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Cover Holotype of *Tympanocryptis lineata houstoni*, drawn by Christine Bruderlin.

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Four New *Lerista* (Lacertilia: Scincidae) from Western and South Australia

G.M. Storr*

Abstract

The new taxa are *L. picturata edwardsae*, a member of the *L. macropisthopus* group from South Australia, and *L. greeri*, *L. griffini* and *L. vermicularis*, members of the *L. bipes* group from Western Australia.

Introduction

Lerista, second-largest genus of Australian skinks, continues to yield undescribed species and subspecies. For descriptions of the *L. macropisthopus* and *L. bipes* groups and of the close relatives of the new taxa see Storr (1972, 1976). This paper is based on material in the South Australian Museum (specimens cited without prefix), Australian Museum (AM) and Western Australian Museum (WAM).

New Taxa

Lerista picturata edwardsae subsp. nov.

Figure 1

Holotype

R17787 in the South Australian Museum, collected by G. Harold and T.M.S. Hanlon on 13 November 1979 in low open *Eucalyptus-Casuarina* woodland on brown limestone soil 6 km SE of Streaky Bay, South Australia, in 32°50′S, 134°15′E.

Paratypes

Ninety-seven specimens in the South Australian, Australian and Western Australian Museums. For details see Material.

Diagnosis

A subspecies of *L. picturata* with minute foreleg, didactyl hindleg and strong colour pattern, including 2 (rarely 4) dark dorsal lines and dark upper lateral stripe. Differing from *L. p. picturata* (Fry, 1914) in its much shorter foreleg, fewer dorsal lines (usually 2, v. 4) and fewer midbody scale rows (18-20, v. 20-22), and from *L. p. baynesi* Storr, 1972 by its much stronger colour pattern and more numerous subdigital lamellae (9-14 under second toe, v. 8-10).

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Description

Foreleg reduced to a papillose tubercle (N 83); hindleg bearing two well-developed toes (N 80). Snout-vent length (mm): 37-95 (N 89, mean 72.9). Length of appendages (% SVL): hindleg 10.8-19.2 (N 80, mean 15.2); tail 75-100 (N 29, mean 87.5); snout to foreleg 20.5-29.0 (N 81, mean 23.5).

Nasals in contact (N 81). Prefrontals widely separated (N 81). Frontoparietals separated, each much smaller than interparietal (N 81). Usually no nuchals, occasionally one or two on each side. Supraoculars 3, first and second in contact with frontal (N 42) or only the second in contact (48). Supraciliaries 0 + 1 (N 7), 0 + 2 (68) or 0 + 3 (14). Temporals 2 (N 1) or 3 (83); upper secondary larger than primary (N 72) or subequal to it (7) or smaller (5); lower secondary much the smallest except in one specimen where it is fused to primary. Upper labials 5 (N 1) or 6 (85); first count due to fusion of second and third. Midbody scale rows 18 (N 48), 19 (4) or 20 (23). Lamellae under longer toe 9-14 (N 77, mean 11.2).

Upper surface pale brownish-grey (silvery-grey in life, at least in holotype) to greyish-brown. Two blackish dorsal lines from neck to tip of tail, each passing through a series of paravertebral scales; occasionally outside of these a series of blackish dorsal spots which rarely (3% of specimens) coalesce to form an additional pair of lines. Head variably marked with blackish, most markings taking form of a thick discontinuous margin to scales. Wide blackish upper lateral stripe from nasal to end of tail. Posterior edge of upper labials thickly margined with blackish-brown. Lower labials sometimes brown-

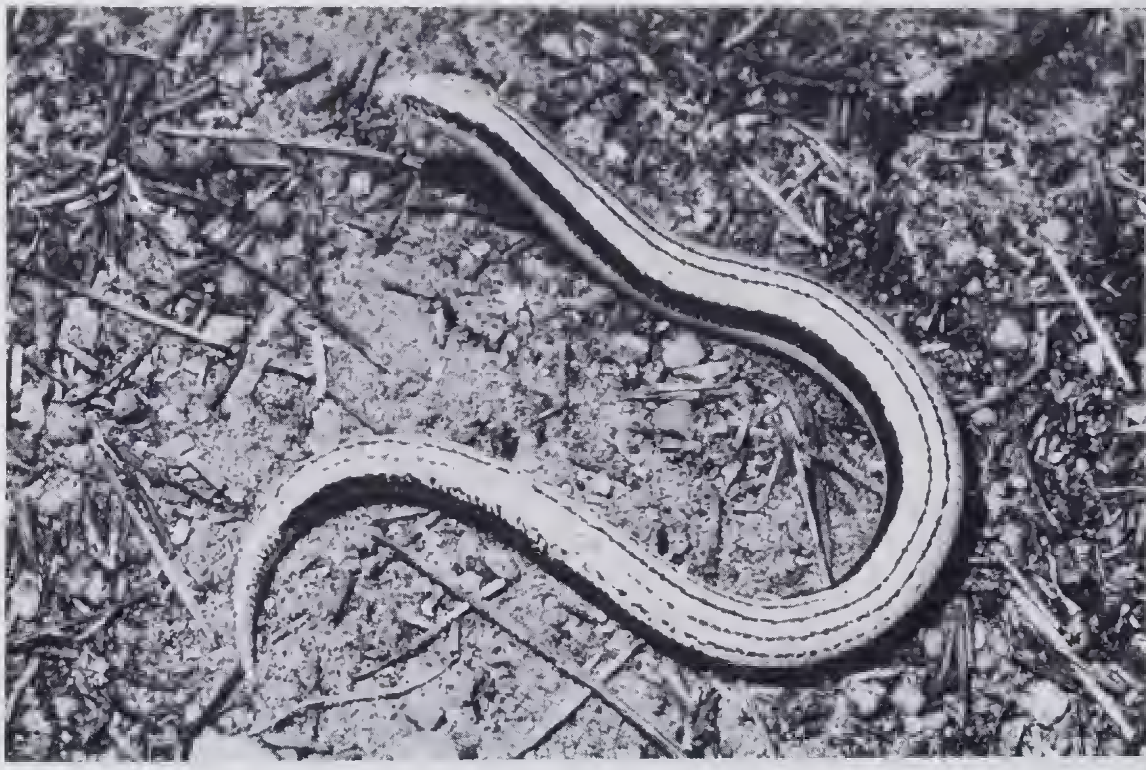

Figure 1 Holotype of *Lerista picturata edwardsae* photographed in life by Gregory Harold.

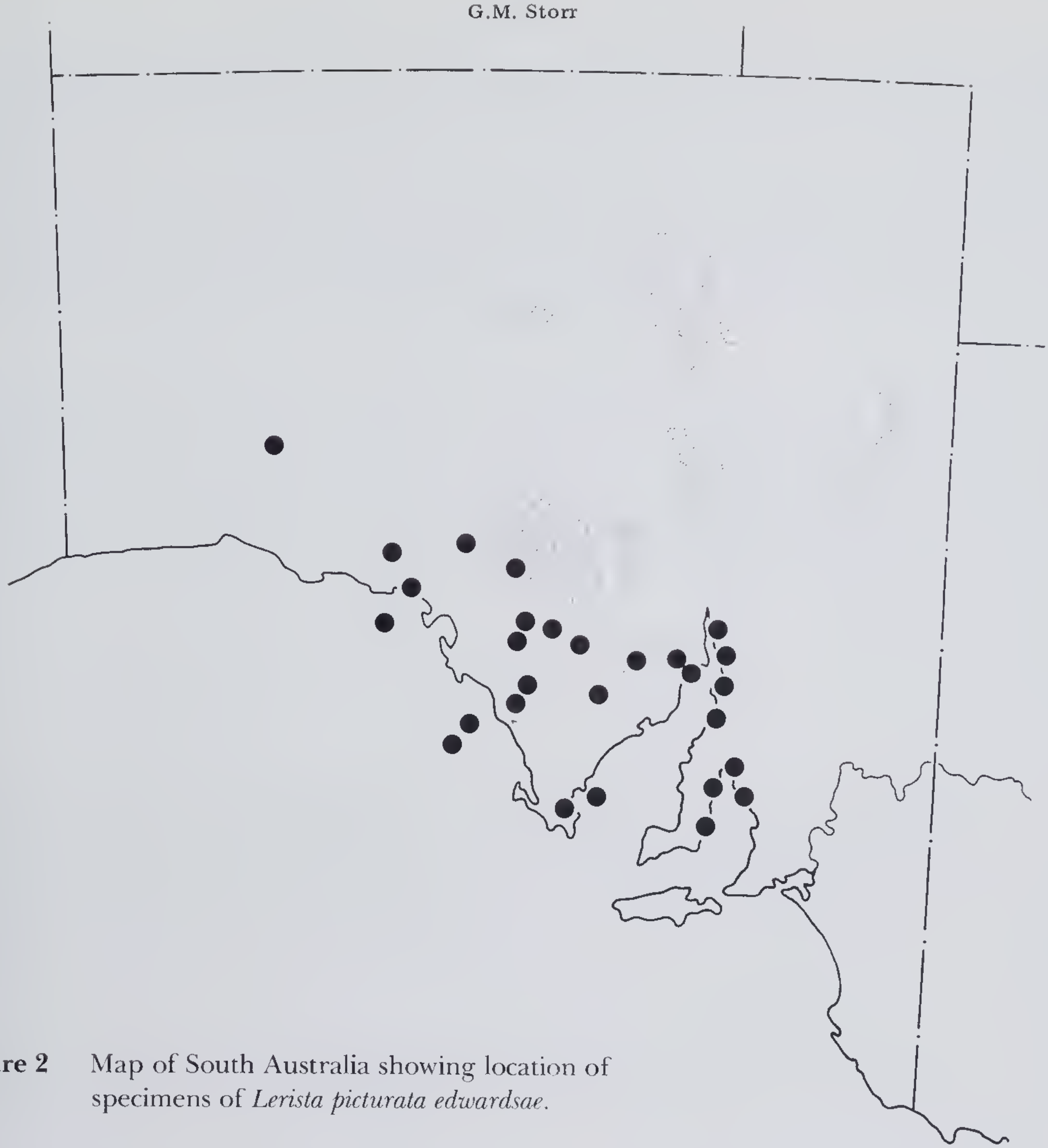

Figure 2 Map of South Australia showing location of specimens of *Lerista picturata edwardsae*.

edged. Forelimb tubercle and under toes greyish-brown. Remaining lower surfaces whitish in spirits (yellow in life—G. Harold and P. Griffin, pers. comm.).

Distribution

Arid and semi-arid lowlands of southern South Australia west of the Flinders and Mt Lofty Ranges (Figure 2).

Geographic Variation

The most distinctive population is that inhabiting the Nuyts Archipelago. These skinks are noticeably longer and stouter than those from elsewhere, e.g. SVL 75-95 mm (N 14, mean 87.1; v. 37-90, N 75, mean 70.3). They share two traits with the population on the Investigator Group (also off the west coast of Eyre Peninsula), namely short hindleg (11.2-14.8% of SVL, N 18, mean 13.2; v. 10.8-19.2, N 62, mean 15.8 elsewhere) and short snout to foreleg (20.5-23.6% of SVL, N 18, mean 22.1; v. 21.6-29.0, N 63, mean 23.9 elsewhere).

The populations east and west of Spencer Gulf differ in two respects. On average the eastern skinks are darker, partly due to the greater extent of the head markings. They are also notable for the high frequency of individuals with only one supraocular in contact with frontal (88%, v. 33% west of Spencer Gulf).

Remarks

Geographically, the subspecies *L. p. picturata, L. p. baynesi* and *L. p. edwardsae* form a west-to-east sequence. Morphologically, however, they do not form a sequence. The various character gradients from *picturata* to *baynesi* are steep, but none of them extends to *edwardsae*. Presumably *baynesi* and *edwardsae* have evolved independently from *picturata*. Indeed the latter and *edwardsae* may yet prove to be in contact in Western Australia north of the Nullarbor Plain.

Derivation of Name

After Adrienne Edwards of the Department of Herpetology, South Australian Museum.

Material

South Australia

Ooldea (1794); 23 km N Koonibba Mission (31°42′S, 133°26′E) (15018); S. Childara Paddock (31°37′S, 134°32′E) (13745); 12 km SSE Lake Everard HS (WAM R69930-1); near Ceduna (3722, 4294); West I., Nuyts Archipelago (15983); St Francis I., Nuyts Archipelago (715 *a-g*, 12880 *a-f*); Pine Lodge HS (11705-6, 15579 *a-b*); Thurlga Woolshed (32°40′S, 135°40′E) (11703-4); Minnipa Hill (549); Buckleboo (1588 *a-c*, 8799); Lake Gilles Conservation Park (14381, 17989); False Bay (6083); Whyalla (14350) and 25 km NW (19061) and 15 km N (18707-8); near Minaro Downs HS (14193, 14203 *a-e*); Carappee Rocks (5752); Mt Wedge (3358); Flinders I., Investigator Group (10211, 10225, 10227); Pearson I., Investigator Group (10235); Reevesby I., Sir Joseph Banks Group (12988; AM R79708); Port Lincoln (AM R6378-9, AM R6380 *a-b*); 24-28 km SSE Port Augusta (14270, 14272 *a-b*, 14279, 14297); Mambray Creek (13965); between Port Pirie and Port Augusta (5457 *a-e*); 6 km N Port Germein (12427 *a-d*, 12593); Port Pirie (12373); 3 km W Warnertown (10850-1); Port Broughton (9416, 14134); Price 11982-4); Ardrossan (11978-81); 7 km NW Stansbury (12499); Tiddy Widdy Beach, Yorke Peninsula (16982 *a-b*); Port Wakefield (4294); Parham (9298, 14604 *a-b*, 15613); 8 km W Dublin (14035); Port Prime (17875, 17878).

Lerista greeri sp. nov.

Holotype

R23005 in the Western Australian Museum, collected by G.M. Storr and A.M. Douglas on 1 September 1964 at 8 km SSE of Derby, W.A., in 17°22′S, 123°40′E.

Paratypes

Kimberley Division (W.A.)

Lake Argyle (WAM R40001-2); 23 km NNE Dunham River HS (WAM R23080); Point Torment (WAM R58571); Derby (WAM R20295-6, 20333-7) and 24 km SSE (WAM R18210, 32169, 32343);

Christmas Creek (WAM R57149); Wolf Creek Meteorite Crater (WAM R64044-5); Granny Soak, Gardiner Range (19°07'S, 128°53'E) (WAM R51239, 51242).

Diagnosis

A member of the *L. bipes* group with movable eyelid, two toes and no trace of forelimb (including groove). Most like *L. bipes* (Fischer, 1882) and *L. labialis* Storr, 1972, but distinguishable from *bipes* by its 6 (rather than 5) upper labials and 20 (rather than 18) midbody scale rows, and from *labialis* by having 2 (rather than 1) supraocular in contact with frontal, and 1 or 2 supraciliaries (rather than none).

Description

Snout-vent length (mm): 26-62 (N 20, mean 46.8). Length of appendages (% SVL): hindleg 13.9-21.2 (N 16, mean 17.0); tail 72-91 (N 6, mean 84).

Nasals narrowly separated (N 18) or in short contact (2). No prefrontals (apparently fused to second loreal, as in *L. bipes* and *L. labialis*). Nuchals 1-3 (N 20, mean 2.0). Supraoculars 3, first two in contact with frontal. Supraciliaries 0 + 1 (N 15) or 0 + 2 (4). Loreals 2, second high with acute apex. Preocular 1. Temporals 3, upper secondary

Figure 3 Map of northern Western Australia showing location of specimens of *Lerista greeri*, *L. griffini* and *L. vermicularis*.

usually largest, lower secondary much the smallest. Upper labials 6 (N 20). Midbody scale rows 19 (N 1) or 20 (19). Lamellae under longer toe 8-10 (N 20, mean 8.9).

Upper surface pale brown or pale reddish brown marked with dark brown as follows: scattered spots or smudges on head; a line of dots through each paravertebral series, dots sometimes coalescing to form a narrow stripe; occasionally a laterodorsal series of faint dots; and a wide upper lateral stripe from nostril to end of tail. Ventral and lower lateral surfaces whitish.

Distribution

Far northern Western Australia (semi-arid zone of south and east Kimberley), mainly on sandy and loamy soils (Figure 3).

Remarks

This species is morphologically intermediate between *L. bipes* and *L. labialis;* it has the supraoculars and supraciliaries of the former, and the upper labials and midbody scale rows of the latter. *Lerista greeri* could thus be close to the common ancestor of these species. However it is now probably sympatric with both of them. In the Kimberley *bipes* generally ranges north to Coulomb Point, the Edgar Ranges and Gregory Salt Lake, i.e. to the south of *greeri,* but there is an isolated population considerably further north (if WAM R37698 from Manning Creek is correctly identified as *bipes*). In the Kimberley, *labialis* has been collected in the southern semi-arid zone near Mt North, Mt Percy and Fitzroy Crossing.

A single specimen (WAM R188) collected in November 1913 by W.B. Alexander on one of the Wallabi Islands, Houtman Abrolhos, is indistinguishable in scutellation from *L. greeri.* However it is now entirely devoid of coloration.

Derivation of Name

After Allen E. Greer of the Australian Museum.

Lerista griffini sp. nov.

Figure 4

Holotype

R75543 in the Western Australian Museum, collected by P. Griffin and G. Harold on 12 March 1981 at Kununurra, Western Australia, in 15°47′S, 128°44′E.

Paratypes

Kimberley Division (W.A.)

Ninbing (WAM R27913): Point Springs, Weaber Range (WAM R26774); 18 km NE Kimberley Research Station (WAM R17105); 21 km SE Kununurra (WAM R23108) and 37 km SE (WAM R23113); Martins Well (8 km S Lombadina) (WAM R60849-50); mainland opposite Packer I. (WAM R60904); 4 km S to 7 km N Coulomb Point (WAM R58472, 60844, 60855-6, 60870, 60906-7, 61362); Broome (WAM R1257, 14112 *a-b,* 29159).

Northern Territory

Bullo River HS (WAM R60337).

Figure 4 Holotype of *Lerista griffini* photographed in life by Philip Griffin.

Diagnosis

A member of the *L. bipes* group with movable eyelid, two toes and no trace of forelimb (including groove). Most like *L. bipes, L. greeri* and *L. labialis,* but differing in its greater size, stouter body, darker coloration, low flat-topped second loreal and lack of preocular.

Description

Snout-vent length (mm): 47-67 (N 22, mean 57.2). Length of appendages (% SVL): hindleg 12.9-18.3 (N 21, mean 15.5); tail 68-106 (N 10, mean 91).

Nasals very narrowly separated (N 16) or in point contact (3). No prefrontals (apparently fused to frontal). Nuchals 0-3 (N 21, mean 1.7). Supraoculars 3, first two in contact with frontal. Supraciliaries 0 + 1 (N 4) or 0 + 2 (18). Loreals 2, second much wider than high. No preocular (fused to second loreal). Temporals 3, upper secondary slightly larger than or subequal to primary, lower secondary much the smallest. Upper labials 5 (N 22). Midbody scale rows 20 (N 21) or 21 (1). Lamellae under longer toe 8-11 (N 22, mean 9.2).

Upper surface brown or reddish-brown marked with dark brown as follows: scattered spots or smudges on head; a paravertebral stripe or line of dots from occiput to end of tail; occasionally a laterodorsal series of small indistinct spots; and a wide upper lateral stripe from nostril to end of tail. Ventral and lower lateral surfaces whitish.

Distribution

Disjunct in far north of Western Australia: semi-arid zone of west Kimberley (Dampier Land) and of east Kimberley (lower Ord valley), and extending from latter into extreme north-west of Northern Territory (Figure 3).

Remarks

This species is sympatric with *L. bipes* on the west coast of Dampier Land and parapatric (perhaps marginally sympatric) with *L. greeri* in the Cockatoo Springs-Lake Argyle region.

Derivation of Name

After Philip Griffin, formerly of the Western Australian Museum, in appreciation of his excellent assistance in 1979-81.

Lerista vermicularis sp. nov.

Holotype

R73814 in the Western Australian Museum collected on 17 August 1981 by M.J. Bamford at Dragon-tree Soak, Western Australia, in 19°39′S, 123°23′E.

Paratypes

Eastern Division (W.A.)

McLarty Hills (19°30′S, 123°30′E) (WAM R73815-6); Joanna Spring (20°05′S, 124°12′E) (WAM R73818).

North-Western Division (W.A.)

63 km SE Wallal (WAM R60157).

Diagnosis

A small slender member of the *L. bipes* group with immovable eyelid, two toes, and no trace of forelimb (including groove). Most like *L. labialis*, *L. greeri* and *L. bipes*, but lacking a preocular and lower secondary temporal, and having an immovable eyelid, smaller supraoculars, body angular at change from lateral to ventral surface, and dark upper lateral stripe not so well defined. Further distinguishable from *L. bipes* and *L. greeri* by absence of supraciliaries, and from *L. labialis* by fewer labialis (5, v. 6) and midbody scale rows (16-18, v. 20). Distinguishable from *L. griffini* by fewer supraoculars (2, v. 3), supraciliaries (0, v. 1-2), temporals (1-2, v. 3) and midbody scale rows (16-18, v. 20-21).

Description

Snout-vent length (mm): 32-41.5 (N 5, mean 37.8). Length of appendages (% SVL): hindleg 15.2-21.3 (N 5, mean 18.3), tail 73-89 (N 4, mean 80).

Nasals separated. No prefrontals. Frontal slightly wider than long. Nuchals 1-2 (N 5, mean 1.8). Supraoculars 2, small, first in contact with frontal. No supraciliaries. Loreals 2. No preocular (fused to second loreal). Temporals usually 2, primary the smaller and occasionally fused to fourth labial. Upper labials 5. Midbody scale rows 16 (N 2) or 18 (3). Lamellae under longer toe 7-11 (N 5, mean 8.8).

Upper surface buff or very pale reddish brown, marked with dark brown as follows: 1-5 small irregular spots on frontonasal and frontal; 0-4 lines of small spots on back, passing through centre of dorsal scales, central (paravertebral) pair extending on to tail, where spots become larger, darker and more closely spaced; and upper lateral stripe from nasal to end of tail, broken on head, variably defined on body, more conspicuous on tail. Ventral and lower lateral surfaces whitish.

Distribution

Crests of dunes in Great Sandy Desert (northern interior of Western Australia) (Figure 3).

Derivation of Name

From Latin *vermiculus* (little worm).

Acknowledgements

I am grateful to Drs T.D. Schwaner and A.E. Greer for the loan of specimens in the South Australian and Australian Museums respectively. I am also grateful to Dr Greer for pointing out the diagnostic characters of *Lerista greeri* and *L. griffini*.

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The Distribution of Earthworms in the Perth Metropolitan Area

Ian Abbott*

Abstract

Thirteen species of earthworm were collected on the coastal plain near metropolitan Perth between 1977 and 1980. Six of these species were introduced following European settlement in 1829. The present known distribution of each species in the metropolitan region is mapped at a scale of 1:400 000; that of the more common species in temperate Western Australia is mapped at a smaller scale (1:8 500 000).

All introduced species were found only in disturbed habitats (gardens, man-made parks, etc.) but only two of the seven native species were confined to undisturbed habitat, principally woodland or swampland. Settlement of the region by European man has resulted in the fragmentation of the range of some of the native species, but the replacement of woodland by gardens has enabled the introduced species to establish. It is unlikely that the local decline in distribution of native earthworm species in the metropolitan area is a result of the introduction of peregrine earthworm species.

Each species is keyed out using external features.

Introduction

In 1905 Professor Wilhelm Michaelsen, one of the world's authorities on the taxonomy of earthworms, spent six months collecting in the settled districts of temperate Western Australia as part of the Hamburg/south-western Australia expedition. Although metropolitan Perth then comprised a small area (Figure 1), Michaelsen examined 23 sites in and around suburban Perth as well as six localities in the Darling Range to the immediate east (Michaelsen 1907). These collections were important for two reasons: Perth had been settled by Europeans only 76 years earlier, and outside the suburban limits there were still extensive areas of pristine *Banksia* woodland.

Michaelsen recorded five species around Perth: one lumbricid *Aporrectodea trapezoides* (as *Helodrilus caliginosus* [Savigny, 1826]) and five megascolecids *Diplotrema cornigravei* (as *Eodrilus cornigravei* Michaelsen, 1907), *Graliophilus levis* (as *Plutellus levis* Michaelsen, 1907), *Microscolex dubius*[1] (Fletcher, 1887) and *Woodwardiella libferti* (as *Woodwardia libferti* Michaelsen, 1907). Because lumbricid earthworms are not native to Australia (Jamieson

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[1] Michaelsen also recorded *Microscolex phosphoreus* (Dugès, 1837). According to Jamieson (1974*a*), this species is indistinguishable from *M. dubius*.

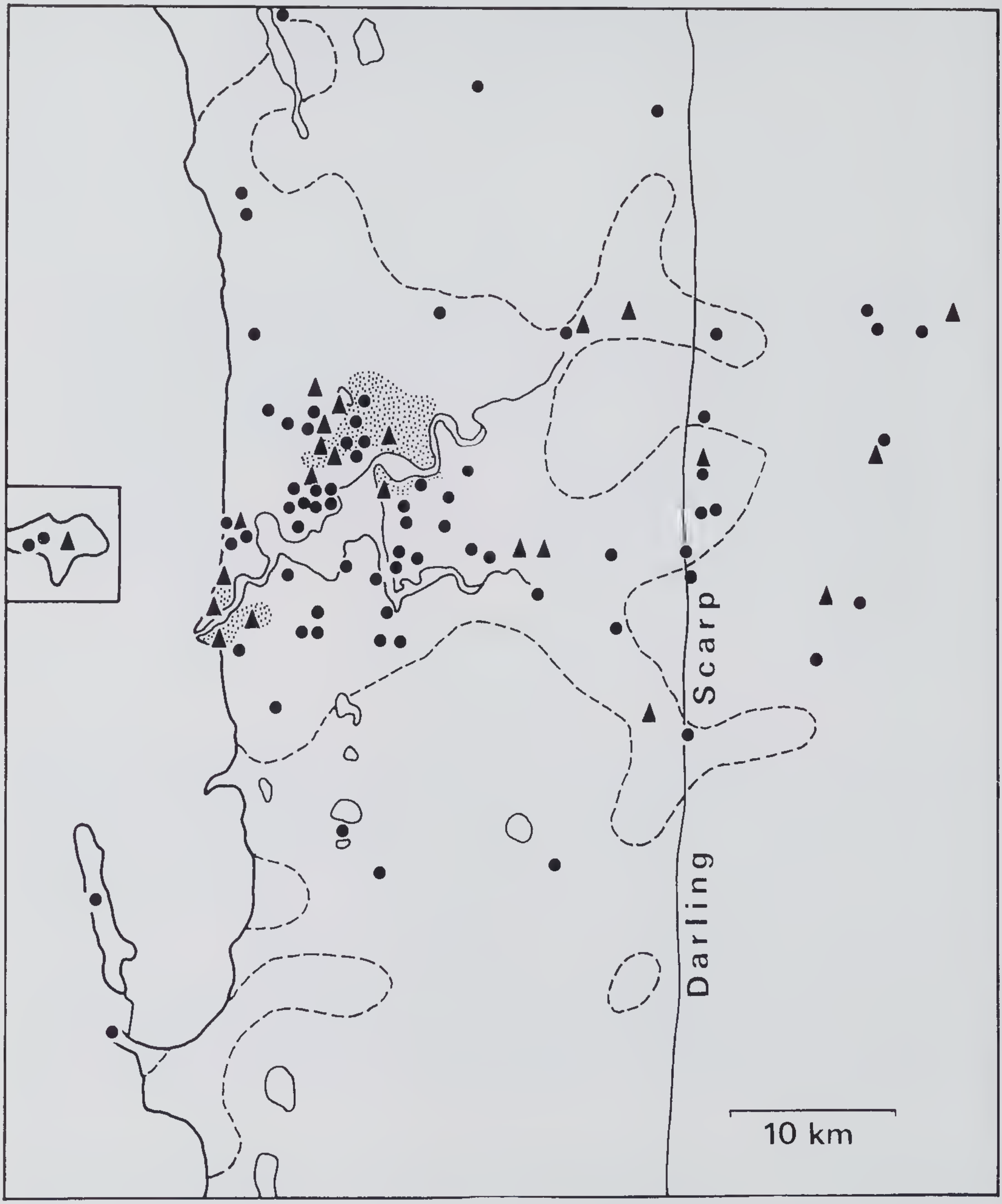

Figure 1 Approximate suburban limits of Perth metropolitan area, 1905 (dotted area) and 1979 (inside dashed line). After Morison 1979 and Department of Lands and Surveys, Perth, 1979. ▲ Sites sampled in 1905 (Michaelsen 1907); ●, sites sampled 1977-1980.

