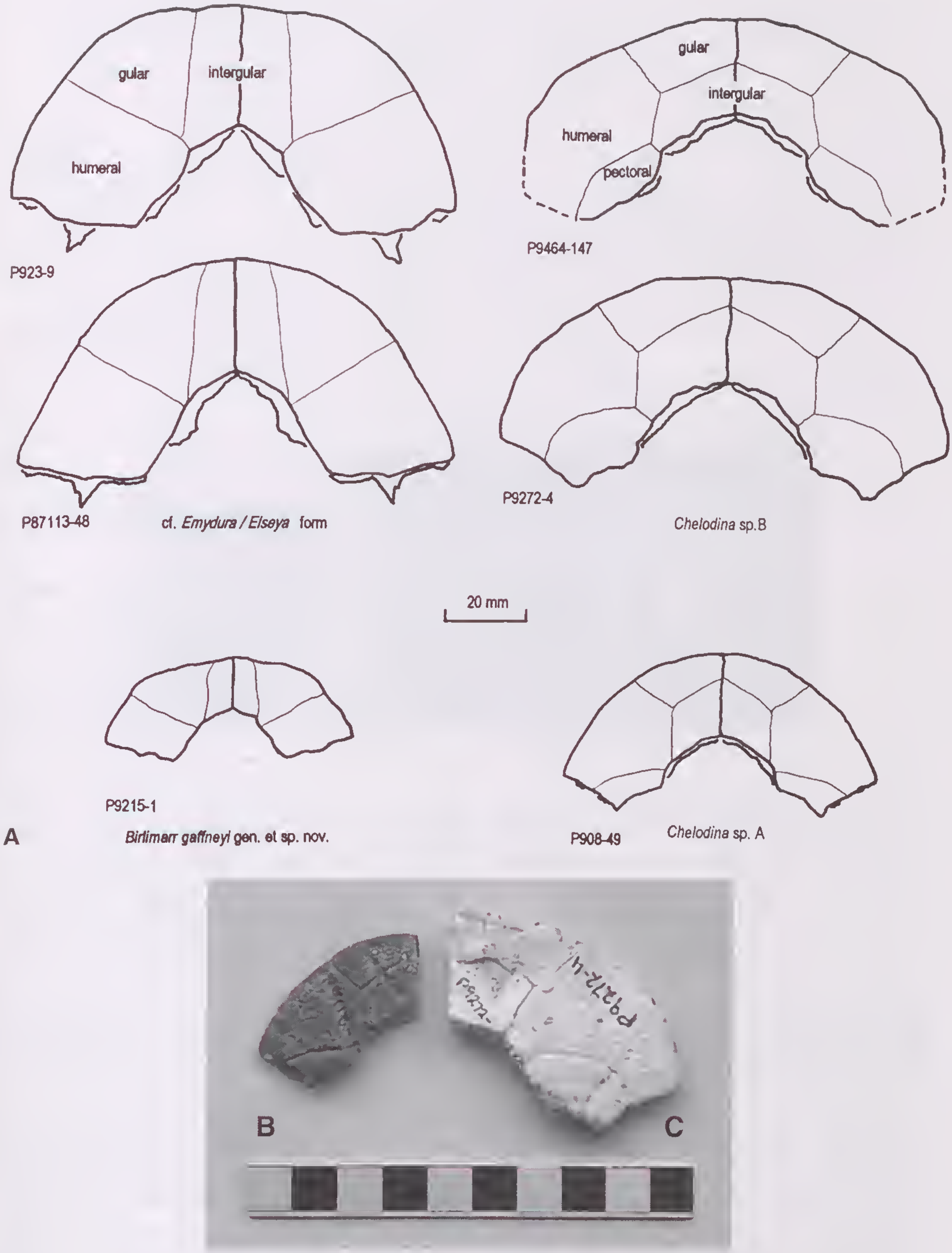


Fig. 21. Epiplastra. **A**, forms of epiplastra present in the Bullock Creek LF assemblage. Excepting *Birlimarr gaffneyi* gen. et sp. nov. P9215-1, each of the other specimens is mirrored. **B**, *Chelodina* sp. A reference specimen, P908-49. **C**, *Chelodina* sp. B reference specimen, P9272-4.

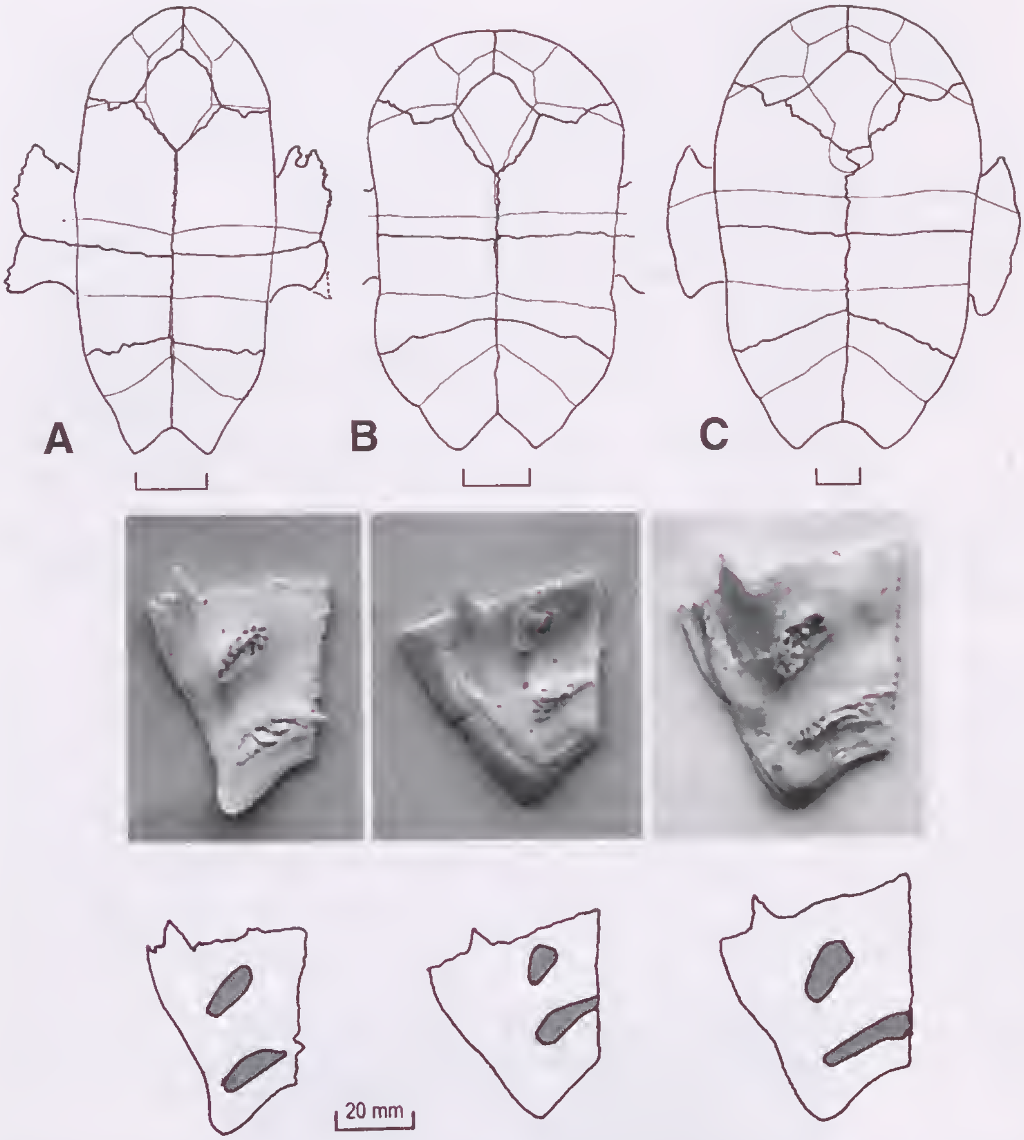


Fig. 22. Relationship of epidermal scales to bones in the plastra of selected extant *Chelodina* spp. and internal detail of the xiphiplastron: **A**, *C. rugosa* (R.24812); **B**, *C. longicollis* (R.24812); **C**, *C. novaeguineae* (R.16325). Individual elements can be identified by reference to Figure 5.

left epiplastron. No other Bullock Creek LF *Chelodina* material described from isolated bones can be assigned to *Chelodina* sp. B until more complete individuals are discovered.

Diagnosis. Diagnosed only by the epiplastron. A species of *Chelodina*, on the grounds that gular scutes are in medial contact anterior to intergular. Anterior margin of plastron squared off, rather than smoothly arced; width of intergular scute greater than one third width of plastron across epi-hyoplastral suture; parallel-sided portion of intergular entirely on entoplastra, tapering posteriorly an unknown distance onto entoplastron.

Description. As for *Chelodina* sp. A, the following description is based on a mirrored restoration of the specimen, in order to give

Table 4. Epiplastra – measurements and classification. Measurements in italics are estimates.

	Birlimarr gaffneyi gen. et sp. nov.				cf. *Elseya/Emydura* form			*Chelodina* sp.A	*Chelodina* sp.B		
	L	R	L	L	L	R	R	R	L	R	L
	P9215-1 holotype		P9612-2	P906-22	P923-9	P87113-48	P87103-51	P908-49 reference	P9272-4 reference	P9464-147	P895-72
Intergular extends to anterior free margin of plastron	yes	yes	yes	yes	yes	yes	yes	no	no	no	no
L1	11.8	11.8	13.1		28.4	26.2	*40.0*	17.2	25.5	22.1	22.5
L2	25.3	*25.7*	26.9		51.4	49.2		36.3	50.4	*47.1*	
W1	27.3	29.8	*32.0*		53.8	50.0		36.8	53.6	49.5	
W2	17.4	18.1	*18.0*	19.7	31.5	28.5		15.3	22.7		
L1/W1	0.43	0.40	0.41		0.53	0.52		0.47	0.48	0.45	
L2/W1	0.93	0.86	0.84		0.96	0.98		0.99	0.94	0.95	
L1/W2	1.47	1.53	1.37		1.11	1.09		0.89	0.89		
L2/W2	1.45	1.42	1.49		1.63	1.73		2.37	2.22		
L1/L2	0.47	0.46	0.49		0.55	0.53		0.47	0.51		
Number of assigned individuals											10
Number of unassigned specimens											3
Minimum number of individuals											13

a more complete impression of the anterior portion of the plastron (Fig. 21).

Chelodina sp. B grew to a size comparable to that of the larger Emydurodd species in the assemblage. The anterior margin of the plastron is not smoothly arced, rather the progression is from a straight medial segment, to a gently arced intermediate segment, to a strongly (posteriorly) curved anterolateral segment. The anterior plastral lobe therefore has a somewhat squared-off profile, in which the margins of the posterolateral extremities of the epiplastra come close to being parallel to each other. *Chelodina* sp. B has the gular-intergular relationship diagnostic of the genus. The marginal parts of the parallel-sided portion of the intergular is entirely on the epiplastra, such that a small part of the postero-medially aligned pectoral-intergular contact is present on the epiplastra. The widest part of the intergular is a little greater than one third of the combined posterior width of the epiplastra. The pectoral humeral contacts cross the epi-hyoplastral sutural surface posteriorly.

Comparative remarks. The proportions of the two Bullock Creek *Chelodina* species are not much different (Table 4). However, *Chelodina* sp. A can be distinguished from *Chelodina* sp. B by its: rounded as opposed to squared off marginal profile of the anterior plastral lobe in ventral view; proportionally long inter-epiplastral contact; and proportionally narrower intergular. *Chelodina* sp. A has an epiplastral scute pattern similar to that of *Chelodina rugosa*, whereas that of *Chelodina* sp. B more closely resembles *C. novaeguineae* and *C. longicollis* in which the widest part of the intergular is entirely on the epiplastra (Fig. 22). P908-49 (*Chelodina* sp. A) resembles the epiplastron of *Chelodina* sp. QM F17415 from the Miocene Carl Creek Limestone described by Gaffney *et al*. (1989: fig. 2).

DESCRIPTION AND COMPARISONS OF ISOLATED AND INDIVIDUAL BONES

Introductory remarks. Small specimens that can only be interpreted as hatchlings or sub-adults are not assigned below to any form or referred to any of the taxa diagnosed above. Insufficient data have been published on sexual dimorphism and individual variability in Australian chelids to make any secure judgements about whether some of the recognised forms might represent the two sexes of the same species or possibly variants of a single morphospecies, and this issue receives no further attention at this time. The bones discussed below are those that were found to be most informative about possible species diversity amongst the entire Bullock Creek LF assemblage.

Epiplastra. Four forms can be distinguished on the basis of epiplastra: *Birlimarr gaffneyi*; a cf. *Elseya/Emydura* form; and *Chelodina* sp. A and sp. B. (Figure 21; Table 4). In the two *Chelodina* species, the intergular does not extend to the anterior margin, the gulars therefore coming in contact with each other at the midline, and the anterior part of the pectoral scute is present.

Birlimarr gaffneyi and the cf. *Elseya/Emydura* form have similar scute patterns, the gulars being entirely separated by the intergular with no part of the pectoral present, but they differ significantly in their proportions. *Birlimarr gaffneyi* has a proportionally short inter-epiplastral contact; the epiplastra are wide in proportion to their total length; the ventral profile is more strongly squared off; and the negative space for the anterior half of the entoplastron is proportionally short and wide. The two figured examples assigned to the cf. *Emydura/Elseya* form differ somewhat from each other. P923-9 has a more squared off ventral profile, compared to that of P87113-41 which is more smoothly arched. In the former, a small part of the humeral-intergular trace is present and the epi-hyoplastral suture is not as straight. However, these differences are not sufficient to propose that two similar but distinct forms are represented.

Entoplastra. Four forms are recognised amongst the sample of entoplastra (Table 5): *Birlimarr gaffneyi* (Fig. 5); cf. *Birlimarr* form; and cf. *Elseya/Emydura* forms 1 and 2 (Fig. 23).

Amongst Australian chelids, the intergular entirely separates the humerals and the anterior portion of the pectorals only in *Pseudemydura* and *Chelodina* (Gaffney 1977: table 3). In *Chelodina* the intergular covers almost the entire entoplastron, the intergular-pectoral grooves lying just medial to the ento-hyoplastral suture and coming together at the posterior tip of the entoplastron or extending onto the hyoplastra (Fig. 22). None of the isolated entoplastra of the Bullock Creek sample show these characters.

In *Birlimarr gaffneyi* the entoplastron is slightly wider than it is long, the intergular extends posteriorly for more than half the length of the bone, the interhumeral contact is short, and the anteromedial corners of the pectorals are present at the posterior margin. P907-44 matches in all these respects; P87103-48 differs only in that the intergular is shorter and the interhumeral contact longer. P87113-45 is just about as wide as it is long, the posterior tips of the gulars are present at the anterolateral margins, and the intergular extends posteriorly to about half way, but there is no trace of the pectorals. P907-44 and P87103-48, in spite of their similarity to the cf. *Birlimarr* form, cannot be assigned to that species on account of their considerably greater size, and are consequently assigned to cf. *Elseya/Emydura* form 1.

P87113-45 may represent an example of *Birlimarr gaffneyi*, but could conceivably also represent another species. It is assigned to cf. *Birlimarr* form on the grounds that there are no intermediate morphotypes which support its referral to the new species. A hyoplastron (P87103-50) of another individual conforms to P87113-45, adding weight to the possibility that another small

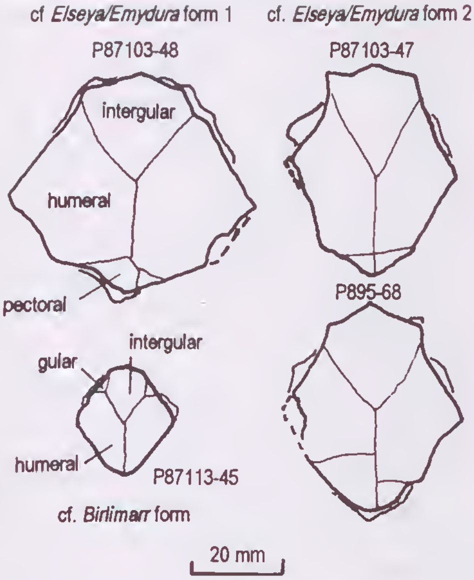
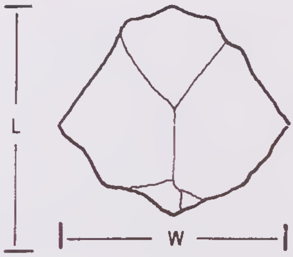


Fig. 23. Entoplastra.

Table 5. Entoplastra – measurements and classification. Measurements in bold = 2 x half-width. P9464-156 is determinate, but not measurable in the scheme used.



	Birlimarr gaffneyi gen. et sp. nov.			cf. *Birlimarr* form	cf. *Elseya/Emydura* form 1		cf. *Elseya/Emydura* form 2	
	P9215-1 holotype	P9464-157	P9464-156	P87113-45	P87103-48	P907-44 / -45	P87103-47	P895-68
L	21.3	24.4		24.1	48.2	48.8	46.5	45.3
W	24.1	**29.6**		22.5	54.8	*55.0*	38.0	**40.2**
L/W	0.88	0.82		1.07	0.88	0.89	1.22	1.13

Number of assigned individuals	8
Number of unassigned specimens	2
Minimum number of individuals	10

short-necked species is present in the assemblage.

P87108-47 and P895-68, assigned to cf. *Elseya/Emydura* form 2, are longer than wide, and the intergular extends posteriorly about half way. The pectorals are respresented posteriorly. These two specimens have proportions that conform most closely to epiplastra P923-9 and P87113-48.

Hyoplastra. The Bullock Creek sample can be sorted into four forms primarily on the basis of a suite of measurements (Fig. 19, Table 6): *Birlimarr gaffneyi*; a cf. *Birlimarr* form; and *Chelidae* forms 1 and 2. Ratios of hyoplastral length to width show some overlap between forms, but the proportions of the negative space occupied by the entoplastron show stronger differentiation.

P9464-149 and P944-10 can be referred to *Birlimarr gaffneyi.* Both are of the right size to represent mature individuals and have the humeral-pectoral groove intersecting the ento-hyoplastral suture, as in the type. P87103-50 is similar, but has slightly higher length to width ratios than specimens of *Birlimarr gaffneyi*, and the humeral-pectoral groove is confined entirely to the hyoplastron, i.e. crosses the interhyoplastral suture posterior to the entoplastron. This morphology conforms to entoplastron P87113-45, and for similar reasons to those given above for P87113-45, is assigned to a cf. *Birlimarr* form.

On the basis of entoplastral and epiplastral scute patterns (Figs 21, 23), it was anticipated that most hyoplastra in the assemblage would show some trace of the humeral scute, either due to the humeral-pectoral groove crossing the hyo-epiplastral suture, or it crossing the ento-hyoplastral suture. No part of the pectoral is present on any of the specimens of Chelidae forms 1 and 2, excepting P87112-34, in which it crosses the ento-hyoplastral suture near the level of the posterior margin of the entoplastron. Specimens in which the scute contact crosses the epi-hyplastral suture might be referrable to a *Chelodina* form, but this is not necessarily a diagnostic character of the genus, appearing to be somewhat variable (Fig. 22A). Hyoplastral morphology has not been shown or found by us to be useful in differentiating natural groups of Chelidae, and consequently the specimens not referrable to *Birlimarr gaffneyi* and cf. *Birlimarr* form can only be classified as Chelidae forms 1 and 2.

Hypoplastra. Three forms of hypoplastra are recognised: *Birlimarr gaffneyi*, gen. aff. *Elseya/Emydura* sp. indet., and Chelidae form 1 (Figs 17, 24; Table 7).

Birlimarr gaffneyi is distinguished by its small size and prounced lateral bulge of the femoral area. The larger hypoplastra group into two forms, gen. aff. *Elseya/Emydura* sp. indet and Chelidae form 1, on the basis of whether the posterior lobe tapers immediately posterior to the bridge, or whether it is parallel/sub-parallel proximally. The length to width ratios of the two forms overlap, but there is a very weak indication that form 2 is, on average, proportionally shorter than form 1. No other discrete morphological character could be found in support of the distinction though.

As already mentioned above in Systematics, P895-67 and associated carapacial fragment P895-66 may represent the same individual. P895-67 has hypoplastral morphology designated Chelidae form 1, while P895-66 is referred to gen. aff. *Elseya/Emydura* sp. indet., on the basis of its similarity to the reference specimen of that taxon (P9464-134). One obvious possibility is that gen. aff. *Elseya/Emydura* sp. indet. is dimorphic, but the apparent paradox cannot be resolved with the available material.

Xiphiplastra. Only three forms of xiphiplastra can be distinguished: *Birlimarr gaffneyi*, and Chelidae forms 1 and 2 (Fig. 25, Table 8). *Birlimarr gaffneyi* is distinguished by its small size, posterior curvature at the lateral extremity of the pubo-plastral suture, broadly oval ischio-plastral suture, and strong lateral flaring of the femoral scute region.

Chelidae form 1 is also small, but lacks a prominent femoral bulge, has no posterior curvature at the lateral extremity of the pubo-plastral suture, and the ischio-plastral suture is subtriangular. Additionally, the Chelidae form 1 xiphiplastron is thick for its size, i.e. more robust than *Birlimarr gaffneyi*, and the posterior extremity is very acute. The sutural pattern shows some resemblances to *Chelodina* species (Fig. 22), especially *C. novaeguineae*, but whether this is of systematic value is not known to us.

All the determinable large xiphiplastra are grouped in Chelidae form 2, and while there is a diversity of form in the sample, no consistency could be found in the expression of any characters or combinations of characters that supported splitting them into sub-groups. A femoral bulge, where present, is only weakly expressed. The ischio-plastral suture is oval, but in no specimens as broadly so as in *Birlimarr gaffneyi*, and the pubo-plastral suture is recurved posteriorly at the lateral extremity. The reference specimen of gen. aff. *Elseya/Emydura* sp. indet., P9464-134, has this form (Fig. 18).

Xiphiplastral morphology has not been shown or found by us from our very limited sample of comparative material to be useful in differentiating genera (or generic groups) of Chelidae, and consequently the specimens not referrable to *Birlimarr gaffneyi* can only be classified as Chelidae forms 1 and 2.

Costal 1. Four forms of costal 1 are present in the assemblage: *Birlimarr gaffneyi*, gen. aff. *Elseya/Emydura* sp. indet., a Chelidae form, and a *Chelodina* form (Fig. 26, Table 9).

In *Birlimarr gaffneyi* and gen. aff *Elseya/Emydura* sp. indet., the bridge carapace suture (BCS) on the internal surface is a broad, well-defined area, as already described above (Figs 7, 16, 17). The two can be distinguished primarily by their significant size difference.

The other two forms are distinguished by a bridge-carapace sutural area which is

Table 6. Hyoplastra – measurements and classification. Measurements in italics are estimates.

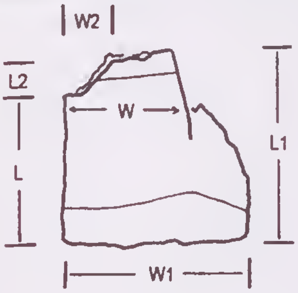
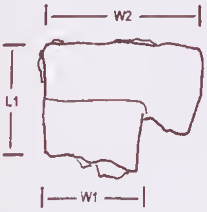
	*Birlimarr gaffneyi* gen. et sp. nov.				cf. *Birlimarr* form	Chelidae form 1					Chelidae form 2		
	L	R	L	R	R	R	R	L	L	L	L	L	L
	P9215-1 holotype		P9464-149	P944-10	P87103-50	P895-82	P895-84	P8695-129	P908-51	P87112-34	P895-85	P907-31	P895-83
L	37.3	35.6	42		51.2	54.0	*43.7*	74.0	24		29.6	30.2	47.5
L1	50.3	49.5	49.5	*53.0*	*59.3*	73.8	68.8	98.0	*35.6*		*43.8*	43.9	
W	33.1	33.6	32	37.3	*36.0*	51.2	53.1	65.2	26	53	32.9	35.9	45.7
W1	52.1	51.6					76.9				54.7		
L/W	1.13	1.06	1.32		1.42	1.05	0.82	1.13	0.90		0.90	0.84	1.04
L/W1	0.72	0.69					0.57				0.54		
L1/W	1.52	1.47	1.56	1.42	1.65	1.44	1.30	1.50	1.35		1.33	1.22	
L2	8.3	*8.6*	9.3	10.0	13.6	19.6	28.3	29.6	*9.3*	19.2	18.9	19.0	20.1
W2	11.4	12.8	12.1	15.0	18.5	22.0	29.0	28.4	8.5	19.6	10.6	14.4	15.2
L2/W2	0.73	0.67	0.77	0.67	0.74	0.89	0.98	1.04	1.09	0.98	1.78	1.32	1.32
Number of assigned individuals													12
Number of unassigned specimens													6
Minimum number of individuals													18

Table 7. Hypoplastra – measurements and classification. Measurements in italics are estimates.