1981), it is certain that *A. trapezoides* was introduced after 1829. In addition, it is almost certain that *M. dubius* was also introduced (Ljungström 1972). The remaining species are indigenous to Western Australia.

In the late 1920s, Ada Jackson collected at a small but undisclosed number of sites 'in the neighbourhood of Perth', and added five species to Michaelsen's list (Jackson 1931). These were the lumbricids *Eisenia fetida*[2] (as *E. foetida* (Savigny, 1826) and *Eiseniella tetraedra*[2] (Savigny, 1826), and the megascolecids *Amynthas corticus*[2] (as *Pheretima heterochaeta* (Michaelsen, 1903), *Megascolex imparicystis* Michaelsen, 1907 and *M. longicystis* Nicholls and Jackson, 1926. Both Michaelsen and Jackson described new species collected from the Darling Range behind Perth: *Graliophilus strelitzi* (as *Plutellus strelitzi* Michaelsen, 1907), *Notoscolex hortensis* Michaelsen, 1907, *N. rubescens* Michaelsen, 1907, *Woodwardiella molaeleonis* (as *Woodwardia molaeleonis* Michaelsen, 1907), *Graliophilus candidus* (as *Plutellus candidus* Jackson, 1931) and *W. magna*[3] (as *Woodwardia magna* Jackson, 1931). Michaelsen also collected the lumbricid *Bimastos parvus*[2] (as *Helodrilus parvus* [Eisen, 1874]). These species are omitted from consideration here because the Darling Range in 1905 and the late 1920s was only sparsely settled, and was not part of suburban Perth as it is now. The Darling Range native earthworm fauna is more properly considered in the context of the northern jarrah forest.

The purpose of this paper is to document the distribution in the Perth metropolitan area of all species of earthworm found there in the late 1970s. Between 1977 and 1980 collections of earthworms were made at 70 sites in and around suburban Perth (Figure 1). The scale of mapping, 1:400 000, is large enough that any real expansion or contraction of distribution of species in the future will be detectable.

A key and glossary of specialist terminology is also provided so that all species can be readily identified from external features. It is hoped that this key will enable naturalists to be better able to realize the significance of new material as it is collected. All the specimens examined for this paper, with details of their places of collection, have been lodged in the Western Australian Museum.

Species Diagnoses and Distributions

Thirteen earthworm species were collected (Table 1). Five of these had not been recorded before: *Aporrectodea caliginosa*, two indeterminate *Megascolex* species, and two indeterminate species belonging to a non-perichaetine genus. These await formal description by a specialist. None of these four indeterminate species can be matched with the descriptions of Michaelsen (1907), so they will probably prove to be new to science. I failed to relocate *Diplotrema cornigravei* and *Graliophilus levis*, collected earlier by Michaelsen. According to Jamieson (1971: 502), *D. cornigravei* is 'widespread in swamps on the Swan Coastal Plain (pers. obs.)'. The only specimens of these species in the Western Australian Museum are those collected by Michaelsen and none of these is suitable for study now. Both species are therefore omitted from the diagnoses and key. All species diagnoses, except where otherwise noted, are based on the material collected, and are composite. The external coloration and maximum length are taken from specimens preserved as follows: held in 35-40% alcohol for one minute: transferred to 4% formaldehyde for 3 hr; and preserved in 75% alcohol.

[2] Introduced to Western Australia.

[3] According to Jamieson (1970:105), this species is a synonym of *W. affinis* (Michaelsen, 1907).

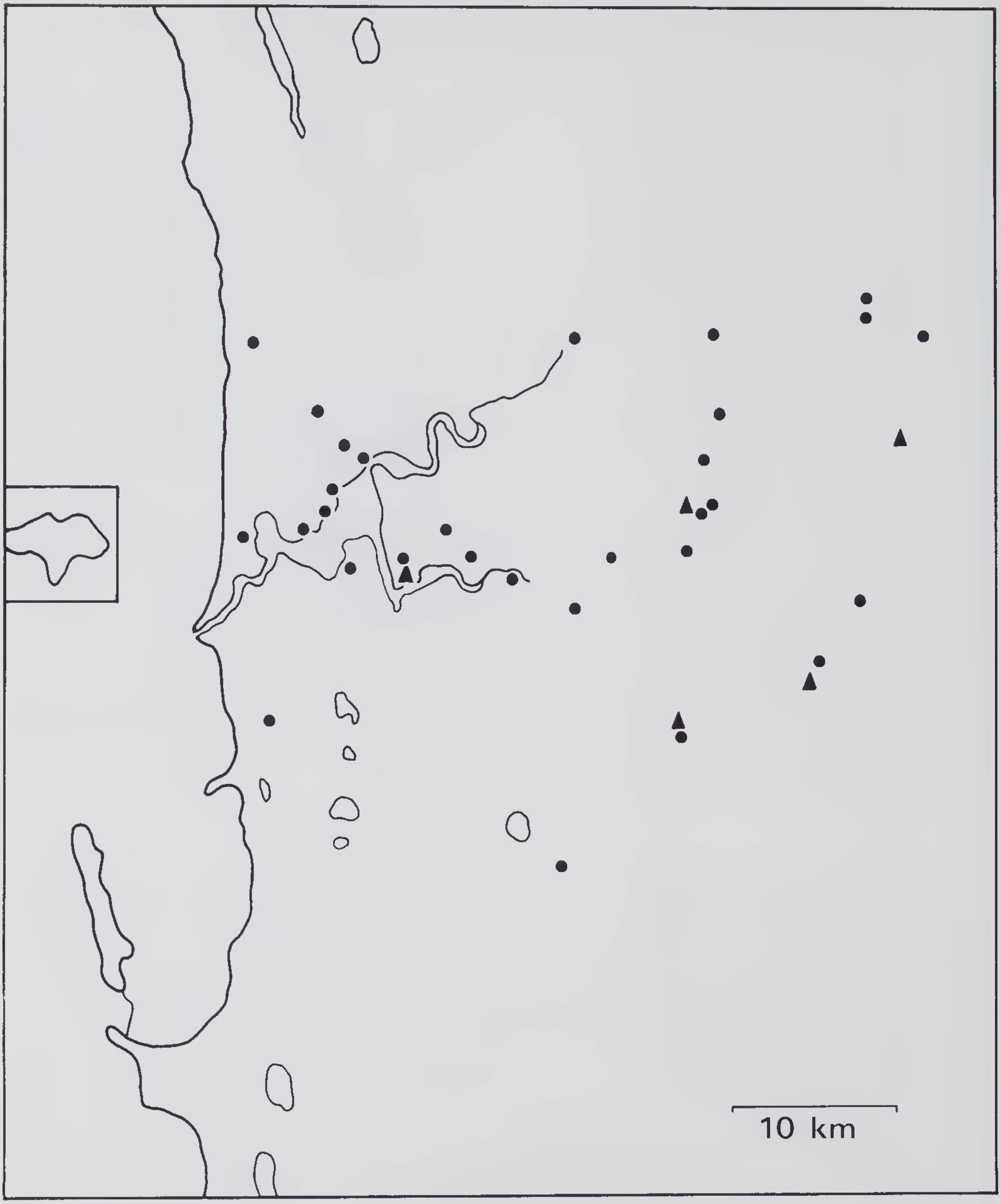

Figure 2 Known distribution in 1977-79 of *Aporrectodea caliginosa* (▲) and *A. trapezoides* (●) in Perth metropolitan area.

Family Lumbricidae

Aporrectodea caliginosa (Savigny, 1826)

Enterion caliginosa Savigny, 1826: 180.
Allolobophora turgida Eisen, 1873: 46.
Aporrectodea caliginosa—Örley 1885: 22.
non Helodrilus caliginosus—Michaelsen 1907: 229; —Michaelsen 1911: 142; —Jackson 1931: 126.

Diagnosis (external)

Length: to 70mm. Colour: pale yellow; pale fawn; pale yellow anterior to segment 15, otherwise light grey; fawn except dorsally on segments 15-29 which are dark grey. Male pores: on segment 15, spreading slightly to neighbouring segments, and lying between *b* and *c* setal lines. Clitellum: variants noted are 27-35, 28-34, 28-½35, ½28-½35, 29-34 (3 specimens), 29-35 (2 specimens), 29-½35. Tubercula pubertatis: Segments 31-33, rarely 31-34, 30-33, or 32-34; always very narrow on the middle segment, and occurring between *b* and *c* setal lines. Genital tumescences: between *a* and *b* setal lines and usually paired. Variants noted are 9-11; 9-11, 27, 30-34; 27 (RHS), 30, 32-33; 9-11, 27; 27 (LHS), 30, 32-33. Setae: closely paired. Behaviour when handled: sluggish.

Gates (1972a) provides a very detailed description of this species.

Distribution

Rare (Figure 2), recorded from only five sites—all gardens (Table 1). From the distribution map it is evident that this species is found in the higher rainfall zone. The range outside the metropolitan area is shown in Figure 9.

Distribution outside Australia: cosmopolitan (Gates 1972*a*).

Aporrectodea trapezoides (Dugès, 1828)

Lumbricus trapezoides Dugès, 1828: 289.
Aporrectodea trapezoides—Örley 1885: 22.
Helodrilus caliginosus—Michaelsen 1907: 229; —Michaelsen 1911: 142; —Jackson 1931: 126.

All of Michaelsen's specimens held in the W.A. Museum and labelled *Helodrilus caliginosus* belong to *A. trapezoides* and not *A. caliginosa* (pers. obs.).

Diagnosis (external)

Length: to 115 mm. Colour: pink to segment 15, thereafter grey; dark grey to segment 13, thereafter brown; all grey but darker dorsally; greyish-fawn; dark grey but nearly purple dorsally; fawn; pale yellow. Male pores: paired on segment 15 with papillae extending on to segments 14 and 16, and lying between setal lines *b* and *c*. (In immature specimens without clitellum and tubercula pubertatis, the male pores do not extend beyond segment 15.) Clitellum: white, fawn or light grey; usually on segments 27-34, occasionally on 27-35, rarely ½26-34, 26-34, ½26-½35, 26-35, 27-33, 28-34 or 28-35. Tubercula pubertatis: usually on segments 31-33, 30-33 or ½30-33; rarely on 30-32, 30-½34, ½30-½34, 31-34 or 31-33; occurring between setal lines *b* and *c*. The tubercula may be either translucent or the same colour (whitish) as the clitellum. Genital tumescences: paired, lying between *a* and *b* setal lines in any of the following arrange-

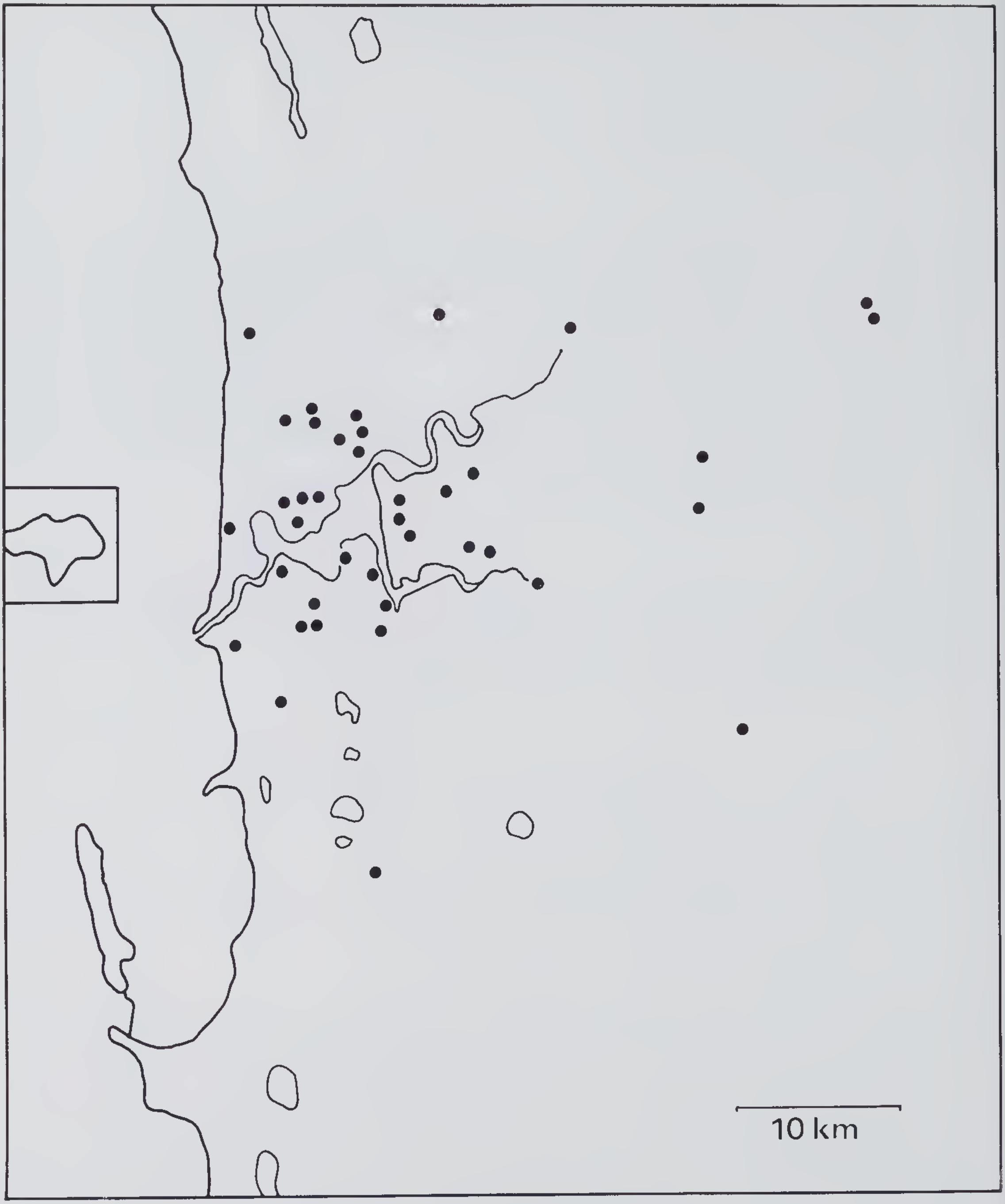

Figure 3 Known distribution in 1977-79 of *Eisenia fetida* in Perth metropolitan area.

ments: 9-11, 32-34; 9-11; 9-11, 27-29, 31-34; 9-11, 27-34; 9-11, 27-30, 32-33; 9-11, 27-29, 29/30, 31/32; 9-11, 30-35; 9-11, 30-31, 32-34; 9-11, 30-34; 9-11, 26-35; 9-11, 26-28, 31-33; 9-11, 30, 32-34; 30, 32-33. Setae: closely paired with *aa* > *bc*. Behaviour when handled: sluggish.

Gates (1972*a*) provides a detailed description.

Distribution

Recorded at 30 sites (Figure 2), associated with gardens and other man-made areas (Table 1). This species is found more frequently in the Darling Range than *Eisenia fetida*. In 1905, *A. trapezoides* was recorded at four widely distributed sites in the metropolitan area. Range outside metropolitan area: widespread (Figure 10), extending farther into semi-arid parts of south-western Australian than *A. caliginosa*. Range outside Australia: cosmopolitan (Gates 1972*a*).

Table 1 Frequency of occurrence of earthworm species in metropolitan Perth region, 1977-1980.

Family and species	Frequency		
	Uncleared sites[1]	Man-affected sites[2]	Total sites
Lumbricidae			
**Aporrectodea caliginosa*	0	5	5
**A. trapezoides*	0	30	30
**Eisenia fetida*	0	38	38
**Eiseniella tetraedra*	0	1	1
Megascolecidae			
**Amynthas corticus*	0	8	8
Megascolex imparicystis	0	3	3
M. longicystis	0	1	1
M. sp. indet. A	0	16	16
M. sp. indet. B	2	0	2
**Microscolex dubius*[3]	0	46	46
Woodwardiella libferti	4	0	4
sp. indet. C	0	1	1
sp. indet. D	0	1	1

*These species are introduced to Western Australia.

[1] Areas that still carry native vegetation with substantial undergrowth of native species, though some weeds may be present.

[2] Includes gardens, plant nurseries, man-made parks, compost areas, stables, lawns, pine plantations, orchards, weedy roadside verges, areas with native trees but with completely weedy undergrowth (native understorey destroyed).

[3] Records from adjacent islands are omitted.

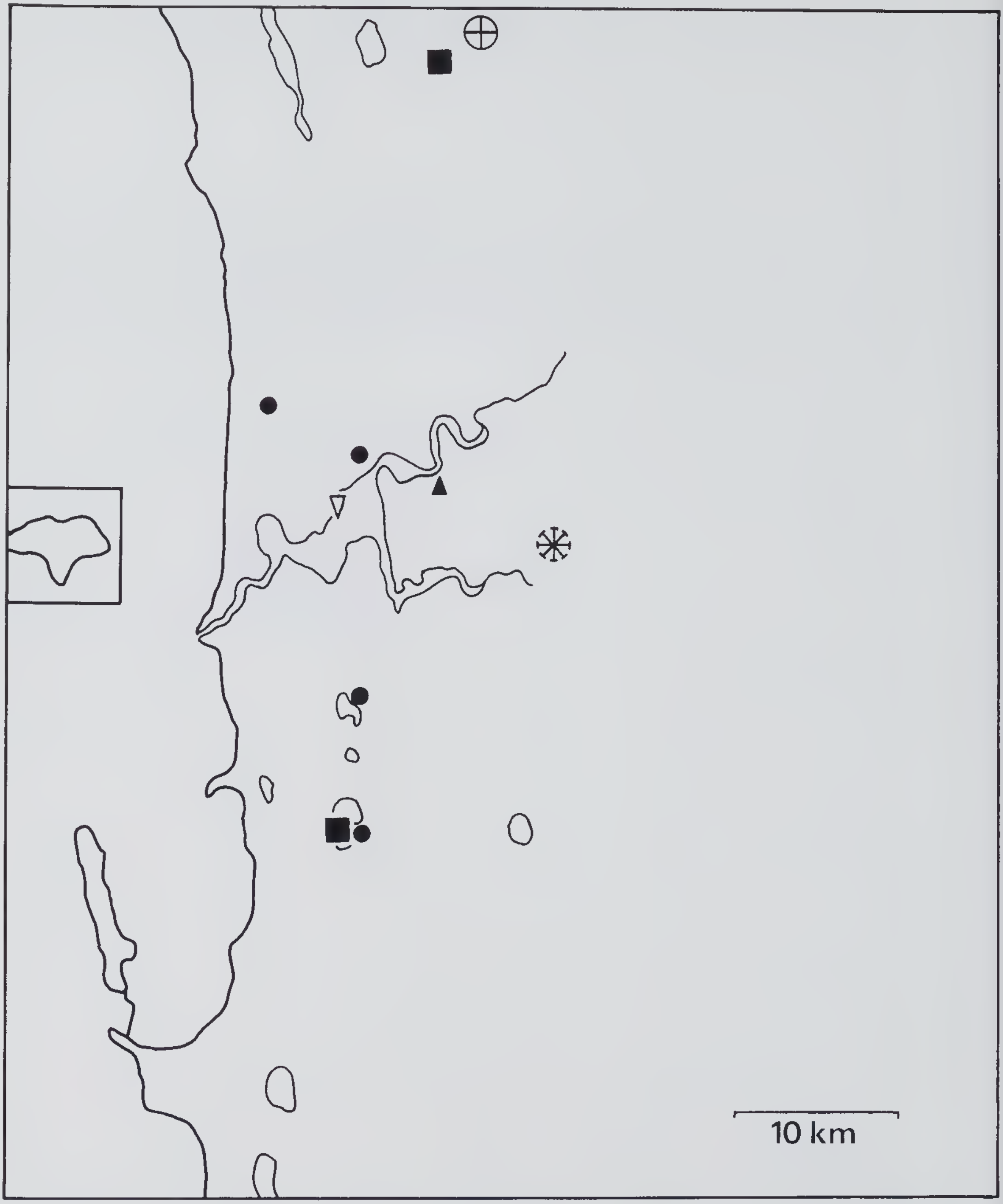

Figure 4 Known distribution in 1977-79 of *Eiseniella tetraedra* (▲), *Megascolex longicystis* (▽), *Megascolex* sp. indet B. (■), *Woodwardiella libferti* (●), sp. indet C. (*), and sp. indet D. (⊕) in Perth metropolitan area.

Eisenia fetida (Savigny, 1826)

Enterion fetidum Savigny 1826: 182.
Eisenia foetida—Malm 1877: 45; —Michaelsen 1907: 228; —Michaelsen 1911: 142; —Jackson 1931: 126.

Diagnosis (external)
Common name: Tigerworm, Brandling, Red Wriggler. Length: to 105 mm. Colour: dorsally purplish-red, ventrally fawn or pale yellow and posteriorly with yellow between the segments. Sometimes purplish-red all over except for the ventral parts of the first ~20 segments, which are yellow. Male pores: paired, on segment 15 between *b* and *c* setal lines. Papillae do not extend onto segments 14 and 16. Clitellum: fawn or off-white, covering on most specimens segments 26-32, occasionally ½24-33, 25-30, 25-32, 26-31, 26-½32, 26-½33, 26-33, or 27-32. Tubercula pubertatis: between *b* and *c* setal lines on segments 28-30 or 28-½31 on majority of specimens examined, occasionally on 25-30, 27-½30, 28-31, ½28-32 or 29-31. Genital tumescences: usually paired, but variably developed: 9-13, 19 (RHS), 23, 26-32; 9, 11 single, 26-32; 8-11, 14, 21, 23, 26-33; 9-12, 14, 16, 26-32; 28-31; 9, 11, 12, 23-32; 8-11, 23-32; 24-32; 9, 12, 26-32; 9-12; 9-12, 26-32; 26-31; 22 (RHS), 23 (LHS), 27-33: 8-12, 26-32; 22-33. On segments before 15 they usually occur between the *c* and *d* setal lines whereas on segments after 15 they occur between the *a* and *b* setal lines. Setae: closely paired, *aa* = *bc*. Behaviour when handled: wriggles and squirms excitedly. A yellow foul smelling fluid is also ejected.

Distribution
Collected at 38 localities (Figure 3), in contrast to Jackson (1931) who noted it at only one locality. Recorded only from man-made habitats such as gardens, stables and chicken runs (Table 1). Range outside metropolitan area: Very localized, see Figure 9. Range outside Australia: cosmopolitan (Michaelsen 1907).

Eiseniella tetraedra (Savigny, 1826)

Enterion tetraedrum Savigny, 1826: 184.
Eiseniella tetraedra Michaelsen 1900: 473; —Michaelsen 1907: 228; —Michaelsen 1911: 142; —Jackson 1931: 123.
Eiseniella intermedius Jackson, 1931: 123; —Michaelsen 1935: 40.

Diagnosis (external)
Length: to 45 mm. Colour: reddish-purple except fawn ventrally. Male pore: on segment 13, between *a* and *c* setal lines. Clitellum: on segments 22-27. Tubercula pubertatis: on segments 23-26 or 23-½26 between *b* and *c* setal lines but closer to *c*. Genital tumescences: obvious only on segments 23-25. Setae: closely paired, with *aa* = *bc*. Note: Segments anterior to 22 are of circular cross-section in contrast to those after the clitellum which are square in transverse section.

Distribution
This species was collected from only one locality, much disturbed, in South Perth close to the left bank of the Swan River (Figure 4). In the 1920s, it was collected only near

Figure 5 Known distribution in 1977-79 of *Amynthas corticus* in Perth metropolitan area.

Lake Monger (Jackson 1931). Range outside metropolitan area: the only record is near Albany (Michaelsen 1907). Range outside Australia: cosmopolitan (Michaelsen 1907). This species would be expected to occur only in or close to water.

Family Megascolecidae

Amynthas corticus (Kinberg, 1867)

Perichaeta corticis Kinberg, 1867: 102.
Amynthas corticus Sims & Easton 1972: 235.
Pheretima heterochaeta Michaelsen 1903: 96; —Michaelsen 1907: 226; —Michaelsen 1911: 142; Jackson 1931: 119.

Diagnosis (external)

Length: to 110 mm. Colour: pale brown-yellow dorsally and fawn ventrally; fawn; pale yellow-fawn; pale brown. Male pore: paired, eyelike, on segment 18, rarely segment 17. The slit may be centred on setal line *f, g, h,* or *j,* and usually extends to one or two setal lines on either side. Clitellum: chocolate coloured or light brown, usually covering segments 14-16, occasionally 14-½16 or ½13-16. Female pore: visible as a central white circle on ventral part of segment 14. Spermathecal pores: usually paired. Variants recorded are: single on 8 (*d* line); 5/6, 6/7, 7/8, 8/9 as small white bulbs on *h* line; 5/6, 6/7, 7/8; 5-8; 7-9 on *d* line; 7-8 on *d* line; 8-9 on *d* line; 8, single (RHS) on *d* line; 7 (paired) and 8 (single) on *c* line; 8 on *c* line. On the basis of such variation in position of these pores, E.G. Easton (pers. comm.) suggests that two species may be involved. However, there is still considerable variation in this feature in earthworms collected at the same locality. Setae: perichaetine with about 40-50 per segment, pointing forward, with the setal rings unbroken dorsally and ventrally. *aa* slightly > *ab*. Dorsal blood vessel not obvious. Behaviour when handled: snake-like in its movements.

Distribution

Rare (Figure 5), recorded in gardens only. In the 1920s, this species was first recorded in what are now Supreme Court Gardens in Perth (Jackson 1931). Range outside metropolitan area: Boyanup (Michaelsen 1907) and banks of Gooralong Brook, Jarrahdale. Range outside Australia: cosmopolitan (Michaelsen, 1907).

Megascolex imparicystis Michaelsen, 1907

Megascolex imparicystis Michaelsen, 1907: 209; —Michaelsen 1911: 141: —Jackson 1931: 109; —Michaelsen 1935: 39.

Diagnosis (external)

Length: mean 215 mm. Range 150-410 mm based on 27 specimens held in Western Australian Museum (mode of preservation not known). Colour: fawn with grey dorsum; very pale yellow with purplish dorsum; light grey but darker dorsally; pale yellow-fawn all over. Male pore: unpaired on segment 18 between *a* setal lines. Clitellum: rarely distinct, 14-19, with sides not meeting ventrally. Accessory glands: arrangement

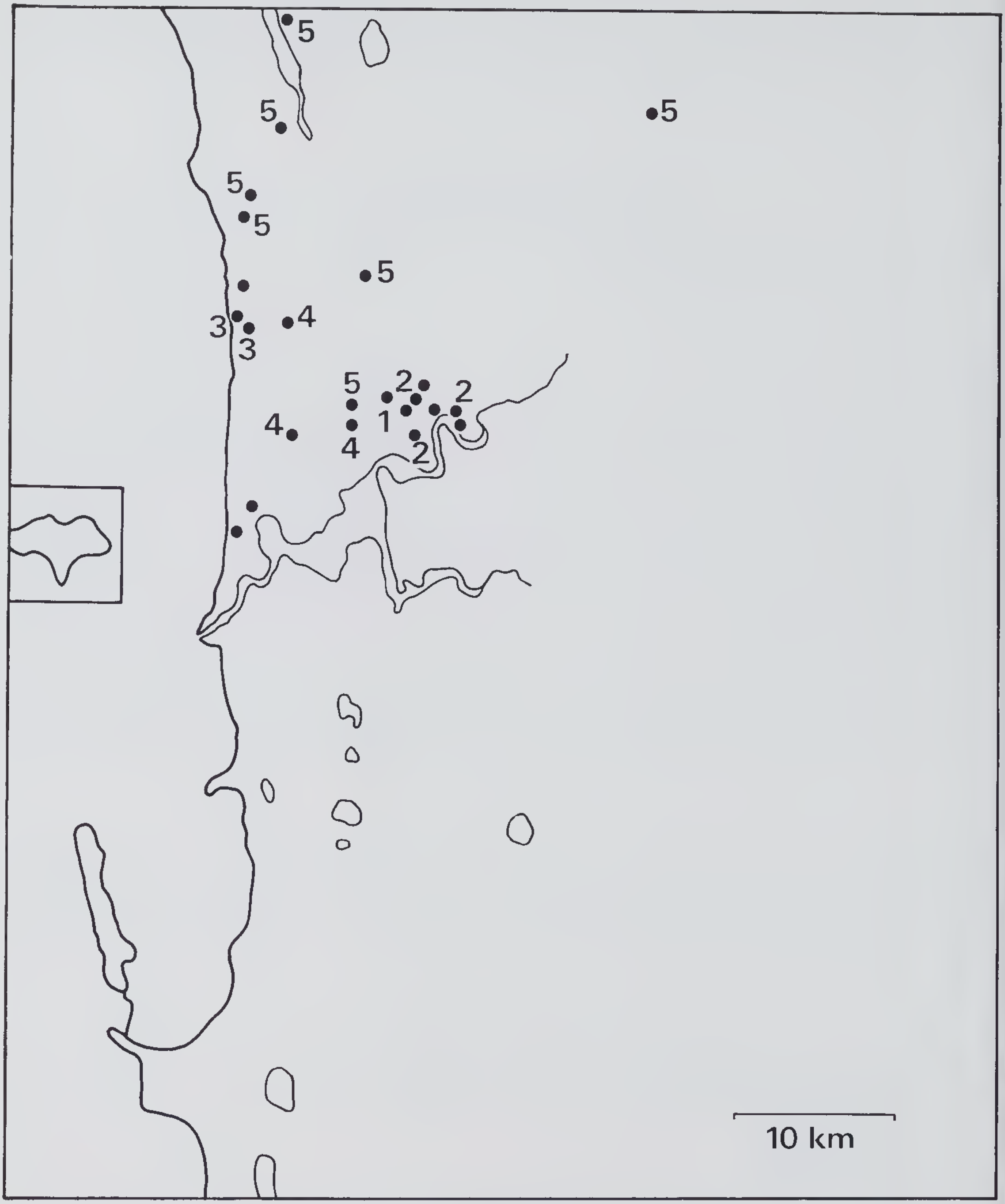

Figure 6 Known distribution of *Megascolex imparicystis,* coded by decades: 1 = 1920s, 2 = 1930s, 3 = 1950s, 4 = 1960s, 5 = 1970s. (Most records from specimens in Western Australian Museum.)

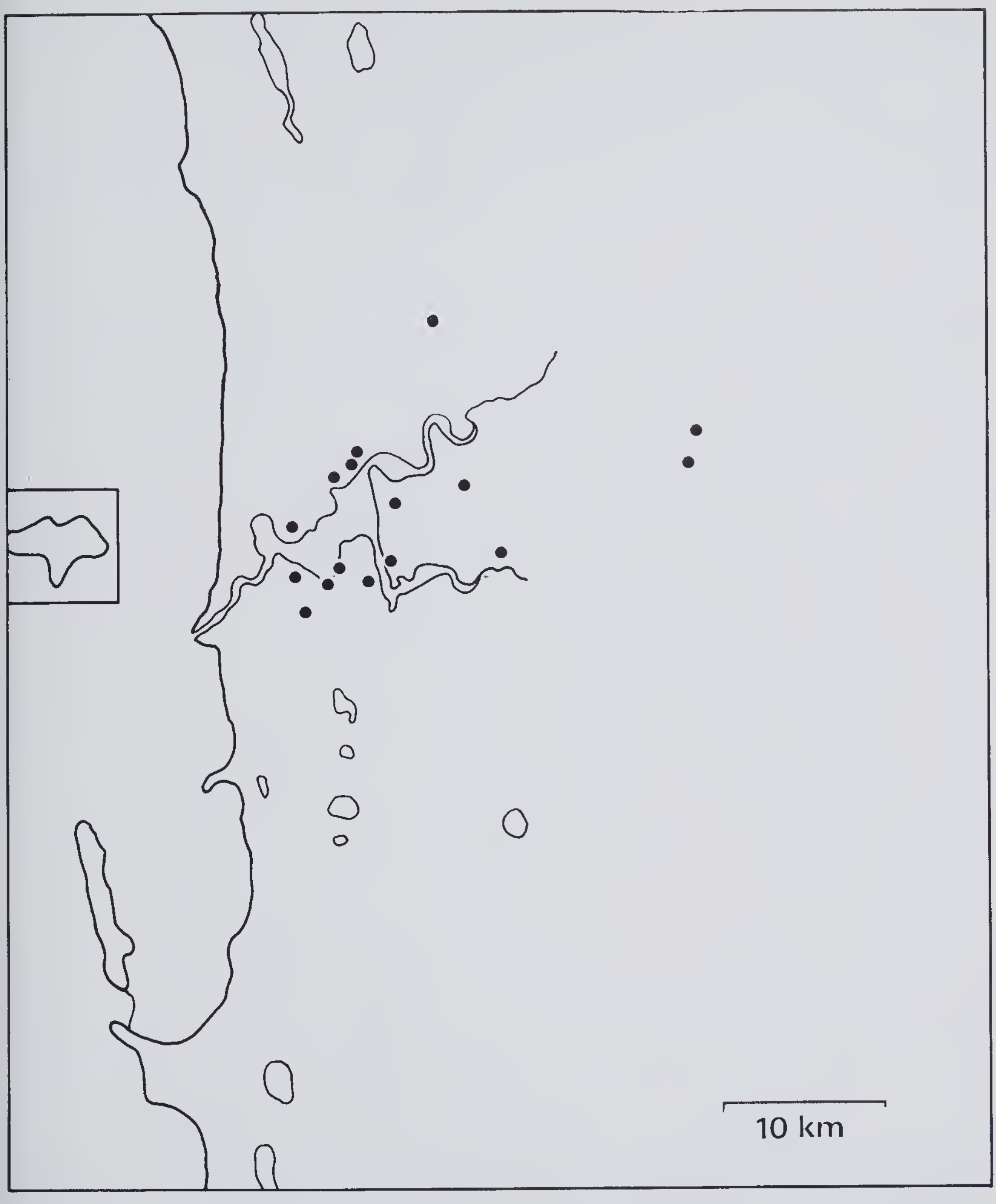

Figure 7 Known distribution in 1977-79 of *Megascolex* sp. indet A in Perth metropolitan area.

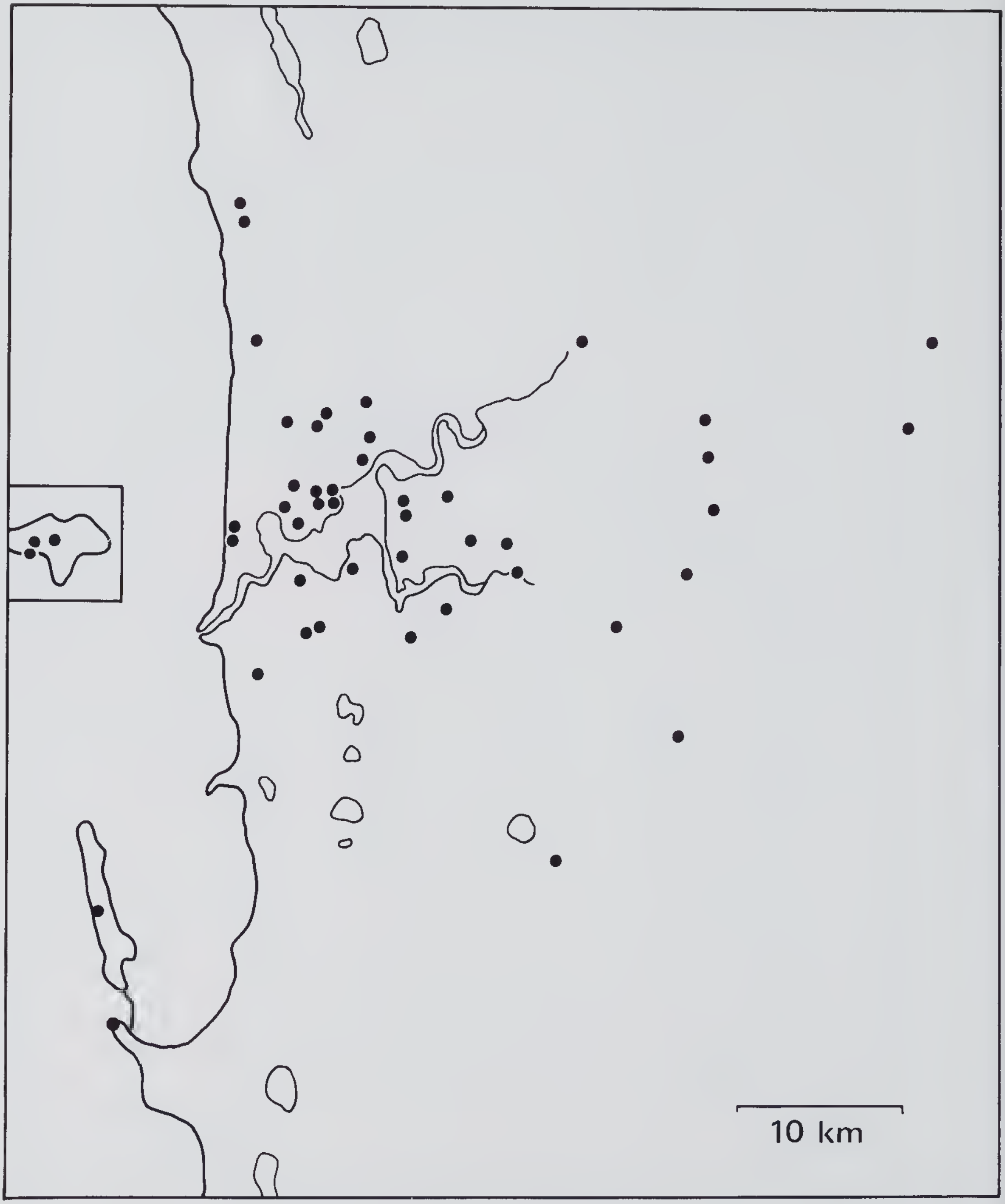

Figure 8 Known distribution in 1977-79 of *Microscolex dubius* in Perth metropolitan area.

quite variable, but always occurring singly and ventrally in furrows between segments: 17-18, 18/19 (twice); 17/18, 18/; 15/16, 16/17-23/24; 14/15-23/24; 15/16-22/23; 4/5-8/9, 17/18-25/26; 14/15-19/20; 16/17-19/20; 16/17-18/19; 6/7, 7/8, 15/16-21/22; 6/7-8/9, 15/16-23/24; 4/5-7/8, 15/16-18/; 16/17-20/21; 15/16-22/23; /16, 16/17, 18/19-23/24; 4/5-7/8, 16/17-25/26. Those before segment 10 lie between *a* setal lines and are not always present. Those accessory glands between segments 15 and 24 are large, but vary in size, lying between *c* setal lines to *g* setal lines. Setae: perichaetine, with 30-50 per segment. *aa* ~ 1.5 *ab*. Behaviour when handled: sluggish.

Distribution

I did not find this species in the metropolitan area in 1977-1980, although specimens from three metropolitan localities were brought into the Western Australian Museum. The date of collection (if available) has been coded by decades in Figure 6. This species has been collected as new suburbs were created from dune scrub or woodland and also

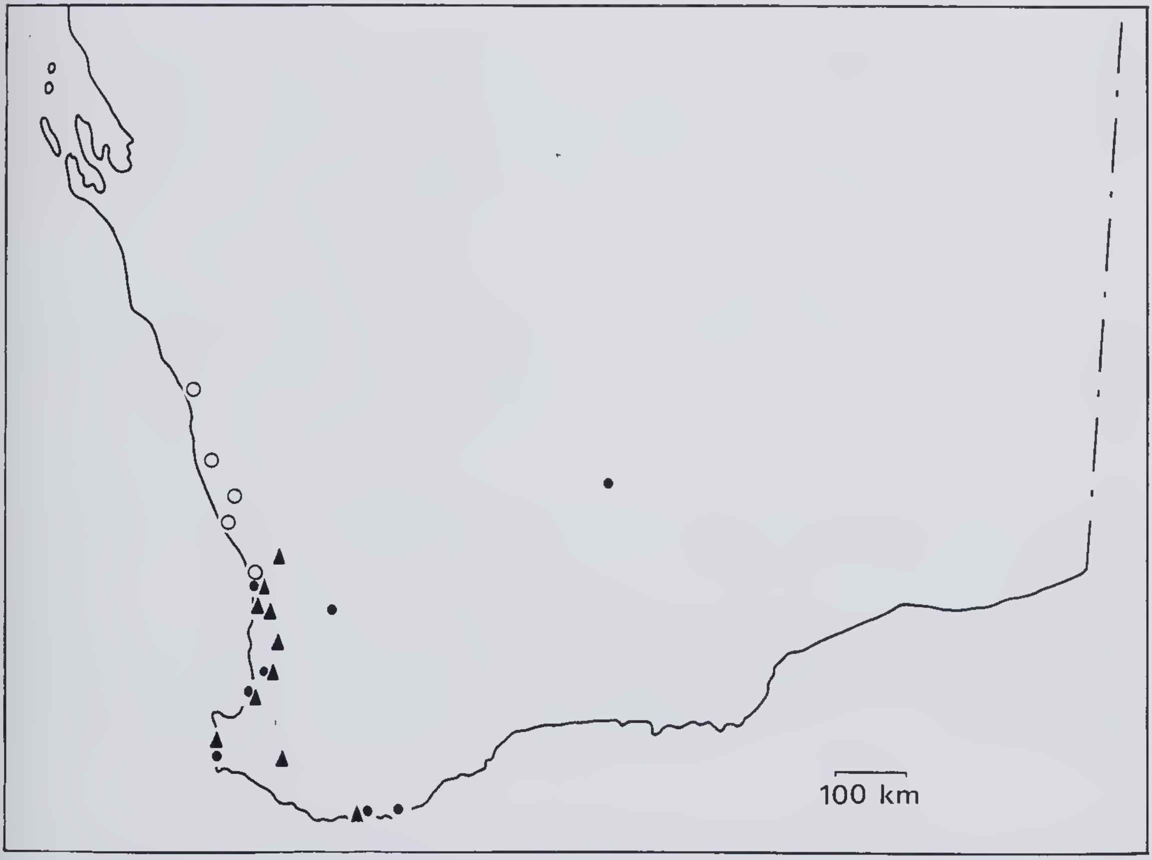

Figure 9 Known distribution of *Eisenia fetida* (●), *Aporrectodea caliginosa* (▲), *Megascolex imparicystis* (○) in temperate Western Australia (based on all records available, i.e. all localized specimens held in the Western Australian Museum, and the author's collection, now in the Western Australian Museum).

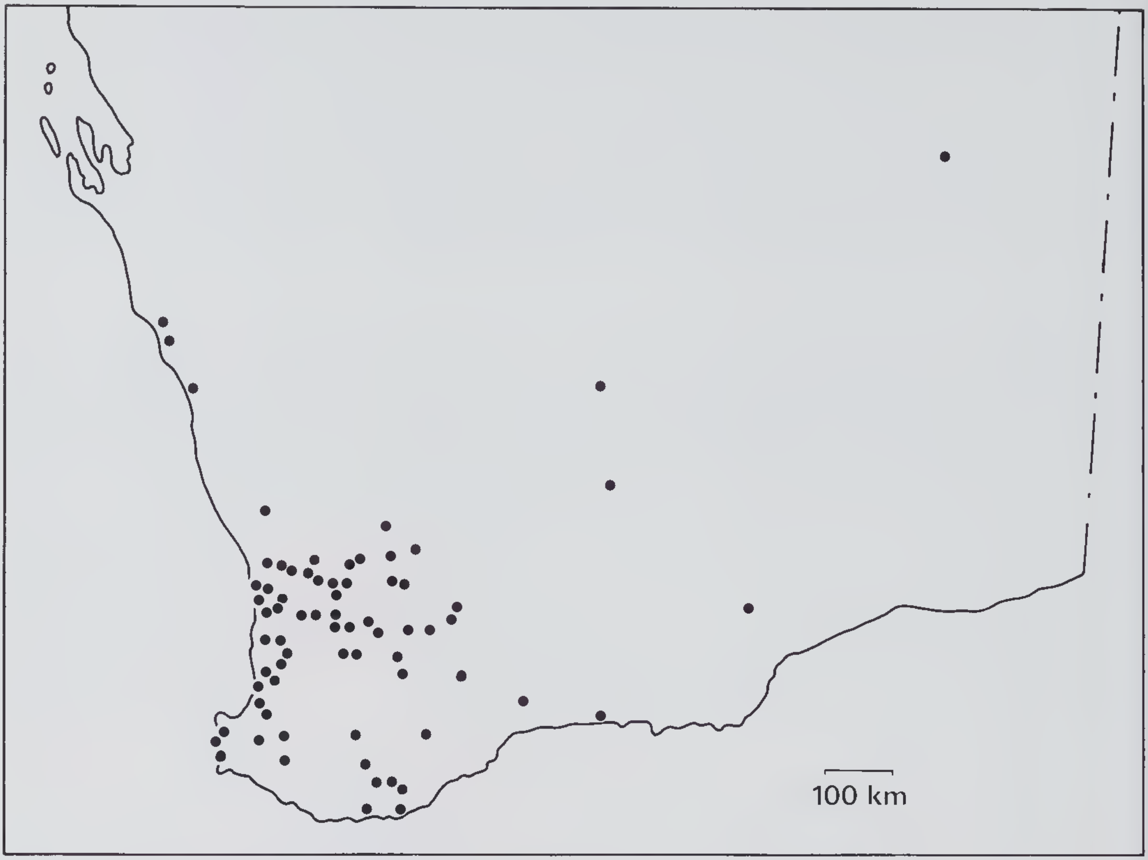

Figure 10 Known distribution of *Aporrectodea trapezoides* in temperate Western Australia (based on all records available).

from reserves and agricultural land remaining. Both Michaelsen (1935) and Jamieson (1971) characterized this indigenous species as peregrine, on the basis that the species has been found in gardens. *Megascolex imparicystis* has not been collected south of the Swan River or in the Darling Range.

Range outside metropolitan area: north of the metropolitan area this species still survives on the coastal plain (Figure 9). I have collected specimens from pasture near Lancelin and Dandarragan. During cultivation large numbers become caught in the tynes near Lancelin (personal observation) and near Upper Swan (R. Barrett-Lennard, pers. comm.).

Megascolex longicystis Nicholls and Jackson, 1926

Megascolex longicystis Nicholls and Jackson, 1926: 142; —Jackson 1931: 116.

Diagnosis (external)

The following description is based on the one specimen collected. Length: 55 mm (to 80 mm, according to Nicholls and Jackson). Colour: purplish-brown dorsally, fawn ventrally, and anterior and posterior extremities tipped white. Male pore: paired on segment 18, centred on *b* setal line and extending from *a* to *c* setal lines. Clitellum, not distinct, 14-½17. Accessory glands, not visible but according to Nicholls and Jackson there are two pairs on anterior margins of 8 and 9 in *c* setal lines. Setae: perichaetine, with about 20-25 per segment. Setal ring is broken ventrally and dorsally, with $aa \sim 1.5\ ab$.

Distribution

Found only at one locality (Figure 4), under eucalypts with a completely weedy undergrowth. Range outside metropolitan area: the two 1920s records, at Wungong and Armadale (Jackson 1931) are still the only non-metropolitan records.

Megascolex sp. indet. A

Diagnosis (external)

Length: to 105 mm. Colour: first 3-12 segments reddish or pinkish-fawn; rest of body grey or pale yellow. Male pore: paired on segment 18, rarely on 17; eyelike, centred on *b* setal line and extending from *a-c* lines or centred on *d* line and extending from *c-e* lines. Female pore: median and unpaired on ventral part of segment 14. Clitellum: chocolate coloured, on segments 14-16, occasionally 14-15, rarely 13-16. Accessory glands: nil. Setae: Perichaetine, with 20-30 per segment. $aa > ab > bc > cd \ldots xy < zz$. Dorsal blood vessel is prominent. Behaviour when handled: wriggles excitedly and will often break in two.

Distribution

See Figure 7. Recorded only in gardens and a plant nursery (Table 1). There are no records from outside the metropolitan area. Note: The material has been registered in the Western Australian Museum collection as WAM 149-81 to 164-81 inclusive.

Megascolex sp. indet. B

Diagnosis (external)

Length: to 55 mm. Colour: dorsally dark red to purple, ventrally fawn; Male pore: paired on prominent papillae on segment 18, between *a* and *b* setal lines. Clitellum: covering segments 13 or 14-17. Genital markings: paired, lying in the furrow of 17/18 between *b* and *c* setal lines. In one specimen there is a single genital marking in the furrow of 19/20 between the LHS *a* and *b* setal lines. Setae: perichaetine, about 20 per segment, with setal ring broken dorsally and ventrally. $aa = 1.5\ ab$. Dorsal blood vessel is visible through preclitellar segments only.

Distribution

Found only at two localities, one in black sand under *Melaleuca* at the edge of a freshwater lake, the other in sand under *Banksia* woodland (Figure 4). This species is not known to occur outside the metropolitan area.

Note: This material has been registered in the Western Australian Museum collection as WAM 165-81 and 166-81.

Microscolex dubius (Fletcher, 1887)

Eudrilus dubius Fletcher, 1887: 378.
Microscolex dubius—Rosa 1890: 511; —Michaelsen 1907: 146; —Michaelsen 1911: 140; – Jackson 1931: 85.
Microscolex phosphoreus Jamieson, 1974: 201.

Diagnosis (external)

Length: to 110 mm. Colour: pinkish or pinkish-white to about segment 12, otherwise pale grey, pale yellow; fawn-yellow to about segment 12, otherwise grey-yellow. Male pore: paired on *a* setal lines of segment 17 or 18 and surrounded by white papillae. Female pore: median ventral on segment 13 or 14, in clitellate specimens only though not always visible. Clitellum: yellow-fawn or light brown, usually on segments 13-16, or 14-17, occasionally on 13-17, 13-½17, ½13-½17, ½13-16, 14-16, 14-½17, or 14-18. Setae: widely spaced; $aa = 2ab$ except on segments 17-20 where b is close to a. The a and b setae on 17 are about twice the length of those on 18. $ab < cd < bc$. Behaviour when handled: sluggish.

Jamieson (1974b) provides a very detailed description of both external and internal features.

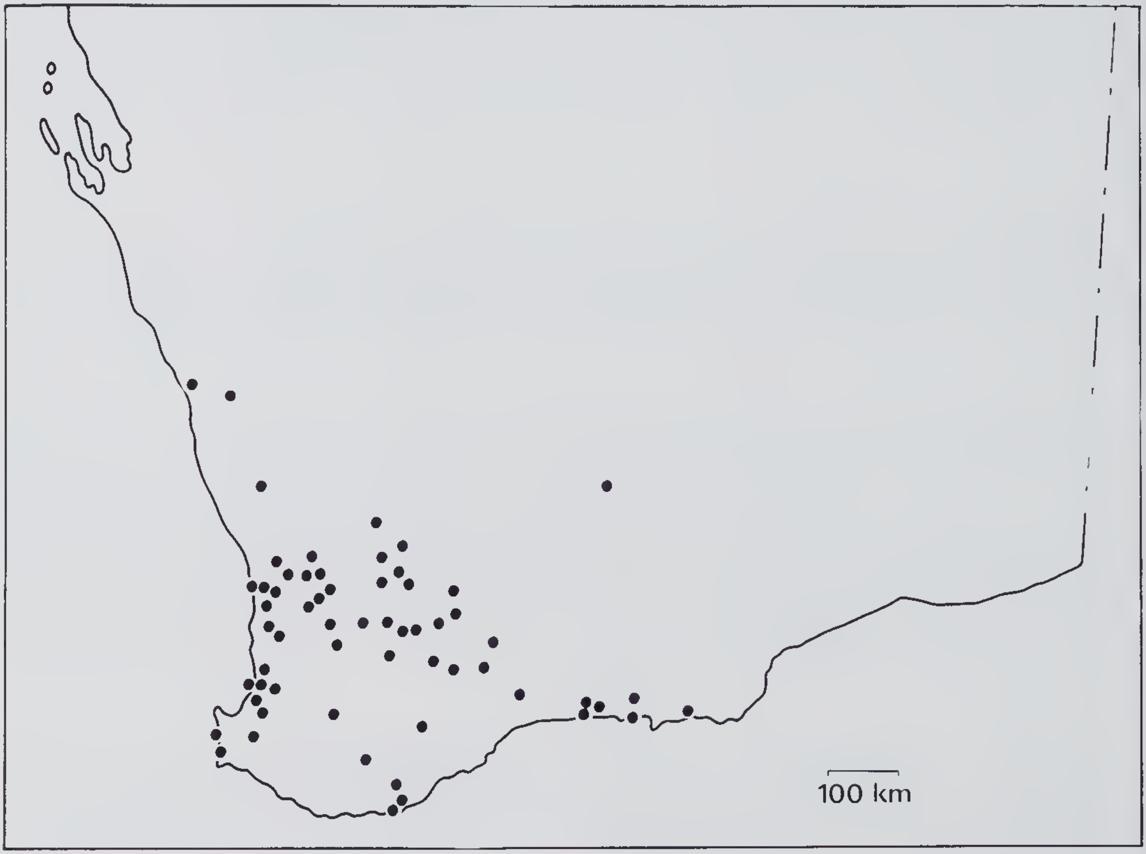

Figure 11 Known distribution of *Microscolex dubius* in temperate Western Australia (based on all records available).

Distribution

See Figure 8. Recorded from man-disturbed sites (Table 1). This species was collected from Green Island, a small stack adjacent to Rottnest Island. It is possible that nesting Silver Gulls *Larus novaehollandiae* have introduced it from nearby Rottnest Island, which is much disturbed by man. *Microcolex dubius* has a wider distribution on the coastal plain than *Aporrectodea trapezoides*. In 1905 this species was recorded at Rottnest Island and six metropolitan sites, and in the 1920s at Rottnest Island, Wungong and Cottesloe. Range outside metropolitan area: Extensive (Figure 11). This species is more widespread than stated by Jamieson (1971: 503). Range outside Australia: cosmopolitan (Michaelsen 1907).