	*Birlimarr gaffneyi* gen. et sp. nov.				gen. aff. *Elseya/Emydura* sp. indet.						Chelidae form 1			
	L	R	R	R	L	R	R	L	L	L	L	R	R	R
	P9215-1 holotype		P9464-166	P925-5	P9464-156 reference		P9464-155	P923-8	P87106-17 + P925-6	P8692-23	P895-66	P895-81	P87112-33	P87103-46
L1	36.2	*38.2*	32.8	41.5	96.4	82.3	*105.6*	60.9		*65.3*	93.6	32.0	46.5	100.2
W1	30.7	30.6	26.4	35.4	76	77.9	84.3	52.8	79.2	*55.3*	90.7	35.2	40	90.4
W2	52.4	51.8						87.3	128.4		152.2			
L1/W1	1.18	1.25	1.24	1.17	1.27	1.06	1.25	1.15		1.18	1.03	0.91	1.16	1.11
L1/W2	0.69	0.74						0.70			0.61			
W1/W2	0.59	0.59						0.60	0.62		0.60			
Number of assigned individuals														12
Number of unassigned specimens														9
Minimum number of individuals														21

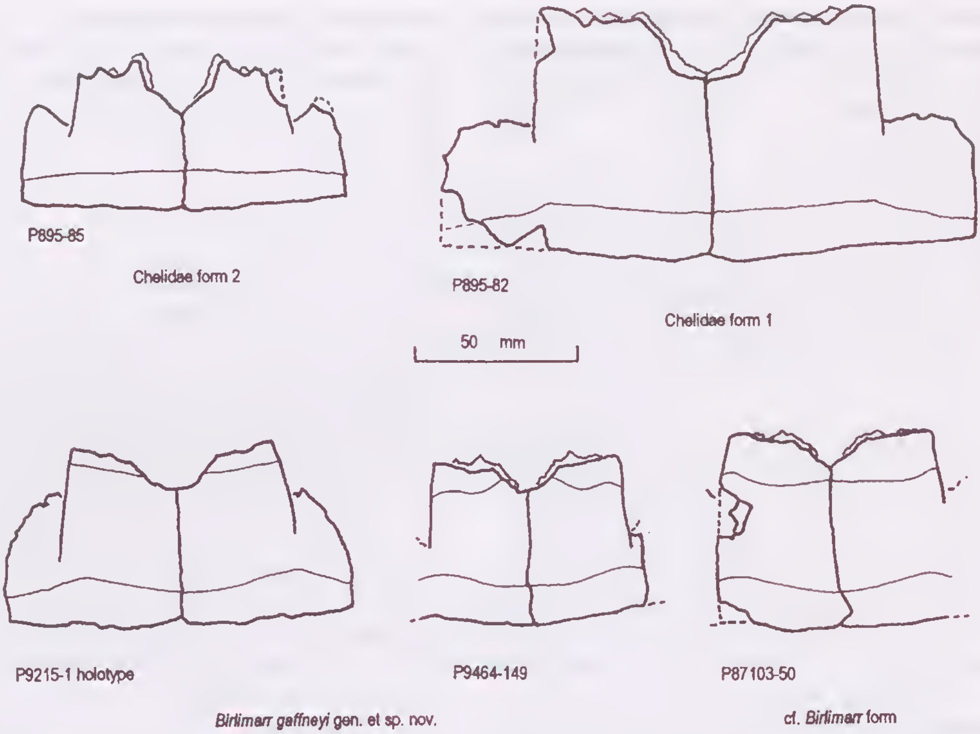


Fig. 24. Hyoplastra. Excepting P9215-1 (*Birlimarr gaffneyi* gen. et sp. nov.), each of the specimens is mirrored.

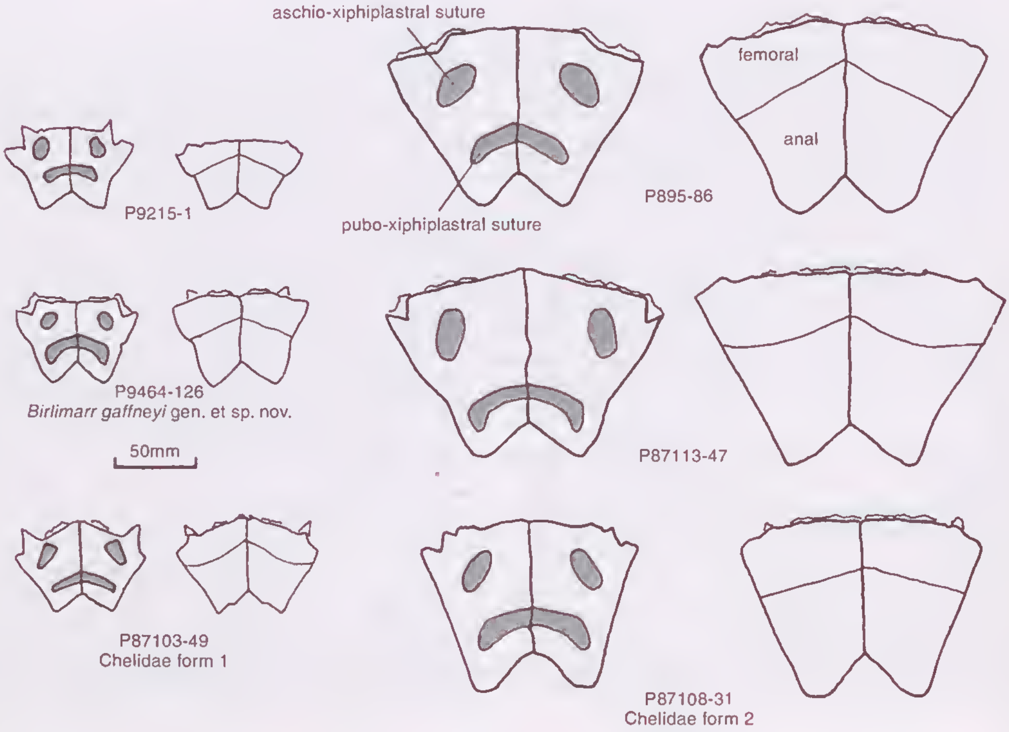


Fig. 25. Xiphiplastra. Excepting *Birlimarr gaffneyi* gen. et sp. nov., P9215-1, each of the other specimens is mirrored.

widest medially and narrows laterally to almost just a thin ridge. This morphology is apparently diagnostic of *Emydura* amongst short-necked chelids (Thomson *et al.* 1997), but is similar in long-necked *Chelodina* (Fig. 27). Additionally, in *Chelodina* the bridge carapace suture appears to be imposed right across the trace of the rib, whereas in *Emydura* and in short-necked species in general, it is imposed on the rib (see Thomson *et al.* 1997), rather than across it. P87115-33 is noteworthy in that the bridge carapace suture clearly extended onto costal 2, which has been observed by us to occur in *Chelodina novaeguineae* and *C. longicollis*: there is some individual variability in this feature, sometimes the bridge carapace suture stops just short of the pleural 1-2 suture, but the superimposition of the BCS over the rib is retained. Thus P87115-33 is assigned to a cf. *Chelodina* form. P908-49 has a similar BCS morphology, but it stops well short of the pleural 1-2 suture, and its cross-cutting relationship to the rib is not so strongly expressed. It may represent another *Chelodina*-like form or an *Emydura*-like form, but insufficient data are available to make a generic determination, and consequently it is simply assigned to a Chelidae form.

Nuchals. All nuchals in the Bullock Creek sample have a cervical scute. Only four informative isolated examples are present in the analysed sample, in addition to that of the *Birlimarr gaffneyi* type (Fig. 6) and those of gen. aff. *Emydura/Elseya* sp. indet. shown in Figures 15 and 16, and are referred to these taxa (Table 10).

Costal 8. Costal 8 is readily identifiable amongst costals as it usually bears the bulk of the carapacial-ilial sutural contact. In extant chelids examined, the sutural contact variously extends posteriorly onto the suprapygal and/or anteriorly onto costal 7. Four forms of costal 8 are present in the Bullock Creek LF assemblage: *Birlimarr gaffneyi*; gen. aff. *Elseya/Emydura* sp. indet., a Chelidae form; and a *Chelodina* form (Fig 28, Table 11).

The *Birlimarr gaffneyi* is distinguished by its small size, and weak expression of the ilial-carapacial suture, which just extends onto the suprapygal and just onto costal 7. On the dorsal surface, the contact between the vertebral 4 and pleural 4 scute runs parallel to the posterior margin. The costal 8 of gen. aff. *Elseya /Emydura* sp. indet. is larger, and the ilial-carapacial suture better defined and more extensive on costal 7, but the scute pattern and length to width proportions are similar. The Chelidae form is proportionally short, the ilial-carapacial suture very strongly defined (considerably more so than in gen. aff. *Elseya /Emydura* sp. indet.) and fails to cross the costal 7-8 suture, but does extend onto the suprapygal. In the Chelidae form, contact of the vertebral 4 and pleural 4 scutes crosses the costal 8-suprapygal suture medially.

In P895-92 and P894-13, the ilial-carapacial suture is extensive on costal 7 but does not extend posteriorly onto the suprapygal. From specimen P894-13, it is clear that the suprapygal was quite a small bone. The morphology of P894-13 has similarities to extant *Chelodina rugosa*, which has a diminutive suprapygal that bears no part of the ilial-carapacial suture (Fig. 28C). The costal 8 of P894-13 is not as expanded at the expense of the suprapygal as in *Chelodina rugosa*. *Chelodina longicollis* and *C. novaeguineae* both have proportionally large suprapygals with ilial contact, similar to those of Emydurodds examined. P894-13 and P895-92 are assigned to a *Chelodina* form on the basis of their similarities to *Chelodina rugosa*.

Suprapygal. Three forms of suprapygal can be discriminated with certainty, but there may be a fourth amongst the small sample of suprapygals available, and a fifth form can be inferred from the morphology of costal 8 specimen P894-13 (designated a *Chelodina* form) as already described above. The suprapygal of the gen aff. *Elseya/Emydura* sp. indet. reference specimen (P9464-134, Figs 15, 28) is unfortunately damaged. The indications are that the length to width ratio was probably low (Fig. 15C), more like in *Birlimarr gaffneyi* (Figs 5, 28) than in the otherwise similar larger specimens assigned to Chelidae form 1 (Fig. 29, Table 12).

Birlimarr gaffneyi is characterised by: its small size; a width almost double the length;

Table 8. Xiphiplastra – measurements and classification. Measurements in italics are estimates. P87115-37 is determinate, but not measurable in the scheme used.

	Birlimarr gaffne gen. et sp. nov			Chelidae form 1			Chelidae form 2							(gen. aff. *Elseya/Emydur.* sp. indet.)	
	L	R	R	R	R	L	R	R	L	R	R	R	R	L	R
	P9215-1	holotype	P9464-126	P87103-49	P908-50	P87115-37	P87113-47	P8695-147	P895-86	P87108-31	P8695-156	P87108-33	P907-38	P9464-134	reference
L1	*29.3*	*29.3*	29.0	31.8			68.2	60.9	70.1	60.7	*58.0*	*58.2*			
L2	37.5	37.3	39.2	37.5			83.6	78.0	81.9	77.0	75.6				
L3	9.9	10.0	10.3	11.6	12.4		24.8	22.7	23.0	18.5	23.4	23.0	27.1		20.5
W1	*30.2*	*30.2*	*30.3*	29.0	32.4		68.3	56.6	60.6	52.6	*61.2*			66.9	75.5
W2	5.8	5.7	6.2	6.4	6.0		12.7	11.4	11.3	9.3	11.5	11.4	13.3		8.8
L1/W1	0.97	0.97	0.96	1.10			1.00	1.08	1.16	1.15	0.95				
L2/W1	1.24	1.24	1.29	1.29			1.22	1.38	1.35	1.46	1.24				
L3/W3	1.71	1.75	1.66	1.81	2.07		1.95	1.99	2.04	1.99	2.03	2.02	2.04		2.33

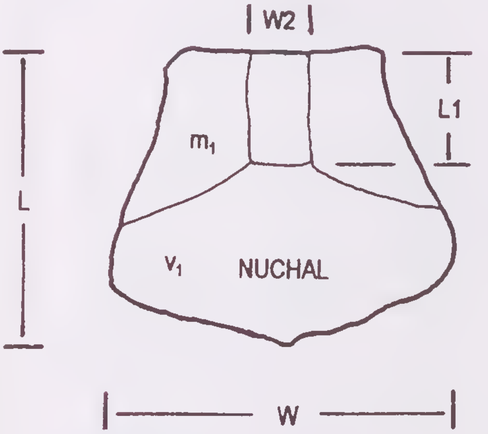
Number of assigned individuals	13
Number of unassigned specimens	18
Minimum number of individuals	31

Table 9. Coastal 1 – measurements and classification.

	Birlimarr gaffneyi gen. et sp. nov.									gen aff. *Elseya/Emydura* sp. indet.			*Chelodina* form cf. *C. novaeguineae*		Chelidae form		
	L	R	R	R	R	R	R	R	L	R	L	L	L	R	L	R	R
	P9215-1	holotype	P87105-17	P9464-137	P9464-139	P9464-140	P9464-142	P9464-138	P9276-6	P9464-134 reference	P895-67	P923-7	P87115-33	P8692-24	P908-48	P895-94	P895-94
L1	29.3	29.7	34.4	30.6	32.3	28.3				76.5	*86.2*	*79.3*		36.8	42.4	46.4	46.4
W1	48.7	48.8	59.4	53.6						122	135.3	119.6		60	68.4		
L1/W1	0.60	0.61	0.58	0.57						0.63	0.64	0.66		0.61	0.62		

Number of assigned specimens	15
Number of unassigned specimens	8
Minumum number of individuals	23

Table 10. Nuchals – measurements and classification. Measurements in italics are estimates; bold = 2 x half width.



	Birlimarr gaffneyi gen. et sp. nov.			gen. aff. *Elseya/Emydura* sp. indet.			
	P9215-1 holotype	P9464-135	P9464-148	P9464-134 reference	P895-67	P895-80	P9464-134
L	*29.3*	29.5	*27.0*	68.4	*73.7*	55.1	63.8
W	**34.4**	35.8	***33.0***	**79.8**	82.0	**61.2**	70.3
L/W	0.85	0.82	0.82	0.86	0.90	0.90	0.91
L1	11.2	12.10	11.40	36.00	36.80	25.00	25.9
W1	**6.8**	6.0	3.9	19.7	9.8	9.7	6.3
L1/W1	1.65	2.02	2.92	1.83	3.76	2.58	4.11
L1/L	0.38	0.20	0.42	0.53	0.50	0.45	0.41

proportionally wide pygal-suprapygal contact; complete coverage by the vertebral 5 scute; and by a weakly defined sutural contact with the ilium. In contrast, Chelidae form 1 has a length to width ratio in the order of 3:4, the pygal-suprapygal contact is proportionally narrow, and the ilial sutural surface is well defined. Coverage by the vertebral 5 scute in Chelidae form 1 is complete.

P8695-130 and P925-2 are intermediate in length to width ratio and have well defined ilial sutural surfaces and narrow pygal-suprapygal contact. Unlike in any of the other forms of suprapygal, the fourth pleural scale covered the bones laterally. The two specimens are designated Chelidae form 2.

ANALYSIS OF THE ASSEMBLAGE

Estimated minimum number of species. Three nominal forms and one species are diagnosed above: gen. aff. *Elseya/Emydura* sp. indet., *Chelodina* sp. A and *Chelodina* sp. B; and *Birlimarr gaffneyi* From the forms of entoplastra, two additional short-necked species are indicated, though one less certainly than the other.

Amongst the sample of Bullock Creek LF entoplastra, no *Chelodina* are indicated, but four short-necked forms are recognisable. Only one of these forms is diagnosable (*Birlimarr gaffneyi*). Parsimony dictates that one or the other of the two large *Elseya/Emydura* forms most probably represents gen. aff. *Elseya/Emydura* sp. indet. Thus, one additional large species of *Elseya/Emydura* can be postulated, and added to the total of diagnosed species. The cf. *Birlimarr* form may represent an additional species, but this is somewhat less certain because it is just possible that the entoplastron assigned to the form (and possibly the hyoplastron which conforms to it) could represent sub-adults of one or the other of the two large *Elseya/Emydura* species.

A variety of individual bones of the turtle shell seem to offer a practical means of determining species diversity in fossil assemblages in which relatively intact specimens are the exception. The methodology applied here, however, warrants further testing by more comprehensive analogy with extant chelid species.

In summary, there is evidence for five, and possibly six species of chelid in the Bullock Creek LF, though only four forms are sufficiently represented at present to assign to a taxonomic group below the level of infrafamily.

Estimated minimum number of individuals. The highest minimum number of individuals indicated by any individual bone is 31 (xiphiplastra: Table 7). However, the minimum number of individuals in the whole assemblage is considerably higher. Other plastral elements not in sutural contact

Table 11. Costal 8s – measurements and classification. Measurements in italics are estimates.

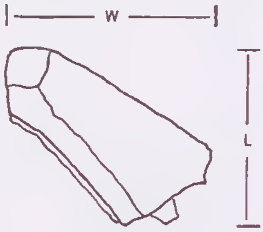
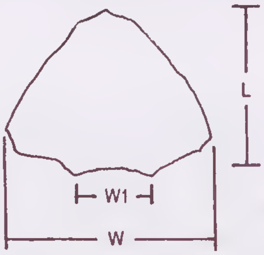
	*Birlimarr gaffneyi* gen. et sp. nov.			gen. aff. *Elseya/Emydura* sp. indet.			Chelidae form	*Chelodina* form	
	R	R	L	R	L	R	L	R	R
	P9215-1 holotype	P87113-50	P87103-53	P9464-134 reference		P927-4	P8694-10	P894-13	P895-92
L	24.0	26.9	32.7	63.8	59.3	59.8	30.2		29.7
W	28.4	*29.5*	35.7	66.7	72.0	70.1	48.6		*37.0*
L/W	0.85	0.91	0.92	0.96	0.83	0.85	0.62		0.80
Ilial carapacial suture well-defined	N	N	N	Y	Y	Y	Y	Y	Y
Ilial carapacial suture extends onto costal 7	Y	Y	Y	Y	Y	Y	N	Y	Y
Ilial carapacial suture extends onto suprapygal	Y	Y	Y	Y	Y	Y	Y	N	N

Table 12. Suprapygals – measurements and classification. Measurements in italics are estimates; bold = 2 x half width.

	*Birlimarr gaffneyi* gen. et sp. nov.	gen. aff. *Elseya/Emydura* sp. indet.	Chelidae form 1 ? = gen aff. *Elseya/Emydura* sp. indet.			Chelidae form 2	
	P9215-1 holotype	P9464-134 reference	P9612-3	P925-3	P87103-59	P8695-130	P925-2
L	17.3	49.0	48.2	24.9	39.5	30.2	34.0
W	**31.0**		59.4	**34.4**	**48.8**	47.9	50.0
L/W	0.56		0.81	0.72	0.81	0.63	0.68
W1	13.9		22.5	12.5	17.2	18.6	18.4
W1/W	0.49		0.38	0.36	0.35	0.38	0.37
Pleural scutes present	N	N	N	N	N	Y	Y
Ilial insertion well defined	N	Y	Y	Y	Y	Y	Y

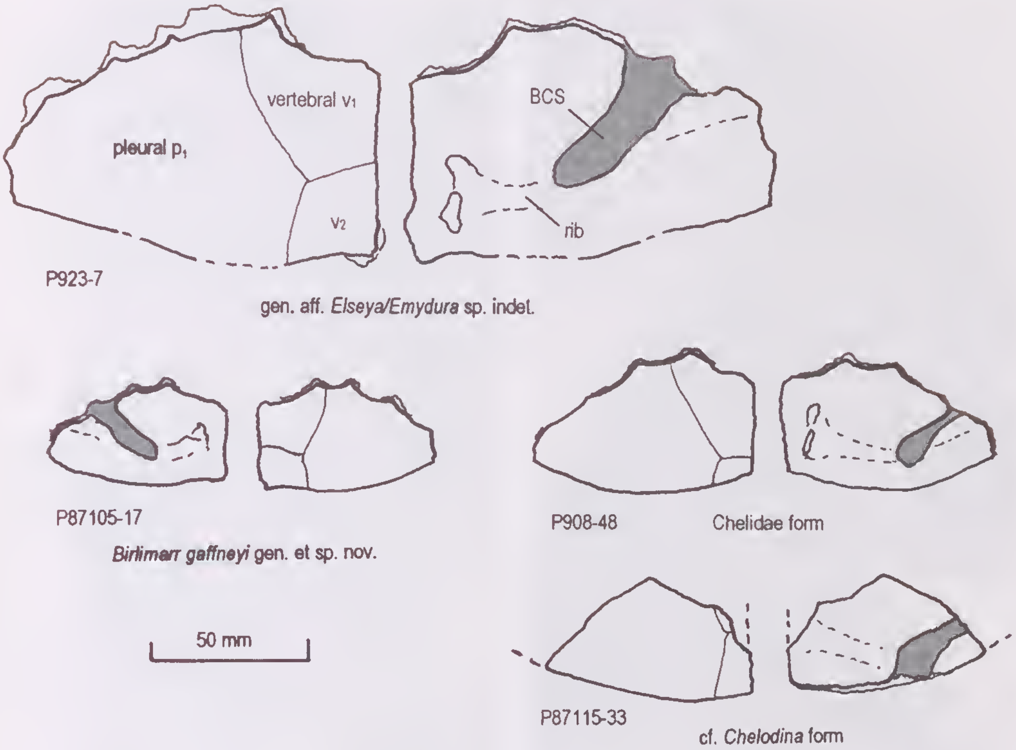


Fig. 26. Costal 1. The costal 1 of gen. aff. *Elseya/Emydura* sp. indet. reference specimen (P9464-134) and referred specimen (P895-67) are shown in Figures 16 and 17 and that of the *Birlimarr gaffneyi* gen. et sp. nov. holotype (P9215-1) in Figure 7.

with each other can be progressively be added to the xiphiplastral total in the anatomical order xiphiplastra > hypoplastra > hyoplastra > epiplastra + entoplastra. (Theoretically, one could continue onto the carapace.) This method may result in an overestimate for the assemblage, as, for example, an isolated xiphiplastron may represent the same individual as an isolated hyoplastron. A more rigorous comparison of the relative size of each element not in sutural contact in the skeleton could be used to identify and take into account all such possibilities. However, the effort involved at arriving at a reasonable estimate of the minimum number of individuals in the sample is not justified. Very few individuals are represented by specimens consisting of two or more bones (only P9215-1, P9464-134, P9564-155 and P895-67). Only P9464-155 was completely re-sutured after preparation, and then from bones whose close association had been noted during preparation: the others were prepared with at least some of their bones in sutural contact. Chelids in the assemblage are therefore typically completely disarticulated and their elements widely dispersed at the scale at which the deposit has been sampled by quarrying. Three of these individuals are represented by at least one xiphiplastron and one hypoplastron, and there are several xiphiplastra and one hypoplastron (P895-66) of the right size to represent the carapacial fragment P895-67 individual. In order to ensure that these individuals or possible individuals are only counted once, four individuals are discounted for every plastral bone besides the xiphiplastron.