Woodwardiella libferti (Michaelsen, 1907)

Woodwardia libferti Michaelsen, 1907: 193
Woodwardia lipferti—Michaelsen 1911: 141.
Woodwardiella libferti—Stephenson 1925: 888; —Jamieson 1970: 105.
Woodwardiella lipferti—Jackson 1931: 103.

Diagnosis (external)

Length: to 50 mm. Colour: Segments 10-50 are yellow, otherwise pale grey; Male pore: paired on papillae on segment 18, between *a* and *b* setal lines; Female pore: small, paired on segment 14, between *a* setal lines. Clitellum: not obvious in specimens examined. Genital markings: a pad lies in the ventral furrow of segments 11 and 12, and extends to between the *a* and *b* setal lines. Setae: *aa* = *2ab*. Behaviour when handled: sluggish.

Distribution

Recorded at four places (Figure 4), all in sand under *Banksia* woodland. This is the only species collected in the *Banksia* woodland of Kings Park and is not known to occur outside the metropolitan area.

Remarks: Michaelsen's text figures for *W. libferti* and *W. molaeleonis* (given on pp. 194 and 195 respectively) have inadvertently been reversed as they do not match his descriptions. This apparently has led to confusion by Jamieson (1971: 487).

Sp. indet. C

Diagnosis (external)

Length: to 55 mm. Colour: Segments 1-15 pale yellow, remainder grey: Male pores: paired on 18, between *a* setal lines; Clitellum: covering 14-17 or not obvious; Genital markings: single, in furrow 19/20 between *b* setal lines. Setae: four pairs, *aa* = 2-3 *ab*.

Distribution

Found in only one site in the metropolitan area (Figure 4). This species has been found at only one location outside the metropolitan area, under undisturbed woodland at Wilbinga Grove north of Perth.

Note: This material has been registered in the Western Australian Museum collection WAM 167-81 and 168-81.

Sp. indet. D

Diagnosis (external)

Length: to 90 mm. Colour: Segments 1-16 fawn, remainder grey; Male pores: paired on 18 on *a* setal lines: Clitellum: not obvious. Genital markings: paired on *a* setal lines of segments 8 and 9, and paired on large papillae in furrows of 15/16, 16/17, 19/20 on *a* setal lines. (Papillae lie between *b-c* setal lines). The only other variants noted were single (LHS) 14/15 (*a* line), and paired 15/16, 16/17, 19/20; and 16/17, 19/20, 20/21.

Distribution

Found only in Gnangara Pine Plantation in bank of a creek (Figure 4).

Note: This material has been registered in the Western Australian Museum collection as WAM 169-81.

Discussion

Causes of Differences in Distribution of Native and Introduced Earthworms

A clear-cut difference was not found between the distribution of native and introduced earthworm species in the Perth metropolitan area. All introduced species were found only in sites disturbed by settlement, but only a minority of native species were found only in uncleared sites. The first finding was expected, but the second was a surprise. The literature on Southern Hemisphere earthworm faunas has often noted that native and introduced species have exclusive distributions, and there has been controversy about the relative roles of interspecific competition between native and introduced species, and the replacement of native habitats by ones suitable for introduced species (Stephenson 1930, Barley 1959, Satchell 1967, Lee 1961, Ljungström 1972).

What is particularly curious is that of the seven native species collected only two (*Megascolex* sp. indet. B and *Woodwardiella libferti)* were found only in uncleared sites. It is not known whether the other five species are native to the Perth region and have adapted to land-clearing, or if they have been introduced from another part of south-western Australia. In either case, the possibility of interspecific competition between these five species and the introduced species cannot be ruled out. I constructed from Michaelsen (1907) a table similar to my Table 1. Unfortunately the number of cases for 1905 is so small that no useful conclusions can be drawn from a comparison with the 1977-9 data.

Introduced Earthworm Fauna Round Perth Compared with Other Australian Regions

Comparisons of the earthworm fauna of metropolitan Perth with that of other capital cities in Australia is difficult for several reasons. There has been inadequate collecting, particularly of introduced species, and many of the older specimens held in museums are in a poor state of preservation, often being impossible to identify.

I have examined the earthworm collection in the South Australian Museum, the catalogued part of the collection in the National Museum of Victoria, and the card indexes of specimens held in the Australian Museum.

Gates (1972*a*, 1973) provides authoritative information on the occurrence of certain lumbricid species in Australia.

The following lumbricid[4] species (with their known occurrence elsewhere in Australia) have not been recorded from the Perth metropolitan area: *Aporrectodea longa* (Tasmania), *A. tuberculata* (New South Wales), *Bimastos parvus* (New South Wales), *Dendrodrilus rubidus* (New South Wales, Victoria), *Lumbricus rubellus* (New South Wales, Victoria), *Octolasion tyrtaeum* (New South Wales). Both *Bimastos parvus* and *Dendrodrilus rubidus* in the above list were recorded in Western Australia in 1905 but outside the metropolitan area (Michaelsen 1907). In addition, *Eisenia rosea* and *Octolasion cyaneum* have recently been recorded in south-western Australia (Abbott 1981), and would seem to be good candidates for colonizing and establishing in the Perth metropolitan area.

Why some lumbricid species and not others have flourished in the Perth metropolitan area is a subject meriting more detailed analysis. At present it is not possible to state whether either opportunity of introduction to the area or difficulties with establishment because of unsuitable climate, soil type etc. is involved. Parthenogenesis is usually stated to be an advantage in a newly colonized environment if mates are scarce. Of the six introduced species present in metropolitan Perth, *Aporrectodea trapezoides, Eiseniella tetraedra, Amynthas corticus* and *Microscolex dubius* are parthenogenetic. *Aporrectodea caliginosa* and *Eisenia fetida* are amphimictic (Gates 1972*b*, Martin 1977, Reynolds *et al.* 1974). There thus seems to be no close association between breeding system and distribution of species in the Perth metropolitan area. Similarly for the eight lumbricid species recorded elsewhere in Australia but not in the Perth region, five species *(Bimastos parvus, Dendrodrilus rubidus, Eisenia rosea, Octolasion cyaneum, O. tyrtaeum)* are parthenogenetic and the remaining three *(Aporrectodea longa, A. tuberculata, Lumbricus rubellus)* are amphimictic. These comparisons suggest that breeding system is not a particularly important characteristic for peregrine earthworm species. Jaenike and Selander (1979) have proposed that 'parthenogenetic earthworms commonly occur in ephemeral or unstable habitats, in which r-selection may be expected, whereas sexual species tend to inhabit more stable environmental situations, where K-selection may be more important'. When this reasoning is applied to Western Australia, we should expect all earthworm species to be parthenogenetic.

It seems more likely that the frequency of human-assisted movements and the ecology of the soil of suburban areas will be of more relevance to understanding the distribution of peregrine species.

Acknowledgements

I thank many friends for collecting specimens; J. Conacher kindly provided a disproportionate share of these. L. Marsh gave me access to the earthworm collection in the Western Australian Museum, and P. Hutchings (Australian Museum), C. Lu (National Museum of Victoria) and W. Zeidler (South Australian Museum) loaned specimens or provided other help. I also thank J.D. Plisko-Winkworth for the method of preserving specimens. The suggestions of two referees substantially improved the manuscript.

[4]All introduced to Australia.

Key to Identification of Species

(*Diplotrema cornigravei* and *Graliophilus levis,* collected by Michaelsen [1907], were not sighted by me and are omitted.)

1	Male pores on segment 13 or 15	2
	Male pores on segment 17 or 18	3
2	Clitellum terminating on or before segment 33	4
	Clitellum terminating on segment 34 or 35	5
3(1)	Setae, 8 on each segment	6
	Setae, more than 8 on each segment	7
4(2)	Clitellum terminating on or before segment 27; tubercula pubertatis terminating on segment 26	*Eiseniella tetraedra*
	Clitellum terminating on or before segment 33; tubercula pubertatis terminating on segment 30, 31 or 32	*Eisenia fetida*
5(2)	Tubercula pubertatis rod-like	*Aporrectodea trapezoides*
	Tubercula pubertatis distinctly bilobed, the lobes joining on segment 32	*Aporrectodea caliginosa*
6(3)	Accessory genital markings present	8
	Accessory genital markings absent	*Microscolex dubius*
7(3)	Male pore single	*Megascolex imparicystis*
	Male pores paired	*9*
8(6)	Genital markings single	10
	Genital markings paired	Sp. indet. D
9(7)	Setae≥40 per segment; setal ring unbroken dorsally and ventrally	*Amynthas corticus*
	Setae<30 per segment; setal ring broken dorsally and ventrally	11
10(8)	Genital marking in furrow 11/12	*Woodwardiella libferti*
	Genital marking in furrow 19/20	Sp. indet. C
11(9)	Dorsal surface purplish or purplish-brown, ventral surface fawn or grey	12
	Dorsal and ventral surface fawn or grey	*Megascolex* sp. indet. A
12(11)	Both ends of body tipped white (genital markings never paired in furrow 17/18)	*Megascolex longicystis*
	Ends of body not white (genital markings often paired in furrow 17/18)	*Megascolex* sp. indet. B.

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Glossary

The following terms used in this paper are standard ones used in the literature of earthworms. Stephenson (1930) and most elementary books on invertebrates provide explanatory diagrams.

Accessory glands	Glands (sometimes called prostates) associated with the male reproductive organ.
Clitellum	A glandular thickening of the body wall associated with cocoon production.
Female pore	External opening of the female reproductive organ; the pore through which eggs leave the body.
Genital markings	Pads or ridges often associated with the male reproductive organs.
Genital tumescence	Papillae or ridges bearing modified setae, probably to facilitate mating.
Male pore	External opening of the male reproductive organ; the pore through which sperm leave the body.
Papillae	White lips surrounding the male pores.
Peregrine	Earthworm species easily transported by Man and which live in areas disturbed by Man e.g. gardens and pasture.
Perichaetine	More than 8 setae per segment. Figures quoted of number of setae per segment refer to segments 20-25.
Segments	These are numbered from the anterior backwards. The prostomium (a lobe over the mouth) is not numbered. The next segment = 1.
Setal lines	Setae are arranged in regular longitudinal lines around the body. The most ventral setae are each labelled *a*, the next *b*, etc. The most dorsal setae are each labelled *z*, the next *y*, etc. Intersetal distances are then quoted as (for example) $aa = ab$, or $aa = 1.5\ ab$.
Spermathecal pores	External openings of the spermathecae (sperm-storage organs); the pores through which sperm leave the body after eggs are produced.
Tubercula pubertatis	In this paper used to designate genital markings found as ventrolateral swellings on the clitellum of lumbricid earthworms.

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Variation in *Pseudechis australis* (Serpentes: Elapidae) in Western Australia and Description of a New Species of *Pseudechis*

L.A. Smith*

Abstract

Pseudechis australis (Gray) and *P. butleri* sp. nov. from Western Australia are described and their distributions are mapped. The substantial variation in *P. australis* is analysed and the relationships of *P. butleri* are discussed.

Introduction

Some of Boulenger's generic concepts for Australian elapid snakes have stood the test of time better than others. There is general agreement amongst herpetologists today that his concept of *Denisonia* (1896) was too broad, although there is still disagreement about the generic position of species removed from *Denisonia (sensu* Boulenger) (Storr 1981).

On the other hand Boulenger's concept of *Pseudechis* (1896) has changed little over the last 85 years. In fact much of the literature pertaining to *Pseudechis* stems from authors with short series of specimens at their disposal describing variants of species, particularly the widely distributed *P. australis*. Boulenger (1896: 328) recognized eight species of *Pseudechis: australis* (Gray, 1842), *cupreus* sp. nov., *darwiniensis* Macleay, 1878, *ferox* (Macleay, 1881) *microlepidotus* (McCoy, 1879), *papuanus* Peters and Doria, 1878, *porphyriacus* (Shaw, 1794) and *scutellatus* Peters, 1867. *Pseudechis colletti* Boulenger, 1902, *P. guttatus* De Vis, 1905, *P. denisonioides* Werner, 1909, *P. mortonensis* De Vis, 1911, *P. platycephalus* Thompson, 1933 and *P. wilesmithii* De Vis, 1911 have subsequently been described.

Kinghorn (1923) removed *P. scutellatus* from *Pseudechis* and erected *Oxyuranus* for it. Thompson (1930) synonymized *cupreus* and *darwiniensis* with *australis* and later described *platycephalus*.

Mack and Gunn (1953) synonymized *mortonensis* with *guttatus* and *P. wilesmithii* De Vis with *O. scutellatus,* the latter being foreshadowed by Longman (1913).

McKay (1955) transferred *P. platycephalus* and *P. denisonioides* to the synonomy of *australis,* the latter first being suggested by Glauert (see Loveridge 1934: 282).

Kinghorn (1955) merged *ferox* with *microlepidotus* and erected *Parademansia* for it. Until recently *O. scutellatus* and *P. microlepidota* were treated conspecifically, the latter being considered an inland form of the other. Covacevich and Wombey (1976) have shown them to be distinct species. Covacevich *et al.* (1981) treat the two species as congeners.

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Figure 1 Top: A *Pseudechis butleri* from near Sandstone. Photographed by S. Wilson. Bottom: A *Pseudechis australis* from Nita Downs. Photographed by R.E. Johnstone.

The unique specimen of *Denisonia brunnea* Mitchell (1951) is considered here to be a *P. australis* possessing two traits unusual for that species. The lower primary temporal is contacting the lower postocular and all subcaudals are divided.

Data for eastern Australian species of *Pseudechis* are taken from McKay (1955).

The 213 specimens of *P. australis* and 21 specimens of *P. butleri* examined are lodged in the Western Australian Museum herpetological collections (R Series).

Scale rows at neck and tail were counted at the first and last ventral respectively. Bilateral characters such as temporals were counted on both sides of the head.

Systematics

Pseudechis australis (Gray, 1842)

Naja australis Gray, 1842. The zoological miscellany: 55. Type locality NE Australia.

Pseudechis darwiniensis Macleay, 1878, Proc. Linn. Soc. N.S.W. **2:** 221. Type locality Port Darwin, Northern Territory.

Pseudechis cupreus Boulenger, 1896, Catalogue of the snakes of the British Museum (Natural History) **3:** 329. Type locality Murray River.

Pseudechis denisonioides Werner, 1909, Die Fauna Südwest-Australiens **2** (16): 258. Type locality Eradu, Western Australia.

Pseudechis platycephalus Thompson, 1933. Proc. zool. Soc. Lond. 1933: 859. Type locality East Alligator River, Northern Territory.

Denisonia brunnea Mitchell, 1951, Rec. S. Aust. Mus. **9:** 551. Type locality Mt Wedge, Eyre Peninsula, South Australia.

Diagnosis

Distinguished from *P. butleri* by its colour, particularly the ventrals which are cream with a reddish-brown base (yellow with a black base in *P. butleri*). *Pseudechis australis* from the same latitudes as *P. butleri* usually have fewer ventrals (189-207 v. 204-216). Lack of crimson or pink pigment on ventrals distinguishes *P. australis* from *P. porphyriacus* (the only other *Pseudechis* species with 17 midbody scale rows).

Description

A very large snake (up to 201 cm total length). Tail 13.5-22.2% of SVL (N 47, mean 17.8). Head slender and neck indistinct in small specimens; head broad and neck moderately distinct in large specimens. Canthus rostralis prominent.

Rostral 1.1-2.1 times as wide as high (N 147, mean 1.5). Frontal 1.1-1.9 times as long as wide (N 160, mean 1.5). Nasal completely divided; in contact with the preocular (97% of specimens). One preocular, two postoculars. Primary temporals 2, the lower wedged deeply between the fifth and sixth labials and separated from the lower postocular (66% of specimens). Secondary temporals 2. Upper labials 6, third and fourth entering orbit. Lower labials 6, second smallest, fourth largest. Two pairs of chin shields, anterior pair always in contact, postocular separated (97% of specimens).

Ventrals 185-220, lowest in south, highest in north (N 170, mean 201.6). Anal rarely single. Subcaudals 50-78 (N 158, mean 58.6), percentage of undivided subcaudals 35.7-100 (N 158, mean 69.0). Sum of ventrals plus subcaudals 236-295 (N 144, mean 258.4). Midbody scale rows 17; scale rows at neck 17-24 (mostly 19); scale rows at tail 13-18 (mostly 17).

Head and neck black, blackish-brown or brown. Dorsal scales black, blackish-brown or brown, rarely without a cream or brown anterior spot. Scales on lower flanks with more pale pigment than those dorsally. Chin, throat and belly cream, base of each ventral reddish-brown (Figure 1).

Iris brick red. Mouth pink or pinkish-grey.

Distribution

In Western Australia from the far north south to Upper Swan, Yornaning, Marvel Loch, Kalgoorlie, Naretha, Haig and Forrest. Also Sir Graham Moore, Cockatoo, Koolan, Rosemary, Barrow, Bernier, Dorre and Dirk Hartog Islands (Figure 2).

Geographic Variation

The sample was divided into 10 classes of latitude (one class for every 2°), and ventrals, subcaudals, and percentage of undivided subcaudals were analysed (see Table 1).

South of 19°S ventrals and sum of ventrals plus subcaudals vary clinally with latitude. North of 19°S the cline is interrupted. Kimberley specimens have on average more undivided subcaudals and slightly longer tails (Kimberley specimens 14.9-22.2% SVL, mean 19.1, south of Kimberley 13.5-20.1% SVL, mean 18.3). The nasal is separated from the preocular only in the Kimberley (16.6% of specimens). At first these differences seemed to correlate with the Kimberley colour form (see below). However, some of the Kimberley and North-West Division specimens with relatively short tails and few undivided subcaudals have some markings on the head.

The lower primary temporal contacts the lower postocular most frequently in the south (43.3% in the South-West Division, 35.4% in the Eastern Division, 33.6% in the North-West Division and 10.3% in the Kimberley Division).

Overall dorsal colour of a specimen varies with three factors:

(a) colour of pale anterior spot on each scale which varies from cream to brown (spot absent when scales are wholly black);

(b) colour of apex of each scale which varies from brown to black;

(c) size of pale anterior spot relative to the whole scale which varies from zero (when scale is wholly black) to more than half the scale.

An attempt at analysing this variation was made by scoring, for individuals, the colour of their mid-dorsal scales and placing the evaluation into one of three categories for (a) and (b) above and expressing the proportion of pale anterior spot relative to a whole scale as one of three conditions for (c) above. Thus:

Score	Colour of anterior spot	Colour of scale apex	Area of pale spot
1	cream	brown	>½ scale
2	brown	blackish-brown	½ scale
3	spot absent (scales wholly black)	black	<½ scale

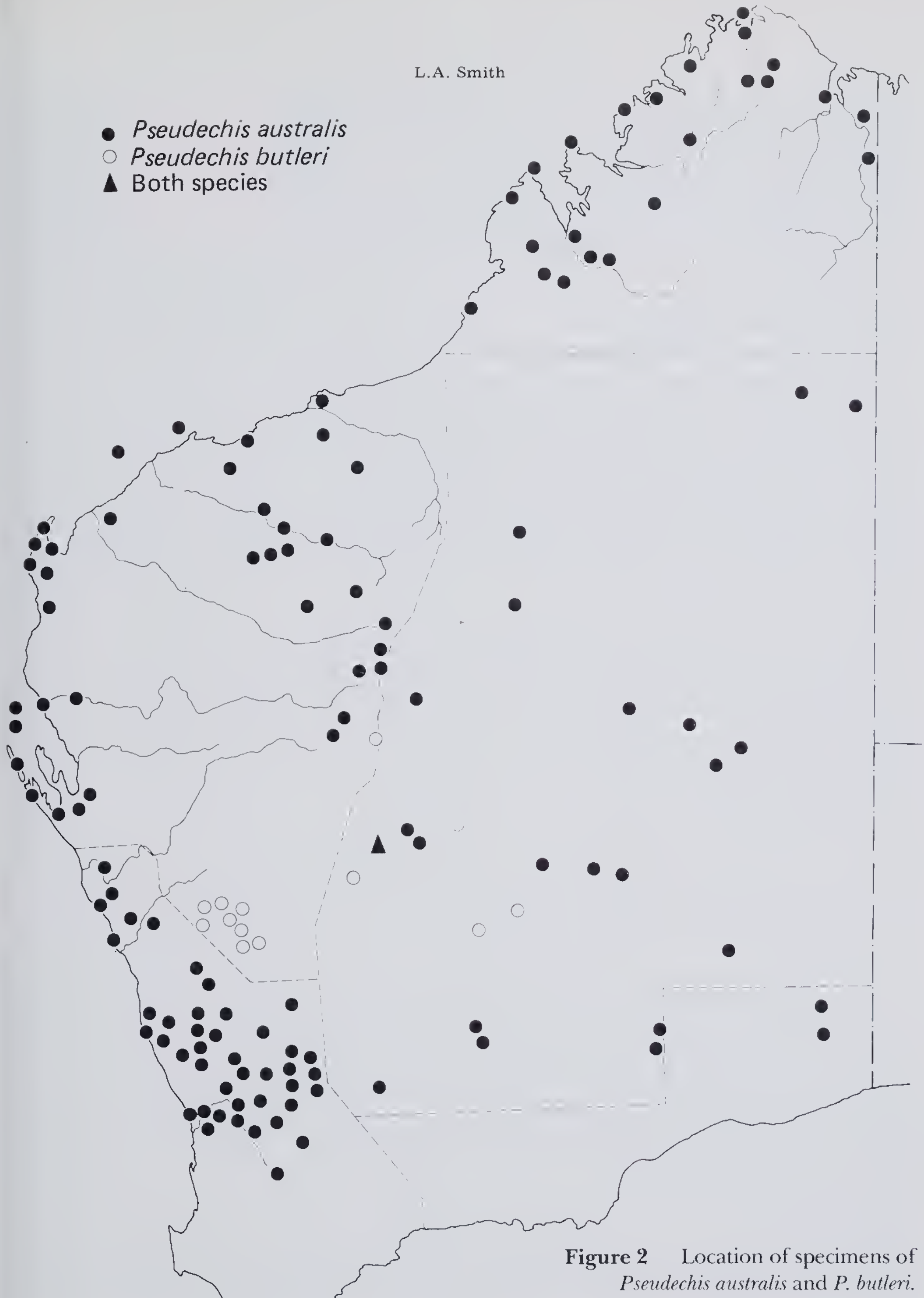

Figure 2 Location of specimens of *Pseudechis australis* and *P. butleri*.

Results indicated that some colour variations had fairly precise geographic boundaries, otherwise colour types at best can only be described as predominating in (but not being confined to) particular areas.

Large anterior spots tend to be cream and cream anterior spots generally precede brown apices (giving an overall impression of a pale snake). Brown anterior spots are usually small and precede blackish-brown or black apices (giving an overall impression of a dark snake).

Darkest specimens occur south of a line joining Jurien Bay, Badgingarra, New Norcia and Quairading. Here the anterior spot is brown or absent (not cream). Only a few specimens have all black dorsals.

Colour of Kimberley specimens is distinctive for two reasons. Firstly, contrast between anterior spot and darker apex of a scale is greatly reduced. Scales are a fairly even brown or slaty grey. Secondly, sutures of head shields, particularly those between parietals, are dark brown. There are also dark spots and flecks on head shields themselves. Juveniles also have three longitudinal stripes (vertebral and dorsolaterals) which begin on the nape and extend a short distance posteriorly. Head and nape markings reduce with age and are usually absent on large adults, the parietal suture mark persisting longest.

Specimens from the vicinity of North West Cape tend to have scales with large cream anterior spots and blackish-brown or black apices, giving specimens a reticulated pattern.

Specimens from eastern areas (Gibson and Great Victoria Deserts and Nullarbor Plain) tend to have scales with a small cream anterior spot and the remainder of scale very dark brown, giving specimens a freckled appearance. Two of these specimens had dark freckling on the belly.

Apices of scales on Cockatoo Island specimens are a distinctive rich reddish-brown and the anterior spot is cream.

Individual Variation

So far meristic data have been arranged to elucidate geographic variation which masks individual variation. The large sample examined included several series from single localities which indicate the extent of individual variation. Range for characters in Table 1 for a series of 5 from Ilgararie Creek was: ventrals 195-212, subcaudals 53-60, sum of ventrals plus subcaudals 248-272 and percentage of undivided subcaudals 62-77%.

Series from Kalumburu (Kimberley Division), Warburton Range Mission (Eastern Division) and Kellerberrin (South-West Division) show similar variation. Greatest variation in percentage of undivided subcaudals was at Kalumburu (49-100%).

The lower primary temporal was fused to the last labial on one side in two specimens. The third upper labial was divided into 3 on one side of one specimen. Last two upper labials were fused on one side of one specimen, and the upper primary and secondary temporal were fused to the parietal on one side of another specimen. One or three secondary temporals are rare.

Material Examined

Kimberley Division

Sir Graham Moore I. (44127); Kalumburu (21853, 28080, 42794); 14 km SSE of Walsh Point (61729); Mitchell Plateau (58318); Drysdale River National Park in 15°02'S, 126°55'E, 15°08′S, 127°06′E and 15°03′S, 126°44′E (50334, 50459 and 50542 respectively); Forest River Mission (12496); Prince Regent River Reserve in 15°07′S, 125°04′E and 15°48′S, 125°20′E (47041-42 and 46896 respectively); Kuri Bay (22778, 22925); Kimberley Research Station (9994, 14487); Kununurra (20569-70); 13 km SE of Kununurra (23106); Cockatoo I. (14073, 14141, 15830, 31959); Koolan I. (29140); Wotjulum (11243, 11722); Lake Argyle (44787, 52666, 70717); 10 km W of One Arm Point (60909); Beagle Bay (3802); Inglis Gap (28077); Yeeda (29722); Broome-Derby road (13846); Camballin (26780); Mt Anderson (58616-17); McHugh Bore (53882); Dampier Downs (58552); LaGrange (28075).

North-West Division

Rosemary I. (41001); DeGrey Station (5106); Carlindi (15067); Barrow I. (28696-98, 48958); Pyramid (25669-70); Marble Bar (13688); 112 km W of Woodstock (28076); 22 km SE of Onslow (22957); Vlaming Head (14012, 19673); Yardie Creek (56129); presumably Exmouth (31420); Wittenoom (11445, 18492); 4 km S of Mt Bruce (69569); 32 km E of Mt Bruce (69571); near Tom Price (31019-20); Ningaloo (32039); 32 km E of Point Cloates (25658); Weeli Wolli (22728); Mt Newman (26438); 14 km SE of South Hill (63811); Turee Creek (17693, 22735); Mundiwindi (19205, 45090); Ilgararie Creek (22721-25); 10 km N of Kumarina (22731-32); 16 km SE of Kumarina (25151); Carnarvon (13472, 32023); Carnarvon area (25830); Meeragoolia (64702); Bernier I. (34092, 64433); Dorre I. (13475, 64875); 37 km W of Neds Creek HS (22727, 25208); 5 km SW of Mt Leake (25209); Dirk Hartog I. (10294, 42397); 3 km SW of False Entrance Well, Carrarang (54730); 19 km E of Hamelin HS (14935); 9 km N of Coburn (66294); Tamala (6519, 6521).

Eastern Division

3 km SW of Lens Bore (63356-57); McGuire Gap (63271); Rudall River (40701); 13 km N of Well 17, Canning Stock Route (31323); 16 km N of Beyonde (21527); Carnarvon Range (51917); south end of Carnarvon Range (53647); 30 km E of Everard Junction (22815); 52 km WSW of Everard Junction (60097); Warburton Mission (22073, 22178, 31350-53); presumably Warburton Mission (22003); 48 km SW of Warburton Mission (28989); Albion Downs (30981); Yakabindie (24691); Booylgoo Spring (1179); Cosmo Newbery (13851, 13853); 30 km N of Neale Junction (48755); 27 km E of Point Sunday (53543); 8 km W of Yamarna HS (28789); 26 km N of Kalgoorlie (15608); Kalgoorlie (61623); Burbidge (29489); Marvel Lock (23329); Naretha (14936); 59 km of WNW of Rawlinna (41228).

Eucla Division

19 km SE of Lake Gidgie (39067); 176 km N of Haig (43903); 58 km N of Forrest (14104).

South-West Division

30 km E of Kalbarri (36465); Balla (26011); presumably Binnu (24856); 11 km E of Hutt River mouth (28079); East Chapman (4449, 4523); Tenindewa (44551); Geraldton (8594); Bowgada (6325); Bunjil (52107); 10 km SW of Eneabba (30306); 16 km E of Green Head (28331); Wubin (12928); 19 km E of Wubin (26202); Gunyidi (6141); 16 km ENE of Jurien Bay (46133); 10 km E of Jurien Bay (60516); Jurien Bay (42380); Namban (21571); 7 km NW of Badgingarra (32082); Badgingarra (17113-14); presumably Badgingarra (21833); presumably Coomberdale (24846); Kulja (5169, 6276); Bindi Bindi (28400); Moora (24991); Moora Shire (34346); presumably Moora area (26080-81); 8 km S of Moora (43922); 20 km W of Dandaragan (59973); 45 km N of Beacon (48390); Bencubbin (5089); 15 km W of Koorda (37886); Wongan Hills (9763, 59973); Mukinbudin area (34702); Moonijin (5520); New Norcia (59979); Bullsbrook (71868); Mangowine, via Nungarin (7852, 7859); Konongorring (12487); Trayning (45975); 48 km E of Dowerin (29490); 16 km S of Calingiri (14662); Goomalling (10767); 8 km S of Bolgart (17089); Bejoording (9775, 10053); Merredin (18502, 22297); 25 km N of Kellerberrin (56542); Baandee (3365, 9988); Kellerberrin and vicinity (22728, 26549-50, 24878, 25973); 19 km NW of Northam (20583); Cunderdin (32000); 10 km E of Northam (24089); Upper Swan (5163); 13 km W of York (22900);

Table 1 Geographic variation in ventrals, subcaudals, ventrals plus subcaudals and percentage of undivided subcaudals in *Pseudechis australis*.

Latitude South		Ventrals	Subcaudals	Ventrals plus subcaudals	Percentage subcaudals undivided
	N	5	4	4	4
13-15°	range	200-217	63-71	263-279	49.2-100
	mean	207.0	66.5	272.0	82.3
	N	21	16	15	16
15-17°	range	196-220	53-78	259-295	54.2-100
	mean	206.7	65.5	274.9	81.7
	N	7	6	6	6
17-19°	range	196-201	57-63	255-262	57.8-91
	mean	198.0	59.1	257.1	70.2
	N	7	8	7	8
19-21°	range	204-216	54-65	258-279	45.4-76.9
	mean	209.0	58.7	268.4	66.0
	N	17	17	17	17
21-23°	range	198-213	53-64	258-279	50-85.7
	mean	208.5	59.1	267.5	69.1
	N	22	20	19	19
23-25°	range	201-213	53-72	248-276	46.2-100
	mean	206.3	57.7	264.1	67.8
	N	19	17	16	17
25-27°	range	196-209	50-69	254-274	50.7-93.2
	mean	203.0	59.1	262.5	67.9
	N	13	9	8	9
27-29°	range	189-204	51-61	234-267	54-100
	mean	197.4	57.0	251.9	68.0
	N	30	29	25	29
29-31°	range	185-206	51-59	238-262	35.7-96.2
	mean	194.5	55.4	250.2	66.5
	N	29	32	27	33
31-33°	range	186-205	50-61	236-263	45.8-81.8
	mean	196.2	57.7	252.3	65.4

7 km SW of York (23341); York area (10559); Quairading area (31321); 13 km E of Quairading (52271); Beverley (68999); presumably Beverley area (23825); Corrigin (64625); 25 km E of Yornaning (50161, 56887).

Northern Territory

Yirrkala Mission (13525); Adelaide River (9986); Katherine (13982, 16505, 21590, 24930, 26348); 34 km SW of Borroloola (32063); 96 km W of Roper River mouth (32064); Kildurk (36333); 3 km S of Elliott (47689); 64 km N of Tennant Creek (34011); 'Tennant Creek' (21514-16).

Pseudechis butleri sp. nov.

Holotype

R22345 a gravid female (SVL 93 cm) collected 19 km SE of Yalgoo, Western Australia, in 28°29′S, 116°49′E, by I.C. Carnaby on 15 October 1963.

Paratypes

North-West Division

New Springs (13703); Wurarga (5372, 7395); Yalgoo (7472); 3 km S of Yalgoo (29232); 48 km S of Yalgoo (12919); 56 km S of Yalgoo (25815); Muralgarra (8177); Barnong (25978); Thundelarra (34694); Fields Find (R13555, 13667); Warriedar (1329).

Eastern Division

Wonganoo (51101); Booylgoo Spring (1519, 1380, 7627); 8 km W of Laverton (44550); Laverton (22395); Mt Malcolm (10701).

Diagnosis

Distinguished from *P. australis* by its colour, particularly the ventrals which are black-based and bright yellow in *butleri* (cream with a reddish-brown base in *australis*). Further distinguished from *P. australis* (from the same latitudes) by usually having more ventrals (204-216 v. 189-207). *Pseudechis porphyriacus* of eastern Australia has fewer ventrals (175-210, mean 186.3) and black-based crimson or pink ventrals.

Description

A large snake (up to 156 cm in total length). Tail 13.9-16.4% of SVL (N 4, mean 15.2). Head broad and moderately distinct in large specimens. Canthus rostralis prominent.

Rostral 1.3-2.0 times as wide as high (N 20, mean 1.6). Frontal 1.1-1.5 times as long as wide (N 19, mean 1.2). Nasal completely divided; in contact with the preocular (98% of specimens). One preocular, two postoculars. Primary temporals 2, the lower wedged deeply between the fifth and sixth labials and separated from the lower postocular (95% of specimens). Secondary temporals 2. Upper labials 6, third and fourth entering orbit. Lower labials 6, second smallest, fourth largest. Two pairs of chin shields, anterior pair always in contact, postocular pair separated (95% of specimens).

Ventrals 204-216 (N 15, mean 211.4). Anal divided. Subcaudals 55-65 (N 16, mean 58.6), percentage of undivided subcaudals 35-76 (N 15, mean 59.6). Sum of ventrals plus subcaudals 268-279 (N 15, mean 270). Midbody scale rows 17; scale rows at neck 16-23 (mostly 19); scale rows at tail 15-18 (mostly 17).

Rostral, nasals, preoculars, labials (except for a short black subocular streak bordering orbit), chin shields and gulars reddish-brown. Remainder of head and nape black with a reddish-brown tinge. Reddish-brown head and neck most prominent in juveniles. Back with irregular groups of all-black scales. Remainder of dorsals black with yellow (rarely brownish) centres. Most yellow is present on scales of lower flanks (black apices), least mid-dorsally (small yellow spots with broad black margins). Ventral surface bright yellow, base of each ventral always unevenly edged black, remainder of ventrals sometimes flecked black (Figure 1).

R7627 arrived at the Western Australian Museum freshly dead. Glauert (1957: 32) described its lighter parts as 'primrose yellow'.

Distribution

Arid mid-west of Western Australia north to New Springs, south and west to Barnong and east to vicinity of Laverton (Figure 2).

Remarks

Glauert (1957: 31) suspected that *P. butleri* was a new taxon but was loath to place a name on a small series. He was not aware that much of the extensive variation in *P. australis* was clinal which prevented him from discovering meristic differences between the two species. That *P. australis* can be very dark (sometimes black) dorsally in the extreme south-west of its range further obscured the situation.

The distinctiveness of *P. butleri* becomes apparent when its meristics are compared with those of *P. australis* from similar latitudes (25°-28°S):

		Ventrals	Subcaudals	Ventrals plus subcaudals	Percentage subcaudals undivided
	N	32	26	24	26
P. australis	range	189-207	50-69	238-267	52.2-100
	mean	201.0	58.3	260.3	64.7
	N	15	16	15	15
P. butleri	range	204-216	55-65	268-279	35-76
	mean	211.4	58.6	270.0	59.6

Pseudechis australis with all-black scales do not occur in these latitudes.

Of the other species of *Pseudechis (australis, colletti, guttatus, papuanus* and *porphyriacus) butleri* is most like *porphyriacus* in having 17 midbody scale rows and a similar colour pattern. Cogger (1979: 396) says *porphyriacus* often has a light brown snout, while McKay (1955: 18) mentions specimens... 'with a few crimson scales scattered on the dorsal surface...' In *butleri* the rostral and lateral head shields are reddish-brown and yellow pigment is always present on most dorsal scales. Thus despite obvious differences in the colour of non-black areas of scales, the two species' patterns are similar, the difference depending on the extent of black pigment.

Like other Australian 'black snakes' *(P. colletti, guttatus* and *porphyriacus) butleri* is not widely distributed compared with *P. australis,* which is found in all but extreme southern parts of Australia (see Cogger 1979: 395). These relatively localised, disparate distributions of the black snakes suggest that *P. australis* may have expanded its range at their expense.

This species is named after Mr W.H. Butler CBE in recognition of his efforts for the cause of conservation in Australia.

Acknowledgements

I am grateful to Dr G.M. Storr, Head, Department of Ornithology and Herpetology, for comments on the manuscript, to Mr S. Wilson for the photograph of *P. butleri* and to Mr R.E. Johnstone for the photograph of *P. australis.*

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The Habitat and Life History of the Pilbara Ningaui *Ningaui timealeyi*

J.N. Dunlop and Maryanne Sawle*

Abstract

The preferred habitat of the Pilbara ningaui is dense to mid-dense hummock grassland especially with an upper stratum of open mallee or scrub. Males are larger than females. Litters of 4-6 pouch young or females with distended mammae were observed from September to March. The species is short-lived, with few individuals surviving into a second breeding season.

Introduction

The ecology of the recently described marsupial genus *Ningaui* is as yet little known. Two species have been described, *Ningaui ridei* from central Western Australia and *N. timealeyi* from the Pilbara (Archer 1975). More species almost certainly exist as specimens of undescribed forms have recently been collected in other arid parts of the continent (D.J. Kitchener, pers. comm.).

This paper presents information on the habitat preferences and life history of *N. timealeyi* based on data collected on a number of biological surveys conducted in the eastern Pilbara between March 1979 and March 1981. Six distinct localities were trapped; three during biological/environmental surveys accompanying mineral exploration and three during a privately organized survey of the Hamersley Range National Park. These localities are shown on Figure 1.

Methods

Ningauis were captured using pitfall and drift fence traplines. These consisted of 10-12 lined pits (0.18 m diameter × 0.43 m deep) placed at 4 m intervals along, and on alternate sides of a 35-50 m long flywire fence, 0.15 m high. Each pit had a minimal catching area of about 12 m of fence and, during the study period, trapping efforts totalled 6333 pit trap days. The vegetation structure of each trapping locality was described using the life-form/density classes of Muir (1977).

Although most ningauis captured were released alive after being toe-clipped for subsequent recognition, some voucher specimens were collected from each locality and lodged at the Western Australian Museum. Animals were weighed to 0.1 g using a Pesola spring balance and the maximal scrotum width of males was measured to 0.1 mm using vernier calipers. Females were examined for pouch and mammae development and for the presence of pouch young.

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Results and Discussion

Habitat Preferences

During the study period, 156 ningauis were trapped (excluding recaptures), making them the most common mammal in the study area. They were trapped in all six localities surveyed. The data from all three years have been combined in the analysis of habitat preferences. The habitat (vegetation structure) preferences of *N. timealeyi* were evaluated in terms of relative abundance from trapping data. Capture rates from each of the six localities sampled were based on different trapping efforts and population sizes and are therefore not directly comparable. However, using an abundance index (AI) similar to that devised by Kitchener (1981), results from different localities can be standardised for effort and population size giving importance values for each habitat type:

$$(AI) = 10^2 \sum_{i=1}^{n} \frac{Pi}{Ti}$$

where Pi = proportion of captures in each locality in the ith habitat type
Ti = number of trap-days in each habitat of the ith type
n = number of ith habitat types sampled.

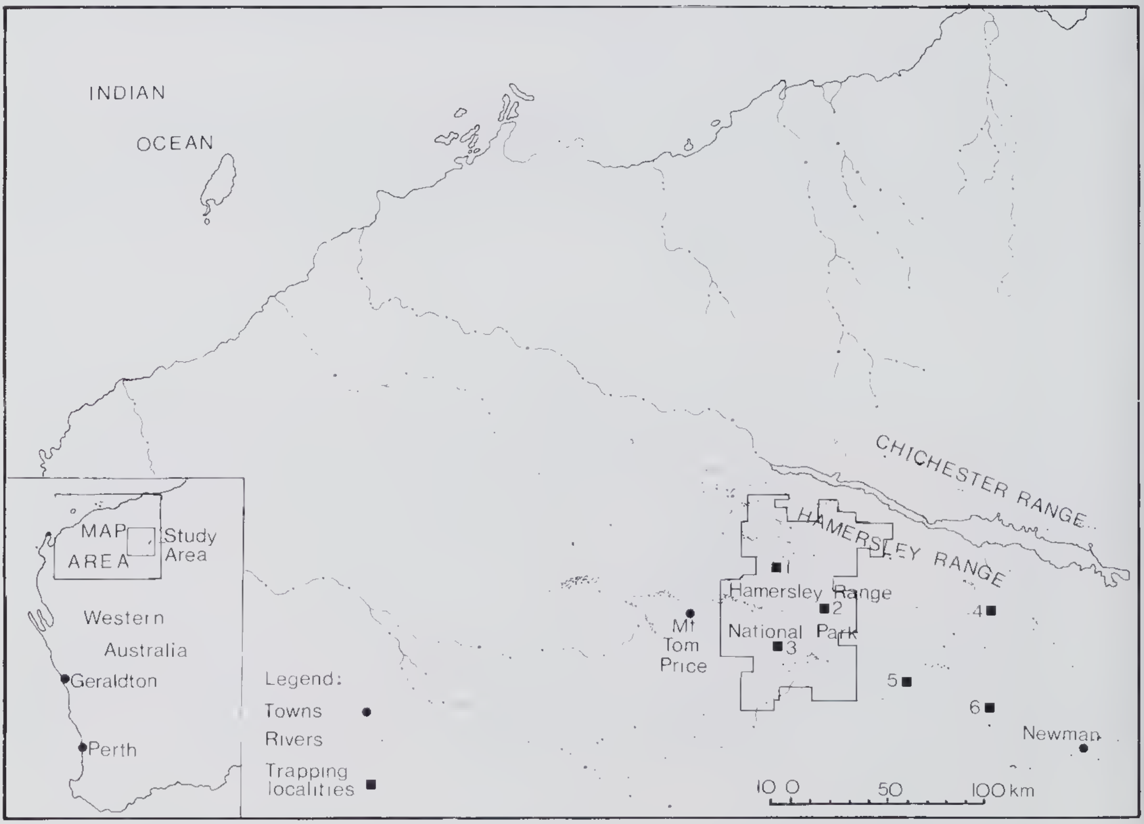

Figure 1 Map showing the location of the study area and of the six trapping locations.

Although trapping success varied seasonally, with the lowest numbers of captures in winter (June/July), ningauis were captured in reasonable numbers throughout the year. Data from all sampling periods have been used in this analysis.

Abundance indices were calculated for each vegetation stratum sampled using the life-form/height and canopy cover density (LFD) classes of Muir (1977). These values are presented in Muir's LFD matrix (Table 1) along with the total trapping effort for each stratum (in parenthesis).

The total AI values in the LFD matrix indicate a preference in *N. timealeyi* for open tree or very open shrub mallee or scrub over dense or mid-dense hummock grass. The open tree and shrub mallee strata almost always comprised the same stands and the AI values for these classes could be lumped together.

The scrub stratum in the area usually consisted of Mulga *Acacia aneura* and associated *Acacia* spp. Both mallee and scrub strata were usually over mid-dense hummock grass.

In Mulga low woodland (sparse trees 5-15 m) the hummock grass stratum was absent. No ningauis were trapped in this LFD. The species was also scarce in sparse or very sparse stands of hummock grass including areas which were regenerating after fire. It would appear that a dense or mid-dense hummock grass stratum is an essential component of the habitat of ningauis. Optimal conditions exist where the hummock grassland has an upper stratum of open mallee or scrub. This may be because the animal is to some degree scansorial. One ningaui was observed at night climbing the stem of a low branching shrub.

Life History

Scrotal size may be used as an indicator of spermatogenesis in dasyurid marsupials (Woolley 1966). The measurements of maximal scrotum width for males trapped in each of five sampling periods (Table 2) suggest that males reached peak sexual development in spring (September/October). Thereafter, those animals continuing in the population showed a decline in gonadal size. Young were produced over the spring

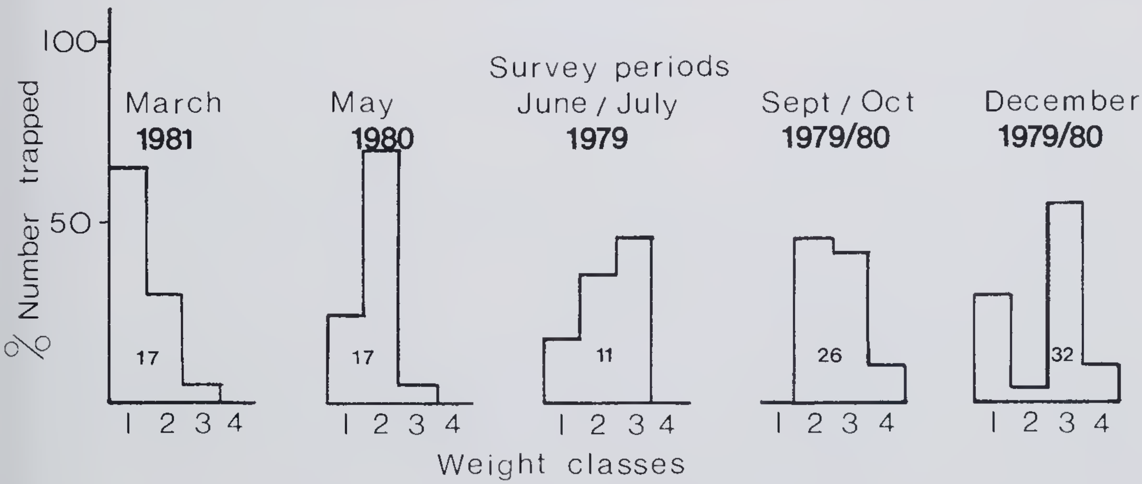

Figure 2 The weight distributions of *Ningaui timealeyi* captured at four times of year.

Table 1 Abundance Index values for *Ningaui timealeyi* for all habitats (strata) trapped. The life-form/height and canopy cover matrix is that of Muir (1977). Values in parenthesis indicate trapping effort, i.e. total trap-days for each habitat.

Life-form/ Height Class	Canopy Cover			
	Dense 70-100%d	**Mid-Dense 30-70%c**	**Sparse 10-30%i**	**Very Sparse 2-10%r**
T Trees >30 m	*–	–	–	–
M Trees 15-30 m	Not sampled	Not sampled	–	–
LA Trees 5-15 m	–	–	0 (100)	Not sampled
LB Trees <5 m	–	–	2.0 (346)	6.4 (633)
KT Mallee tree form	–	–	12.9 (174)	
KS Mallee shrub form	–	–	3.6 (629)	26.4 (3168)
S Shrubs >2 m	–	0 (297)	28.4 (1845)	9.8 (1835)
SA Shrubs 1.5-2.0 m	–	–	5.4 (308)	Not sampled
SB Shrubs 1.0-1.5 m	–	–	4.2 (2558)	0 (179)
SC Shrubs 0.5-10. m	–	–	8.3 (12)	–
SD Shrubs 0.0-0.5 m	–	–	3.6 (140)	–
P Mat plants	–	–	–	–
H Hummock grass	17.9 (659)	24.9 (4520)	10.3 (537)	0.5 (316)
GT Bunch grass >0.5 m	–	Not sampled	–	–
GL Bunch grass <0.5 m	0 (40)	–	–	–
J Herbaceous spp.	–	–	0 (100)	–
VT Sedges >0.5 m	–	–	–	–
VL Sedges <0.5 m	–	–	–	–
X Ferns	–	–	–	–
Mosses, liverworts	–	–	–	–

* Indicates that LFD is not present in the study area.

and summer months (Table 2) with pouch young as early as September in 1979 and females still lactating in late March 1980. During 1978, however, pouch young were recorded only in December, suggesting a shorter breeding period in poorer seasons. Litters consisted of four to six pouch young.

Data for March were collected in 1981, for May in 1980 and for June/July during 1979. Animals trapped during September/October and December were of similar sizes in both 1979 and 1980 (Table 3), and data from both years have therefore been combined. Figure 2 presents the weight distributions of all ningauis at five different times of year. It is assumed that seasonal weight distributions reflect the age structures of the population at these times. During the breeding period the mean weight of males trapped (7.0 g ± s.e. 0.2) was significantly greater than the mean weight of females (5.8 g ± s.e. 0.3) (t_{48} = +3.67; P < 0.001). Females as small as 5.5 g were recorded with pouch young

Table 2 Breeding data for Pilbara Ningaui, *Ningaui timealeyi*.

	Males			Females			
Trapping period	Number measured	Scrotum width (mm) Mean	Scrotum width (mm) Range	Number recorded	Number with unfurred pouch	Number with pouch young (N: CRL)*	Number with distended mammae in pouch
March	10	4.6	2.0-6.3	7	–	–	1
May	4	6.3	5.0-7.0	13	–	–	–
June/July	5	7.0	5.0-8.8	7	–	–	–
September/October	17	9.0	7.1-10.3	6	1	1 (6: 7mm)	–
December	18	7.7	6.7-9.2	5	–	2 (5: 11 mm) (6: 6 mm)	4

* (Number of pouch young: Crown-rump length [mm] of pouch young.)

indicating maturity at around 5 grams. Males weighing 7.0 g or over were considered to be adults since scrotal width did not increase after this weight.

Animals caught in March consisted predominantly of immatures and there were few surviving adults from the previous year. This annual cohort of young moved progressively into the larger weight classes in May and June/July (Figure 2). Only four adults were trapped in May and none in June/July. This suggests that adults from the previous year probably disappeared from the population by mid-winter and would not have reproduced a second time. In September/October all animals trapped were adults; males had reached peak breeding condition and some females had developed pouches or were carrying pouch young. The histogram for December was markedly bi-modal with a new cohort of young evident as class 1 and the large breeding and post-breeding adults making up classes 3 and 4. Animals as small as 2.1 g were trapped in December and March.

Table 3 The live weights (g) of male and female *Ningaui timealeyi* captured during September, October and December during both 1979 and 1980.

	1979		1980	
Trapping period	Males	Females	Males	Females
September/October	4.6,6.7,7.0, 7.4,7.9,9.4	4.3,6.0,6.5	5.0,5.0,5.5,6.0, 6.0,6.5,6.5,7.0, 7.0,7.5,7.9,8.0, 8.4,8.5,8.5	4.5,5.5*
December	5.9,7.5,8.4,8.5	6.5*	3.0,3.9,6.6,6.7, 6.7,6.7,7.0,7.0, 7.2,7.3,7.5,7.6, 7.9,7.9,8.8	2.1,2.5,2.5, 3.0,3.1,3.3, 3.5,5.9,6.0, 6.5,6.5,7.5*

* Indicates a female with pouch young.

Conclusion

These results suggest that *N. timealeyi* is a short-lived seasonally breeding species. Probably few, if any, individuals survive into a second breeding season. Populations are therefore dependent on the progress of a single, annual cohort of young. This characteristic could make the species vulnerable to local extinctions if populations were isolated in small pockets of habitat by burning patterns or development. However, the habitat of this ningaui is so widespread in the region that the species is unlikely to be endangered in the foreseeable future.

Acknowledgements

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Two New *Gehyra* (Lacertilia: Gekkonidae) from Australia

G.M. Storr*

Abstract

The new species are *G. purpurascens* from the arid interior of the continent and *G. montium* from the Central Australian highlands; both are closely related to *G. variegata* (Duméril and Bibron). *Gehyra punctata* (Fry) is redescribed.

Introduction

A few of the Australian species of *Gehyra* are easily identified on peculiarities of their habit, subdigital scales or chin-shields. The remainder, including the widespread and abundant *G. variegata,* can often be distinguished only after the consideration of several characters, viz. rostral shape, size of postnasal (relative to posterior supranasal), height of first upper labial (relative to second), number of upper labials, subdigital lamellae and pre-anal pores, and certain details of coloration. The present paper adds two more species to this difficult section of the genus. One of the new species *(G. montium)* has been confused with *G. punctata* (Fry); the latter is therefore redescribed.

This study is based on material in the Western Australian Museum (R series). Subdigital lamellar counts do not include the distal azygous scale of the pad; upper labials are counted back to the level of centre of eye; and the only internasals counted are those in contact with the rostral.

Systematics

Gehyra purpurascens sp. nov.

Holotype

R72660 in Western Australian Museum, collected by A.V. Milewski on 6 October 1980 at 3.5 km NE of Comet Vale, Western Australia, in 29°55′S, 121°08′E.

Paratypes

One hundred and eighteen specimens in Western Australian Museum from Western Australia, Northern Territory and South Australia. For details see Material.

Diagnosis

A medium-sized arboreal *Gehyra*, most like *G. variegata* but larger (SVL up to 64, v. up to 54 mm) and with ground colour greyish (rather than brownish), dorsal pattern less

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prominent and lacking white spots or short white bars, top of rostral almost horizontal (more acutely gable-shaped in *variegata*) and fewer pre-anal pores (often less than 11, v. rarely less than 11 in *variegata*). Distinguishable from *G. pilbara* Mitchell and *G. montium* sp. nov. by absence of pale spots and by postnasal not much larger than posterior supranasal, and additionally from *pilbara* by first upper labial not higher than second.

Description

Snout-vent length (mm): 34-64 (N 119, mean 51.6). Length of tail (% SVL): 87-119 (N 24, mean 104.9).

Rostral about half as high as wide; top horizontal or sloping slightly downwards on each side, usually with a small median notch from which a groove descends to about centre of scale. Nostril surrounded by rostral, first labial, postnasal (about same size as posterior supranasal) and two supranasals (anterior much the larger). Internasals 0 (N 13), 1 (95), 2 (6) or 3 (1). Upper labials 7 (N 61), 8 (53) or 9 (4). Anterior chin-shields not in contact with second lower labial. Lamellae under pad of fourth toe in 6 (N 2), 7 (68), 8 (44) or 9 (3) pairs. Pre-anal pores 8-11 (N 58, mean 9.8) in males; pore-bearing scales contiguous and arranged in a chevron, i.e. median pore is anteriormost.

Upper surfaces pale purplish-grey, occasionally without pattern but usually with sparse to moderately dense, brownish-grey to blackish-grey markings in form of irregular spots or short streaks.

Distribution

Arid interior of western two-thirds of Australia: Western Australia from far north of Great Sandy Desert and Tanami Desert south nearly to Beacon, Comet Vale and Queen Victoria Spring (i.e. south to about the mulga-eucalypt line but excluding the Nullarbor Plain); central and southern Northern Territory, north to Elliott; and northern South Australia. See Figure 1.

Remarks

The name *purpurascens* is Latin for 'purplish'.

Material

Kimberley Division (W.A.)

26 km NE McLarty Hills (46049) and 21 km NNE (46087-8).

North-West Division (W.A.)