Using the estimation method outlined above, and bearing in mind that part of the methodology for this study involved testing

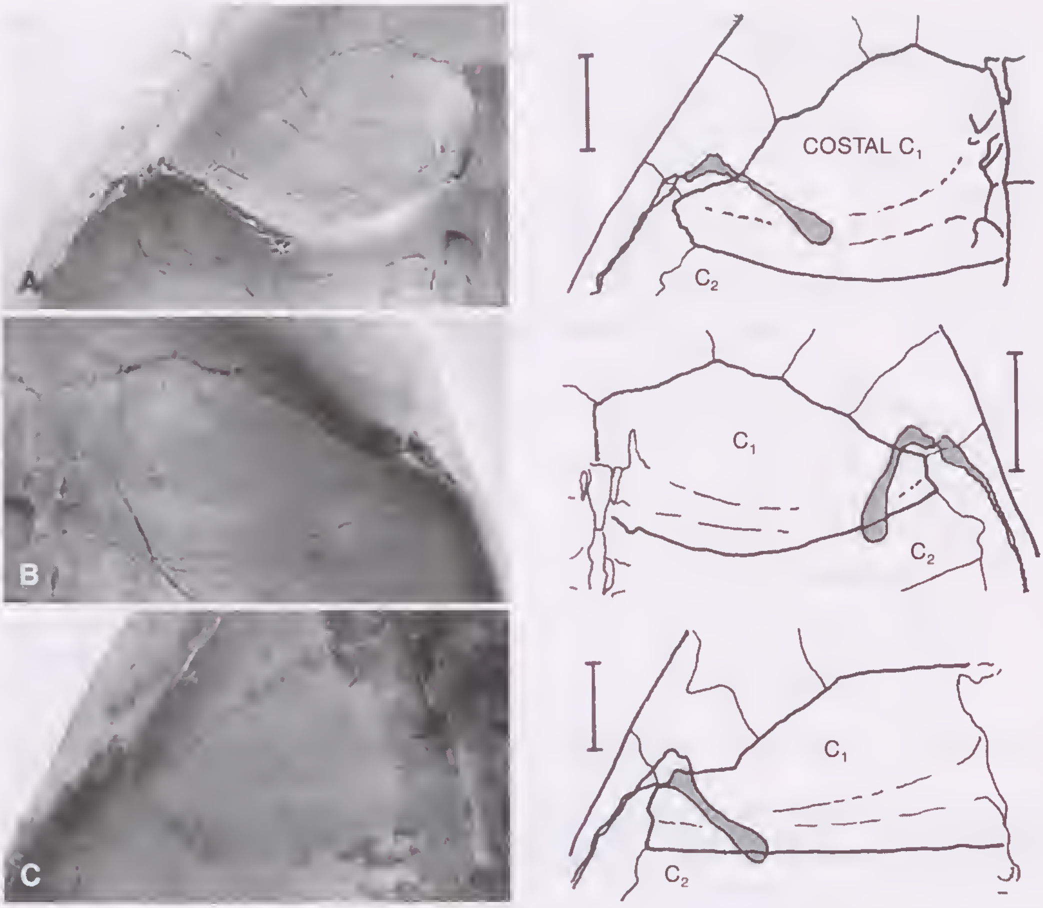


Fig. 27. Internal morphology, showing the shape and extent of the bridge carapace suture (BCS) on costal 1 in: **A**, *Chelodina rugosa* (unregistered carapace); **B**, *C. longicollis* (NTM R.24812); **C**, *C. novaguineae* (NTM R.16325). Scale bars = 20 mm.

each bone against every other bone it could possibly be sutured to, the analysed Bullock Creek chelid assemblage can minimally be accounted for by 77 individuals. [Xiphiplastra (31) + hypoplastra (21-4) + hyoplastra (18-4) + epiplastra (13-4) + entoplastra (10-4) = 77].

Most of the determined material appears to belong to species of Emydurodd. Establishing the frequency of Chelodd (*Chelodina*) is problematic because much of the material could not be classified to infrafamily or lower level. Out of ten individuals classified by epiplastra, four are *Chelodina*. The only other material identified as possibly representing *Chelodina* is one xiphiplastron and two costal 8s. A frequency of about 9% (7 out 77 individuals) of Chelodd in the assemblage is suggested as a first order approximation.

Evidence of predation by crocodiles. As remarked above, chelids in the Bullock Creek LF assemblage are typically completely disarticulated and their elements widely dispersed. The exceptional preservation of P9215-1 warranted special attention to its taphonomy, and it was concluded above in the description of *Birlimarr gaffneyi* that the holotype was the victim of a crocodile. What is exceptional about the holotype of *Birlimarr gaffneyi* is not the evidence for crocodile attack, but its completeness.

The role of crocodilians in the accumulation of the Bullock Creek Local

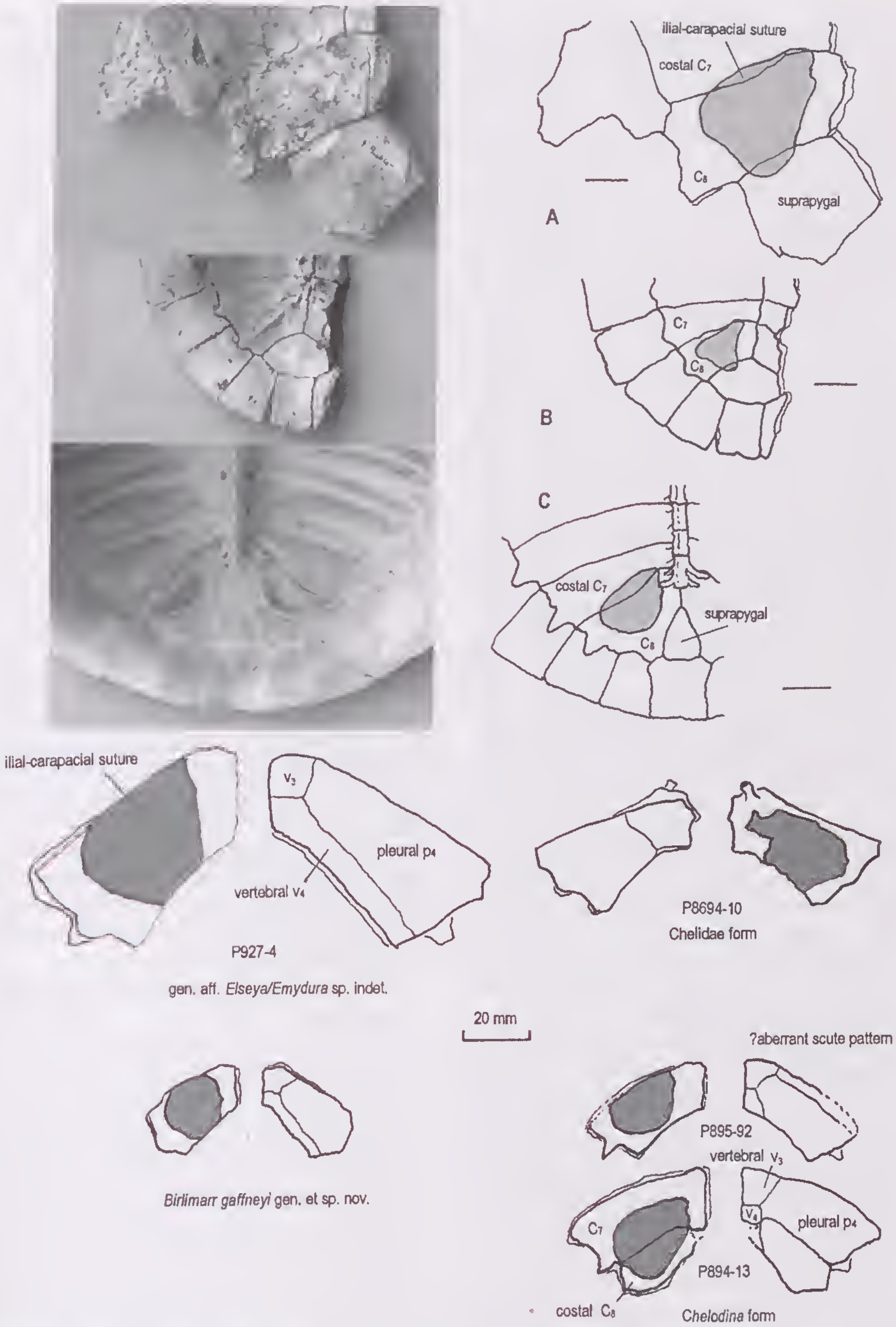


Fig. 28. Costal 8. Relationships of ilial-carapacial suture to bone of the carapace in: **A**, gen. aff. *Elseya/Emydura* sp. indet. reference specimen P9464-134; **B**, *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1; and **C**, extant *Chelodina rugosa*, R.24813. Scale bars 20 mm.

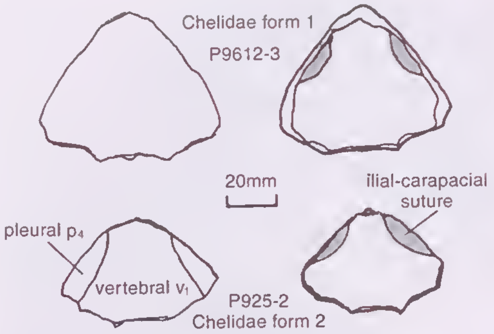


Fig. 29. Suprapygals, Chelidae form 1 and form 2.

Fauna was alluded to by Murray and Megirian (1992). Murray (1986) drew attention to tooth puncture marks in the holotype of the marsupial tapir *Propalorchestes novaculacephalus*, but the NTM Bullock Creek LF assemblage contains numerous taxa that can be identified as crocodile victims. Work in progress on this aspect of the assemblage will be more fully reported elsewhere.

Several examples of crocodilian predator damage to chelid shells are shown in Figure 30. They include depressed areas, sometimes with distinct point impacts, with radiating irregular fractures. Clean punctures such as have been found in avian limb bones for example, are uncommon, possibly due to the flexibility of the spongy bone of turtle shells. Many isolated chelid shell bones preserve this evidence, the fractured bone often having remained together, presumably due to the cohesive properties of collagen and soft tissues, though bones of the shell became disarticulated and separated from each other before burial. Numerous highly fractured turtle bones survive acid-processing, which appears to be due to the presence of early diagenetic crystalline calcite (as fringing cements) in the fractures. Crystalline calcite is slightly more resistant to acid digestion, compared to the micritic matrix typical of the fossiliferous facies, presumably due to lower free surface energy of the larger crystal faces. The hardening agent used in preparation (Synacryl 9122X) progressively replaces the calcite cement, thereby maintaining the relationships of fragments. Ten out of the 21 individuals represented by hypoplastra, for example, exhibit fracturing characteristic of predator damage: all the others are either perfectly intact, or else have planar to curviplanar broken surfaces that are attributable to post-depositional breakage or quarrying of the host limestone. A similar pattern is evident on all the other bones listed above, and suggests that most individuals in the assemblage were preyed upon or scavenged by crocodilians.

Palaeoecology. The present aquatic turtle diversity of Australian river systems is low compared to that of other continents (Gaffney 1991), and occurrences of more than four sympatric species are notable. Georges and Adams (1996) record that the Douglas-Daly River system of the Northern Teritory contains eight turtle species (seven chelids plus the Pig-nosed Turtle, *Carrettochelys insculpta* (Carrettochelydidae), which is more than have been recorded in any other river system, but so far only six species (five chelids plus *Carrettochelys*) have been observed in sympatry. White (1997) reports five sympatric chelid species in the Gregory River (Queensland) at Riversleigh. Amongst climatic variables, total annual precipitation (but not the seasonal distribution of this rainfall), mean annual temperature, and frost-free days, in that order, appear to be the major factors controlling turtle diversity on Australia today (Pianka and Schall 1981), to which may be added the physiographic factor of habitat variation.

The two river systems with the highest recorded turtle diversity in Australia today are in a zone where mean annual temperature is in the order of 27°C, there are no frost days, and median annual precipitation within the catchments varies from about 500 mm inland to about 1200 mm in coastal areas for the Douglas-Daly system and from about 400 mm inland and about 800 mm at the coast for the Gregory system. This rainfall is highly seasonal in its distribution, with most falling during the summer wet season (Bureau of Meterology 1989). Significant flow in both these river systems is maintained throughout the year by groundwater discharge, in contrast to many other rivers in the region which flow only seasonally, and perennial bodies of water become limited to billabongs.

The presence of five and possibly six species in the Miocene Bullock Creek Local Fauna is comparable to the six species of chelids reported from Miocene Carl Creek Limestone, Queensland, assemblages by White (1997), and suggests that comparatively low turtle diversity in Australian freshwater systems is a long established pattern. By analogy with present day patterns of chelid species diversity, palaeoenvironmental conditions at both Miocene fossil localities appear to have been in the optimal range for chelids. In both Miocene assemblages, the chelid fauna is dominated by Emydurodd species, with *Chelodina* (Chelodd) a minor component. The presence of pseudemydurines in the Carl Creek Limestone suggests that some ephemeral swamp habitats such as those occupied by the extant species, *Pseudemydura umbrina*, may have been present at Riversleigh. As for the Carl Creek Limestone assemblages, the high frequency of Emydurodd species and low frequency of carnivorous *Chelodina* in the Bullock Creek LF implies the presence of clear, perennial water bodies with an aquatic flora suiting the omnivorous diets of most emydurodds (White 1997). Ephemeral and perennial aquatic depositional environments with the general characteristics inferred above have been recognised from sedimentological data in the Carl Creek Limestone (Megirian 1992, 1997, in prep.) and in the Camfield Beds (Murray and Megirian 1992).

PHYLOGENY RECONSTRUCTION

Introductory remarks. Gaffney's (1977) phylogeny of chelids, based on osteological characters, provides the basic foundation for evaluating the possible phylogenetic affinities of *Birlimarr gaffneyi*. By way of a preliminary analysis, *Birlimarr gaffneyi* was scored for the informative subset of characters by which Gaffney diagnosed chelid clades and processed using techniques available in Phylip (Felsenstein 1986) and Hennig86 (Farris 1988). As expected, *Birlimarr gaffneyi* was resolved as a member of Gaffney's Chelinae. In terms of phenetic similarities to *Emydura*, *Elseya*, *Rheodytes* and *Elusor* (Tables 1-3), *Birlimarr gaffneyi* is a member of Gaffney's (1977) Emydurodd, a taxon which has not been diagnosed by shared derived characters.

Thomson *et al.* (1997) nominated five post-cranial osteological characters, including a novel one of the morphology of the bridge carapace suture on costal 1, as useful in diagnosing Australian short-necked chelid turtles to genus/generic group level. The objective of Thomson *et al.* (1977) was not phylogeny reconstruction, and consequently their expressed or implied character polarities were not discussed in any detail or substantiated by reference to an outgroup to the Chelidae. Polarity was specified for their characters A, C and E, but not explicitly for B and D. The phylogenetic analysis of these and other characters is the subject of work in progress by S. Thomson (written comm. February, 1999), using South American chelids and *Pelomedusa* as outgroups. *Birlimarr gaffneyi* was added to the matrix, which was then analysed using Hennig86. The character matrix and resulting consensus trees are shown in Figure 20.

A new hypothesis of relationships between Australian chelids at generic level, which incorporates *Birlimarr*, is proposed here, based on a combination of useful morphological characters (in some cases re-defined) drawn from Gaffney (1977), Cann and Legler (1994), Thomson *et al.* (1997), as well as two additional ones suggested to us by the study of *Birlimarr gaffneyi*. By 'useful', we mean apparently derived characters shared by at least two of the ingroup basic taxa, as defined below; autapomorphic characters that merely help diagnose terminal branches are not discussed or analysed.

In discussion below of character polarities, references are made to a variety of 'pelomedusids', including the recently re-described Early Cretaceous (possibly Albian) Santana Formation (Brazil) species, *Araripemys barretoi* Price (Meylan 1996). A second early pelomedusid from the Santana

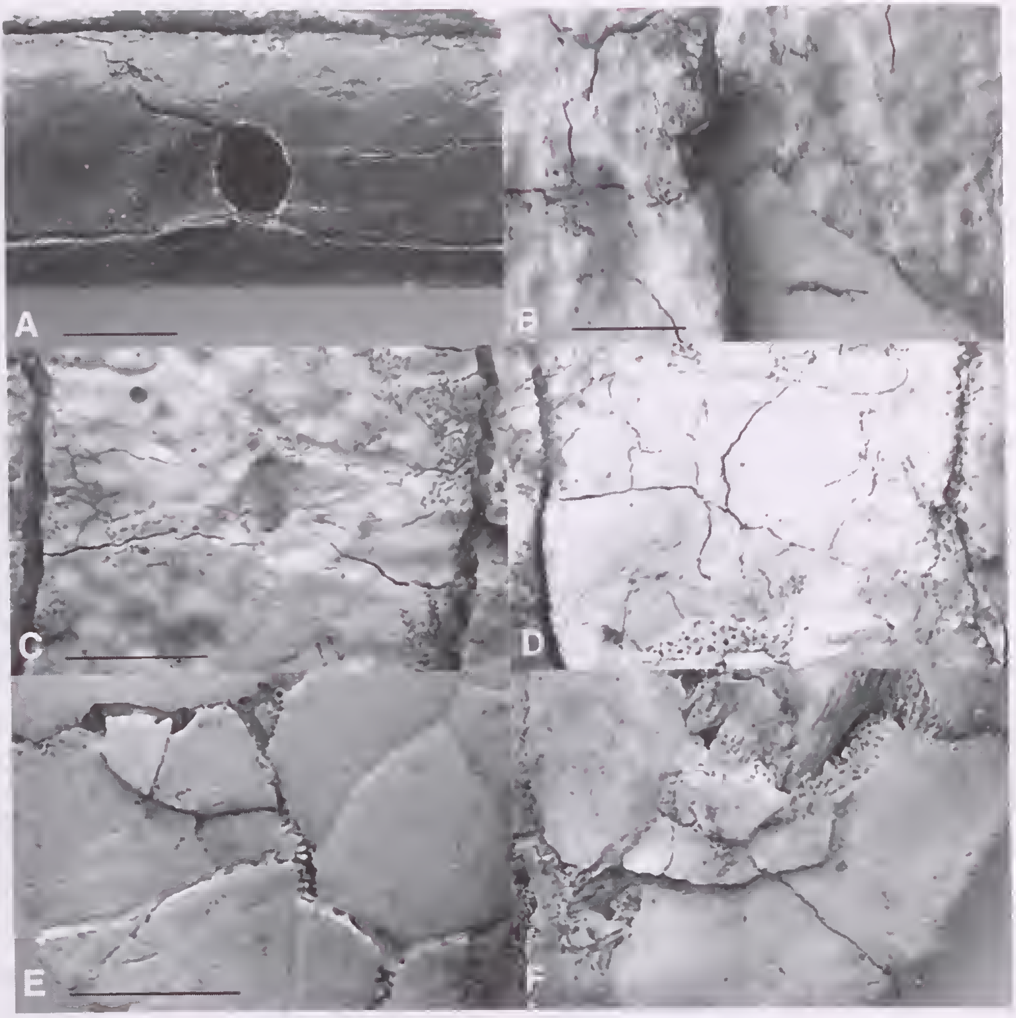


Fig. 30. Evidence of predator damage to Bullock Creek LF vertebrate remains. **A**, avian long-bone with a tooth puncture mark with cross-sectional shape characteristic of the teeth of the crocodilian *Baru darrowi*; **B** tooth puncture in turtle carapace P9464-134; **C**, external point impact and **D**, associated fractures inside turtle carapace P9464-134; **E** (external view) and **F** (internal view) of a depressed fracture thought to have been caused by a crocodilian in the plastron of the *Birlimarr gaffneyi* gen. et sp. nov. holotype P9215-1. Scale bars: 10 mm.

Formation, described by Gaffney and Meylan (1991) and included in Meylan's (1996) phylogenetic analysis has yet to be named and is referred to here by its catalogue number, SMF 4922 (= FR 4922 in Meylan, 1996). In Meylan's (1996) revised systematics, the Pelomedusidae is one of four families within the hyperfamily Pelomedusoides, but here the term 'pelomedusid' is used in the broad sense of Gaffney and Meylan (1988), rather than strictly for the living genera *Pelusios* + *Pelomedusa*. Meylan (1996) resolved *Araripemys barretoi* + SMF 4922 as a sister clade, the Araripemydidae, to all other pelomedusids. *Araripemys barretoi* appears to be quite a specialised pelomedusid in some respects, especially in shell morphology, but SMF 4922 is quite generalised and is thought to provide a fair indication of the primitive states of the outgroup.

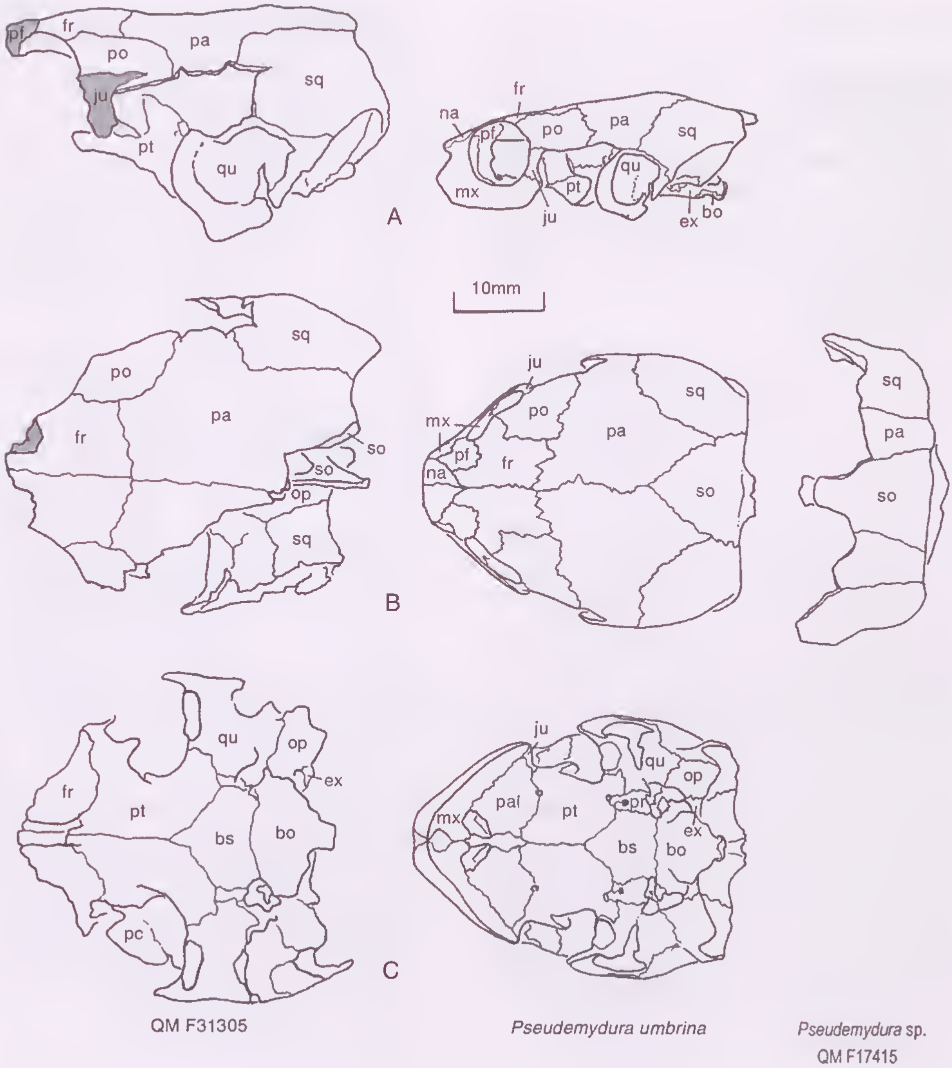


Fig. 31. Cranial structure of the pseudemydurines QM F31305 (Miocene Carl Creek Limestone – after White 1997: fig. 4), *Pseudemydura umbrina* (Recent – after Gaffney 1977: figs 1B, 2B, 4B) and *Pseudemydura* sp. QM F17415 (Miocene Carl Creek Limestone - after Gaffney *et al.* 1989: fig. 1C). **A**, lateral view (QM F31305 reversed); **B**, dorsal view; **C**, ventral view. Sutural surfaces stippled.