33 km NE Bulgamulgardy Soak (63209).

Eastern Division (W.A.)

92 km S Balgo Mission (47679); Swindell Field (29382); Well 35, Canning Stock Route (40157); 14 km SE Miles Hill (22°30'S, 122°23'E) (63767); 8 km NW Gary Junction (26961); 15 km W Dakota Hills (57253); 72 km W Terry Range (45115) and 7 km E (45221-2); 36 km E Jupiter Well (45210-3) and 65 km E (40152); Pollock Hills (40175, 45173-4, 45176, 57068); 37 km SE Gargoonyah WH (22°52'S, 121°58'E) (63844); Well 24, CSR (63905-6, 63916-7); 60 km N Windy Corner (45225-6); Durba Springs (51935); Well 11, CSR (51950); Pass of the Abencerrages (20753); 207 km ENE Carnegie (28867) and 65 km NE (40598) and 56 km NE (26883-4); 12 km SE Mt Beadell (21039); Winburn Rocks (20992-8); Mt Eveline (15702); Warburton Range (16480-1, 21015, 21018, 21020, 22029-31); 64 km E Skipper Knob (37498); 96 km N Neale

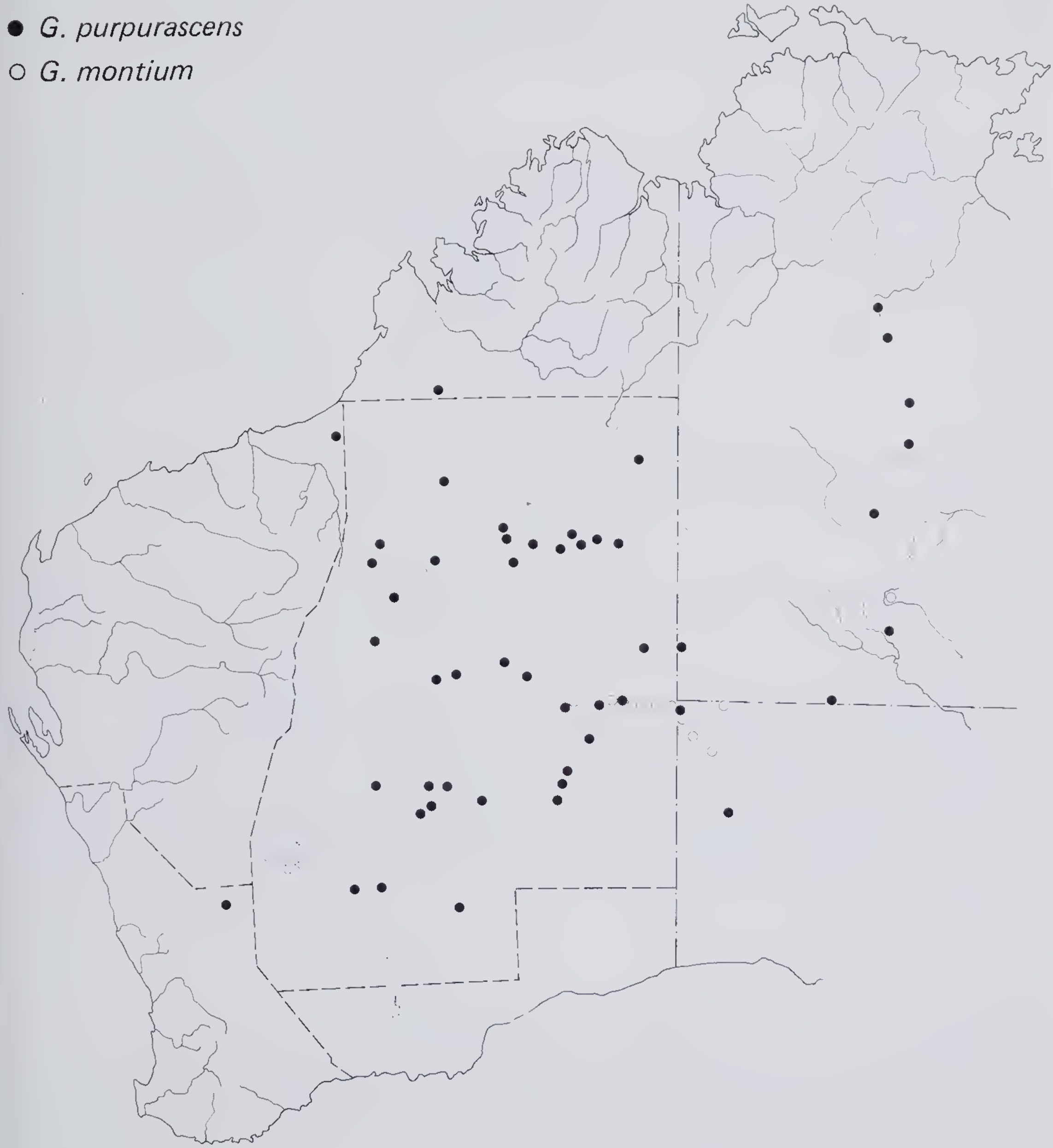

Figure 1 Map of western half of Australia showing location of specimens of *Gehyra purpurascens* and *G. montium.*

Junction (41579) and 70 km N (31909, 41578) and 35 km N (48777); 23 km ENE Cosmo Newbery (73912); 27 km E Point Sunday (53536-9); 138 km NE Laverton (13103*a*); White Cliffs (21195-7) and 27 km NE (53336-9); 9 km SSE Banjawarn (66039) and 13 km SE (69245-7, 69249-53, 69313-4, 74756, 74792); 3.5 km NE Comet Vale (65799) and 50 km E (72595); Queen Victoria Spring (58728).

South-West Division (W.A.)
48 km N Beacon (48342, 48359).

Northern Territory
Elliott (24185); Renner Springs (74019); Tennant Creek (21381) and 10 km E (21394-5); 23 km N Wauchope (24293-4) and 10 km N (34635-6); 26 km NE Teatree (24375-7); 8 km SW Deep Well RS (24466); Docker River (20771); 35 km W Victory Downs (20927).

South Australia
Mt Davies Camp (31702); 10 km E Vokes Hill (36606).

***Gehyra montium* sp. nov.**

Holotype
R31732 in Western Australian Museum, collected by G.M. Storr, J.R. Ford and P.J. Fuller on 29 August 1968 at Mt Lindsay, South Australia, in 27°02′S, 129°53′E.

Paratypes
Seventy-six specimens in Western Australian Museum from Western Australia, Northern Territory and South Australia. For details see Material.

Diagnosis
A small rock-inhabiting *Gehyra*, most like *G. variegata* but slightly smaller (SVL up to 50, v. up to 54 mm) and with ground colour reddish (rather than brownish), pale dorsal spots usually detached from dark markings (in *variegata* the white spots or short white transverse bars are contiguous to posterior edge of dark transverse bars and are partly enclosed by these bars when they curve concavely backwards), and top of rostral less acutely gable-shaped. Further distinguishable from *G. pilbara* by first upper labial not higher than second, and from *G. purpurascens* by larger postnasal and presence of pale spots on head and back.

Description
Snout-vent length (mm): 28-50 (N 77, mean 40.7). Length of tail (% SVL): 87-124 (N 29, mean 107.5).

Rostral about half as wide as high; top horizontal or sloping slightly downwards on each side, usually with a small median notch from which a groove descends to about centre of scale. Nostril surrounded by rostral, first labial, postnasal (usually much larger than posterior supranasal) and two supranasals (anterior much the larger). Internasals 0 (N 15), 1 (50), 2 (7) or 3 (1). Upper labials 6 (N 20), 7 (42), 8 (11) or 9 (2). Anterior chin-shields not in contact with second lower labial. Lamellae under pad of fourth toe in 6 (N 13), 7 (40) or 8 (22 pairs). Pre-anal pores 9-15 (N 30, mean 11.5) in males; pore-bearing scales contiguous and arranged in a chevron, i.e. median pore is anteriormost.

Upper and lateral surfaces pale reddish-brown (more yellowish on head), marked with short blackish-brown streaks, mostly oblique on head (except for two longitudinal stripes on side of head), mostly transverse on back and tail; oblique and transverse streaks sometimes short enough to call spots; transverse streaks sometimes long enough to call cross-bands. Pale spots (especially yellowish spots on head) usually discernible and tending to alternate longitudinally with dark markings on back and tail.

Distribution

Rocky hills and granite outcrops of Central Australia: central and southern Northern Territory, north to Devils Marbles; far east of Western Australia, west to the Warburton Range; far north-west of South Australia, south to the Birksgate Range. See Figure 1.

Geographic Variation

Throughout most of its range *G. montium* has mostly 6 or 7 (rarely 8) subdigital lamellae. At Mt Lindsay counts of 8 exceed those of 7, and 6 is unknown. Upper labials are also more numerous at Mt Lindsay than elsewhere.

Remarks

This species is the chromosome race 2n = 38 of King (1979: 381). The name *montium* is Latin for 'of the mountains'.

Material

Eastern Division (W.A.)

Warburton Range (22028, 22032); Barrow Range (20715-23); Cavenagh Range (20730-3); Blackstone Pass (20981-7, 34149); Hinckley Range (31692).

Northern Territory

Devils Marbles (12 km N Wauchope) (24296-9, 24301); 2 km E Emily Gap (54289, formerly M. King no. 534).

South Australia

Cave Hill, Musgrave Ranges (20944); Piltadi Rockhole, Mann Ranges (20967); 8 km NW Mt Davies Camp (31698-700) and 18 km S (31712); Krewinkel Hill (31721-3); Mt Lindsay (31732-66, 44364-5) and 28 km NW (31728).

Gehyra punctata (Fry, 1914)

Peropus variegatus var. *punctatus* Fry 1914, Rec. West. Aust. Mus. **1:** 178. Strelley River, W.A.
Gehyra fenestra Mitchell 1965, Senck. biol. **46:** 307. Mt Herbert, W.A.

Diagnosis

A medium-sized rock-inhabiting *Gehyra* with depressed head and body, swollen nostril region, boldly patterned upper surfaces (large dark and pale spots arranged in alternating transverse rows on back and tail), and large chin-shields, the anterior pair usually in contact with second lower labial.

Description

Snout-vent length (mm): 23-65 (N 246, mean 44.1). Length of tail (% SVL): 90-133 (N 74, mean 111.7); original tails slender and circular in section.

Rostral a little more than half as high as wide; top horizontal or sloping downwards on each side; rarely a small notch at top of groove that descends to about centre of scale. Nostril surrounded by rostral, two supranasals (anterior much the larger), postnasal (very much larger than posterior supranasal and often precluding first labial from nostril), and often first labial. Internasals 0 (N 67), 1 (109), 2 (6) or 3 (2). Upper labials 6 (N 3), 7 (68), 8 (94) or 9 (14), first usually a little higher and considerably narrower than second. Anterior chin-shields (at least on one side) in contact with second lower labial (N 92) or narrowly separated (25). Lamellae under pad of fourth toe in 6 (N 3), 7 (20), 8 (86), 9 (51) or 10 (5) pairs. Pre-anal pores 7-18 (N 53, mean 11.8) in males; pore-bearing scales contiguous and arranged in a chevron, i.e. median pore is anteriormost.

Upper and lateral surfaces brown, heavily spotted with blackish-brown and yellow; spots on back and tail arranged in transverse rows, a row of pale spots alternating with a row of dark spots. Lips and two stripes on side of head dark brown.

Distribution

Rocky hills and granite outcrops in arid north-west of Western Australia from the Pilbara (including several continental islands but not Barrow I.) south to the Yalgoo district. Also semi-arid south-west Kimberley (Napier Downs).

Geographic Variation

The isolated Kimberley population, judging from our single male specimen, is notable for the low number (7) of pre-anal pores. Otherwise variation is clinal. From north to south there is a decrease in number of pre-anal pores (9-18 in the Pilbara, v. 8-13 south of the Tropic), a decrease in number of upper labials (mostly 8 north of the Tropic, mostly 7 further south), a decrease in number of subdigital lamellae (9 almost as frequent as 8 north of the Tropic, much less frequent than 8 further south), a decrease in frequency of contact between first upper labial and nostril (usually in narrow contact north of the Tropic, usually not in contact further south), an increase in number of internasals (none as frequent as one north of Tropic, none much less frequent than one further south), and an increase in frequency of contact between anterior chin-shields and second lower labial (83% north of the Tropic, v. 94% further south). From north to south the colour pattern becomes more conspicuous: in the south the spots tend to be larger and less circular (i.e. elliptic with longer axis longitudinal); the pale spots are more richly yellow (golden yellow v. yellowish-white), and the dark spots may be edged with pale yellowish-brown.

Remarks

Mitchell (1965) divided this species into a larger *G. fenestra* sp. nov. restricted to the Pilbara and a smaller *G. punctata* (Fry) widespread in Australia between latitudes 20 and 25°S. This division was made largely on the number of mesosternal ribs (two in the former, and one in the latter). I have not checked this character for constancy, but

I suspect that Mitchell's concept of *G. punctata* was partly based on Pilbara specimens of *G. variegata* and/or *G. pilbara*. At any rate I believe that only three species of *Gehyra* occur in the Pilbara.

Material

Kimberley Division (W.A.)
9 km SSE Mt Amy (70039, 70554, 70663).

North-West Division (W.A.)
Strelley River (holotype); 22 km S Port Hedland (52122-4); Depuch I. (14553); Dolphin I. (14245-6, 14284-7, 14292, 37268-72); Angel I. (37250-4); Rosemary I. (14522-9, 37366-70); Enderby I. (37344-6); West Lewis I. (37329-30); Trimouille I. (37450); Point Samson (14576-7); Eramurra Creek (16084-6); 10 km NW Yandeyarra (25373); Doolena Pool, Coongan River (63603-5); Marble Bar (16079-80, 51718) and 10 km E (16081, 58976-9); Mt Edgar (16034, 16036-65, 16095); Woodie Woodie (63149); 34 km N Nullagine (37014); Abydos (10814); Mt Herbert (16083, 20199, 20203-4); Tambrey (20201); Muiron Is (37231-3); 19 km SW Peedamulla (52121, 52130); 10 km SW Pannawonica (68320-8); Hooley (10821-2); Cockeraga River (39742-3); 'Fortescue flats' [presumably N of Wittenoom] (37077); 15 km S Wittenoom (37080-1); Hancock Gorge (69807); Coppin Pool (69800-4, 69808-9); Paraburdoo (56138); Barradale (69997); Lyndon River (8211); 37 km NW Mt Vernon HS (25241); 18 km S Moogooree (62415); Mt Phillips (40635); Yinnietharra (40619-31, 53010, 56853) and 40 km S (53011); Mooka (47845); Landor (52131); 16 km W Dairy Creek HS (24830-4); Coordewandy (28367, 31079, 51692); 23 km N Meekatharra (16087-99); Mileura (15810, 40221-2, 45720-1) and 7 km W (28332-3); Beebyn (54311-2); Afghan Rock (34721-2); Big Bell (31508); Meka (29243-64); Billabalong (51184-5); near Tallering Peak (47713-4); 43 km W Mt Magnet (16100-6); 'between Yalgoo and Mt Magnet' (22785); 32 km E Yalgoo (45902-6) and 13 km SE (45902-6) and 30 km W (50062-9, 60502-4); 'Wurarga granite outcrop' (30214-25); Muralgarra (7509-10).

Eastern Division (W.A.)
32 km E Jiggalong (25207); Mt Davis, Canning Stock Route (28601).

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Rec. West. Aust. Mus. 1982, 10 (1): 61-66

Taxonomic Notes on the Genus *Tympanocryptis* Peters (Lacertilia: Agamidae)

G.M. Storr*

Abstract

Two new subspecies of *Tympanocryptis lineata* Peters are described: *T. l. houstoni* from the Nullarbor Plain and *T. l. macra* from the Kimberley and neighbouring part of Northern Territory. *Tympanocryptis tetraporophora* Lucas and Frost and *T. uniformis* Mitchell are removed from the Western Australian list, and *T. cephala gigas* Mitchell is merged in *T. cephala* Günther.

Introduction

Since my revision of *Tympanocryptis* (Storr 1964) the concept of the genus has been amended. *Tympanocryptis parviceps* was transferred to *Amphibolurus*, even though it lacked an external ear opening (Storr 1977). On the other hand *aurita* was placed in *Tympanocryptis* despite its exposed tympanum and numerous femoral and pre-anal pores (Storr 1981).

Four other matters in my earlier paper require amendment. First, the identification of Kimberley specimens as *T. tetraporophora* is now seen to be wrong, and the population from which they came is described as a new subspecies of *T. lineata*. Also wrong was my assumption that the Nullarbor population of *T. lineata* belonged to the nominate race; it too is described as a new subspecies. Recently acquired specimens of *T. cephala* from the Pilbara are compared with material from the remainder of the species' range. Finally the specimen of '*Tympanocryptis uniformis*' from the Kimberley is re-identified.

With one exception, all the specimens cited in this study are lodged in the Western Australian Museum (R series).

Systematics

Tympanocryptis lineata macra subsp. nov.

Holotype

R44553 in Western Australian Museum, collected by L.A. Smith and R.E. Johnstone on 20 January 1972 at 16 km S of main dam at Lake Argyle, Western Australia, in 16°15′S, 128°40′E.

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Paratypes

Kimberley Division (W.A.)

Ord River below main dam, Lake Argyle (11752); Argyle Downs (42728-9, 42734-5, 44552); Old Lissadell (42672-5); King Sound (Macleay Mus. 930); 5 km NNW Mt Percy (70682); Fitzroy Crossing (75123) and 50 km SE (36164).

Northern Territory

40 km SSW Bullo River HS (60330).

Diagnosis

A moderately large, relatively slender subspecies of *T. lineata* Peters, most like *T. l. centralis* Sternfeld but larger and having longer limbs and tail and more subdigital lamellae.

Description

Snout-vent length (mm): 36-64 (N 16, mean 51.8; v. 23-61, 41, 44.8 in *centralis*). Length of appendages (% SVL): foreleg 42-50 (N 14, mean 46.1; v. 36-46, 39, 40.8); hindleg 64-81 (N 14, mean 74.2; v. 52-69, 39, 61.6); tail 137-185 (N 14, mean 166.1; v. 120-175, 37, 149.3). A pre-anal pore discernible in most specimens. Usually no femoral pore (one in one specimen). Lamellae under fourth toe 17-22 (N 14, mean 19.5; v. 15-20, 40, 17.5).

Scales on head strongly keeled. Scales on back varying much in size, the largest being spinose and more strongly keeled than others. No midlateral fold. Gulars weakly keeled and mucronate.

Dorsal and lateral ground colour pale reddish-brown to greyish-brown. A pale grey vertebral stripe and a brownish-white to greyish-white dorsolateral stripe occasionally discernible; vertebral stripe no wider than dorsolateral. Reddish-brown to greyish-brown cross-bands on body, limbs and tail, interrupted by the longitudinal stripes and sometimes barely discernible on body. No pattern on head or indication of midlateral stripe.

Distribution

Semi-arid zone of south and east Kimberley and adjacent part of Northern Territory (see Figure 1).

Remarks

Previously (Storr 1964), this population was confused with *T. tetraporophora* Lucas and Frost, a species (or subspecies of *T. lineata*) confined to the Lake Eyre drainage and characterized by having a femoral pore.

The name *macra* is Latin for 'lean'.

Tympanocryptis lineata houstoni subsp. nov.

Figure 2

Holotype

R53427 in Western Australian Museum, collected by G. Harold, G. Barron and M. Peterson on 25 April 1976 at 10 km SSE of Cocklebiddy, Western Australia, in 32°07′S, 126°06′E.

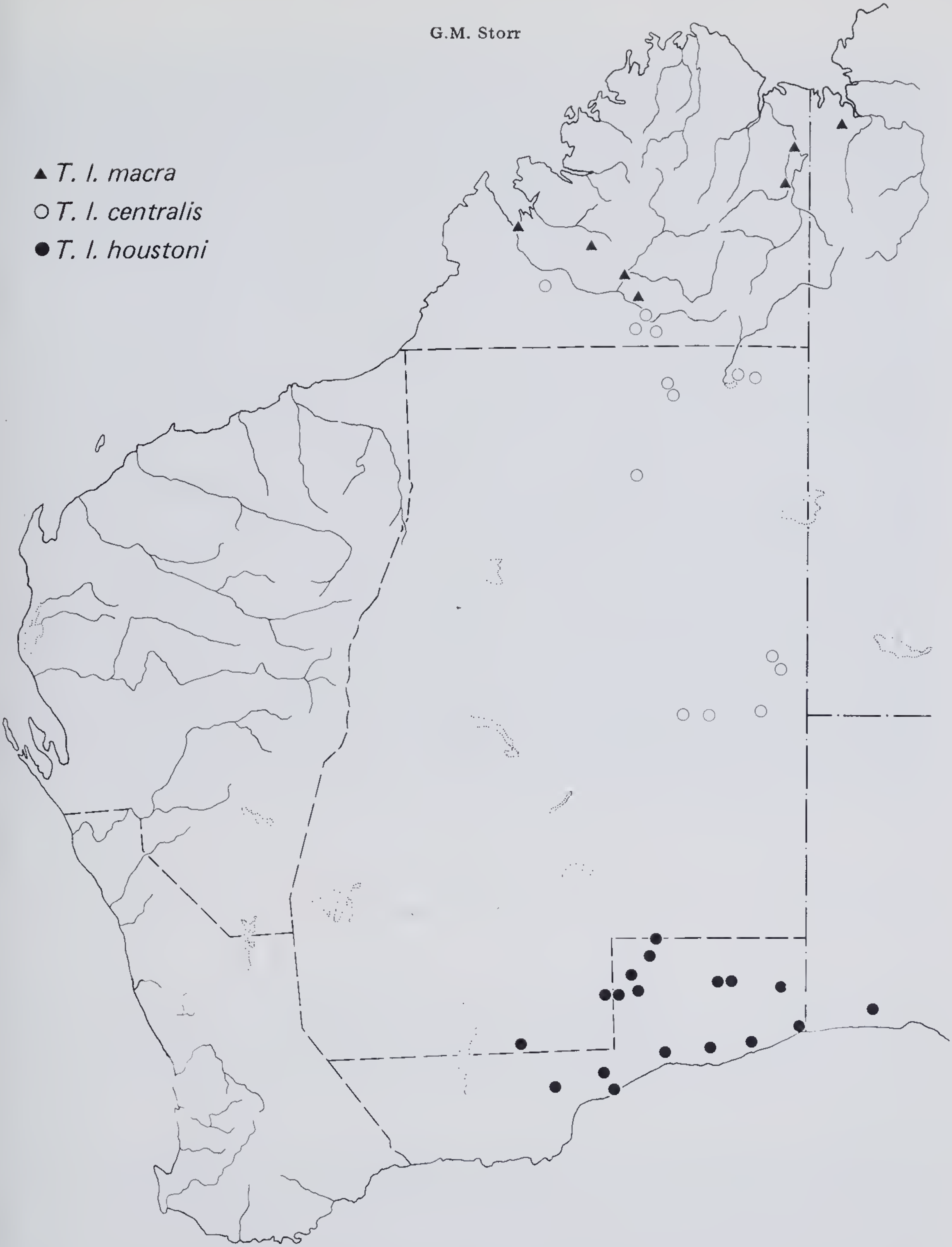

Figure 1 Map of Western Australia showing location of specimens of *Tympanocryptis lineata macra*, *T. l. centralis* and *T. l. houstoni*.

Figure 2 Holotype of *Tympanocryptis lineata houstoni*, photographed in life by G. Harold.

Paratypes

For details of 61 specimens in Western Australian Museum from Western Australia and South Australia, see Material.

Diagnosis

A large subspecies of *T. lineata* Peters, distinguishable from all others by its broad vertebral stripe. Further differing from *T. l. centralis* Sternfeld in its stouter habit, thicker neck and more strongly developed colour pattern (especially on head).

Description

Snout-vent length (mm): 22-68 (N 62, mean 46.5). Length of appendages (% SVL): foreleg 33-48 (N 59, mean 41.9); hindleg 56-80 (N 59, mean 67.0); tail 134-196 (N 62, mean 156.3). A pre-anal pore discernible in most specimens; 17% of latter also having a femoral pore. Lamellae under fourth toe 18-22 (N 55, mean 19.7).

Scales on head strongly keeled. Scales along vertebral stripe weakly keeled; remaining dorsals strongly keeled, spinose scales higher but not much larger than ordinary dorsals.

A slight midlateral fold on body, coincident with white stripe. Gulars smooth, not mucronate.

Dorsal and lateral ground colour reddish-brown to greyish-brown. Head variegated with pale and dark brown, including a brownish-white band from orbit to orbit. Broad greyish-white vertebral stripe, 2-4 times as wide as dorsolateral stripe. Narrow creamy-white dorsolateral stripe, sometimes discernible only where crossing dark bands. Chocolate-brown or blackish-brown bands across body and base of tail, interrupted by vertebral stripe, extending down to narrow white midlateral stripe, and widest at contact with vertebral stripe. Throat and venter white, except occasionally for irregular grey streaks or vermiculations.

See also description and figure in Houston (1978: 46-47).

Distribution

Nullarbor Plain of Western Australia and South Australia (see Figure 1).

Remarks

Previously (Storr 1964), I included this population in the nominate race, but, as Houston (1978) was first to appreciate, it is distinct from that subspecies.

Material

Eastern Division (W.A.)

16 km NE Fraser Range (14184); Kanandah (39711, 41225); Naretha (19101-4, 51804-6) and 3 km W (29656); 95-115 km NNE Rawlinna (33399, 34022, 36475, 37053-4, 41216, 45358).

Eucla Division (W.A.)

20 km E Naretha (12222) and 32 km E (25866); 70 km NNE Rawlinna (36475, 41646, 43592-4); Seymour Downs (19105-10); Rawlinna (15209) and 10 km N (53756-7); Loongana (29174-5) and 5 km S (28706) and 18 km E (41603); Forrest (16502, 29335); 23 km S Reid (37674); 7 km NNW Eucla (66499-500); Mundrabilla (67261); Madura (24649); Cocklebiddy (67249-53) and 10 km SSE (53428-30); 41 km SW Caiguna (66762); Toolinna Cave (56883); Toolinna Rockhole (45646-7, 66789-92); 20 km SW Balladonia HS (17418).

South Australia

77 km S Cook (36119).

Tympanocryptis cephala Günther, 1867

Tympanocryptis cephalus Günther 1867, Ann. Mag. nat. Hist. (3) **20:** 52. Nickol Bay, W.A.
Tympanocryptis cephalus gigas Mitchell 1948, Rec. S. Aust. Mus. **9:** 65. Between Ashburton and Gascoyne Rivers, W.A.

Remarks

For my earlier paper (Storr 1964) I had only a single specimen (12495) from the vicinity of the type locality of *T. cephala*. As it and the syntypes differed slightly in coloration and scalation from the populations further south and east, the latter were tentatively treated as a distinct subspecies, *T. c. gigas*. Subsequently the Western Australian Museum has accessed several adult specimens from the Pilbara coastal plain. These specimens do not differ substantially from those from elsewhere; the attempt to divide *cephala* into subspecies is therefore abandoned.

Tympanocryptis uniformis Mitchell, 1948

Tympanocryptis uniformis Mitchell 1948, Rec. S. Aust. Mus. **9:** 76. Near Darwin, N T.

Remarks

In my revision (Storr 1964) a juvenile specimen (13638) from 32 km SE of Luluigui in arid south-west Kimberley was identified as *T. uniformis*. I now find that this specimen agrees in coloration and scalation with northern juveniles of *Tympanocryptis lineata centralis* Sternfeld, e.g. 51275-6 from 50 km SE of Christmas Creek HS. From the latter, 13638 only differs in its shorter snout and more obtrusive eyes; these were the very characters that formerly induced me to identify 13638 as *uniformis*. However, the original description of *uniformis* indicates a very different lizard, Mitchell particularly drawing attention to its extremely stout body and almost uniform dorsal scalation.

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Received 3 December 1981 Accepted 15 February 1982 Published 30 June 1982

GUIDE TO AUTHORS

Subject Matter

Reviews and papers reporting results of research in all branches of natural science and human studies will be considered for publication. However, emphasis is placed on studies pertaining to Western Australia. Material must be original and not have been published elsewhere.

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Authors are advised to follow the layout and style in the most recent issue of the *Rec. West. Aust. Mus.* including headings, tables, illustrations and references.

The title should be concise, informative and contain key words necessary for retrieval by modern searching techniques. Names of new taxa must not be included. An abridged title (not exceeding 50 letter spaces) should be included for use as a running head.

An abstract must be given, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and should be suitable for reprinting in reference periodicals. Contrary to Recommendation 23 of the International Code of Zoological Nomenclature it may include names of new taxa.

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Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

Spelling should follow the *Concise Oxford Dictionary.*

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The original and two copies of manuscripts should be submitted to the Publications Officer, Western Australian Museum, Francis Street, Perth, Western Australia 6000. They must be in double-spaced typescript on A4 sheets. All margins should be at least 30 mm wide. Tables plus headings and legends to illustrations should be typed on separate pages. The desired positions for insertion of tables and illustrations in the text should be indicated in pencil. Tables should be numbered consecutively, have headings which make them understandable without reference to the text, and be referred to in the text.

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Contents

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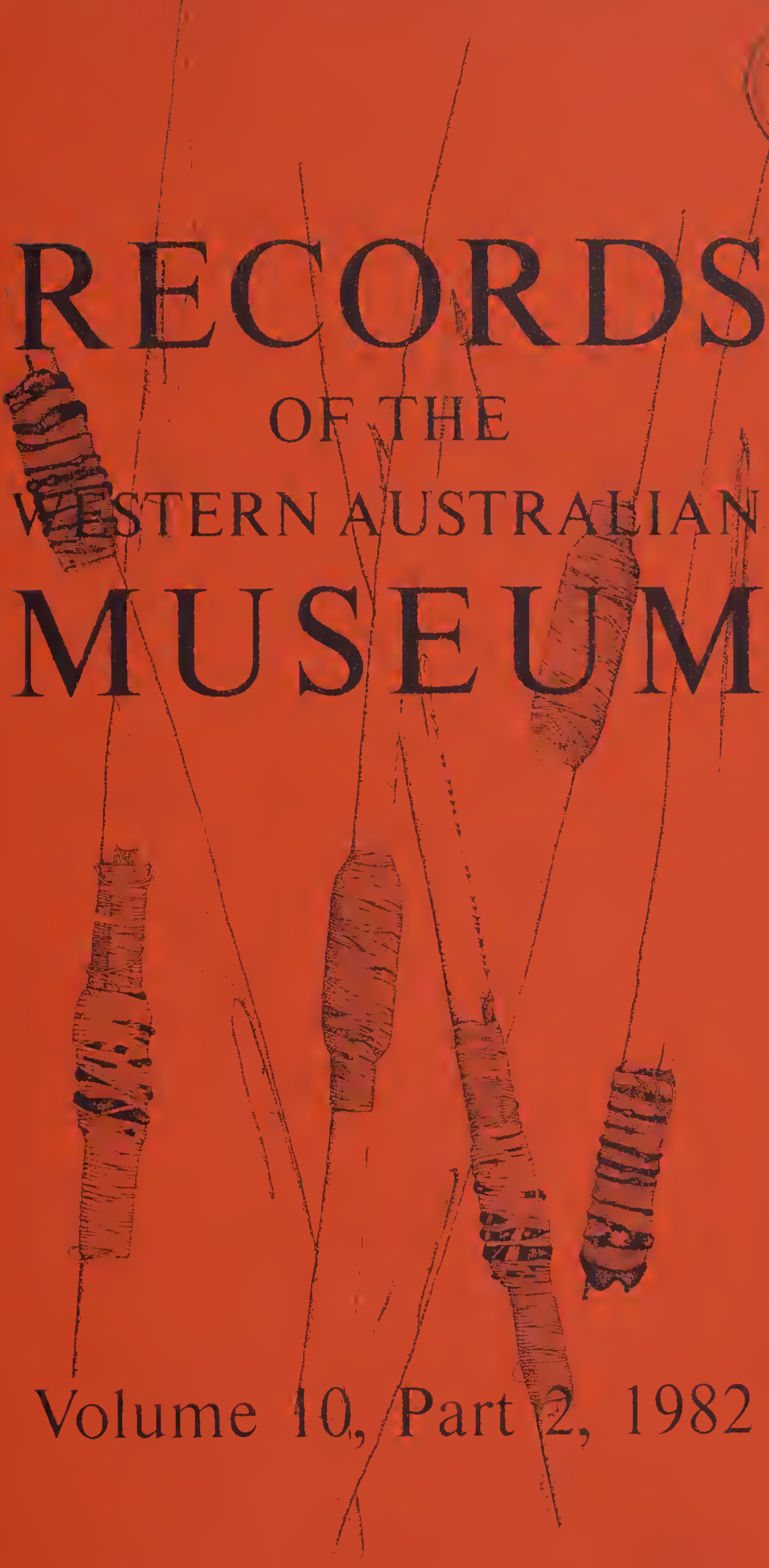

Volume 10, Part 2, 1982

Records of the Western Australian Museum

The *Records of the Western Australian Museum (Rec. West. Aust. Mus.)* is published irregularly with up to four parts appearing each year. A series of supplements, usually devoted to recording the basic data and results of specific Museum studies, is also produced. The journal and supplements are available for sale or exchange, the current price per part being $5.00 plus postage. All but a few back issues are available and orders and enquiries should be addressed to the Bookshop, Western Australian Museum, Francis Street, Perth, W.A. 6000, Australia.

Cover Spears from the Pilbara Region, Western Australia. Illustrations by Ben Jackson.

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A Collection of Freshwater Fishes from Western New Guinea with Descriptions of Two New Species (Gobiidae and Eleotridae)

Gerald R. Allen* and M. Boeseman†

Abstract

Collections of freshwater fishes from western New Guinea (Irian Jaya) are reported. They were procured mainly during two expeditions from the Rijksmuseum van Natuurlijke Historie (Leiden) during 1954-55 and 1959. Collections were made at or in the vicinity of Ajamaru Lakes, Jamur Lake, Wissel Lakes, Digul River at Tanah Merah, Merauke, Japen Island, and the vicinity of Jayapura including Lake Sentani and the Tami River. The material includes 77 species representing 50 genera and 30 families. Two new species are described. *Glossogobius hoesei* sp. nov. (Gobiidae) from the Ajamaru Lakes region is characterized by a truncate tongue, the absence of a branched pit organ canal below the eye, and a relatively short head (about 26 to 28% of the standard length). *Oxyeleotris wisselensis* sp. nov. (Eleotridae) from the mountainous Wissel Lakes region is related to the widely distributed lowland species *O. fimbriata.* It differs, however, with regard to head shape, coloration, and maximum size. A brief diagnosis, illustrations and table of proportional measurements are presented for the new species. Other species are treated in an annotated checklist. In addition, a list of the 158 species thus far recorded from fresh waters of New Guinea is appended. A brief zoogeographical discussion of the New Guinea fauna is also included.

Introduction

The freshwater fish fauna of New Guinea is relatively impoverished compared with the rich cypriniform-dominated fauna lying to the west. The New Guinea species, with the exception of *Scleropages jardinii,* are secondary freshwater forms having evolved in relatively recent times from marine ancestors. Most of the species thus far documented were collected by Dutch expeditions between 1903 and 1920. Major collectors during this period included de Beaufort (1903 and 1910), Gjellerup (1910-1911), Gooszen (1909), van Heurn (1920), van Kampen (1910-1911), Koch (1904), and Lorentz (1907 and 1909). The majority of these collections were summarized by Weber (1908 and 1913).

The only major collections since 1920 are those from the Fly, Purari, and Laloki Rivers reported by Roberts (1978), Berra *et al.* (1975), and Haines (1979)

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respectively, and those from western New Guinea reported in the present paper. Most of the latter collections were procured between October 1954 and May 1955 by the second author on an expedition from the Rijksmuseum van Natuurlijke Historie (Leiden) at the request of the prevailing government of western New Guinea. Additional specimens were obtained in the vicinity of Tanah Merah during August and September 1959. These were collected at the conclusion of an RMNH expedition to the Star Mountains under the direction of Dr L.D. Brongersma. As a result of personal contact made during the RMNH expeditions a number of complementary collections were subsequently sent to Leiden, mainly by government civil and naval personnel.

Our present collection includes 268 lots containing 2,124 specimens. Seventy-seven species are represented belonging to 50 genera and 30 families. Two species,

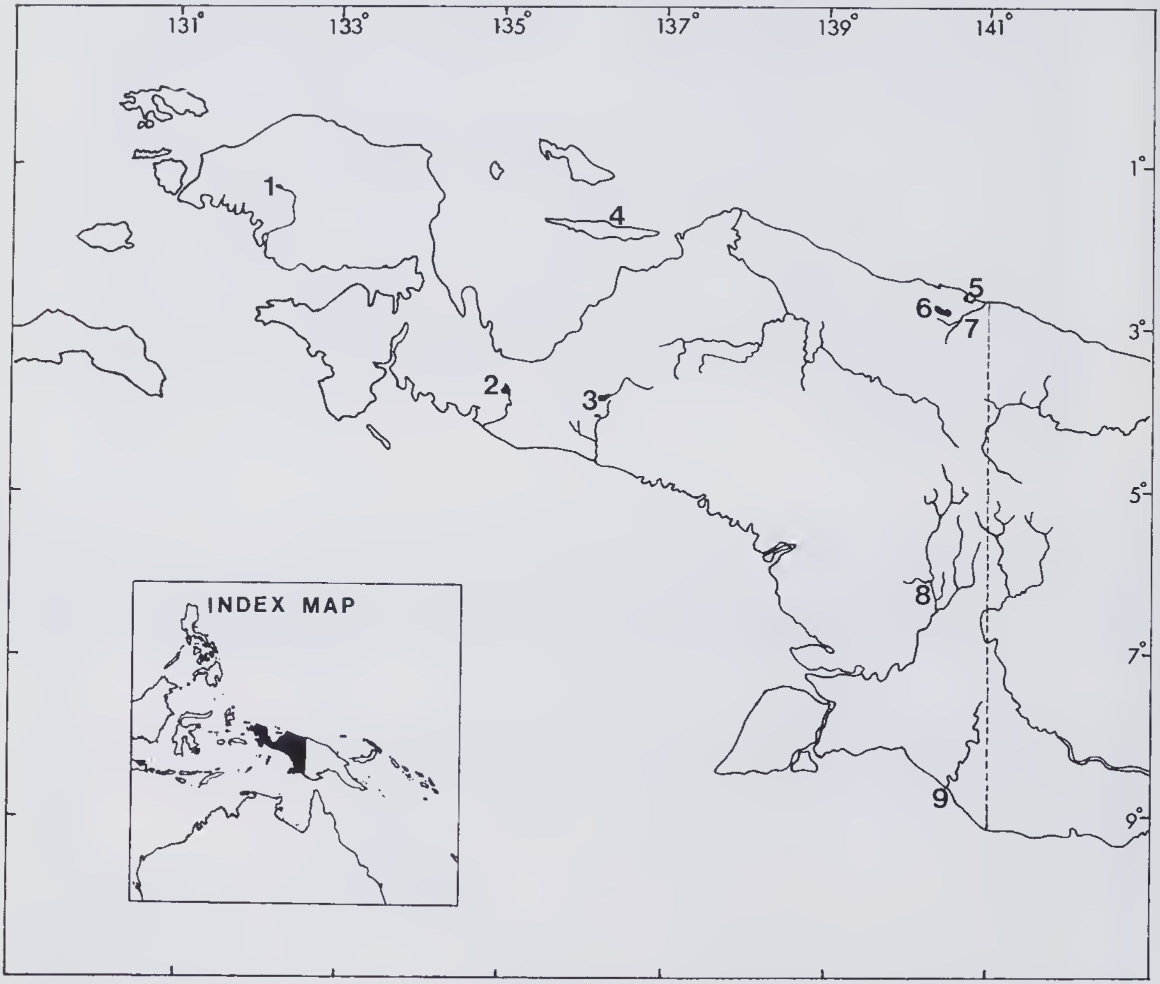

Figure 1 Map of western New Guinea (Irian Jaya). Numbers denote principle collection areas: (1) Ajamaru Lakes; (2) Jamur Lake; (3) Wissel Lakes; (4) Japen Island; (5) Jayapura; (6) Lake Sentani; (7) Tami River; (8) Tanah Merah (9) Merauke.

a gobiid and eleotrid, are herein described as new. In addition, Allen and Cross (1980) published descriptions of four new rainbowfishes (Melanotaeniidae) resulting from these collections.

The principal collection areas are indicated in Figure 1. Boeseman (1963) presented detailed information regarding the physiography and climate of the various sites visited by the 1954-55 expedition. A detailed itinerary was also presented with a series of maps and index of geographic place names. The 1959 fishes were taken from the Digul River near the settlement of Tanah Merah mainly between 5 and 13 September. These specimens are indicated by an asterisk (*) in the species section which follows.

Families are arranged in phylogenetic sequence following Greenwood *et al.* (1966). An abbreviated reference is given for the original description of each species. The complete reference appears in the bibliography. Under each species a list of specimen lots is given with an abbreviated locality reference (see below) and the museum registration number followed by the number and size range of the specimens. All lengths are standard length unless indicated otherwise. Annotations are included for each species which contain information on the distribution, and in some cases comments on the current status of problematical taxa. Counts and proportions which appear in parentheses in the descriptions of the two new species refer to the range for paratypes if different from the holotype.

Abbreviations

Institutions -- Lembaga Biologi Nasional, Bogor, Indonesia (LBM); Rijksmuseum van Natuurlijke Histoire, Leiden (RMNH); National Museum of Natural History, Washington, D.C. (USNM); and Western Australian Museum, Perth (WAM).

Collection localities (see also Boeseman 1963) –

AJ – vicinity of Ajamaru on Jow Lake, Vogelkop Peninsula, 3-7 March 1955.
AT – vicinity of Aitinjo on Aitinjo Lake, Vogelkop Peninsula, 11-14 March 1955.
DA – vicinity of Dimija Village on Dimija River between Paniai and Tage Lakes (Wissel Lakes), 3-9 January 1955.
DR – Digul River at Tanah Merah, March and June 1956.
DU – vicinity of Djitmau, about 12 km east of Ajamaru, Vogelkop Peninsula, 8-9 March 1955.
IR – Ibaru River on the Nimboran Plain about 60 km west of Jayapura near the native villages of Nangkuku and Benjom, 3 November 1954.
JI – Japen Island near village of Serui, 1954, collected by D.L. Leiker.
JL – Jamur Lakes, along lake shore and in small streams in vicinity of Gariau Village, 7-13 December 1954.
JR – Jawej River at Keniapi Village, Wissel Lakes region, 28-30 December 1954.

JV — small streams and ponds in vicinity of Jayapura (formerly Hollandia), November 1954.

MN — Wosi River, west of Manokwari, 9 March 1955, collected by L.B. Holthuis.

MV — small streams in vicinity of Merauke, 4-10 April 1955.

PL — streams in vicinity of Paniai Lake, Wissel Lakes, 26-28 December 1954.

SL — Sentani Lake near Jayapura, most specimens collected between 20-26 October 1954, but a few taken in September and November 1954 and November 1960.

TA — streams in vicinity of Tage Lake, Wissel Lakes, 30 December 1954 to 3 January 1955.

TGG — Digul River in vicinity of Tanahtinggi, 10-11 March 1956, collected by Lt Romer, Royal Netherlands Navy.

TI — streams in vicinity of Tigi Lake, Wissel Lakes, 11-17 January 1955.

TM — Digul River in vicinity of Tanah Merah, 14-17 April 1955 unless indicated by an asterisk (*) in which case specimens collected 5-13 September 1959.

TR — Tami River, cut-off arm (oxbow lake) and main channel, about 22 km SE of Jayapura, 18-21 November 1955.

Systematics

Family Carcharhinidae . . . Sharks

Carcharhinus leucas (Müller and Henle)

Carcharias leucas Müller and Henle, 1841: 42 (Antilles). JL (FMNH 24698), male, 148 cm TL; JL (RMNH 24699), male, 146 cm TL; JL (RMNH 24611), female, 73 cm TL; JL (RMNH 24697), female, 125 cm TL.

World-wide circumtropical distribution, frequently entering and sometimes breeding in fresh water. The occurrence of this shark in Lake Jamur was reported by Boeseman (1964).

Family Pristidae . . . Saw Sharks

Pristis microdon Latham

Pristis microdon Latham, 1794: 280 (locality unknown). SL (RMNH 28608), 241 cm; SL (RMNH 28609), 284 cm; SL (RMNH 28659), 61.5 cm; TM* (RMNH 28430), 10: 71-79 cm. In addition, the RMNH collection contains 8 saws measuring 200-690 mm taken from specimens collected at Sentani Lake, Moif River near Genjem (see Boeseman 1963), and Digul River near Tanah Merah (RMNH reg. nos D3051-52, D3054-58 and D3026).

Widespread in the tropical Indo-Pacific region frequently found in fresh water, particularly in large rivers.

Family Megalopidae . . . Oxeye Herrings

Megalops cyprinoides (Broussonet)

Clupea cyprinoides Broussonet, 1782: plate ix (Jamaica, Antigua, Brazil, and New Hebrides). TM (RMNH 28431), 2: 190 and 225 mm; MV (RMNH 24527), 2: 118 and 128 mm.

World-wide circumtropical distribution, occurring in the sea and estuaries, but frequently entering fresh water.

Family Clupeidae . . . Herrings

Nematalosa erebi (Günther)

Chatoessus erebi Günther, 1868 (see Günther 1866): 407 (Mary River, Queensland). JL (RMNH 28432), 23: 27-92 mm; JL (RMNH 28433), 33: 31-83 mm; TM* (RMNH 28434), 6: 79-105 mm; TM (RMNH 28435), 11: 106-148 mm; TM (RMNH 25078), 4: 270-275 mm; TM (RMNH 28436), 2: 203 and 220 mm; TM (RMNH 28437), 5: 74-127 mm; TM* (RMNH 28438), 3: 92-108 mm; JL (RMNH 28439), 10: 33-97 mm.

We provisionally follow Nelson and Rothman (1973) in identifying our southern New Guinea material as *Nematalosa erebi*. Roberts (1978) reported two different forms of *Nematalosa* from the Fly River and stressed the need for a re-evaluation of the New Guinea populations. Distributed in fresh waters of Australia and southern New Guinea.

Family Engraulidae . . . Anchovies

Thryssa scratchleyi (Ramsay and Ogilby)

Engraulis scratchleyi Ramsay and Ogilby, 1887: 18 (Strickland R., New Guinea). TM* (RMNH 28440), 2: 135 and 138 mm.

Fresh and brackish waters of northern Australia and southern New Guinea.

Family Osteoglossidae . . . Bony Tongues

Scleropages jardinii (Kent)

Figure 2

Osteoglossum jardinii Kent, 1892: 105 (Batavia River, Cape York, Australia). TM (RMNH 23976), 2: 172 and 182 mm; DR (RMNH 25928), 560 mm; DR (RMNH 25929), 485 mm; TM (RMNH 28441), 2: 470 and 550 mm.

Some confusion exists regarding the identity and nomenclature of *Scleropages* from the New Guinea-Australia region. Most works, for example Fowler (1941), Munro (1956), and Lake (1978) recognized the existence of two species, one from the Fitzroy River system of central-eastern Queensland, and another from a few rivers in far northern Australia and central southern New Guinea. Inadequate comparison of the two forms in the literature has caused some speculation that only a single species may exist. Even among authors who recognize two species there is not universal agreement on nomenclature. Fowler (1941) used the names *S. leichardti* Günther and *S. guntheri* Castelnau for the northern and southern forms respectively. Munro (1956) recognized these forms as being distinct only at the subspecific level, assigning the names *S. leichardti leichardti* and *S. leichardti guntheri.* Lake (1978) used *S. jardinii* (Kent) for the northern fish and *S. leichardti* for the southern one. Weber and de Beaufort (1913) recognized only one species from Queensland and New Guinea, *S. leichardti,* placing *S. jardinii* in its synonymy and failed to mention *S. guntheri.*

We have made direct comparisons at RMNH of similar-sized specimens (Figures 2 and 3) belonging to the two forms. They exhibit significant differences related to a number of features. Our findings are summarized in Table 1. The northern form is characterized by a sloping nape profile, a longer more gradually sloping jaw, a more forward directed mouth, and a much larger head. By contrast, the southern or Fitzroy system fish has a straight, non-sloping profile from the dorsal fin origin to the snout tip and a short jaw inclined upward at a very steep angle with the mouth directed more dorsally.

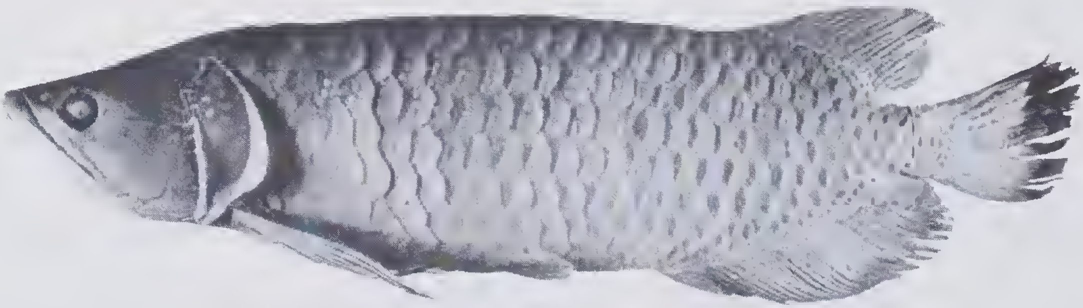

Figure 2 *Scleropages jardinii* (RMNH 28441), 55 cm SL, Digul River near Tanah Merah, Irian Jaya.

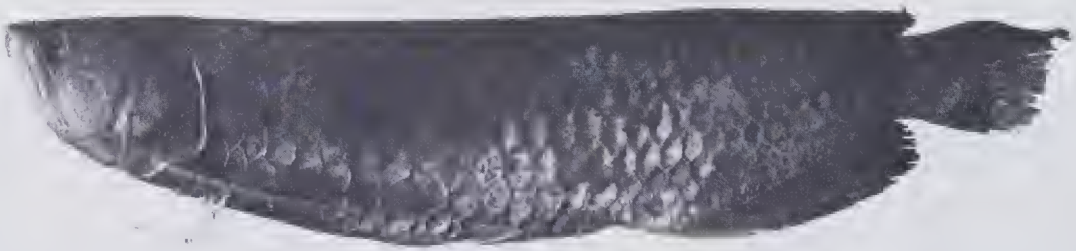

Figure 3 *Scleropages leichardti* (RMNH 28613), 56 cm SL, Fitzroy River system, Queensland, Australia.

Table 1 Comparison of certain characters of *Scleropages jardinii* and *S. leichardti* (based on two specimens of *S. jardinii*, 455 and 550 mm, Digul River, New Guinea and two specimens of *S. leichardti*, 470 and 553 mm, Fitzroy River system, Queensland.

Character	*S. jardinii*	*S. leichardti*
Body depth – % SL	26.8-27.5	24.0-24.2
Head length – % SL	28.7-30.5	22.3-24.4
Angle of mouth (in relation to horizontal axis of body)	41-45°	24-25°
Extent of maxillary	to well beyond eye	not beyond rear of eye
Dorsal profile	nape arched	flat
Colour pattern	cresentic mark at rear of most scales	1-2 spots at centre of most scales
Dorsal rays	20-21	15-16
Anal rays	28-29	25

The only name available for the northern form is *S. jardinii* described by Kent (1892) from the Batavia (now the Wenlock) and Gregory Rivers of far northern Queensland. This species is presently known from the northernmost section of Cape York Peninsula, the Gregory River flowing into the Gulf of Carpentaria, and the East Alligator system of the Northern Territory, all in the far north of Australia. New Guinea localities include the Fly and Digul Rivers.

The oldest name for the southern form is *S. leichardti* described by Günther (1864) from the Burdekin and Fitzroy Rivers. Castelnau (1876) failed to give exact locality data in his description of *S. guntheri*, but from the fin ray counts (D. 17; A. 26) and proportions which are given it is clearly referable to the synonymy of *S. leichardti*. Castelnau's type appears to be missing. It is neither in Paris or in the collections of Australian museums.

Family Ariidae . . . Fork-tail Catfishes

Arius carinatus Weber

Arius carinatus Weber, 1913: 537 (Lorentz River, West New Guinea). TM (RMNH 28007), 210 mm SL.

Rivers of central-southern New Guinea; thus far recorded from the Purari, Digul, Lorentz, and Fly Rivers.

Arius leptaspis (Bleeker)

Hexanematichthys leptaspis Bleeker, 1862: 27 (south-east New Guinea). TM (RMNH 28442), 4: 275-370 mm; TM* (RMNH 28385), 335 mm; TM (RMNH 28008), 2: 360 and 380 mm;

TM (RMNH 28009), 370 mm; TM (RMNH 28810), 2: 360 and 390 mm; JL (RMNH 28443), 7: 45-175 mm.

Widely distributed in fresh waters of northern Australia and New Guinea (both north and south of the central dividing range). The identification of this species is provisional pending further studies by P. Kailola.

Arius sp. A

JL (RMNH 28811), 2: 255 and 350 mm.

This species is presently under study by P. Kailola, who is revising the Ariidae of the Australia-New Guinea region. It is very similar to *A. australis* Günther, which is widely distributed in northern Australia.

Arius sp. B

TGG (RMNH 28812), 400 mm; TM (RMNH 28813), 320 mm.

According to Kailola, this species which is characterized by a strongly depressed, spatulate head, is closely related to a similar species inhabiting fresh waters of northern Australia.

Arius sp. C

TR (RMNH 28814), 89 mm.

According to Kailola this species, which occurs on the northern side of New Guinea's central dividing range, has been erroneously referred to as *Arius leptaspis* by previous authors. The northern population appears to represent a distinct species which is presently under study by Kailola.

Arius sp. D

SL (RMNH 28815), 6: 225-345 mm.

This is a new species which will be described by P. Kailola. It is characterized by a single ovate patch of teeth on each side of the palate. It also occurs in the Ramu and Sepik Rivers of northern Papua New Guinea.

Cinetodus froggatti (Ramsay and Ogilby)

Arius froggatti Ramsay and Ogilby, 1887: 14 (Strickland River, New Guinea). TM (RMNH 28816), 380 mm.

Cinetodus, a monotypic genus, was previously thought to be endemic to rivers of central-southern New Guinea. However, according to Kailola (pers. comm.) specimens have been collectcd in the Roper River, Northern Territory, Australia.

Cochlefelis spatula (Ramsay and Ogilby)

Arius spatula Ramsay and Ogilby, 1887: 15 (Strickland River, New Guinea). TGG (RMNH 28817), 540 mm.

Rivers of central-southern New Guinea; known thus far only from the Fly and Digul systems.

Hemipimelodus macrorhynchus Weber

Hemipimelodus macrorhynchus Weber, 1913. 549 (Lorentz River, New Guinea). TM (RMNH 28818), 6: 179-295 mm.

Rivers of central-southern New Guinea; known thus far only from the Purari, Fly, Digul, and Lorentz systems.