Basic taxa. Gaffney (1977) and Thomson *et al.* (1997) compared different sets of basic taxa, and so their matrices cannot simply be combined. The following basic taxa are used in this analysis: *Pseudemydura, Elseya latisternum* generic group (GG); *Elseya dentata* GG; *Emydura, Rheodytes*, and *Birlimarr*. The un-named chelid skull from the Miocene Carl Creek Limestone, QM F31305, described by White (1997) is also analysed (Fig. 31). *Elseya novaeguineae* and the Queensland *Elseya* species complex are simply treated here as part of the *Elseya dentata* generic group (Fig. 3), though they have some distinctive character expressions (Fig. 20). This selection facilitates comparison of our results with hypotheses of relationships presented by Gaffney (1977), Georges and Adams (1992) and Georges *et al.* (in press)

	characters																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PELOMEDUSIDS	0	0	0	0	?	?	?	0	0	0	?	?	0	0	0	0	0
Pseudemydura	1	1	1	0	0	0	0	0	?	1	0	0	1	1	1	1	1
QM F31305	1	1	?	?	?	?	?	?	0	1	0	?	1	1	1	1	1
Elseya latisternum GG	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0
Elusor	1	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0
Rheodytes	1	1	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0
Birlimarr gen. nov.	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Emydura	1	1	1	1	1	3	1	0	0	1	1	0	0	0	0	0	0
Elseya dentata GG	1	1	1	1	1	2	1	0	0	1	1	0	0	0	0	0	0

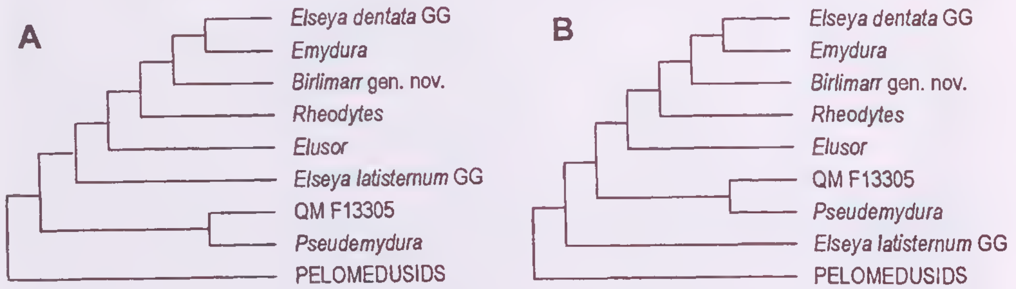


Fig. 32. Generic level hypotheses of phylogeny of Australasian short-necked chelids based on shared, derived morphological characters, analysed using Hennig86, Version 1.5 (Farris 1988). (Equally short trees; consistency index, 82; retention index, 78).

(Figs 2-4), which we regard as being the currently best resolved hypotheses of relationships. Cann and Legler (1994) analysed a combined set of characters (morphological, biochemical and behavioural) and while their results are interesting, their model is not easily tested by, or applicable to the evaluation of, hypotheses resulting from discrete sets of data.

Without an ideal set of comparative material, and without a comprehensive knowledge of chelids in particular or turtles in general, we are compelled to assume that the specimens at our disposal, and those depicted in the literature, are representative of the basic taxon to which each specimen belongs. Legler and Cann (1980) state that their observations on *Elseya dentata* and *Elseya latisternum* are true of all species in their generic groups. Wherever possible we have verified observations presented by Gaffney (1977), Thomson *et al.* (1997), Legler and Cann (1980) and Cann and Legler (1994) in our own material, and where specified, accept their polarity determinations unless as discussed below. Character states for *Rheodytes* were scored from information in Legler and Cann (1990), and for *Elusor* from Cann and Legler (1994).

Description of characters. Characters are expressed as the derived state relative to the pelomedusid outgroup, and their expression for each of the basic taxa are given with Figure 32.

1. Unusually developed lateral cheek emargination (Gaffney 1977: synapomorphy of Chelidae).
2. Loss of quadratojugal (Gaffney 1977: synapomorphy of Chelidae).
3. Loss of mesoplastra (Gaffney 1977: synapomorphy of Chelidae).
4. Anterior frontal process at least partially separating nasals (Gaffney 1977: synapomorphy of Chelinae).
5. Bridge carapace suture BCS diverges anterolaterally from trace of the rib on pleural 1 (Thomson *et al.* 1997: table 1, character A).
6. Bridge carapace suture morphology:

multistate (Thomson *et al.* 1997: table 1, character B): 0 (= state 1 of Thomson *et al.* 1997) - anterior and posterior edges diverge, widest distal to vertebral column; 1 (= state 2 of Thomson *et al.* 1997) - anterior and posterior edges essentially parallel, with prominent suture surface between them; 2 (= state 3 of Thomson *et al.* 1997) - prominent suture surface with marked medial constriction; 3 (= state 4 of Thomson *et al.* 1997) - sutural surface widest proximal to vertebral column, constricting distally to form a ridge.

7. Trace of rib on pleural 1 showing no distal posterior inflection, and no axial torsion (Thomson *et al.* 1997: table 1, character C).
8. First vertebral scute narrower than the second. Thomson *et al.* (1997: table 1, character D) identify two states of vertebral proportions: 'first three vertebral scutes equal or subequal in width' scored as 1 and 'first vertebral scute wider than the second and third' scored as 2, placing no order (polarity) on the two states (S. Thomson pers. comm.). Gaffney (1977 - corrected in Gaffney 1979a: 13) identified 'first vertebral scute (wider) than second' as a derived condition within chelids, and identified it as a synapomorphy of Chelodd. In *Pseudemydura*, the first vertebral scute is narrower than the second, but unlike in other short-necked forms, is parallel-sided (Thomson *et al.* 1997: fig. 4A), and this particular character expression is regarded here as an autapomorphy of *Pseudemydura umbrina* and scored as ? for this analysis. In the primitive pelomedusid SMF 4922 (Gaffney and Meylan 1991), the first vertebral scute is wider than the second, and this is taken here as indicative of the primitive state. (*Araripemys barretoi* is unusual in having the anterior part of the carapace emarginated so that the first vertebral scute is in a marginal position, rather than bounded anteriorly by peripherals - Meylan 1996: fig. 1). The common condition of the first vertebral scute being about equal in width to the second is also here regarded as being plesiomorphic, so that the derived condition is the state in which the first vertebral scute is distinctly narrower than the second.
9. Posteromedial process of frontal partially separating parietals. In *Birlimarr gaffneyi*, the frontal has a medial posterior projection partially separating the parietals. A similar structure is present in *Elseya latisternum*. There appears to be no such structure in *Emydura victoriae* and *Emydura macquarii*, discounting any miniscule expression in some individuals which appears to be due to interdigitation across the suture, rather than a true process. In *Elseya latisternum*, the continuation of the fronto-parietal suture lateral to the posterior process of the frontal is straight, and perpendicular to the axis of the skull, whereas in *Birlimarr gaffneyi* it has an anterolateral vector. The result in both cases is that the fronto-orbital is short. In contrast, in *Emydura* the fronto-parietal sutures are co-linear, perpendicular to the axis, and the fronto-orbital suture is long. *Pseudemydura* has a complex fronto-parietal suture: a medial posterior frontal process is absent, and the fronto-orbital suture is long, but shows complexity not found in other chelids. The *Pseudemydura* morphology is here considered an autapomorphy related to secondary re-roofing of the temporal fossa. No other chelids figured by Gaffney (1977) have a posterior frontal process, nor is it present in pelomedusids figured by Gaffney (1979b: *Pelomedusa subrufa*, ~fig. 130; *Pelusios niger*, ~fig. 132; *Bothremys cooki*, ~fig 125; *Schweboemys antiqua*, ~fig. 136; *Erymnochelys madagascariensis*, ~fig. 129; *Peltocephalus dumeriliana*, ~fig 131; *Podocnemis expansa*, ~fig. 134) or in *Araripemys barretoi* (Meylan 1996: fig. 4). In SMF 4922 (Gaffney and Meylan 1991), it is the frontals which are partly separated by short, broad anterior processes of the parietal. We therefore hypothesise that the absence of a

posteromedial frontal process is the primitive state for chelids. (Somewhat similar structures in the cryptodirans *Malaclemys terrapin*, Gaffney 1979b: fig. 244; *Clemmys insculpta* ~fig. 231; and *Chrysemys concinna*, ~fig. 229, must have evolved independently).

10. Anterior basiphenoid process stops short of the level of the lateral trochlear processes of the pterygoids. In *Pseudemydura, Emydura, Rheodytes* and *Birlimarr gaffneyi* the anterior basiphenoid process fails to reach the level of the lateral trochlear processes of the pterygoid, whereas it clearly does reach or projects beyond in all other chelids. Amongst pelomedusids figured by Gaffney (1979), the anterior basisphenoid process shows the elongate condition in *Pelomedusa subrufa*, ~fig. 130; *Pelusios* sp., ~fig. 34C: *Pelusios niger*, ~fig. 132; *Bothremys cooki*, ~figs 125, 126; *Schweboemys antiqua*, ~fig. 136; and *Erymnochelys madagascariensis*, ~fig. 129. The exceptions are *Peltocephalus dumeriliana* (Gaffney 1979b: fig. 131) and *Podocnemis expansa* (Gaffney 1979b: fig. 134), which at generic level comprise the un-named taxon B11 in Gaffney and Meylan (1988). Taxon B11 is shown in Gaffney and Meylan (1988: fig. 5.7) as the most derived pelomedusid clade, and therefore probably not representative of the ancestral state for the two families. *Araripemys barretoi* shows the elongate condition (Meylan 1996: fig. 4), as does SMF 4922 (Gaffney and Meylan 1991). We hypothesise that the elongate basisphenoid condition is primitive for both pelomedusids and chelids, and that the reduced state was independently derived within these families.

11. Ventral ridges of frontal bone vertical and parallel (Cann and Legler 1994: table 4, character 3). Amongst short-necked chelids, the ventral ridges of the frontals are either parallel and vertical (*Elseya dentata, Rheodytes, Elusor, Emydura, Pseudemydura*, and *Birlimarr gaffneyi*) or turned sharply inwards (*Pseudemydura* and *Elseya latisternum*). Amongst pelomedusids, where mentioned or figured, the ridges appear to be weakly developed (*Araripemys barretoi* - Meylan 1996: 23; *Pelusios* sp. - Gaffney 1979b: fig. 4; *Taphrosphys sulcatus* - Gaffney 1979b: fig. 138). It therefore seems possible that well-developed ridges are a shared derived character of chelids, but whether the two different expressions of the character evolved independently, or one gave rise to the other, is unclear. Cann and Legler (1994) nominated *Chelodina* as their outgroup - in *Chelodina rugosa* the ridges are turned sharply inwards – implying that this is the primitive state for chelids. A slight constriction is also evident in *Pelusios* sp. (Gaffney 1997: fig. 4), and thus we accept the view that this represents the primitive state for chelids.

12. Axillary and inguinal buttresses of approximately equal size (Cann and Legler 1994: Table 4, character 11). In *Elusor* and *Rheodytes* the inguinal and axillary butresses contribute about equally to the bridge, whereas in all other short-necked chelids, including *Birlimarr gaffneyi*, the axillary contributes proportionally more. Most pelomedusids retain mesoplastra, complicating the interpretation of the primitive state for chelids. In *Araripemys barretoi*, which is unusual amongst pelomedusids in lacking mesoplastra and has other peculiarities of the shell, the inguinal buttress is larger than the axillary (Meylan 1996: fig. 2). In the more generalised early pelomedusid, SMF 4922, a projection of the hyo-hypoplastral suture through the mesoplastron would suggest that the axillary buttress would come to form more of the bridge than the inguinal, were the evolutionary trajectory simply one of the hyo- and hypoplastra replacing the mesoplastra in this manner. This is taken here as reflective of the primitive condition in chelids.

13. Quadrate parietal contact (Gaffney 1977: identified as an autapomorphy of a monospecific Pseudemydurinae). Quad-

rate-parietal contact is a derived feature of the extant Western Swamp Tortoise, *Pseudemydura umbrina*. In the Miocene fossil skull from the Carl Creek Limestone of Queensland, QM F31305 (Fig. 31) (White 1997), the more complete right hand side of the skull is damaged in the critical area, but unless the missing portion of the squamosal-parietal suture somehow followed a significantly different course from that of *Pseudemydura*, it would appear that the quadrate and parietal did make contact. This feature is attributed by Gaffney (1977) to a secondary re-roofing of the temporal fossa.

14. Supraoccipital laterally expanded (Gaffney 1977: identified as an autapomorphy of a monospecific Pseudemydurinae). In *Pseudemydura umbrina* the supraoccipital of the skull roof is laterally expanded compared to the typical chelid (and the pelomedusid outgroup) condition, to the extent that the supraoccipital usually contacts the squamosal laterally, thereby excluding the parietal from the posterior skull margin (Fig. 31). In QM F31305, the supraoccipital is less in its extent than in *Pseudemydura umbrina*, such that the parietal remains interposed between it and the squamosal. Parietal interposition between the supraoccipital and squamosal is a feature of Ringtail Site, Carl Creek Limestone *Pseudemydura* sp., QM F17415, described by Gaffney *et al.* (1989: fig. 1) (Fig. 31). Although not as expanded as in *Pseudemydura*, the supraoccipital of QM F31305 is significantly expanded compared to the plesiomorphic condition.
15. Postorbital posteriorly and ventrolaterally expanded. Gaffney (1977) observed that the postorbital is large in *Pseudemydura*, expanded ventrolaterally compared to its small dorsal expression in all other chelids and the pelomedusid outgroup, and therefore nominated it an autapomorphy of the Pseudemydurinae. Loss of the quadratojugal is a shared derived character of chelids apparently related to extreme lateral cheek emargination. Pelomedusids retain a quadratojugal, even in species showing quite a significant degree of lateral cheek emargination. Pelomedusids figured by Gaffney (1979b) show no great consistency in the size and shape of the postorbital, ranging from proportionally very small in *Podocnemis expansa* (Gaffney1979b: fig. 134); to quite substantial in *Schweboemys antiqua* (Gaffney1979b: fig. 136). In *Araripemys barretoi* (Meylan 1996: fig. 4A) it is of intermediate size within the range expressed by *Podocnemis* and *Schweboemys*, though long and narrow compared to most pelomedusids, including the more generalised early pelomedusid SMF 4922 (Gaffney and Meylan 1991). Meylan (1996) indicates that a long postorbital is primitive for pleurodires, and scores Chelidae as fundamentally exhibiting the primitive state, with pelomedusids exhibiting derived conditions in which the postorbital is shortened, the parietal and jugal variously making or not making contact. Gaffney (1977) argues that a ventrolaterally expanded postorbital is related to the secondary re-roofing of the temporal fossa in *Pseudemydura*. The postorbital of QM F31305 is very similar in size and extent to *Pseudemydura* (Fig. 31).

While the postorbital of *Birlimarr* is not as large as that of *Pseudemydura* and QM F31305, it is proportionally somewhat larger than in all other short-necked chelids. It is similar to *Pseudemydura* and QM F31305 in terms of the relative proportion of its contribution to the orbital margin, though its posterior development is notably less, but ventral development perhaps only slightly less. There are several ways of interpreting this character amongst Australian short-necked chelids. One possibility is that a relatively large postorbital (or at least relatively large contribution to the orbital margin) represents a synapomorphy of *Pseudemydura, Birlimarr* and QM F31305. Alternatively, the large contribution to the orbital margin in *Birlimarr* evolved independently of *Pseudemydura* and QM F31305, which is our preferred hypothesis in the absence of other possible derived states shared only by these taxa. We therefore adopt a slightly modified form of Gaffney's (1977) definition of the derived state, treating *Birlimarr* as exhibiting the primitive state in terms of overall postorbital size.

16. <u>Anterior extension of squamosal</u> (Gaffney 1977: identified as an autapomorphy of a monospecific Pseudemydurinae.) In *Pseudemydura*, the squamosal is expanded anteriorly to roof the posterolateral portion of the temporal fossa. It is developed anteriorly to a similar extent in QM F31305.

Discussion and conclusions. A generic-level analysis of apparently derived morphological characters of short-necked chelids using Hennig86 (Farris 1988) produces two equally short trees (Fig. 32). *Birlimarr* is resolved as one of the more derived genera, the plesiomorphic sister taxon only to *Emydura* + *Elseya dentata* GG.

Of seven characters identified by Gaffney (1977) as autapomorphies of *Pseudemydura*, the five which can be assessed for QM F31305 are shared. QM F31305 is thus resolved in this analysis to be a member of Gaffney's (1977) previously monospecific Pseudemydurinae. White (1977) details the morphological differences between *Pseudemydura umbrina* and QM F31305, drawing attention to osteological details suggesting an unusual distribution of the musculature between cranium and lower jaw. He concluded that QM F13305 cannot be referred to any known infraorder or genus. However, the nature of the jaw articulation is fundamentally pleurodirous, in that a processus trochlearis pterygoideus is present. Furthermore, the specimen shares at least two shared derived characters diagnostic of the Chelidae (1 and 2 of this work), but the sole identified synapomorphy of Chelinae (4 of this work) cannot be assessed. QM F31305 appears be too specialised to have given rise to *Pseudemydura umbrina* and Carl Creek Limestone *Pseudemydura* sp., but the present indications are that these forms are closer to each other than each is to something else.

The only difference between the two hypotheses of relationships advanced here (Fig. 32) is whether the Pseudemydurinae (*Pseudemydura* + QM F31305) or the *Elseya latisternum* generic group is the plesiomorphic sister-taxon to all other Australasian short-necked chelids. It is conceivable that the Pseudemydurinae evolved from an *Elseya latisternum*-like form early in chelid evolution (possibly in the Cretaceous), but in the absence of adequate comparative fossil material until the Miocene, the possible morphology of an ancestral chelid can only be inferred. The alternative hypotheses are seen here simply as artifactual of limited morphological data, rather than a basis for a particular perspective on early chelid evolution.

Comparison of the phylogenies of the short-necked chelids based on morphological data (Figs 2, 20, 32) and molecular data (Figs 3, 4) reveals certain similarities. Both lines of evidence indicate that *Elseya* is paraphyletic, and that *Pseudemydura, Elusor* and *Rheodytes* are, in that order, progressively less plesiomorphic members of the group. The geochronological (mid Miocene) age of *Birlimarr*, and its phylogenetic position relative to *Emydura*, also supports the idea from molecular data that *Emydura* evolved relatively more recently than other genera (Georges and Adams 1992, 1996).

While *Elseya* appears to be paraphyletic, it is not yet firmly established which species form monophyletic groups (compare Figs 3, 4 and 20). Some better understanding is required of the extent to which *Elseya latisternum* is generically characteristic of its group, as it appears variously as representative of a plesiomorphic generic group (Figs 20 and 32 A, B), as representative of a more derived generic group (Fig. 3), and as one of the two most highly derived chelids (Fig. 4B). A need for comprehensive comparative osteologies of all living species is evident, both to test phylogenies founded in biochemistry, and to complement stratigraphic evidence of chelid evolution.

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UNEARTHING FANNIE BAY GAOL: ARCHIVES AND THE ARCHAEOLOGY OF WATER MANAGEMENT IN DARWIN'S FIRST PURPOSE-BUILT PRISON

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ABSTRACT

In 1998 the author conducted an archaeological excavation at Fannie Bay Gaol, Darwin (Northern Territory, Australia). This focused on features that related to early water management; specifically one of two wells dug in 1883 and one of two subterranean water tanks constructed in 1884. With the aid of early plans and other historical references the location of the well and water tank were determined with what was considered to be a reasonable degree of accuracy. Excavation found no evidence for a well. Instead a shallow pit was uncovered, possibly relating to a later above-ground water tank. The subterranean tank was successfully located and partially excavated. This revealed that the tank was probably the first of the two to be built in the Gaol, and was possibly infilled as recently as the mid-twentieth century.

KEYWORDS: Fannie Bay Gaol, Darwin, Northern Territory, Australia, nineteenth-century water management, archival information, archaeological excavation.

INTRODUCTION

Until 1979 Fannie Bay Gaol, more properly 'Her Majesty's Gaol and Labour Prison', was the main detention centre for Darwin and the surrounding region of the Northern Territory. In that year it ceased operation and prisoners were transferred to a new facility at Berrimah. The Gaol was placed under the control of the Museum and Art Gallery of the Northern Territory (then Northern Territory Museum of Arts and Sciences) and has since been maintained as a public attraction. Local residents and interstate and international tourists routinely visit the Gaol, to walk through its grounds, enter the old convict cells and other buildings, and engage with the history of the facility to obtain an appreciation of the life of inmates interned in this distinctively tropical-style jail.

However, the visual evidence forms only part of the picture of the Gaol's past. From the extant buildings visitors obtain merely a glimpse of the lifestyles of former inmates and warders. The visitor comes away with little in-depth understanding of the day-to-day lives of former residents; their living conditions, the ethnic composition of the prison population, the food they ate, hygiene, prison discipline, and other pieces of the historic fabric of the Gaol. Historical research can uncover some of this information (e.g. Dewar 1997a, b, in press) but archival data derive from largely one source – prison officials and records. The testimony of the inmates remains largely silent, especially for the early years of the Gaol's history. This is where archaeology has a role to play. Archaeological investigation can complement and fill gaps in the archival record through recovery of the material evidence of past occupation. The information obtained by archaeology has proven to be vital in aiding public interpretation, or the 'visitor experience', of other early prisons. Examples include Hyde Park Barracks in Sydney (Emmett 1993) and Port Arthur in Tasmania (Boyer 1995). The potential that evidence uncovered by archaeology has for enhancing public presentation provides the impetus for the Fannie Bay Gaol archaeological project.

The archaeological project is a co-operative venture involving the Museum and Art Gallery of the Northern Territory and the

Northern Territory University. Excavations are run on a yearly basis to provide students from Northern Territory University with an opportunity to obtain experience in archaeological field techniques. The excavation reported here was undertaken over a 12 day period in 1998. A specific objective of this investigation was the retrieval of information relating to nineteenth-century water management practices within a tropical prison environment. This paper summarises the findings of that excavation.

BRIEF HISTORY

Fannie Bay Gaol was opened on 20 September 1883. The Gaol replaced the earlier house of detention which had been established soon after the founding of Darwin in 1869. The earlier jail was situated on the Esplanade, near the centre of Darwin, and was a very rudimentary affair, consisting of a small lock-up enclosed by a 2.5 m high galvanised iron fence (Dewar in press). The lock-up was extended in an *ad hoc* manner with the addition in the 1870s and early 1880s of extra cells and the incorporation of buildings erected for other police purposes (Troppo Architects 1996). The inadequacy of the first jail soon became apparent and plans were made as early as 1878 for the construction of a larger facility. It was, however, not until 1881 that work proceeded on the new jail on 31 hectares (77 acres) of government land in the present-day suburb of Fannie Bay (Fig. 1). Although today Fannie Bay is part of the city of Darwin, in the late nineteenth-century it was some distance north of the settlement, thereby ensuring Gaol inmates were conveniently separated from the good citizens of the town.

When it opened in 1883, 31 prisoners, consisting of 18 Chinese, 10 Aborigines and three Europeans, were moved from the old lock-up to the new facility (Dewar in press). The predominance of Chinese and Aboriginal inmates is a reflection of the demography of the Northern Territory at that time, when Europeans were very much a minority. Reliable estimates of the Aboriginal population of the nineteenth-century are unavailable, but by the late 1880s the Chinese population of the Territory stood at just over 7000, outnumbering Europeans by more than six to one (Powell 1996). Over the 96 years between the opening of the Gaol and its closure in 1979 the size of the prison population fluctuated considerably. It was largest during the years before World War Two and immediately after, when the Gaol was the only detention centre serving the Territory. During the post-war years the Gaol came to be used to house mainly short-term prisoners, with those convicted of more serious offences sent to prisons in Alice Springs or South Australia (Dewar in press).

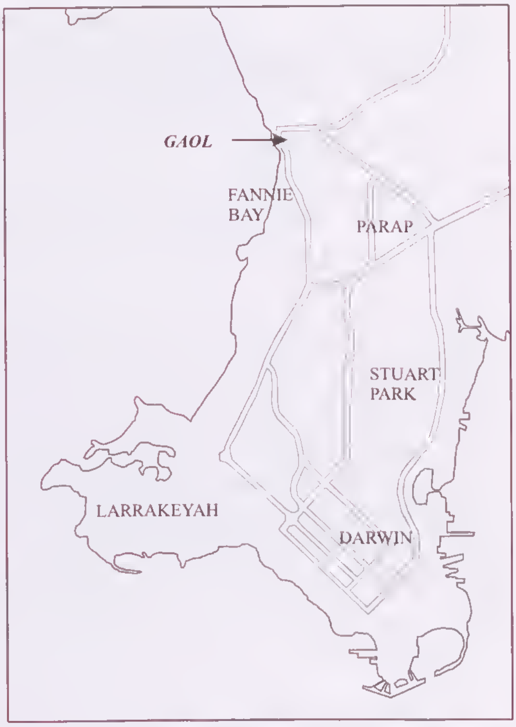

Fig. 1. Inner suburbs of present-day Darwin showing major roads and location of Fannie Bay Gaol (north to top of map).

Over its near century of use, Fannie Bay Gaol underwent major architectural change. The history of this development has been compiled by Troppo Architects (1996) in an unpublished consultancy report prepared for the Museum and Art Gallery of the Northern Territory. The following overview is based on information contained in the report. The 1883 Gaol had three main buildings – a stone cellblock (which still exists today) and separate Gaoler's and Guards' quarters, constructed at either corner of the western perimeter fence (Fig. 2). A watchtower was built a little later, probably 1887 (Dewar in press), and a kitchen possibly later still, perhaps near the turn of the century (Troppo Architects 1996). In 1887 an infirmary was erected outside the southern fence of the Gaol. This building was constructed of roughly dressed blocks of porcellanite which were probably quarried from Doctors Gully, a few kilometres from the Gaol (National Trust 1981). The infirmary remains standing today. The Gaol was initially enclosed by a 3.6 m (12 foot) high perimeter fence made of timber and iron (Troppo Architects 1996). The maintenance of the fence was a source of constant concern to the authorities throughout the early history of the Gaol. The ravages of tropical climate and termites rendered the fence ineffective after only a few years of its construction and repairs required continual attention. Escapes were numerous and this, along with a seemingly relaxed attitude toward security, gave the Gaol in the nineteenth and early twentieth centuries an undeserved reputation as a lax institution. In fact, as Dewar (1997a) recounts, conditions were harsh, characterised by unsatisfactory and frequently overcrowded living conditions, floggings, and a daily routine of hard labour on a variety of government projects outside the Gaol.

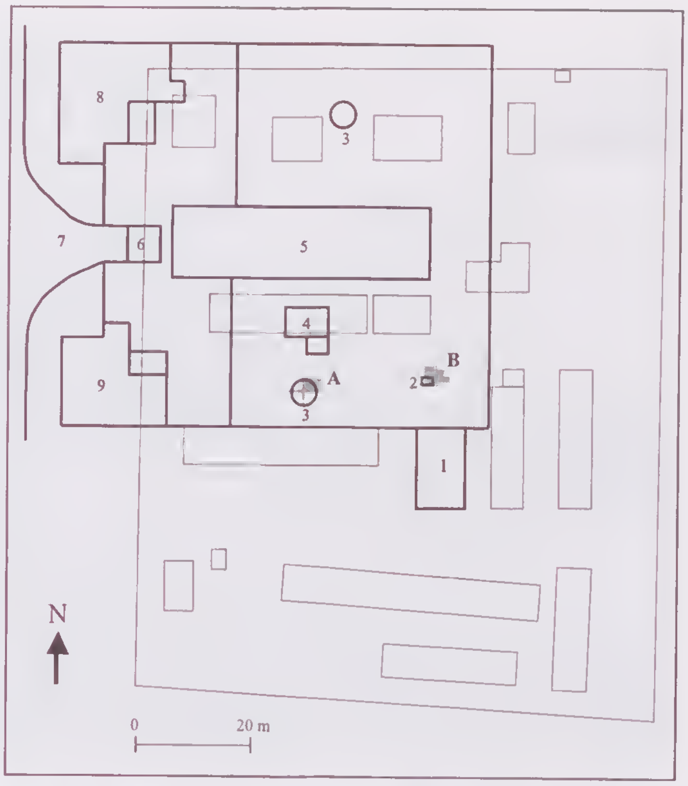

Fig. 2. Plan of Fannie Bay Gaol, with 1880s structures superimposed in heavy outline. The location of Excavation Areas A and B is shown. Key to numbers; 1 = infirmary, 2 = location of well, from historical sources, 3 = underground water tanks, 4 = kitchen, 5 = cellblock, 6 = watchtower, 7 = entrance, 8 = gaoler's residence, 9 = guards' barracks (Adapted from Troppo Architects 1996, with modification).

The next major architectural change to the Gaol came in 1928 with the addition of women's cells. After the 1937 cyclone, the damaged 1887 watchtower was removed and repairs undertaken on the buildings (Troppo Architects 1996). Most of the perimeter fence may have been removed at this time as well (Troppo Architects 1996). During World War Two the Gaol was evacuated of prisoners and occupied by the Royal Australian Air Force. The airforce used the 1883 cell as an armory and store, while the infirmary was employed as a recreation centre and post office. Other buildings were converted for use as photographic rooms, a sick bay, and a mess (National Trust 1981). This period saw the demolition of many Gaol buildings, some of which were requisitioned to provide materials for the forces (Troppo Architects 1996).

The final stage of major modification came in the 1950s and 1960s. The original Guards' accommodation building, constructed in 1883, was demolished in the early 1950s, perhaps just prior to 1952 (Troppo Architects 1996). A galvanised iron perimeter fence was constructed to enclose a larger area of the Gaol. This was replaced by a new iron fence in 1961, which in 1966 was extended to enclose the present Gaol area. The fence was rebuilt after the 1974 cyclone. The 1950s saw the addition of new kitchen, laundry and ablution buildings, and two watchtowers which were erected at the northeast and southeast corners of the perimeter fence (Troppo Architects 1996). Additional buildings, including an isolation

Fig. 3. Photograph of subterranean tank in Area A, looking toward eastern perimeter fence. Note concrete lid, pumps, drainage channel and washstand and tub (in background). Photograph of unknown date but almost certainly within the period 1910-1930s. (Photo: Museum and Art Gallery of the Northern Territory).

block and guards' office, were constructed in the 1960s. In 1962 the 1883 Gaoler's house was demolished to make way for the new isolation block (Troppo Architects 1996).

ARCHAEOLOGICAL INVESTIGATION

The 1998 excavation focused on two areas of the Gaol which relate to late 1800s occupation. The aim of the investigation was the uncovery of information relating to methods for provisioning the inmate population with water. Two areas were selected for investigation - a well dug in 1883, and one of two concrete subterranean water tanks constructed in 1884 as replacements for the well (Fig. 2). Both the well and water tank not only represented early attempts at water management, but also held the possibility of containing discarded general domestic refuse (food remains, clothing items, broken ceramics, utensils, etc), rubbish which would reveal information on the everyday lives of the Gaol's inhabitants.

The excavation was also undertaken in the knowledge that the Museum and Art Gallery of the Northern Territory could at some future date give consideration to developing the features for public exhibition. Once excavated, visually enticing wells and tanks provide ideal structures for enhancing public education of the early difficulties encountered in providing a reliable and clean water supply to a confined population living in a tropical climate.

The tank investigation (Area A). Both subterranean tanks were constructed in 1884 to replace the well. The tanks were dug by prisoners and designed to contain 163,659 litres (36,000 gallons) of rainwater (Troppo Architects 1996). One was lined with concrete bricks made by prisoners, although the actual laying of bricks was undertaken by outside contractors, including two Chinese bricklayers. The other tank was lined with stone, apparently to expedite completion before the onset of the 1884 wet season. Both were originally capped with concrete lids, to which force pumps were added in 1910 (Troppo Architects 1996). The tanks were not altogether successful. From the outset they leaked and required constant maintenance. One suffered severe damaged in an earthquake in June 1894. They were nevertheless repaired and used into relatively recent times. A photograph taken of the Area A tank sometime in the early decades of the twentieth century depicts a concrete lid with attached force pump (Fig. 3). The lid and pump are also visible in a 1930s oblique aerial photograph, in which the tank is clearly shown in the corner of the prison complex (Fig. 4). Both subterranean tanks may have been filled in sometime between 1955 and 1960 (Troppo Architects 1996). Certainly they were completely infilled by the mid 1960s (Troppo Architects 1996). It is possible however that infilling postdated the time the tanks ceased to be used for water storage.

A decision was taken to excavate the southernmost of the tanks. This was made for purely practical reasons, this tank being closest to the 1883 well site (Area B), thereby facilitating coordination of student activity in the two excavation areas. Owing to limited time, it was planned to excavate only one quarter of the tank. This was done to both ascertain how the tank was constructed and to retrieve information on the material deposited inside it.

Excavation. Two 50 cm wide trenches were laid out to form a 'cross' across the depression which marked the tank's location. Removal of the layer of turf exposed the concrete edging of the rim of the tank. This was of a standardised 18 cm thickness (Fig. 5). Excavation of the northeast quadrant of the 'cross' exposed a concrete drainage channel, which in Figures 3 and 4 is evident as having extended from the tank out toward the eastern perimeter fence. The mouth of the drain was formed by cementing clay bricks to form a 28 cm wide channel. This fed into the drain itself, which was 40 cm wide at the base and 90-130 cm wide at the top. The drain was constructed of roughly poured concrete and formed a feature approximately 20 cm deep. It was clear from their downward slope that the channel and drain were intended to direct water from, not into, the tank. The drain may have served to direct water out of the tank for washing, perhaps laundry, purposes. What appear to be a washstand and tub are illustrated adjacent to the drain in Figure 3.

Excavation next proceeded down through layers of soil and sand, which had

Fig. 4. 1930s aerial photograph of the Gaol. Area A tank is visible beyond the white kitchen building, in the top left (southwest) corner of the area enclosed by the perimeter fence. Note also the above-ground water tank on a stand in the lower left (southeast) corner of the Gaol, in front of the infirmary. (Photo: Museum and Art Gallery of the Northern Territory).

been used to infill the tank (Fig. 6). This was initially undertaken in 10 cm deep spits, later increased to 20 cm spits. Six different layers were exposed beneath the turf (Fig. 7). The uppermost was a widespread layer of mixed dark brown soil with small porcellanite nodules throughout (Layer 1). Immediately beneath the topsoil was a grey to black fine-textured soil (Layer 2). A charcoal lens was present within this layer. At the western end of the section was an intrusive layer of dark brown to grey soil (Layer 3), the lower part of which was differentiated by the presence of small stones. Beneath this layer were two layers of beach sand. One, restricted to the eastern part of the section and abutting the tank wall, consisted of light brown coarse sand (Layer 4). More extensive was a layer of very fine white beach sand (Layer 5), which partially overlaid Layer 4. Layer 5 was distinguished by the presence of a vertical feature, tapering from 25 cm to 10 cm and extending to the base of the excavation. This may have represented a posthole or similar depression. The sand of Layer 5 had evidently been poured into the abandoned tank and in so doing had infilled this depression or hole. The depression had been dug into the underlying layer (Layer 6), which consisted of dark brown soil with loosely placed porcellanite pieces. Layer 6 was similar in colour and texture to the Layer 1 topsoil and was probably redeposited topsoil mixed with pieces of extracted basement porcellanite.

The excavation ceased at a depth of approximately 55 cm below the lip of the tank. At this depth the soil was noticeably damp, especially in the northeast part of the excavation. A spade hole sunk in this area reached water a further 50 cm down. The presence of water at approximately 100 cm below the top of the tank indicated that the tank still retains water, even during the dry season. The source of the water was probably the automatic sprinkler system, which is employed to maintain the lawns inside the Gaol. The presence of water precluded further excavation to identify the depth of the tank, which must form a major objective of any future investigation. This will require shutting off the sprinkler system, or use of a pump to empty the tank.

Artefacts. An assortment of artefacts was recovered from the tank fill. These included four brown beer bottle shards; clear, green and black bottle glass; a piece of stippled window glass; a tin can, paint(?) can lid and tin can fragments; copper electrical wire; a 23 cm long iron spike; a concrete brick; two pieces of concrete (the largest measuring 18 x 16 x 3 cm); a glazed piece of roof tile or heavy ceramic; one piece of white porcelain; a fragment of asbestos sheet; and numerous nails, including roofing nails. Almost all artefacts came from Layer 6. Exceptions were 700 gm of assorted nails, along with some glass, from the interface of the turf and Layer 1; four pieces of glass from Layer 3 (two fused together); and two pieces of blue/green glass from Layer 5. The presence in Layer 6 of a number of demonstrably mid-twentieth century artefacts indicates a relatively recent date for this period of

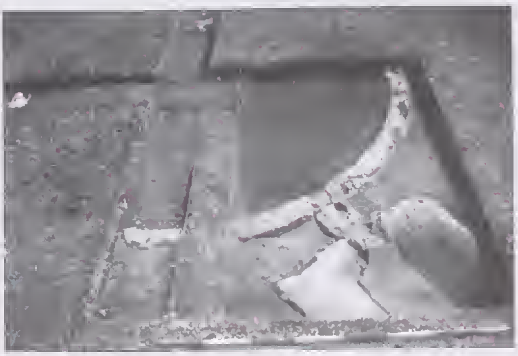

Fig. 5. Photograph of Area A depicting edge of water tank, and concrete drainage channel (in foreground).

Fig. 6. Photograph of stratified fill uncovered inside the Area A water tank.

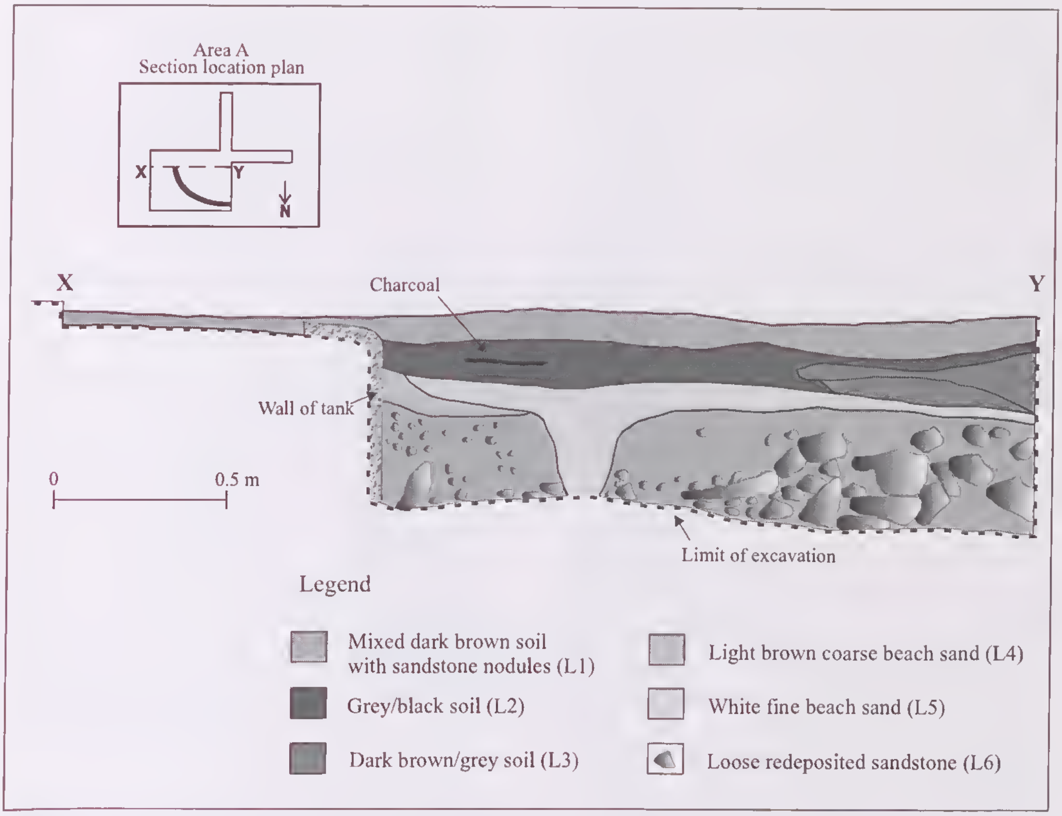

Fig. 7. Area A section depicting stratigraphy of fill inside the water tank.

infilling. However, as the excavation did not reach the base of the tank, earlier episodes of infilling may yet await discovery.

In addition to human-made artefacts, the excavation also revealed shells and stones that had been transported from elsewhere. Shells included gastropods and bivalves, including *Anadara* and four pieces of pearlshell (the largest 8 x 4 cm). Stones were mainly water-rolled pieces, the largest weighing 1,217 gm. Some bivalve shell and stone was recovered from the turf/Layer 1 interface, but the remainder derived from Layers 5 and 6, but predominantly Layer 6.

Discussion. The exposed section of the water tank was filled in over a number of episodes, beginning probably no earlier than the 1940s. It is possible that much of this infilling relates to the period of prison redevelopment which took place between 1955 and 1965. During this decade, a laundry building was constructed immediately south of the tank (1957-8), and the kitchen and dining areas to the north were extended (1963-4) (Troppo Architects 1996). The nearby abandoned tank would have been a convenient disposal place for excavated soil and building refuse. The fine beach sand discovered inside the tank may have been utilised in the preparation of concrete for building, such as for the construction of the platform foundation for the adjacent laundry. The association of shells and water-rolled stones with this sand is likely to be fortuitous. The abandoned tank may have also been used at one time as a convenient incinerator. This can be inferred from the presence in Layer 2 of a dense lens of charcoal and numerous charcoal pieces, as well as the discovery of fused glass in Layer 3.

One unanswered question relates to the fate of the concrete lid which originally capped the tank. One possibility, perhaps the most likely scenario, is that it was broken up when the decision was taken to use the tank as a refuse tip. A number of pieces of concrete were found in Layer 6, with the largest piece, referred to above, presenting a good candidate for a structural item. Excavation toward to the base of the tank may uncover the remains of the lid, perhaps along with the associated force pump.

On the evidence from the excavation it seems that the Area A tank was the subterranean tank mentioned in historical records as constructed of concrete bricks. This would therefore be the first tank to be constructed inside the Gaol. The tank in the northern section of the Gaol will probably be found to be the one lined with stones.

The well investigation (Area B). Two wells were dug in 1883 to supply the Gaol with drinking water. One was situated in a paddock outside the eastern perimeter fence. The other was excavated in the southeast area of the Gaol, immediately north of the location of the 1887 infirmary. The wells were found to be inadequate, with the water soon becoming unsuitable for drinking. The quality of the water was blamed for disease and general ill-health in the prison population (Troppo Architects 1996). Within 12 months of the Gaol opening, plans were made for the construction of subterranean water tanks, described above.

The location of the internal well has been given by Troppo Architects, on the basis of nineteenth and early twentieth century records, as approximately 10 m in front of the northwest corner of the infirmary. Today there is no surface evidence of the well's location. Presumably it was filled in at the time the water tanks came into use in 1884, or soon after. However, in their report Troppo Architects (1996) describe the well as in existence until 1944, although presumably by this time it had been capped. On this point it is noteworthy that in the nineteenth and early twentieth centuries wells were quickly infilled after they fell into disuse, to prevent the breeding of disease-carrying mosquitoes. An open and abandoned well inside a prison would certainly pose a serious health problem, as well as a safety risk.

Excavation. The purpose of the Area B excavation was to locate the well and excavate out a portion of its contents (bearing in mind that many wells around Darwin were in excess of 10 m deep). Preliminary probing with a steel drain-layer's probe failed to locate any evidence of a well. The next stage involved laying out a 20 cm wide by 4.5 m long exploratory trench. This was subsequently expanded by the excavation of three extensions, to the east, northwest, and southwest (Fig. 8). In total, 10.2 m^2 was opened up by excavation. The investigation proceeded down to between 15 cm and 70 cm below datum (which was approximately 5 cm above the turf). It soon became evident that Area B had been extensively modified by historically recent trench digging. This was associated with the laying of iron water pipes and plastic conduit of the type used to house electrical cables (similar, perhaps the same, conduit was also uncovered in part of one of the excavation trenches of Area A). The pipes and electrical conduit were not marked on plans consulted before the start of the investigation, and upon discovery of the conduit, the NT Power and Water Authority was contacted and an official subsequently carried out an inspection.

This evidence of relatively recent activity in Area B complicated interpretation of earlier activity. Nevertheless, a distinct stratigraphic profile was uncovered. This consisted of turf and topsoil (Layer 1) overlying a light brown coarse sandy gravel. In places, the sandy gravel contained scattered marine shells. The layer appeared to represent a redeposited beach sand, similar to Layer 4 in Area A. In places, chips of porcellanite were present in the sandy gravel. In the Southwest Extension, large pieces of mortar rested on and within the sand (Fig. 8). Over most of the eastern part of Area B the sandy gravel was sandwiched between topsoil and natural subsoil of red/orange compacted gravel, which rested on consolidated porcellanite bedrock (approximately 70 cm below datum). However, near the centre of Area B, a layer of grey/black soil (Layer 2) was present between the topsoil (Layer 1) and sandy gravel (Layer 3). Approximately one third of the extent of the Layer 2 grey/black soil layer was exposed, indicating it covered an area of around 3 m by 2 m (Fig. 8).

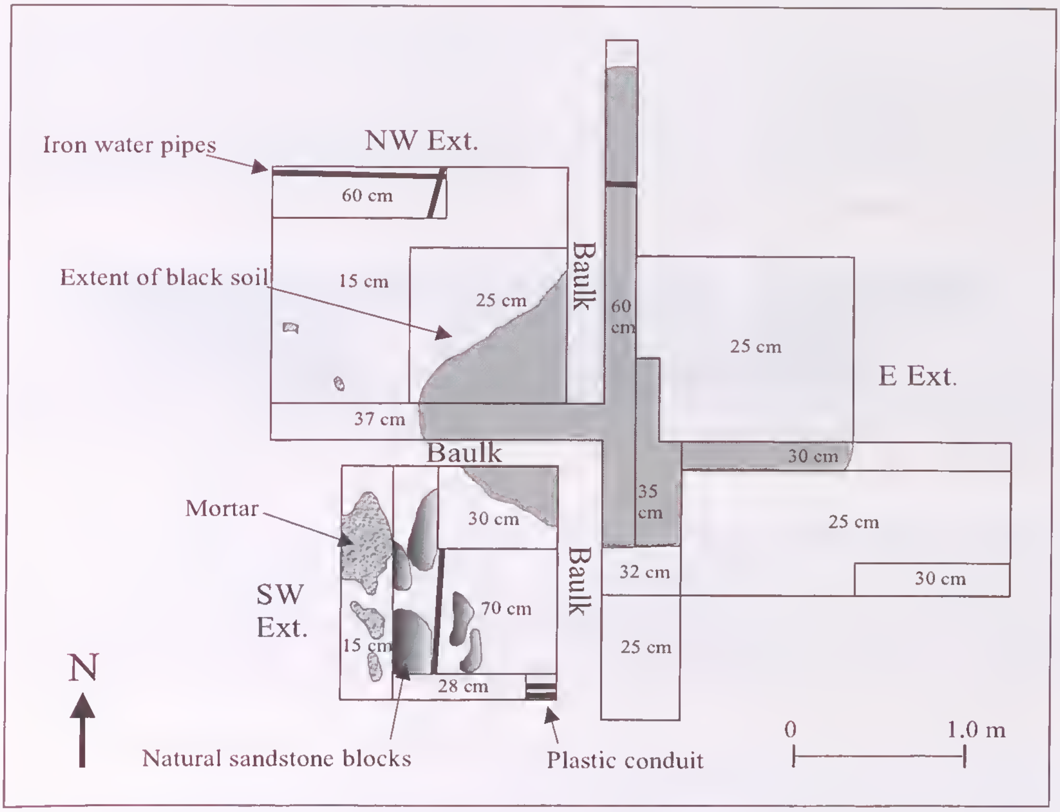

Fig. 8. Excavation Area B showing location of features and extent of black soil. Numbers refer to excavation depth below datum.

The depth of Layer 2 was ascertained by excavating the original 20 cm wide exploratory trench to a depth of 60 cm. This revealed that the Layer 3 light brown sandy gravel was discontinuous beneath Layer 2, and therefore did not extend over the entire excavation (Fig. 9). Beneath Layers 2 and 3 a 20-35 cm deep layer of black greasy soil containing pockets of ash and gravel was discovered. This black greasy deposit (Layer 4) had been produced as a result of the Gaol's former inhabitants burning organic material, including wood. Underlying Layer 4 was natural red/orange gravel. It was evident that a shallow pit had been excavated into the natural basal layer to contain the burnt organic material. The southern edge of the pit was vertically cut and originally lined with corrugated iron nailed to wooden batons. Pieces of iron were discovered still adhering to the face, along with nails and wood fragments. The northern edge was less distinct. It may have been cut into a brown soil (Layer 5) which extended northward in the section (Fig. 9). However, no evidence of corrugated iron lining was discovered here.

Artefacts. Surprisingly few artefacts were present in Area B. From the pit feature itself, which would perhaps be the most likely place to find artefacts, only 26 nails and two pieces of corrugated iron were recovered, all associated with retaining the southern edge of the pit. The nails were not diagnostically early (Varman 1987) and probably date to the twentieth century. Two possible glass marble fragments were found in the Northwest and Southwest Extensions at between 20 cm and 35 cm below datum. The topsoil revealed broken concrete (seven pieces), two pieces of brown bottle glass, a plastic trouser button, and a piece of electrical cord.

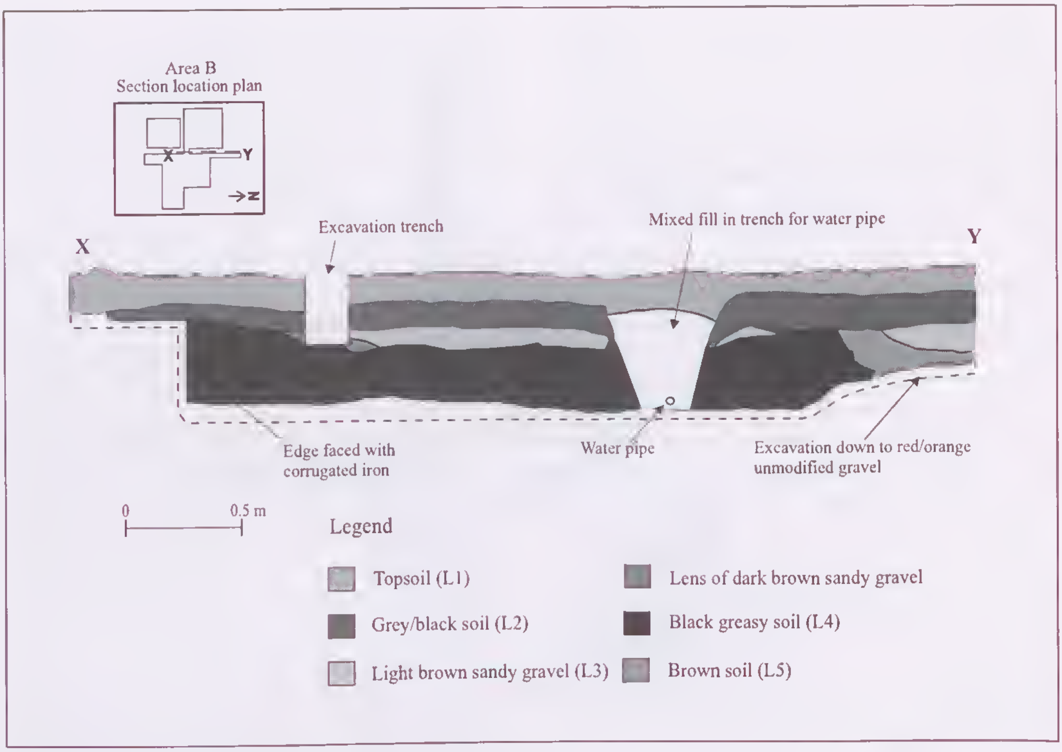

Fig. 9. Area B section depicting soil layers and pit feature.

Discussion. The primary objective of the excavation of Area B, the identification of the 1883 well, was not achieved. This was in spite of placing the excavation on the site of the well, as identified from nineteenth-century records. During the course of the investigation some consideration was given to the possibility that the shallow pit may have been purposefully excavated around the mouth of the well when the latter was dug, perhaps to prevent loose debris falling inside. However, the trench placed through the centre of the pit failed to uncover any indication of a well. Probing with the drain-layer's probe also failed to detect anything but solid porcellanite beneath the black soil. One possible explanation is that the pit was associated with a water tank stand, which the 1930s aerial photograph shows to be immediately north of the infirmary in the same general location as the Area B excavation (Fig. 4). The excavation may therefore have been unwittingly placed on the tank stand site. This raises the question of the location of the well. In both Figures 3 and 4 a pipe can be discerned protruding from the side of the water tank and then turning to extend vertically down to ground level, presumably into an underground cistern or well. When combined with the negative evidence from the Area B excavation, this provides a clue as to the possible location of the well. If the Gaol's first well is at the point where the tank pipe entered the ground, then it is situated only a few metres north of the excavation, probably beneath a present-day concrete path. Further archaeological investigation will be required to determine if this is indeed the case.

CONCLUSION

The 1998 excavation season was successful in locating one of the 1884 subterranean water tanks. We are now in possession of information on its construction and size that was not previously known. The investigation was also able to identify the tank as the first one constructed in the Gaol. Artefacts recovered from the tank indicate that at least one episode of infilling was carried out during recent times. This may postdate the time the tank fell into disuse; information on this awaits complete excavation of the tank. The tank was found to be in a good state of preservation and, once emptied, would make an ideal feature for interpretation and public display.

The excavation of Area B provides an illustration of how archival information can be misleading when used to attempt to precisely locate early historical features. Excavation of the area which archival information indicated to be the location of the 1883 well failed to uncover evidence of a well. It is possible the excavation was placed south of the well's actual location. The shallow pit uncovered in Area B may relate to an elevated water tank constructed some time after the well ceased to be used as a regular source of water, or may represent an even more recent feature, perhaps a rubbish disposal pit or a 'flaming fury' latrine.

In conclusion, results of the 1998 excavation demonstrate that physical evidence of the early history of Fannie Bay Gaol will be found beneath the ground surface, as well as in the extant buildings visible today on the site. Some of the hidden evidence, as with the well, will not tie in with opinions and knowledge formed from archival research. Other evidence, such as the subterranean tank, will neatly mesh with information derived from archival research. The investigation of water storage features at Fannie Bay Gaol serves to reinforce the observation that, irrespective of whether archaeology builds upon or causes us to query the written historical record, an understanding of the total history of the Gaol will be achieved only through analysis of both the written word and the material remains of past occupation.

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REPORT ON A VISIT TO THE RECENTLY EXCAVATED KILN SITE AT BAN INTAKIN, NORTHERN THAILAND

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ABSTRACT

The study of Thai ceramics is complicated by the lack of records, and while some ceramics are signed, none are dated. Given the expensive nature of field work, the most recent kiln site excavation in the north, by the Thai Department of Fine Arts in 1996, at Intakin near Chiang Mai, is of great interest. But the findings of the report (Prishanit and Suphamas 1997) are questioned, particularly that these kilns fired high temperature glazed stoneware, because of the complete absence of slag or natural fly ash glaze on kiln surfaces usually associated with wood fired kilns, and the absence of kiln furniture essential for glaze firings. Further, the construction method used for the kilns is suggested to be surface/slab, but there is no evidence of a slab of clay forming the kiln, and, rather than being surface built, the kilns appear to have been fired from a pit – i.e. they are in-ground. In-ground technology is simple but effective, and was used unchanged over many centuries concurrently with an evolving technology that led to the development of surface brick-built kilns. This paper argues that the Intakin kilns belong to the former technology and so are unrelated to Thai glazed stoneware.

KEYWORDS: Thailand, Sukothai, Chiang Mai, Intakin site, ceramics, kilns, glazed stoneware, northern kilns, ceramic technology.

INTRODUCTION

> The study of South East Asian ceramics is a compelling adventure because of the dearth of records left by the potters themselves or by merchants and others who dealt directly with (them) (Richards 1995).

It is only recently (since 1980) that scientific exploration of Thai kiln sites has been undertaken. Until then, authors relied on historically or stylistically based approaches, commonly with an assumed belief that technology was imported and Chinese influence dominant. On the contrary, Thai kilns, once introduced, have been shown to evolve indigenously at Si Satchanali (or Sawankalok as the wares have come to be known) on the central plains over centuries, perhaps from the C10 to C17, from simple in-ground kilns to surface brick built kilns that at the peak of the industry competed on the export market with the Chinese (Brown 1988; Hein 1990). There were also northern Thai or Lanna ceramics similar to, but different from Sawankalok: scattered rather than focused, and regional rather than export, but some of the finest stoneware was made in the north. How the industry began and ended is still unclear. For example, while it is argued that the Khmer could have introduced glazed stoneware to Thailand from the south (Grave 1995), it is also suggested that the technology may have first developed in the north where many kiln sites are known (Shaw1989).

In February of 1999 I visited the recently excavated kiln site at Intakin as part of ongoing field-work. The focus of my research is the high-fired stoneware of the central region of Ban Ko Noi (or Si Satchanali). I have visited many kilns and kiln sites from Khmer in Buriram province in the south through central Si Satchanali and Sukothai to Kalong, Pa Sarn, Wang Nua and Phan in the north, as well as visited major public and private collections throughout Thailand.

The Intakin site is a group of five kilns in northern Thailand about 40 km from Chiang

Fig. 1. Map of mainland South East Asia showing Intakin site near Chiang Mai in northern Thailand.

Mai (Fig. 1). The kilns are of the wood-fired cross draught typical of the Thai genre of kilns (Fig. 2). Initial investigation of the group of five in-ground kilns was undertaken by a team from the Thai Department of Fine Arts, Archaeology Division in 1996 (Prishanit and Suphamas 1997).

The Fine Arts Department has so far surveyed thirteen northern sites but excavated only a few of them. Therefore, given the expensive nature of the field-work, new information is important to the increased understanding of the emerging story of the development of Thai ceramics.

THE DEVELOPMENT OF THAI STONEWARE

Glazed stoneware has been produced in China from very early times. Certainly by the Han Dynasty (started C3 BC), a wide variety of ash glazed vessels were produced in significant numbers after several centuries of prototypes and experiment (Brown 1989).

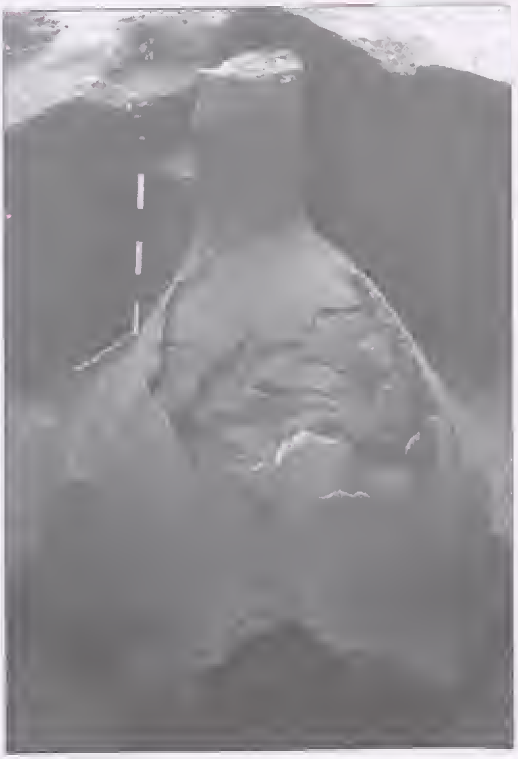

Fig. 2. Intakin kiln No 1, a small in ground kiln about 4 metres long, excavated by the Thai Department of Fine Arts in 1996.

It should also be remembered that the first stoneware, German salt glaze, was not widely produced in Europe until much later, around the C14 AD, and true porcelain not until the early C18 (Charleston 1977).

The development of high fired ceramics in Thailand. Stoneware appears in Thailand by at least the C10, though the means of dissemination are unclear. Brown (1989) argues that the least likely explanation for the beginnings of the Thai pottery industry is that it was a local invention. It cannot be mere coincidence that the only other countries in the world besides China to make high-fired ceramics in early times are all on or near the border of China (Brown 1989).

Without access to accurate historical records, the story of Thai ceramics relies on archaeological evidence, and so remains at this stage still in part untold. It is an exciting if somewhat unlikely prospect that high-fired ceramics developed independently in the northern regions, as stoneware had already developed in China many centuries before. But because fly ash falling onto the ware, or build up of glaze slag on the kiln (or furnace) itself must have been the inspiration for stoneware glazes, the possibility of independent discovery remains open. It must also be remembered that the metal smelting of the Ban Chiang culture, which also produced ceramics, evolved in the northeast in very early times (Labbe 1985; White 1982). Bronze smelting has both the required temperature and reducing atmosphere required for high fired ceramics. Further discoveries in the future may confirm a continuous sequence of development.

Theories for the origins of Thai high-fired ceramics. The traditionally accepted and still widely held popular view is that Thai ceramics were introduced by King Ramkamhaeng, who brought back "500" potters after a visit to China in 1296 as is recorded on his famous (or infamous) stone inscription which is now thought to be mostly legend (Krairiskh 1988; Vickery 1987). Until about twenty years ago most writers (eg. Willets 1973; Spinks 1965) referred to the Chinese connection for the introduction of the ceramics industry and ongoing influences. The extent of ethnic Chinese influence in Thai ceramics is debatable. The Tai, who are believed to have filtered into what is now Thailand from parts of (what is now) southern China where cross draft kilns producing glazed stoneware are known to have been active since at least the Tang dynasty (AD 618 - 906), could perhaps have brought the kiln technology themselves (Brown 1988).

Technology transfer is evident for the introduction of in-ground kilns, and some other developments such as the move to primary white clay, and some design and decoration. Throughout the early 1980s, a team of Australian archaeologists led by Don Hein undertook excavations at Ban Ko Noi and found no evidence at the site of foreign presence:

> An awareness of other sites and ceramic products from foreign sources were certainly known and these seem to be the inspiration of some ideas, but essentially the existence of the Ban Ko Noi ceramic site was the product of local knowledge and initiative. There is no evidence of foreign people; no graves, habitation sites, inscriptions, coins or artefacts or objects that might support the notion of foreign presence (Hein 1990).

Potters' marks as writing rather than symbols are not common on Thai ceramics, but when present they are all in Thai script. There were no Chinese (or other) characters used. Chinese wares are found at some sites, particularly Ming shards at upper levels.

A possible Khmer origin is argued (Grave 1995). One of the last major technological innovations of centralised polities in pre-industrial Southeast Asia is the production of high temperature glazed and unglazed stoneware. The introduction of stoneware production in mainland Southeast Asia happened around 1000 AD. At this time, stoneware production is argued to have commenced at a number of Khmer controlled regions, e.g. Ban Kruat in Buriram province (Grave 1995). While the Khmer did occupy northern central Thailand before the rise of Sukothai, the ware produced, and the kilns, are very different. The Khmer kilns are surface built slab kilns with common walls and internal roof supports, nothing like the Thai in-ground kilns (Hein 1984).

Vickery (1986) has identified Mon words for ceramic terms, even possibly for the origins of the term Sawankalok itself, suggesting a Mon link to the early Thai Kilns. It is clear that while many theories exist for the origins of the industry, it is evident that once in-ground technology is introduced, a localised evolution occurs, as is clearly demonstrated at Ban Ko Noi (Hein 1990), and also in the north, though northern developments are not so clear (Shaw 1989).

In-ground kilns. These first Thai kilns were simply holes dug in a river bank, later from a pit, somewhat like a rabbit burrow. There was a hole down the bank to load and fire, a chamber for the wares and a hole or flue two or three metres higher up the slope for the exit of smoke (Hein 1984). River banks have a high clay content and so the earth itself formed the kiln walls. The kilns were easy enough to construct as the kiln was the dug hole, but they were not without problems. The kilns were subject to annual flooding of the river in monsoon season. They were doomed to fail as repeated firings progressively shrunk the clay content and opened up cracks in the roof which eventually would cause the roof to fall onto the wares. Before this happened, slag from the iron rich walls, composed of river terrace clay into which the kilns were dug, formed and dripped onto the wares (Hein 1990). All the same, it is estimated that an in-ground kiln lasted for a generation or so; for more than a couple of hundred firings.

Constructed kilns. Grave (1995) argued that without some modification, simple in-ground kilns could not fire to stoneware. Typically, modification to the fire-box was one of the first developments to improve the efficiency of the kiln, as high firing (to temperatures of 1260 degrees or so) required technological innovation, particularly to the firewall, the slope of the chamber, and the chimney. There are powerful reasons for the development of kiln technology; bringing kilns out of the ground was labour saving and overcame seasonal dampness problems. A constructed chimney, one of the earliest developments, meant that no longer was a deep firing pit needed, and work could occur at or near ground level. Constructed kilns, when they failed, could be thrown down and rebuilt on the spot, whereas in-ground kilns always required relocation, and more importantly, costly relocation of related production infrastructures.

The marvellous sequence of localised invention and development from in-ground to above-ground brick built kilns is revealed at Ko Noi, the major Sawankalok site, where the later kilns still retain the quaint burrow shape of their predecessors (Hein 1990, 1984).

Thai ceramics at Sukothai. Sukothai was the first of the Thai city-states to gain independence from Khmer rule in the C13 and is regarded as the foundation of the modern Thai nation (Shaw 1989). Thai ceramics are best known by the export wares from this area found in the Philippines, and more recently in Indonesia, for example from grave sites in Sulawesi (Richards 1995; Brown 1989). The major kiln site is at Ban Ko Noi near Si Satchanali, a sister city to Sukothai, on the central plains. Here is one of the best preserved and largest kiln complexes in the Asian region. These kilns (Fig. 3) evolved indigenously over many centuries, perhaps C 10-17 (Barbetti and Hein 1989), from in-ground to surface brick built kilns up to ten metres long. At its peak, the industry competed on the export market with the Chinese, as well as producing large amounts of domestic sculptural and architectural ceramics for brick palaces and temples. Northern ceramics, which were not export oriented, have often been overshadowed by the scale of the Sawankalok sites and the extensive research undertaken there (e.g. Hein 1990; Hein and Barbetti 1989).

Northern Thai ceramics. In the north, separated physically (and culturally) from Sukothai by mountain ranges that eventually become the foothills of the Himalayas, the second major Thai state of Lan Na with its capital at Chiang Mai was established also in the C13. Lan Na translates literally as one million rice fields, and there are many paddies in a series of isolated fertile valleys separated by mountain ranges and jungle, and dozens of kilns in scattered groups, some in-ground, and some utilising slab and brick construction. These sites include Phan (Gluckman 1974), Kalong, Samkampaeng, Phayao, and Nan. (Shaw 1989; Rooney 1990). Brown (1989) lists nine northern sites. Kalong is perhaps the major region, and a kiln from Wang Nua was excavated and rebuilt in the grounds of the Chiang Mai Museum by the Department of Fine Arts in 1982. Unlike the potters of the central plains with access to river systems and the export trade, Lan Na potters produced for the domestic market. As northern palaces and temples were built of teak, there was no demand for architectural ceramics. There were northern trade routes down the Mekong and into Burma and the coast, but Lan Na ceramics have so far not been found at export sites outside Thailand.

In the north, food was traditionally eaten (and still is) from a banana leaf, and sticky rice scooped directly from the cooking pot

Fig. 3. Ban Ko Noi surface kiln, partly reconstructed, about 10 metres long, which produced high-fired stoneware for export about the late 16th century.

and rolled into a ball with fingers. The bowl illustrated (Fig. 4), with underglaze decoration of a stylised chrysanthemum, would have been prestige ware for palace or temple, and is an excellent example of a high-fired stoneware from Kalong, just north of Intakin. The bowl is typical of the finely potted and strikingly decorated ware that in Shaw's opinion:

> ...vindicated my belief that Northern Thai ceramics should not be treated as poor country cousins of the wares produced further south. They are probably the finest ceramics ever produced in South East Asia (Shaw 1989).

What is badly needed is another find giving clearly datable ware and kilns to provide more concise evidence about the nature and development of the industry.

Possible causes for the decline of the industry. In the late C16 the Burmese overran and ransacked Thailand, and the ceramics industry may have been too weakened to return to operation (Shaw 1989). However Chiang Mai and Sukothai fought a series of wars in the late C14, but during the conflict the industry continued, and in fact was at one of its peaks. (Brown 1989). Thus war may not have ended the industry. There are many other theories for the decline: changing demand, competition from Chinese blue and white porcelain which the Thais did not produce (Richards 1995), or the appearance of European traders and the emergence of a new global rather than regional economic trade structure (Grave 1995), are all possible factors.

The Europeans, particularly the Dutch, did keep accurate records, and there is some archaeological evidence from sunken ships and their cargo (Green 1990). The Thai ceramics export industry finished around the end of the C16 or early C17, and it cannot be coincidence that the northern industry also declined around the same time (Shaw 1989).

Scientific dating of Thai kilns. A great deal of investigation has been undertaken for Sawankalok ceramics, but comparatively

Fig. 4. Kalong dish, dimensions 240 x 550 mm. Stoneware with underglazed brushed geometric floral design, about 15th century. Collection: MAGNT (ref no IND 2062). Kalong, near Intakin was a major production centre of glazed stoneware.

little for northern wares and kilns. At Si Satchanali, three major museums have now been built. In the Kiln 42 Museum, a sequence of eleven kilns is revealed (Hein 1984), with a large brick built kiln KN111 uppermost, and an in-ground kiln KN110 at the bottom. In the Kiln 61 Museum, a collapsed in-ground kiln reveals unglazed stoneware jars still in situ in the firing chamber.

Radiocarbon, thermo-luminescence and palaeomagnetic dating, although preliminary (Barbetti and Hein 1989), seem to confirm the C10-17 time line for the operation of the Ko Noi industry. An important point to note is that while KN110 dates to 970 years BP, KN61 is 400 years younger, though both are in-ground kilns (Barbetti and Hein 1989). What this indicates is that demand for unglazed wares continued for a long time, and the in-ground kilns which were most suited to fire them continued to be used contemporaneously with above ground kilns which evolved at the same time.

In the north, no kiln groups have been dated except for the Intakin group. Preliminary unpublished findings for these kilns is a series of readings giving a range of dates consistent with the fifteenth century (Barbetti 1998, pers com). That is, like KN61 at Ko Noi, the Intakin kilns in northern Thailand are later rather than early in-ground kilns.

The importance of the northern kilns. Because of the long sequence of development in the ceramics of the Sukothai region, it was at first assumed that the northern kilns were derivative: most writers preferred the simple theory that all of the northern kilns were the work of potters from Si Satchanali. But as more and more kiln sites have been discovered (with no end in sight) it has become clear that the explanation must be far more complex. The earliest wares in the north and at Si Satchanali seem to be offshoots from a single shared tradition still undetected (Brown 1988). The Intakin kilns therefore are important to the understanding of kiln evolution.

Shaw (1989) has no doubt that the northern in-ground kilns evolved first, and the technology spread south, and that the early Lan Na dishes fired rim to rim and base to base are the common denominator:

> ... there is no doubt that they are closely related. An even more striking similarity is the use of incised decoration on the vases and dishes of Payao and "Mon' Ko Noi. Which then is the father of all kilns working in this tradition? - Payao seems to me to be the most likely to have been the centre whence spread the knowledge of making high-fired ceramics (Shaw 1988).

It is an exciting prospect that high-fired ceramics developed independently in the northern region, though stoneware in a different form had developed in China a long time before. Further discoveries in the future may confirm further details of the sequence of development. In this context the Intakin kilns are potentially very important to our understanding of Thai ceramics.

THE INTAKIN KILNS

The Intakin kilns are literally in the back yard of a villager's house. The site has been roofed, making it protected. The villager has a caretaker role, and also sells postcards to help fund this. Directions to the kilns for tourists are given in English and Thai are accessible, unlike earlier northern sites which, left unprotected, are now hard to access. The site is on a slope at the edge of an alluvial plain known as *Thung Phan Eag Phan Fyn Muang Khaen*, 'the field of a thousand yokes and harrows', about 40 km from Chiang Mai. This would have been an important rice cultivation area that supported the population of the early city. Clay, wood and water were in abundant supply. Three kiln sites have been identified here so far by the Department of Fine Arts, but there must be dozens spread about the north (Brown 1989).

There are five kilns in the Intakin group, and the two excavation pits reveal that the kilns are small, less than four metres long, and have an unusual wedge-shape with high fire-wall and flat, low roof to the firing chamber. They are important kilns confirming a mature variation on a theme, reflecting the indigenous nature of the industry and demonstrating that they are not a slavish copy of an imported design. Prishanit and Suphamas (1997) describe the kilns as:

> ... clay slab kilns of cross draught type which are determined as above ground type, relatively intact except for the collapsed roof of the firing chamber.. The Kiln's shape viewing from above are similar to laid jar with mouth rim down to earth at lower level and it's narrow foot rim raised up. such shape defined as 'jar like kiln' or Tao Hai.

In my opinion, the kilns are not surface/slab, but in-ground, and the jar-like shape indicates the presence of a firing pit needed for in-ground but not surface kilns. I also doubt that the kilns fired glazed wares.

Dimensions, floor slope, orientation etc are given, and the accompanying shards found in the excavation catalogued as 'kiln wasters'. (Wasters are rejected pots that are too badly damaged in the firing to be commercial, though in practice any pot that could function at all was used). The glazed finds at the kiln site are classified (Prishanit and Suphamas 1997) as celadon plates, dishes and lidded jars, and large storage jars with greenish or brown glaze. These finds are common products of the region (Shaw 1987) and I believe these are are not necessarily products of the Intakin kilns. The presence of these ceramics also suggests that the kilns are not early - such wares are from the mature period, but while in-ground kilns with simple technology were the earliest kilns, they have continued to operate along side the more advanced kilns.

In the following discussion I seek to support these arguments and to re-evaluate the findings of the report of Prishanit and Suphamas (1997).

REINTERPRETATION OF THE INTAKIN KILNS

On the basis of my research into similar kilns in Thailand, observations of ceramics collections, and my experience as a potter using wood fired kilns, I propose some alternative explanations for the observed features of the Intakin kilns.

Lack of slag or glassy coating on kiln surfaces. It is unlikely that these kilns were used to produce high temperature glazed stonewares. An examination of a fragment of the Intakin firing chamber (Fig. 5b) shows very little build up of slag due to fly ash and volatilised glaze as one would expect, and which is present on the Ko Noi kiln sample (Fig. 5a). The piece of the Intakin wall has only a very thin, dry coating of a matt slag, and the rest of the wall is quite friable compared to the vitrified brick of the other kiln. It must be remembered that these kilns were fired to the end of their life, perhaps ten or twenty years, that is, until the roof collapsed. If high-fired glazed stoneware

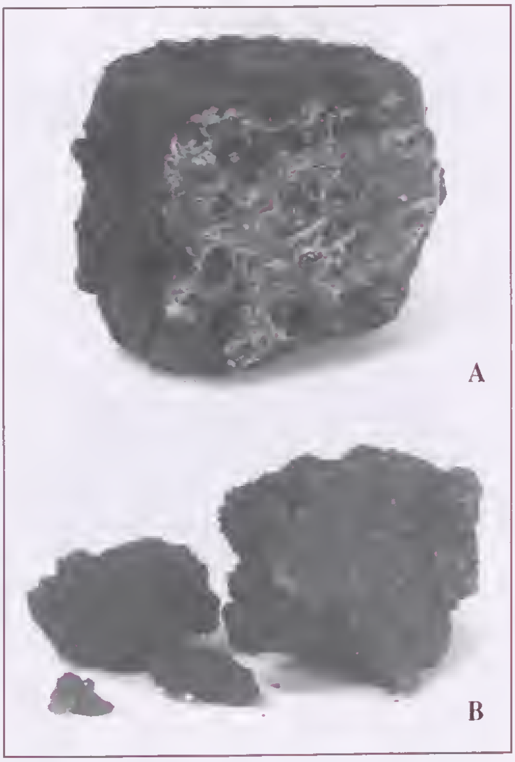

Fig. 5. Comparison of firing chamber fragments from Intakin and Ko Noi kilns: **A**, the Ko Noi piece shows glassy slag, is vitrified and dense due to repeated high firings; **B**, the Intakin section has only a thin matt crust and is friable. This suggests the Intakin kilns did not high fire glazed wares.

was produced, the characteristic slag is unavoidable, as it builds up, after repeated firings from fly ash and volatilised glaze at the high temperature required to produce a glaze. While the Ko Noi sample is from large scale export production, this slag is present on other Thai cross draft wood fired kilns that I have observed, from Khmer onwards. The excavation of a kiln at Ban Bok Suak, Nan province (Praicharnchit 1985) found glazed wasters in association with kiln structure (walls) lumps of fired clay covered on one face with a natural ash glaze 0.4 - 1.0 cm thick, and kiln furniture coated with an olive brown natural fly ash glaze. This report (Praicharnchit 1985) details a northern kiln site with substantial evidence for glaze production through wasters and slag deposits. Yet glassy slag is completely absent at the Intakin kilns either in the chamber or the firebox.

Lack of associated kiln furniture. Unglazed wares can be stacked together, but all glazed surfaces must be separated from contact with each other during firing. There is no associated kiln furniture, such as tubular firing supports or spurred discs usually used to separate glazed pots (Hein 1990), listed amongst the finds at the Intakin site by Prishanit and Suphamas (1997). A common northern practice was to fire bowls rim to unglazed rim (Shaw 1989), but such wares as the glazed celadon bowls discovered at this site cannot be stacked together and need furniture, yet no such furniture is disclosed at the Intakin site. John Shaw's extensive collection of northern ceramics also includes many items of kiln furniture, in fact much more varied than Sawankalok, so it is curious that none at all were found at the Intakin site if glazed stoneware was produced there.

Waster or rubbish? Kilns are typically surrounded by evidence of what was fired in them; wasters, that is ware with firing faults thrown to the side as quality control is exercised over a long period, as at Ko Noi (Hein 1984) and indeed at all kiln sites that I have visited. But at Intakin, these shards were found in the work areas - i.e. the firing pit and down the chimney. It is unlikely that the potters would have dangerously cluttered the work areas, and certainly not the firing pit. I suggest that when the kiln was finally abandoned, the hole was used as a rubbish tip, typical of any hole in the ground. The broken ceramics are consistent with the range of wares in use in a community of that era as mentioned above, and that might break in use and so be discarded. The variety of shards found down the chimney of the abandoned kiln No 2 may well be rubbish rather than wasters.

Some evidence of what the kilns did fire would be expected to lie near the kilns as wasters, but the excavation was perhaps not broad enough to locate such a dump outside the kiln/firing pit area, though the 'prefired potsherds' (that is unglazed potsherds mentioned as 'unusual finds' by Prishanit and Suphamas (1997)) might be such wasters.

At the kiln site only a couple of samples of broken pottery remain, and a further half dozen or are illustrated in the report by Prishanit and Suphamas. These shards would appear to be broken pottery rather than wasters which should show kiln damage. These shards are from a very wide range of wares from large brown glazed jars to incised celadons typical of export ware. There is a greater variety present than might be expected to be produced from a small group of kilns, given the degree of specialisation that is typical of most kiln sites (Hein 1990).

The construction of the kiln. Although reported as being a slab kiln by Prishanit and Suphamas (1997), the body of the kiln shows no evidence of being produced from a slab of clay, which would be expected to be of different colour and texture to the surrounding earth, and with a clearly defined boundary. Only the upper part of the chimneys at ground level seem to be constructed of a separate slab of clay. What the excavation has revealed is the band of heat-treated earth caused by repeated firings. From about twenty centimetres or more from the kiln chamber, into the surrounding earth, some effect would be noticed - typically a reddish discolouration at the outer limit - but only the first few centimetres physically changed to fired clay, fired high enough for the wall to become hard and permanent. It is to this point that the kiln excavation has pared down, but it is not a slab. What is present is a friable, iron rich fire hardened earth typical of alluvial clay / loam soil of the kiln surrounds. This indicates that the kilns are of the in-ground genre, excavated rather than built.

In-ground kilns are operated from a firing pit. The kiln (Fig. 6b) does look like a jar, but the rim at the mouth is not a feature of the kiln itself, but rather a remnant arc of the excavated firing pit. A rim or snout is needed with in-ground kilns to support the earth around the kiln, whereas a slab kiln is supported by the thickness of the slab and needs no such support.

The kilns were fired from a pit, as shown in Figure 6b, which was re-used for subsequent kilns. A second kiln is clearly dug lower and a third kiln is offset deeper again at a different angle to take advantage of the existing infrastructure of the pit such as access steps, fuel storage and sorting and loading areas. It would not be logical for this to occur with a surface kiln construction because the kiln would simply be knocked down and rebuilt on the same spot.

Fig. 6. A, lateral; and B, plan view of the Intaken kiln showing the free-form shape with the chimney at a slight lean and off-set to the side, indicating that it was excavated rather than constructed. The dotted line indicates a small fire hardened arc that was a section of the circular firing pit, rather than a jar-like rim to the kiln itself as interpreted by Prishanit and Suphamas (1997).

The shape of the kiln. The roof of the kiln is almost flat. This would be very difficult but not impossible to construct, over a bamboo frame for example. However, when the slab was covered with earth, it could not have long sustained the weight of the covering soil, or its own weight over more than a limited number of firings. Later kilns were built on the surface to provide a saving of labour, but Intakin kilns are clearly in-ground, not slab, and were fired from a dugout pit.

The kiln shapes as illustrated in Prishanit and Suphamas (1997: Plan 4) are very geometric. In actual fact, the kilns are very organic or free-form shapes as the sketch (Fig. 6) shows, with curves varying and the chimney off to one side, which one would expect of a dug kiln with technicians working by eye in a poorly lit space, rather than a constructed kiln that could be erected carefully according to a precise plan.

The Intakin kilns are clearly of cross draught construction traditionally producing high fired stoneware. Earthenware has been produced in the region for centuries, but the earthenware kilns are a different style, being simple constructions for low-fired cooking and other domestic wares. A fire is lit under the ware in a hollow chamber and enclosed at the top with broken pottery etc. to seal in heat, and then fired to less than 1000° C - very basic kilns compared to the Intakin kilns. It would make no sense to build a complex kiln to produce earthenware in lieu of available simple updraught technology.

Possible wares fired at Intakin. By deduction, if the kilns did not produce high-fired glazed stoneware or earthenware, it is possible that they mostly fired low temperature unglazed but vitrified vessels of a uniform size because of the flat and fairly low roof. These vessels, perhaps jars or bottles, if of a red clay, might well have vitrified at around 1100° C. At this lower temperature little or no fly ash slag would occur, and there would be no volatilisation from glaze. Many stoneware jars such as water storage jars were, and still are, unglazed (Hein 1984), and there would have been a large domestic demand, when the Intakin kilns were operating, particularly as Intakin was in a heavily populated region. Some unglazed stonewares are still produced today, for example the ubiquitous mortar and pestle used for green pawpaw salad. Prishanit and Suphamas (1997) note unglazed fish net weights were found at the site, and:

> Pre fired pot sherds found in excavation are rare and unusual evidences among archaeological finds ever discovered at ancient kiln sites in Thailand. They are unfired dish or bowl of white body.

Prishanit and Suphamas (1997) seem to be referring to the general Thai practice of once-firing wares and not bisque firing and glazing separately with two firings as is the more widely used industry technique in manufacturing ceramics. But "unfired" may be a translator's error: if we read *unglazed* for *unfired* this may in fact indicate the presence of unglazed stoneware. These unglazed stonewares would quite likely be products of the Intakin kilns; the glazed stonewares, I have suggested, were more likely to have been rubbish thrown into the kilns areas after their working life ended in the fifteen century.

CONCLUSION

The Intakin site is valuable to our understanding of the origins of Thai ceramics, given the limited body of knowledge and the expense of excavations restricting further information. I have argued that they are simple, dug out in-ground kilns rather than technically more complicated constructed slab built kilns as suggested in the report by Prishanit and Suphamas (1997).

The texture and composition of the kiln's earth construction is consistent with the surrounding soil; an introduced slab would be of a different and better quality clay. There are indications that the operation was from a firing pit, and that this same pit was used for at least three kilns because of their orientation towards a central work point. The Intakin kilns date to the C15, well after ceramics production first began in the north. They are clearly a variation on a regional theme, similar to, but different from, other northern kilns. Modifications to the firebox and the flue confirm later technology, but not that of the evolution to surface/brick construction, and provide no new information about the evolution or origin of northern Thai kilns.

There is no evidence, apart from a few pieces of broken ceramics recovered at the site, to suggest that these kilns fired glazed stoneware. There is no indication of slag or fly ash glazing on kiln surfaces and there is a complete absence of kiln furniture needed to produce glazed wares. The discarded ceramics are likely to be accumulated rubbish rather than kiln wasters. Unglazed wares were in demand for domestic consumption, and it is probable that these were the products of these kilns. Further research is required into the structure of the Intakin kilns and the wares fired in them to clarify the place of these kilns in the history of Thai ceramics. In the absence of recorded information, and the existence of often fanciful chronicles written centuries after the event, and with the rapid decay of wooden structures, ceramics provides important clues to the past. How the Thai ceramics industry began and ended is still unclear, and must reflect the rise and fall of Thai culture itself. Continued ceramics research will provide further answers, not just about ceramics, but also about the history and culture of Thailand and the South- east Asian region.

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THE SHIP'S MAST. THE LEGACY OF THE MACASSAN PRESENCE IN NORTHERN AUSTRALIA

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ABSTRACT

A ship's mast with flags attached stands anchored to the ground in a cleared area near the centre of a number of Yolngu (Aboriginal) communities in north-east Arnhem Land. The mast is, I argue, the most significant and enduring legacy of contact with Macassan[1] trepangers from Sulawesi, who ventured onto the northern Australian coast from at least 1700 until the early years of this century. Drawing on Taussig's (1993) text 'Mimesis and Alterity,' and more recently Merlan's (1998) examination of the mimetic quality of the Aboriginal social agenda, I discuss the ways in which lessons from the Arnhem Land mast are of political import for contemporary Arnhem Landers pursuing self-determination. I also examine the proposition that the revelation of sacred Dreaming law by Aborigines, in particular those narratives incorporating representations of non-Aborigines, is a strategy being pursued by Yolngu in order to advance the reconciliation process in Australia.

KEYWORDS: Aboriginal reconciliation, Bayini, Birrinydji, Flag (Bandirra), Macassans, North-east Arnhem Land, Ship's Mast (Marayarr), Walitha'walitha, Warramiri, Yolngu.

INTRODUCTION

In Indonesia, the spread of Islam followed the seafaring routes taken by Moslem traders from Arabia, Persia and India. As Tjandrasasmita (1978) notes, while their main objective was trade, their next was religious conversion. They would acquire power in an area, recruit religious preachers from amongst local populations, build mosques, and encourage immigration of other Muslims (Melink-Roelofz 1970). Though Islam had been in the East Indies since perhaps as early as the seventh century, it only expanded rapidly in the sixteenth century. Schricke (1957) argues that 'it is... impossible to understand [this rapid expansion]...unless one takes into account the antagonism between the Moslem traders and the Portuguese.' Not only was it a means of providing a united front against the colonizers, the new religion sought to embrace converts into the faith by synthesising the Islamic creed with existing beliefs. There was no compulsion to abandon older traditions (Turnbull 1989).

From as early as 1511, wealthy Moslem traders were being exiled from Portuguese held territories, and were forced to settle in other centres of faith such as Aceh, Johor, Banten, Ternate, and Macassar, which all became great relgious centres and trading ports (McKay 1976). The rise of Macassar, in particular, was a phenomenon unequalled in Indonesian history (Reid 1983). From uncertain origins around 1500, in a little over 100 years, the kingdom had risen to a position of political and economic dominance. The Sultanate of Gowa (Macassar) saw it as a religious duty to bring this new religion to their neighbours, by conquest if need be.

It is therefore not surprising, given the Islamization of South Sulawesi, that today

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[1] I use the expression to refer to all Indonesians involved in the trepang industry, as Aborigines do. In reality, the crews of the fishing vessels were drawn not only from the Macassarese from Ujung Pandang (Macassar), but also Bugis and Sama-Bajau or Sea Gypsies, as well as people from islands such as Ambon, Ceram, Irian Jaya and so on.

there is scant evidence of ceremonial mast and flag beliefs and practices comparable to those found in north-east Arnhem Land. In East and West Timor, however, Traube (1986) has recorded narratives which are somewhat similar in that the flagpole is a paramount symbol in discussions pertaining to colonization. For the Mambai of East Timor, for example, the flagpole and flag tell the story of a lost brotherhood or unity between indigenous 'black' Timorese and 'white' Europeans. The return of the young brother in the form of the colonial Portuguese was a mixed blessing for the elder brother (indigenous Timorese), who remained. The flagpole and flag is a metaphor for complimentary governance, describing a division between temporal power (Portuguese flag) and spiritual authority (Timorese pole)[2]. The recorded narratives describe the tension between affirmation of the colonial order and the moral condemnation of Portuguese rulers who disregarded or were ignorant of the real significance of this tradition.

The Arnhem Land mast, from the perspective of members of the Warramiri clan, refers to a Dreaming figure named Birrinydji, rather than to the superstructure of any ocean-going sea craft - including that belonging to the Dreaming being itself.[3] The origin of the word Birrinydji is from a term for the colonial Portuguese ('Franks'[4]). For Aborigines, Birrinydji is an 'inside' or sacred expression for Balanda (from 'Hollander', a term commonly used also by Indonesians to refer to the 'white man'). But Birrinydji is also known by Aborigines as Gombaniya (or Compania), which is a Bahasa Indonesian term for the V.O.C. - the Dutch East India Company. The flag is symbolic of the realm of Walitha'walitha[5], an Aboriginal Dreaming in the image of Allah - and of the continued life of the deceased Aborigine on a mythical island paradise in the seas to the north of Arnhem Land. The discussion that follows is based on the premise that a Macassan mast and flag ritual complex addressed, in some measure, Indonesian experience with Europeans. Following contact with the trepangers, Australian Aborigines adopted the mast and flag ritual complex in ways relevant to their own situation.

In this paper I ask: In what manner have momentous historical events in Indonesia been interpreted by Macassans, and then upon contact with Aborigines, translated into Arnhem Land cosmology? In reviewing mast and flag beliefs and practices in Arnhem Land, how is Aboriginal contact with trepangers relevant today in Aboriginal interpretations of, and responses to, non-Aboriginal hegemony? And finally, can the revelation of sacred Dreaming narratives, in particular those incorporating Aboriginal representations of non-Aborigines, positively influence the reconciliation process in Australia?

THE YOLNGU AND THE MURNGIN

The people of north-east Arnhem Land are known as Yolngu, but they have also been referred to in the literature as Murngin[6] and Wulamba. Dualism is the defining feature of the Yolngu universe. Each person is born into a patrimoiety, named Dhuwa or Yirritja, as well as a patrilineal land-owning clan or Mala which again is either Dhuwa or Yirritja. Each member possesses rights to access and

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[2] Referred to as 'The Walk of Rule and Ban' or 'the Walk of the Flag' (Traube 1986: 54).

[3] Birrinydji's boat was known as the Matjala and Yinderama.

[4] A general term for the Portuguese was the 'Franks' (McKay 1976: 98). Variations appear wherever the Portuguese travelled, i.e Falang, Feringhi or Frinji (Abdurachman 1978: 162); Parrangi in Sulawesi (Reid 1983: 139); and Fo-lang-ki in China (Bayly 1989: 20). It is still used in various parts of the world to refer to Europeans, i.e. Batu Ferringhu, a tourist beach in Penang, Malaysia, while in Maluku, Indonesia, the descendants of the Portuguese are known as 'Orang Feringghi'.

[5] An Islamic chant - *La ilaha illa'llah*: 'There is no god but God'.

[6] Murngin or Murrnginy refers to the 'iron-age' of Birrinydji, and the use of this term corresponds with a view in the 1920s that the way of life that Aborigines were then living was directly inspired by this Dreaming (McIntosh 1996b).

use certain lands through their father, who gives a person their clan identity, but they also have specified interests in the land of their mother and their mother's mother.

The geographic focus of this study is the Aboriginal community of Galiwin'ku (Elcho Island), 500 kilometres east of the Northern Territory capital of Darwin. The largest settlement in north-east Arnhem Land, Galiwin'ku was established as a mission in 1942 by the Methodist Church. The community is home to approximately 1500 out of a total Yolngu population of 5000. The traditional Aboriginal owners of the island, the Liyagawumirr, share their homeland with eight other closely related clan groups, whose country lies in the immediate vicinity of the settlement. In this paper attention is focussed on the Yirritja moiety and in particular on one resident clan, the Warramiri, and the views of its ex-leader, the late David Burrumarra M.B.E. From the 1950s through the 1980s, Burrumarra was a leading spokesperson for Elcho Island Aborigines on the history of contact with Macassans, and also on their relations with the Government and the Uniting (previously Methodist) Church.

HISTORICAL REVIEW

Non-Aboriginal academics have written a great deal about the exotic historical episode of contact between Islamic fishermen and Aboriginal hunter-gatherers, but very little about an obvious legacy of that contact - the ship's mast (*marayarr*). Yet on remote beaches and isolated headlands, in the middle of bustling settlements, in cemeteries or at places were Yirritja moiety Birrinydji ceremonies have been held, one will notice tall bamboo poles with strips of cloth (*bandirra*) attached. In the major communities of north-east Arnhem Land one also encounters a variation on this theme - a replica of a ship's mast - a flagpole - complete with elaborately decorated hand-painted flags. Both items of material culture (bamboo pole and mast) refer to the Wangarr or Dreaming entities Birrinydji and Walithaíwalitha. The pole and flag is associated with funerary rites, and at the cemetery at Galiwin'ku there are perhaps a hundred in various stages of dilapidation. The mast is usually located upon graves of Yirritja moiety Warramiri, Dhalwangu or Gumatj clan leaders, but more commonly at places where these influential indigenous leaders sat to deliberate the politics of the day. The ship's mast stands at least three meters high and is painted with distinctive black, white, yellow and red triangles, associating it with the Yirritja moiety. At Galiwin'ku, the Warramiri mast is located where the late Warramiri leader Nyambi once lived[7]. The Gumatj mast is located alongside the grave of a deceased Gumatj leader (McIntosh 1996b).

In the ethnographic record, an interpretation of the significance of the ship's mast (and pole) recorded by the anthropologist Lloyd Warner in the 1920s has been repeated verbatim by scholars over the years. The mast and flag, it is reported, symbolizes the departure of the soul of a deceased Aborigine, who is to sail away to the mythical land of the dead, just as the Macassan prau would depart for Macassar at the end of each trepanging season (Warner 1969). As already hinted, my contention is that it is a vastly more complex story.

For Aborigines, Macassan trepangers were the first people with whom they had prolonged contact. For Macassans, the trip was a business venture. Arnhem Land, or Marege as they called it, was the farthest coast, and one of the more lucrative of the fishermen's sojourns at sea. All along north-east Arnhem Land beaches are traces of the presence of these Asian traders: stone lines that once supported cooking pots; fragments of pottery and glass; and tamarind trees, which were place markers for the seasonal travellers.

Despite many recorded episodes of violence and bloodshed, north-east Arnhem Landers today view the heroic times of trade and travel to and from Macassar aboard sailing vessels as a golden era. Macassan seafarers were a hardy lot and it was the greatest of all adventures for a young Aborigine to embark upon the voyage to

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[7] Nyambi was David Burrumarra's older brother.

Sulawesi.[8] But the industry is remembered for other reasons as well as I will detail throughout this paper. In a vision of the past inspired by myth, the Macassans came at the tail-end of a series of foreign visitations, each less friendly or cooperative than the last. Differences in the visitor's skin coloration from black in the earliest stories, to white in the most recent, marked the various mythical waves of newcomers - a point I will return to later. These contact narratives address fundamental questions: Were the visitors related to the Aborigines, and did they adhere to the principles of Aboriginal law (were their patterns of behaviour predictable)? Who provided these intrepid travellers with a mandate to embark each year on a voyage on the north-east trade winds? Why did Arnhem Land give up its wealth to these outsiders? For Aborigines in north-east Arnhem Land, it was the Yirritja moiety or half of society who had the answers. Ownership of the ship's mast by certain groups signified pre-eminence in this regard.

Taussig (1993), in his text, *Mimesis and Alterity*, speaks of the 'magical power of replication, the image affected by what it is an image of, wherein the representation shares in or takes power from the represented.' In terms of the narratives pertaining to the ship's mast, we have a representation[9] of Aborigines as being au fait with sacred laws considered to underpin non-Aboriginal wealth and influence. The Dreaming figure Birrinydji, embodying the wealth and status of non-Aborigines (and guided by Walitha'walitha or Allah), sanctioned the emerging relations between Aborigines and newcomers, including Europeans. Birrinydji would 'bring the Aborigines up-to-date', one Aboriginal leader advised, 'but over time things went wrong'. Addiction to the products of trade engendered bitterness and relegated Aborigines to a position of dependency - their rightful status as land owners was threatened - until Walitha'walitha intervened.[10] So in one symbolic complex there are references to an unchanging Dreaming from which power may be ritually drawn, images of dependency upon and domination by outsiders, and redemption through belief in an All-Being held in common with outsiders (McIntosh 1996b).

The extent to which this Dreaming narrative remains of relevance in the intercultural arena is best understood in the light of Merlan's (1998) discussion of continuity and change from a southern Arnhem Land perspective. Merlan (1998) argues that the shift in Government policy towards Aborigines from one of assimilation to self-determination, from the imposition upon Aborigines of alien values to seeking to elicit from them fixed ideas concerning 'tradition', has engendered imitation or mimesis on the part of the present generation. In short, Merlan says that representations of Aborigines made most powerfully by non-Aborigines have come to affect who and what Aborigines consider themselves to be. But does not the reverse also apply? Can the revelation by Aborigines of sacred narratives which incorporate representations of non-Aborigines (as in the myths of Birrinydji and Walitha'walitha) be considered a strategy for positively influencing the course of intercultural relations in the Aborigines favour?

In the 1980s, early on in the age of consultation, Victoria River Aborigines believed that by telling the world about their complex history of representations of non-Aborigines as immoral and imperialistic (as being in the image of a mythical 'Captain

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[8] Aborigines are now retracing by plane the voyage to Macassar, and some of them hope to make contact with long lost relatives.

[9] Really a representation of a representation.

[10] This corresponds with an 'outside' or 'historical' view of contact in the Cape Wilberforce area of north-east Arnhem Land. In the last stages of the trepang industry, deteriorating relations between certain clans, such as the Warramiri, and Macassans, led to bloodshed. The 'inside' story described here provides a Dreaming 'blueprint' for this and also the consequent departure of Macassans in 1907. However in the 'inside' narrative, it is an earlier wave of visitors, the Bayini, who depart. See later in this paper.

Cook'), non-Aborigines would learn that they were morally bound to live up to an ideal envisioned in the Dreaming narratives (Rose 1992). Similarly, in north-east Arnhem Land, followers of Birrinydji and Walitha'walitha anticipated a time to come when non-Aborigines would understand the full significance of 'traditional' Aboriginal belief' and learn to live by the precepts of Aboriginal law. From a Warramiri standpoint, lessons from the mast and flag permeate discussions about human rights and a proposed treaty between Aborigines and non-Aborigines, for they speak to a deeply held belief in what some elders referred to as 'membership and remembership.' Non-Aborigines could never totally dominate Aborigines because 'white' and 'black' were united (members) in a belief in God - symbolized by the flag. If there was to be reconciliation in Australia, non-Aborigines would have to acknowledge (or remember) that their power and influence over Aborigines came from an Aboriginal Dreaming - that symbolized by the mast.

BIRRINYDJI AND WALITHA'WALITHA

All that is known of the Birrinydji Dreaming has been passed down to the present through many hands and interpretive processes. A Warramiri leader named Bukulatjpi who lived in the mid-1800s is credited by contemporary Warramiri leaders with 'uncovering the truth' about Birrinydji and the Macassans. In many parts of Australia the first settlers were deemed to be ancestors returned from the dead, their light skin colour being evidence of the bodily decay that takes place in the weeks following a death. Bukulatjpi, living on remote Cape Wilberforce in the mid-1800s, understood that Macassans were not Yolngu or in any way divine. Rather, their inordinate material wealth and willingness to share this with Aborigines in exchange for labour was having a major impact on Warramiri lifeways. The first impulse, Burrumarra said (recalling Bukulatjpi's words), was for the Yolngu to send these newcomers away. But then he thought to himself - maybe these are the same people who had come much, much earlier - as so many of the myths detail. The trepanger's possession of modern technology was equated with their being recipients of Birrinydji's bounty. Bukulatjpi therefore reasoned that something had gone wrong at the 'beginning of time' for Birrinydji was an Aboriginal Dreaming and his material wealth was the right of clans such as the Warramiri, so long as his many rituals were performed. But it was the Macassans who performed these sacred dances on the beaches of Arnhem Land. Yolngu had long 'forgotten' them.

Just as a totem represents the outward form of a Dreaming being, a Macassan *bunggawa* (boat captain) by the name of Luki provides a visual image of what Birrinydji is supposed to be like. Otherwise, Birrinydji is indistinguishable from other Dreaming figures. Sacred objects or rangga, like the mast and flag, are the basis of extensive clan alliances within the Yirritja moiety. Numerous totemic species also owe their form to Birrinydji's intervention: the sword fish, the fish with sails like a boat, and the bird with a tail like a metal axe, signify to members of Yirritja clans such as the Warramiri the continuing relevance of his laws.

Bukulatjpi viewed Birrinydji as a Dreaming figure that controlled the seasonal movement of the Macassan trading fleet and also the winds that would bring the visitors onto the coast each November. Birrinydji had also provided the earlier waves of visiting fishermen with the skill to fashion swords from coastal haematite outcrops, pottery from local antbed, and to grow rice and other plants foods in Warramiri billabongs. But Birrinydji did not act alone. Bukulatjpi understood that he was answerable to a higher Dreaming authority - Walitha'walitha or Allah.

Birrinydji and his wife Bayini were described as ancestors of Warramiri Yolngu - creational figures that emerged from the Australian mainland at a point beyond memory. Birrinydji ordained that certain non-Aborigines would come to Arnhem Land 'to make the land and the people strong' and introduce to them the technology and ideas of the modern world. First there were mysterious black whale hunters from the mythical islands of Badu to the north-east of Galiwin'ku; then mythical golden-brown workers for Birrinydji, known by the term 'Bayini'; then historical light brown Macassans from the north-west; and finally white Japanese pearlers in the 1920s and European colonists. The colour change in the visitors in this constructed history from black to white corresponds with a change in attitude towards reciprocity in dealings with Aborigines, and therefore knowledge or ignorance of Birrinydji's law.

In the first wave Aborigines and whale hunters were united in the laws of Birrinydji and Walitha'walitha through the whale, an outside symbol for these Dreamings. Together, Aborigines and whale hunters upheld the law of the sea (McIntosh 1996b). The alliance between the two was such that the souls of the Aboriginal dead from the Yirritja moiety went on the backs of whales to the land of the dead, guided by these hunters. The 'Bayini', on the other hand, after introducing the laws of Birrinydji to the Yolngu, kept the secrets of iron-making and weaving to themselves when they departed (McIntosh 1995a). From a Warramiri perspective, certain Macassan leaders recognized the law of Birrinydji and respected Aboriginal sovereignty, but most did not and there was great disparity in wealth between the visitors and land owners. Finally, Japanese and Europeans totally ignored Aboriginal rights and there was little or no reciprocity in relationships - a situation that persists until the present, in Burrumarra's view.

By far the most significant of these supposed 'waves' of contact was the 'Bayini', the bringers of Birrinydji's laws to Aborigines (McIntosh 1995a). During this period, the Warramiri homeland of Dholtji is claimed to have become a centre for iron manufacture, boat building, and rice, clothing and pottery production - a 'Mecca' according to one Warramiri leader. When Aborigines and the 'Bayini' were united, they both prospered, but over time relations soured. 'Warramiri Aborigines desired only good, but bad came too,' Burrumarra said. A 'fire came to the Yolngu' and 'there was great bitterness between white and black'. The spirit of the dead or 'Wurramu' took over Yolngu lives. Birrinydji wanted to bring more non-Aboriginal people to Arnhem Land but Walitha'walitha sent Birrinydji and the newcomers away, for Walitha'walitha could see how the Yolngu were suffering. Jealousy and greed was tearing away at the population, and Aboriginal addiction to tobacco and alcohol provoked inter-clan feuding, threatening their survival. So the 'Bayini' left the Australian mainland before their work of teaching was completed, and their parting words to the Aborigines 'From now on you must look after yourself' (pers.comm. Timothy Buthimang 1988) was the signal for the beginning of an era of impoverishment for Aborigines. The maintenance of the status quo (reciprocity and respect in intercultural dealings between Aborigines and non-Aborigines) required ceremonial input from both blacks and whites, but as Burrumarra said, 'Birrinydji did not want to stay in Australia, but he left the Wurramu and Walitha'walitha here.' Birrinydji and Bayini's legacy in Arnhem Land is the continuing unpleasant consequences of contact, and ideas of the good life and salvation in Allah or God (McIntosh 1996a).

THE CHANGING DREAMING

All clans in north-east Arnhem Land are responsible for a specific aspect or interpretation of the moiety narrative, and the operation of the moiety depends, to a degree, on the clans working in harmony. Dreaming tracks or songlines cover more than the territory of a single clan, and each group is responsible for maintaining their part of the law. In the case of Birrinydji, the same applies, and responsibility for ritual performance was shared between three Yirritja moiety clans (Warramiri, Dhalwangu and Gumatj), but in a Warramiri perspective, it spread beyond the confines of the Australian mainland to seafaring groups from the islands of eastern Indonesia and elsewhere.

In sacred ceremonies, Aboriginal leaders recreate events from the Dreaming in a way reminiscent of how they were first experienced. The symbol of a deity (in our case Birrinydji's mast), is positioned on ritual ground so as to attract and hold the spiritual force of the Dreaming, while actors play out the parts of the drama accompanied by the sounds of the *didjeridu* (drone pipe), *bilma* (clapsticks) and a *manikay* (song). When the ritual conditions are satisfied, the deity may bestow its power or meaning to participants through the leader. In the days of Macassan trepanging, the Birrinydji ritual would be performed upon receipt of trade goods. According to Warramiri clan elder David Burrumarra, the gift acknowledged that Balanda and Yolngu were 'one' through Birrinydji and Walitha'walitha, and that the visitors wished to bring 'honour' to the land and its traditional owners.

In these pre-colonial times, and during the early decades of this century, Yolngu religion and politics were inextricably inter-twined. The Warramiri, for example, had aspirations that members of their clan would acquire mobility, talent and worldly status as followers of Birrinydji. This Dreaming represented the wealth that comes from the earth, Aboriginal earth, assets to which non-Aborigines alone now appeared to have access to. However, as a result of prolonged contact with outsiders, non-rational modes of thought have now come to play much less of a role in the political process. Since the advent of the mission at Galiwin'ku in the 1940s, the Aboriginal *Weltanschauung* has been subjected to a process of rationalization, and a new generation of Warramiri has been forced to re-think many traditional concepts. The meaning of myth and ritual is drastically changing (Kolig 1989). In some cases, the Dreaming no longer provides the eternal, immutable blueprint for the world and human existence. Some younger Aborigines do not believe, for example, that in performing a rite they will achieve a particular outcome. The Dreaming, for many, has become a reservoir of political symbolism, but not instrumentality. The Birrinydji ritual, for instance, rather than being a pre-condition for reciprocity in dealings with the other, expresses an entitlement to land in the face of non-Aboriginal encroachment. Aborigines need to remind themselves, as well as others, of their privileged position in relation to 'country'.[11]

The history of race relations in Arnhem Land has been such that many Yolngu feel resentment towards Balanda and the performance of the Birrinydji ritual provides an avenue for the expression of defiance. Yirritja moiety, Dhalwangu and Gumatj clan members treasure their detailed knowledge of Birrinydji's songs and ceremonies, and carefully maintain sacred Birrinydji sites, but in the late 1980s community leaders were not able or willing to speak about the related narrative. The Birrinydji Dreaming had become all but a mythless rite. The Warramiri, however, being advocates of a reconciliation with Balanda, had elaborate stories concerning Birrinydji, but were cautious about revealing them. Whites might come to believe that the Dreaming condoned perceived present-day discriminatory practices, I was informed.

THE MAST AND FLAG

Belief in the ancient nature of Birrinydji and Walitha'walitha (or at least how it is presumed to pre-date the arrival in Arnhem Land of Macassans) is supported by the widespread incidence of items of material culture and terminology associated with them. While it is not possible to say that there has ever been any large scale uniformity of belief in Birrinydji, there is evidence to suggest that from the 1920s through to the 1940s, first contact and colonization was contemplated by members of both Dhuwa and Yirritja moieties in terms of this Dreaming.

Not long after the end of the Macassan era, Aboriginal oral historical accounts described how the Macassan prayer-man would climb the mast and chant for Allah - the most High God - prior to the journey home to Indonesia (Berndt and Berndt 1954). Other records indicated that when a mast of a Macassan boat had broken or a member of the crew was about to die, a

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[11] An expression that refers both to the land and the sea.

ceremony involving the mast would be performed. It is implied by anthropologists and historians that Aborigines adopted this ceremony as their own and, in the process, attached additional meanings to its performance relevant only to themselves. In the 1920s Warner, for example, witnessed the way in which Yirritja clan members would pick up a dead body during a funeral and move it up and down as if they were lifting the mast, while others danced as if pulling on the rigging in order to raise the sails. (Today certain Yirritja Yolngu lift the coffin in a similar fashion). They would then sing for Allah (Walitha'walitha), describing the song as a Macassar prayer, and ask for unspecified blessings from this 'man-god in the moon' (Warner 1969). Warner chronicled how this mast ceremony facilitated the passage of the soul of a deceased Yirritja Aborigine to an unknown land of plenty to the north. The soul was to sail away just as the Macassar prau used to do.

All Yolngu have some memory of Macassans through stories passed down from generation to generation, but it was only David Burrumarra, according to his brothers, who could speak the truth of this past as it was known from the 'inside'. Men in their seventies, even they deferred to Burrumarra's interpretations. This was because the Warramiri consider themselves to be the primary custodians of Birrinydji, and according to their tradition, Birrinydji speaks to Yolngu through the leader of this clan (mimicking in some sense the order of command aboard a Macassan prau).

Warramiri oral history details the gift in 1907 of a mast and flag to the Warramiri leader Ganimbirrngu by the Macassan Daeng Rangka, the last trepanger to visit the Arnhem Land coast (McIntosh 1994). For Yolngu this was interpreted as the re-enactment of a Dreaming incident whereby the ancestral being Birrinydji planted his flag at Dholtji at the 'beginning of time.' Daeng Rangka's mast was to replace an old decaying mast at the Warramiri homeland, which itself was a replica of a large metal pole which had stood on that same site in Birrinydji's day. Described as being like a chimney associated with iron smelting, the mast stood for Birrinydji's law or the new world order imposed on Aborigines following first contact - an order that 'turned the Aboriginal world upside down' (McIntosh 1996b).

Statements by Burrumarra and other Yolngu elders such as, 'the mast and flag is the way the law is carried,' suggests that the mast was placed on Arnhem Land shores in a way reminiscent of the English hoisting the Union Jack in 1788, but it is not straightforward. Burrumarra said that Macassans visiting Arnhem Land shores recognized the old mast and flag at Dholtji, which had then been in Warramiri possession for countless generations, and knew that Aborigines were the custodians of laws that had united them at some point in the distant past, as in the East Timorese narratives[12]. Aborigines and the visitors from Sulawesi were 'one' through Birrinydji and Walitha'walitha, just as Christianity was now seen to unite Yolngu and Balanda.

A DEFIANT DEITY

When anthropologists Lloyd Warner and the Berndts encountered Birrinydji ceremonies in the first half of this century, they witnessed, in the bodily movements of performers, a powerful demonstration of Aboriginal authority as owners of land. When Aborigines recreate the planting of the mast and assert Birrinydji's dominion over the land, they swirl Birrinydji's swords overhead, and do a quick-step as if propelling Birrinydji's boat through a torrid sea. As Burrumarra advised, the purpose of the ceremony is to 'show the Yolngu', that is, to make it apparent that the Yolngu have an important ceremonial role to play in maintaining a law from which ostensibly whites also draw their power.

In the 1940s the Berndts recorded 150 garma, public or 'outside' songs pertaining to Macassan influences - including the mast ceremonial (Berndt and Berndt 1954). By

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[12] In Mambai oral tradition, the flagpole and flag inspire 'fear and trembling' amongst Timorese (i.e. obedience to the law) and ascribe to the Mambai the powers of a legitimate sovereign.

the late 1980s however, these same songs were regarded as 'inside' or sacred. Yolngu at Galiwin'ku were now openly practicing Christianity, and there were conflicts between the two beliefs. Statements by Yolngu leaders such as 'The followers of Birrinydji should be Christians', or, 'We are Murrnginy, we believe in God,' or 'Walitha'walitha is one and the same as the Christian God,' are indicative of the transformation that was taking place. From the 1950s onwards, Burrumarra said there was a conscious effort to restrict and change what was known of the Warramiri and Yirritja past. The old ways were 'too hard, too far, and too difficult to explain' to the younger generation. The view of Yirritja moiety Aboriginal leaders was that there was great similarity between Walitha'walitha and the Christian God and there was a possibility of confusion, so they openly promoted the latter and hid the former. Birrinydji, however, could not so easily be set aside. His influence was now seen to encompass all places affected by European colonialism.

Burrumarra believed that the establishment of the Methodist (Uniting) Christian mission at Galiwin'ku was Birrinydji's plan for Yolngu. They would become Christians and Birrinydji could 'put down his swords.' In other words, there would be peace and harmony as Aborigines reaped the benefits of the Dreaming. This was not to be of course, but the dream did not fade. Burrumarra re-evaluated his strategy and in the 1980s decided to make public many of the myths of Birrinydji as part of a reconciliation proposal to the federal government (McIntosh 1995a). Other Yolngu followed Burrumarra's lead and Birrinydji soon became a rallying point for pan-Yolngu resistance to non-Aboriginal hegemony. Former 'Australian of the Year,' Gumatj spokesperson and lead singer of the rock group Yothu Yindi, Mandawuy Yunupingu, used Birrinydji dances in songs about maintaining one's Yolngu identity while 'living in the mainstream'; Terry Yumbulul of Warramiri clan stirred Yolngu to unite and demand their rights to the sea by invoking the memory of this Dreaming (McIntosh 1995b). And at Gurrumurru, Dhalwangu leaders were given approval by the Warramiri to use the image of Birrinydji on the community school flag during that period when the local education system was being 'Aboriginalized'.

MEMBERSHIP AND REMEMBERSHIP

Following a widescale conversion to Christianity after the departure of missionaries in 1974, Yolngu were inspired to reposition major Dreamings in a broader universe - a universe that included non-Aborigines (McIntosh 1997). Major moiety Dreamings were henceforth referred to as prophets, in an old testament sense. Walitha'walitha was spoken of as an 'angel of God'. This repositioning was known by people such as David Burrumarra as 'membership-and-remembership'. In a vision of the world united by Jesus, each social unit within the whole represents a self-governing entity. Through Christianity, Yolngu and Balanda are united in a larger system of belief which sees all Australians as being members of a single family. While Walitha'walitha and Christian beliefs are interpreted in relation to one another, their significance for Yolngu is seen separately, at different levels of membership, i.e. Christianity is for all people, Walitha'walitha is for Macassans and Yolngu, Birrinydji is for the Yirritja moiety and Macassans, and the whale is a Warramiri totem etc. But membership-and-remembership is more than this. It refers to the interplay of 'inside' and 'outside' and mythical and historical narratives. Yolngu may be dominated by non-Aborigines as a consequence of history, but they 'remember' Walitha'walitha. They may be united with non-Aborigines through a belief in God, but they also 'remember' that Birrinydji is an Aboriginal Dreaming and that the wealth of non-Aborigines comes from Aboriginal land.

There is no single word in the Warramiri or other Yolngu languages that translates as membership-and-remembership, and indeed it is not easily translatable into English. The Jewish theologian Martin Buber (1949), however, proposes a similar outlook to membership-and-remembership in his essay, *In the midst of crisis*. He describes a community as a circle with a clearly defined centre. Members have a common relation to this centre which overrides all other relations. The community, i.e. the circle, is described by the radii, and not by the points along its circumference. The common centre must be something concrete, like a sacred text such as the Torah, a person (like Jesus Christ), or a set of rituals (as in Confucianism). As people see, study, and come to understand the centre, they become aware of the divine, and their attention is turned outward to the world around them, to larger levels of membership, where their work lies, for it is beyond this circle or community that the authority and authenticity of the centre is proven.

In north-east Arnhem Land, many Yolngu still look to the Dreaming as the sacred centre of their community, and in a perspective based on membership-and-remembership, they consider their emerging roles and responsibilities in a world lying well beyond their homelands. The fact that Birrinydji takes the form of a white man is evidence of membership-and-remembership. His symbol, the mast, signals 'remembership' of long ago, of the perceived partnership between Aborigines and non-Aborigines, and also Aboriginal 'membership' in belief in this law. The flag on the other hand, in Burrumarra's words, represents the heavenly dimension, and the idea that all people are, or will be, united. A legacy of contact between Aborigines and Macassans and spoken of in terms of honor, the ship's mast and flag stands for the law of Birrinydji and Walitha'walitha, which Macassans, Japanese and Europeans ignored or 'forgot.'

When Birrinydji left the country, with him went the affluence that only non-Aborigines now possess. Aborigines have the songs and the stories of Birrinydji, sites in the landscape, and a memory of a grand and noble past. In Burrumarra's words, the Yolngu now have 'plenty but nothing.' Because of Birrinydji, the earth is a place of struggle, and Dreaming narratives inspire followers of the law to pursue the earthly paradise to come. The mast and flag therefore speak to a deeply held belief by the Warramiri that non-Aborigines can never totally dominate Aborigines because white and black people are united (members) in their belief in God. Following Burrumarra's lead, lessons from the 'inside' and 'outside' pertaining to the mast permeated discussions about human rights and the treaty in the early 1990s. In Burrumarra's view, if there is to be reconciliation in Australia, non-Aborigines must acknowledge (or remember) that their power and influence over Aborigines comes from an Aboriginal Dreaming. Alternatively, there needs to be recognition of the privileged place of Aborigines in relation to the land and sea. The recognition by the Federal Government of Aboriginal Native Title land and sea rights, and contemplation of the design for an Australian flag which incorporates Aboriginal motifs, means we are closer now to such a reality than ever before. The achievement of reconciliation, still to come, will be viewed by senior Warramiri as a testimony to the truth and continuing relevance of the Birrinydji Dreaming.

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In the descriptive text, numbers from one to nine should be spelt out and figures used for numbers over nine. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

Systematic papers must conform with the International Code of Zoological Nomenclature and, wherever possible, with their recommendations.

Synonymies should be given in the short form (*taxon* author, date: page) and the full reference cited at the end of the paper. Full citations of taxa used in the text (i.e. *taxon* author, date) must also be included in the references, whereas the short citation (i.e. taxon author) need not be included. Subsequent citations of taxa given in synonymies should be separated from bibliographical details by a dash (-).

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