Hemipimelodus taylori Roberts

Hemipimelodus taylori Roberts, 1978: 40 (Fly River, Papual New Guinea). TM (RMNH 28444), 59 mm.

Recently described from the Fly River of Papua New Guinea.

Hemipimelodus velutinus Weber

Hemipimelodus velutinus Weber, 1908: 125 (northern New Guinea). SL (RMNH 28445), 250 mm.

Fresh water of northern New Guinea bctwecn thc Tami and Tawarin Rivers.

Hemipimelodus sp.

TR (RMNH 28819), 3: 246-331 mm.

According to Kailola this spccies is possible undescribcd. It is most closely related to *H. papillifer* of northern New Guinca but differs with regard to anal and pectoral ray counts, and proportional mcasuremcnts rclated to the length of the adipose fin base and eye diameter. The species is characterized by the following combination of characters (counts and measurements for *H. papillifer* indicated in parentheses): anal rays 20 to 21 (19); pectoral rays I, 11 (I, 10); adipose fin base in interdorsal space 1.6 to 2.0 (3.4 to 4.0); eye diameter in head length 8.6 to 9.4 (7.0 to 7.6).

Thus far known only on the basis of the three specimens collected in the Tami River near Jayapura.

Nedystoma dayi (Ramsay and Ogilby)

Hemipimelodus dayi Ramsay and Ogilby, 1886: 16 (Strickland River, New Guinea). TM (RMNH 28446), 9: 91-164 mm; TM (RMNH 28820), 5: 135-170 mm.

Rivers of central-southern New Guinea. Thus far reported from the Purari, Fly, Digul, and Lorentz systems.

Family Plotosidae . . . Eel-tail Catfishes

Neosilurus ater (Perugia)

Lambertia atra Perugia, 1894: 551 (Inawi, Papua). TM (RMNH 28447), 3: 308-375 mm; TM (RMNH 28138), 2: 335 and 395 mm; JL (RMNH 28139), 3: 345-375 mm; JL (RMNH 28821), 3: 315-333 mm.

Fresh waters of central southern New Guinea and northern Australia.

Neosilurus brevidorsalis (Günther)

Copidoglanis brevidorsalis Günther, 1867: 22 (Cape York, Australia). AJ (RMNH 28448), 2: 105 and 121 mm; JL (RMNH 28134), 2: 60 and 79 mm; AJ (RMNH 28135), 3: 81-115 mm; AT (RMNH 28136), 5: 68-110 mm; DU (RMNH 28137), 7: 62-94 mm.

Fresh waters of central southern New Guinea and northern Cape York Peninsula, Australia.

Family Belonidae . . . Needlefishes

Strongylura kreffti (Günther)

Belone kreffti Günther, 1866: 250 (Australia). JL (RMNH 24674), 180 mm; TM* (RMNH 28449), 6: 395-575 mm.

Freshwater streams of New Guinea and northern Australia.

Family Hemirhamphidae . . . Halfbeaks

Zenarchopterus novaeguineae (Weber)

Hemiramphus (Zenarchopterus) novae-guineae Weber, 1913: 553 (Lorentz River, southern New Guinea). TGG (RMNH 27386), 163 mm.

Freshwater streams and estuaries of central southern New Guinea.

Family Melantoaeniidae . . . Rainbowfishes

Chilatherina crassispinosa (Weber)

Rhombatractus crassispinosa Weber, 1913: 567 (Buarin River, Sepik River, Begowre River, Sermowai River and Tawarin River, northern New Guinea). IR (RMNH 28427), 32 mm.

Streams of northern New Guinea between the Markham and Tawarin Rivers.

Chilatherina fasciata (Weber)

Rhombatractus fasciatus Weber, 1913: 565 (Sermowai River, river near Njao, and tributary of Sepik River, northern New Guinea). JV (RMNH 28424), 62 mm.

Streams of northern New Guinea between the Markham and Mamberamo Rivers.

Chilatherina sentaniensis (Weber)

Rhombatractus sentaniensis Weber, 1908: 235 (Lake Sentani, northern New Guinea). SL (RMNH 28426), 51: 43-78 mm; SL (RMNH 27809), 36: 48-72 mm; SL (RMNH 27810), 15: 59-86 mm; SL (RMNH 27814), 59 mm; SL (RMNH 27815), 3: 72-80 mm.

Lake Sentani and nearby Sekanto River, northern New Guinea.

Glossolepis incisus Weber

Glossolepis incisus Weber, 1908: (Lake Sentani, northern New Guinea). SL (RMNH 28410), 2: 41 and 49 mm; SL (RMNH 28428), 11: 50-78 mm; SL (RMNH 27812), 16: 39-56 mm; SL (RMNH 27813), 21: 38-56 mm; SL (RMNH 27816), 2: 78 and 86 mm; SL (RMNH 27818), 54 mm.

Lake Sentani, northern New Guinea.

Glossolepis pseudoincisus Allen and Cross

Glossolepis pseudoincisus Allen and Cross, 1980: 392 (Tami River, northern New Guinea). TR (RMNH 28072, holotype), 76 mm; TR (LBN 2489, paratypes), 4: 41-64 mm; TR

(RMNH 28073, paratypes), 41: 33-79 mm; TR (USNM 220907, paratypes), 4: 48-67 mm; TR (WAM P26793-001), 5: 60-77 mm.

Known only from an ox-bow lake next to the Tami River, 23 km SE of Jayapura, northern New Guinea.

Melanotaenis affinis (Weber)

Rhombatractus affinis Weber, 1908: 234 (Lake Sentani, Sekanto River, and Wagani Rivers, northern New Guinea). JV (RMNH 28412), 3: 25-37 mm; IR (RMNH 28413), 6: 9-18 mm; IR (RMNH 28420), 13: 25-75 mm; SL (RMNH 28411), 46 mm.

Streams and lakes of northern New Guinea between the Markham and Sermowai Rivers.

Melanotaenia ajamaruensis Allen and Cross

Melanotaenia ajamaruensis Allen and Cross, 1980: 348 (Ajamaru Lakes, western New Guinea). AJ (RMNH 28068, holotype), 78 mm; AJ (LBN 2488, paratypes), 4: 37-45 mm; AJ (RMNH 28069, paratypes), 46: 26-65 mm; AJ (RMNH 28070, paratypes), 6: 32-62 mm; AJ (RMNH 28071, paratype), 57 mm; AJ (USNM 220905, paratypes), 3: 43-59 mm; AJ (WAM P26792-001, paratypes), 6: 44-68 mm.

Ajamaru Lakes System in the central Vogelkop Peninsula of Western New Guinea.

Melanotaenia boesemani Allen and Cross

Melanotaenia boesemani Allen and Cross, 1980: 379 (Ajamaru Lakes, western New Guinea). AJ (RMNH 28061, holotype), 66 mm; AJ (LBN 2487, paratypes), 3: 50-63 mm; AJ (RMNH 28062, paratypes), 27: 35-63; AJ (RMNH 28063, paratypes), 9: 36-61 mm; DU (RMNH 28064, paratypes), 7: 32-53 mm; AJ (RMNH 28065, paratypes), 3: 27-49 mm; AT (RMNH 28066, paratypes), 3: 54-56 mm; AJ (RMNH 28067, paratypes), 6: 42-87 mm; AJ (USNM 220904, paratypes), 3: 47-53 mm; AJ (WAM P26791-001, paratypes), 3: 50-63 mm.

Ajamaru Lakes system and nearby Aitinjo Lake in the central Vogelkop Peninsula of western New Guinea.

Melanotaenia goldiei (Macleay)

Aristeus goldiei Macleay, 1883: 269 (Goldie River, southern New Guinea). TM (RMNH 28419), 77 mm; JL (RMNH 28414), 47 mm; JL (RMNH 28422), 41: 16-75; TM (RMNH 24561), 3: 88-97; TGG (RMNH 25263), 100 m; TM* (RMNH 28450), 10: 21-99 mm.

Lowland and foothill streams of southern New Guinea and the Aru Islands.

Melanotaenia japenensis Allen and Cross

Melanotaenia japenensis Allen and Cross, 1980: 387 (Japen Island, off northern New Guinea). JI (RMNH 28140, holotype), 77 mm; JI (RMNH 28141, paratypes), 2: 57 and 60 mm.

Japen Island in the vicinity of Serui, off northern New Guinea.

Melanotaenia splendida rubrostriata (Ramsay and Ogilby)

Nematocentrus rubrostriatus Ramsay and Ogilby, 1887: 14 (Strickland River, southern New Guinea), MV (RMNH 28415), 9: 14-20 mm; TM (RMNH 28421), 6: 78-103 mm; TM (RMNH 24561), 3: 88-97 mm; TM (RMNH 25263), 100 mm.

Lowland streams of central southern New Guinea and the Aru Islands.

Family Atherinidae . . . Hardyheads

Craterocephalus randi Nichols and Raven

Craterocephalus randi Nichols and Raven, 1934: 3 (Kubuna, southern New Guinea). JL (RMNH 28451), 6: 16-60 mm.

Our specimens possess about seven longitudinal rows of distinctive dark spots on the sides and in this respect are very similar in appearance to *C. stercusmuscarum* of northern Australia. The *Craterocephalus* of New Guinea require further studies. Known from streams and lakes of central southern New Guinea.

Family Syngathidae . . . Pipefishes

Doryichthys retzii (Bleeker)

Syngnathus retzii Bleeker, 1856: 76 (Celebes). JI (RMNH 25235), 4: 68-102 mm; JI (RMNH 27531), 2: 53 and 59 mm; MN (RMNH 27591), 66 mm.

Freshwater streams, tidal creeks and brackish estuarics of the Indo-Australian Archipelago and Philippine Islands.

Family Ambassidae . . . Glassfishes

Ambassis macleayi (Castelnau)

Pseudoambassis macleayi Castelnau, 1878: 43 (Norman River, Queensland). TM (RMNH 28452), 3: 38-56 mm.

Fresh waters of central southern New Guinea and northern Australia.

Ambassis reticulata Weber

Ambassis interruptus var. *reticulatus* Weber, 1913: 574 (Merauke and Lorentz Rivers, southern New Guinea). JL (RMNH 25244), 7: 38-47 mm; JL (RMNH 28453), 4: 34-44 mm.

Munro (1967) placed *A. reticulata* in the synonymy of *A. macleayi.* We have examined the types of both species and find them to be distinct differing in gill rakers and fin-ray counts and coloration. *Ambassis reticulata* generally has 17-20 rakers on the lower limb of the first gill arch (25 or more in *macleayi*), 9½ soft rays in the second dorsal and anal fins (10½ in *macleayi*), and lacks a distinct black marking on the pectoral base which is characteristic for *macleayi.* There is a possibility that our specimens from Lake Majur represent an undescribed species. They have a higher lateral scale count (28-34, usually 30-31 v. 25-28) and a taller first dorsal fin (> than head length vs. < than head) than syntypes of *A. reticulata* examined at RMNH and ZMA.

Fresh waters of central southern New Guinea.

Parambassis gullivera (Castelnau)

Acanthoperca gulliveri Castelnau, 1878: 45 (Norman River, Queensland). TM (RMNH 25876), 203 mm; TM (RMNH 25879), 4: 78-174 mm.

Fresh waters of central southern New Guinea and northern Australia.

Family Centropomidae . . . Barramundi

Lates calcarifer (Bloch)

Holocentrus calcarifer Bloch, 1790: 100 (Japan). MV (RMNH 24691), 2: 69 and 75 mm; TM (RMNH 28454), 2: 420 and 460 mm.

Widely distributed in estuaries and freshwater streams from the Persian Gulf eastward to southern China and the Indo-Australian Archipelago.

Family Lobotidae . . . Tripletails

Lobotes surinamensis (Bloch)

Holocentrus surinamensis Bloch, 1790: 98 (Surinam), TR (RMNH 28455), 150 mm.

Circumtropical distribution in coastal and brackish water, occasionally in lower reaches of freshwater streams.

Family Teraponidae . . Grunters

Amniataba affinis (Mees and Kailola)

Therapon affinis Mees and Kailola, 1977: 72 (Morehead and Fly River systems, southern New Guinea). TM (RMNH 28456), 4: 70-142 mm.

We follow the recent family revision of Vari (1978) in placing this species in the genus *Amniataba.* Known from the Fly, Morehead, and Digul River systems of central southern New Guinea.

Hephaestus roemeri (Weber)

Therapon romeri Weber, 1910: 233 (Lorentz River). TM (RMNH 24936), 2: 117 and 143 mm; TM (RMNH 24941), 123 mm; TM* (RMNH 25909), 88 mm; TM (RMNH 28457), 155 mm.

Known only from the Lorentz and Digul Rivers of central southern New Guinea.

Pingalla lorentzi (Weber)

Helotes lorentzi Weber, 1910: 236 (Lorentz River, southern New Guinea). TM* (RMNH 25390), 2: 50 and 53 mm.

Streams of central southern New Guinea and northern portion of Cape York Peninsula, Australia.

Terapon jamoerensis (Mees)

Therapon jamoerensis Mees, 1971: 214 (Lake Jamur, western New Guinea). JL (RMNH 25225, holotype), 82 mm; JL (RMNH 25224, paratypes), 4: 63-71 mm.

Known only from Lake Jamur, western New Guinea.

Family Apogonidae . . . Cardinalfishes

Glossamia aprion (Richardson)

Apogon aprion Richardson, 1842: 16 (near Darwin, Australia). TM (RMNH 24562), 2: 112 and 120 mm; TM (RMNH 28386), 180 mm; TM* (RMNH 28465), 2: 69 and 72 mm; TM (RMNH 28466), 5: 14-35 mm; JL (RMNH 28458), 12 mm; JL (RMNH 28459), 29 mm; JL (RMNH 28460), 54 mm.

Coastal streams of central southern New Guinea and northern and eastern Australia.

Glossamia beauforti (Weber)

Apogon beauforti Weber, 1908: 246 (Lake Sentani, northern New Guinea). SL (RMNH 28461), 24 mm.

Northern New Guinea between Lake Sentani and the Mamberamo River.

Glossamia wichmanni (Weber)

Apogon wichmanni Weber, 1908: 248 (Lake Sentani, Tawarin River, Moso River, Sekanto River – northern New Guinea). IR (RMNH 28462), 40 mm; SL (RMNH 28463), 2: 25 and 26 mm; SL (RMNH 28464), 81 mm.

Northern New Guinea between the Ramu and Tawarin Rivers.

Family Silliginidae . . . Sand Whitings

Sillago sihama (Forsskål)

Atherina sihama Forsskål, 1775: 70 (Arabia). TR (RMNH 24547), 150 mm.

Widely distributed in the tropical Indo-west Pacific. Generally a marine or estuarine fish, but occasionally entering the lower reaches of freshwater streams.

Family Sciaenidae . . . Croakers

Johnius belengerii (Cuvier)

Corvina belengerii Cuvier (in Cuvier and Valenciennes), 1830 (Malabar). TM (RMNH 28467), 147 mm; TGG (RMNH 27128), 325 mm; TM (RMNH 27129), 4: 135-203 mm.

Widely distributed in shallow seas of the Indo-west Pacific region, frequently entering estuaries and freshwater streams.

Family Toxotidae . . . Archerfishes

Toxotes chatareus (Hamilton)

Coius chatareus Hamilton, 1822: 101 and 370 (Ganges River, India). JL (RMNH 27808), 2: 50 and 71 mm; JL (RMNH 27811), 7: 23-108 mm; JL (RMNH 28468), 3: 20-24 mm; JL (RMNH 28469), 8: 10-24 mm; TM (RMNH 28384), 230 mm.

Estuaries and freshwater streams of South-East Asia (India to China), Malaysia, Indonesia, New Guinea, and northern Australia.

Toxotes jaculatrix (Pallas)

Sciaenia jaculatrix Pallas, 1767: 186 (Batavia Jakarta, Java), JL (RMNH 28470), 21 mm.

Widely distributed between India and the New Hebrides. Usually found in salt or brackish conditions, seldom entering pure fresh water.

Family Scatophagidae . . . Scats

Scatophagus argus (Linnaeus)

Chaetodon argus Linnaeus, 1766: 464 (Indies), MV (RMNH 28471), 11 mm.

Widely distributed in coastal seas of the Indo-west Pacific region, frequently in fresh or brackish water, particularly juveniles.

Family Mugilidae . . . Mullets

Liza dussumieri (Valenciennes)

Mugil dussumieri Valenciennes (in Cuvier and Valenciennes), 1836: 147 (Bombay and Coromandel), SL (RMNH 28472), 146 mm.

Widely distributed in the tropical Indo-west Pacific, frequently found in estuaries and fresh water.

Liza macrolepis (Smith)

Mugil macrolepis Smith, 1849: pl. 28 (South Africa). TM (RMNH 28473), 2: 158 and 162 mm; TM (RMNH 28474), 4: 355-390 mm.

Widely distributed in the tropical Indo-west Pacific, frequently found in estuaries and rivers.

Valamugil seheli (Forsskål)

Mugil seheli Forsskål, 1775: 73 (Lohajae, Red Sea), SL (RMNH 28475), 3: 227-240 mm.

Widely distributed in the tropical Indo-west Pacific, frequently found in estuaries and fresh water.

Family Gobiidae . . . Gobies

Glossogobius aureus Akihito and Meguro

Glossogobius aureus Akihito and Meguro, 1975: 128 (Okinawa, Japan). JL (RMNH 28476), 4: 35-106 mm; SL (RMNH 28477), 127 mm; SL (RMNH 28478), 5: 31-69 mm; SL (RMNH

28479), 14: 26-41 mm; SL (RMNH 28480), 103 mm; JL (RMNH 28481), 68 mm; TR (RMNH 28482), 142 mm; TM (RMNH 28483), 149 mm; SL (RMNH 25233), 5: 35-74 mm; JL (RMNH 25240), 73 mm; SL (RMNH 28485), 2: 87 and 150 mm; SL (RMNH 28486), 6: 24-43 mm; TM* (RMNH 28487), 2: 74 and 82 mm.

Widely distributed in the western tropical Pacific including Okinawa, Taiwan, Philippine Islands, Thailand, Malaysia, Singapore, Indonesia, New Guinea, and northern Australia. Usually found in fresh water.

Glossogobius celebius (Valenciennes)

Gobius celebius Valenciennes (in Cuvier and Valenciennes, 1837: 69 (Celebes). TM* (RMNH 28488), 2: 61 and 71 mm.

Widely distributed in the western tropical Pacific including Okinawa, Philippine Islands, Indonesia, New Guinea and northern Australia. Usually found in fresh or brackish water.

Glossogobius hoesei sp. nov.

Figures 4 and 5; Table 2

Holotype

RMNH 28560, 63.2 mm, Jow Lake in vicinity of Ajamaru, Vogelkop Peninsula, Irian Jaya, Indonesia (approximately 1°21'S, 132°16'E), M. Boeseman, 3-7 March 1955.

Paratypes

AJ (RMNH 28489), 20: 36-65 mm; AJ (RMNH 28490), 41: 29-71 mm; AJ (RMNH 28491), 54: 36-70 mm; DU (RMNH 28492), 16: 28-50 mm; AJ (RMNH 28493), 35: 43-67 mm; AJ (WAM P27387-001), 10: 50-65 mm.

Diagnosis

A species of *Glossogobius* which closely resembles *G. concavifrons*, but differs in lacking a branched pit-organ canal below the eye, in possessing a slightly shorter head (about 26 to 28% of standard length v. 28 to 32%), and usually 16 pectoral rays (17 or 18 in *concavifrons*).

Description

Dorsal rays VI-I,11 (9 to 12); anal rays, I,9 (9 or 10); pectoral rays 16 (14 to 17); gill rakers poorly developed, about 5 or 6 low rudiments on lower limb of first branchial arch; scales in lateral series 31 (31 or 32); horizontal scale rows between anal fin origin and dorsal fin base 10; predorsal scales 15 (15 to 17).

Body elongate, laterally compressed in posterior portion, more cylindrical anteriorly; maximum depth 5.2 (4.8 to 5.4) in standard length. Head blunt with moderately produced, rounded snout; maximum depth of head about equal to its maximum width or 1.9 (1.7 to 2.0) in standard length; length of head 3.6

(3.5 to 3.7) in standard length. Interorbital narrow, its width 11.6 (9.8 to 11.2) in head length. Snout 3.6 (3.4 to 3.9), eye 4.4 (4.2 to 5.2), both in head length.

Lower jaw slightly produced; teeth canine-like arranged in several rows in both upper and lower jaws, those of outer row enlarged; palate endentulous; tongue notched (sometimes not apparent if tongue folded); maxillary extends to level of front of eye or slightly anterior to this point. Gill opening extends to level of posterior preopercular margin. A series of six horizontal pit organ canals on cheek, each canal composed of a single row of pit organs (see Figure 5 for arrangement of cephalic sensory canals). A prominent, rounded bony protrusion on lower jaw on side of isthmus.

Figure 4 *Glossogobius hoesei,* holotype, 63.2 mm, Ajamaru Lakes.

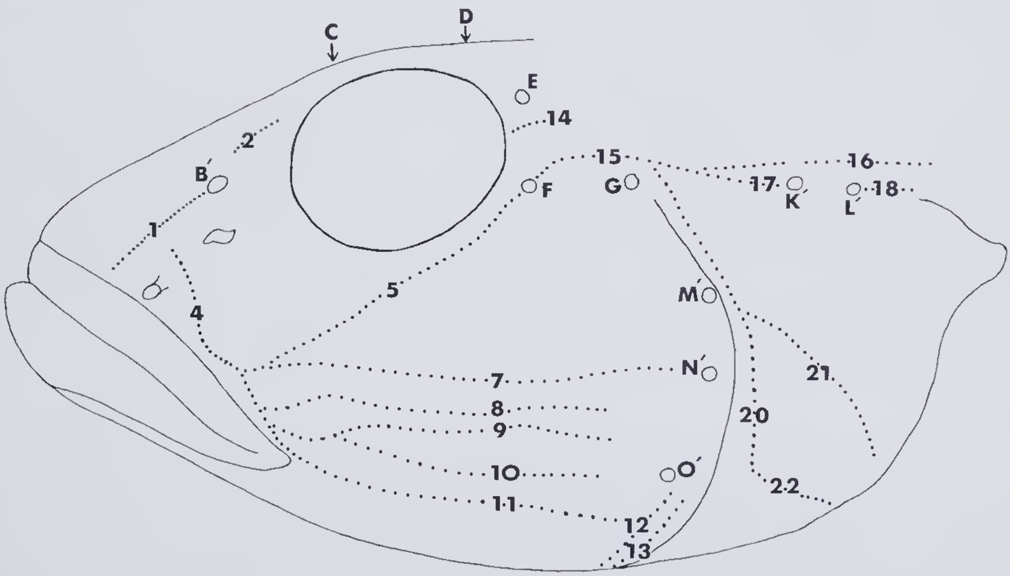

Figure 5 Cephalic sensory canals and pores of *Glossogobius hoesei.* The numbering system follows that of Akihito and Meguro (1975).

Table 2 Proportional measurements of selected type specimens of *Glossogobius hoesei* (expressed as a percentage of the standard length).

	Holotype RMNH 28560	Paratypes RMNH 28489				
Standard length (mm)	63.2	67.9	60.3	58.5	58.0	50.0
Body depth	19.0	18.4	19.9	20.6	19.1	19.1
Head length	27.6	28.1	28.2	28.5	27.3	27.5
Head depth	14.7	13.8	16.6	14.9	15.9	16.0
Head width	15.8	16.5	15.9	14.5	16.4	14.8
Snout length	7.6	7.2	8.3	7.9	7.6	7.6
Eye diameter	6.3	6.2	6.6	5.5	6.2	6.4
Interorbital width	2.4	2.5	2.7	2.9	2.8	2.6
Pectoral fin length	23.7	22.8	25.7	23.1	26.2	24.6
Pelvic fin length	21.4	23.0	24.2	22.6	23.3	23.8
Caudal fin length	24.5*	28.7	31.5	28.0	29.3	30.7

* fin damaged

Scales of head and body cycloid or finely ctenoid. Preopercle, opercle, interorbital, snout, lips, chin, and lower jaw scaleless.

Pectoral and pelvic fins relatively elongate, their lengths 1.2 (1.0 to 1.2) and 1.3 (1.2 to 1.3) respectively in head length. Pelvic fins united. Caudal fin oblong, its posterior margin rounded, its length 1.1 (0.9 to 1.1) in head length.

Colour in alcohol: generally light tan, scales on upper back dusky brown; a series of 5 or 6 diffuse brown blotches, about twice size of cye on middle of side; a distinct, circular brown spot, about eye size or slightly larger at base of caudal fin; head with dusky brown band from lower, anterior corner of eyc to premaxillary; a large brown spot on lower half of opercle; first dorsal fin palc tan basally with broad dark brown to blackish band across middle portion, outer margin of fin pale tan; second dorsal fin with faint alternating dark and light stripes; caudal fin with scries of faint, vertical brown bands; anal fin whitish on basal half, brownish distally; pelvic fins mainly dark brown; pectoral fins pale tan with brown bar across basc of uppermost rays.

Remarks

Glossogobius hoesei is thus far known only from thc vicinity of the Ajamaru Lakes which are located near the centre of the Vogelkop Peninsula at the western extrcmity of Irian Jaya. The lakes are situated at thc headwaters of the Ajamaru River which drain into the Kais River, eventually flowing southward to the Ceram Sea. Boescman (1963) gavc further details for the area in which the type specimens were collected. He recorded an elevation of about 250 m for the main system of lakes and a pH of 6.4. Two specics of rainbowfishcs (Melanotaeniidae), which are possibly endemic to the Ajamaru Lakes system, have been described by Allen and Cross (1980).

Glossogobius hoesei is very similar in many respects to *G. concavifrons* (Ramsay and Ogilby) previously known only from the Fly River system of southern New Guinea, but recently collected by D. Hoese and the senior author from several streams near the northern extremity of Cape York Peninsula, Australia. The important difference between these species are indicated in the diagnosis section above. Both *G. concavifrons* and *G. hoesei* share a modal count of 11 soft dorsal rays, which is relatively high for the genus. Akihito and Meguro (1975) presented brief diagnoses, cephalic sensory canal diagrams, and a key to the species of *Glossogobius.*

The species is named *hoesei* in honour of Dr Douglass F. Hoese, Curator of Ichthyology at the Australian Museum, Sydney, in recognition of his contributions to the knowledge of gobiid taxonomy. According to the second author's field notes the local name for this species is 'buseek'.

Glossogobius koragensis Herre

Glossogobius koragensis Herre, 1935: 419 (Sepik River, New Guinea). SL (RMNH 28484), 3: 96-142 mm.

Known only from northern New Guinea between the Sepik River and Lake Sentani. Inhabits fresh water.

Mugilogobius sp.

TR (RMNH 28494), 15: 10-23 mm.

Counts of 5 specimens as follows: dorsal rays VI-I,8; anal rays I,8; pectoral rays 16; vertical scale rows from upper corner of gill cover to caudal fin base 33 or 34; horizontal scale rows from anal fin origin to base of dorsal fin 9 or 10; predorsal scales 14-16, extending to rear of interorbital. Colour pale tan with series of about 10 irregular branched brown bars along sides and a pair of distinctive dark brown spots at base of caudal fin. There is a black blotch on the distal portion of the first dorsal fin.

Stiphodon elegans (Steindachner)

Sicydium elegans Steindachner, 1880: 152 (Society Islands). JV (RMNH 28495), 31 mm.

Widely distributed in freshwater streams of islands in the tropical western Pacific from Sumatra eastward to the Marquesas and Society Islands.

Family Eleotridae . . . Gudgeons

Bostrychus strigogenys Nichols

Bostrychus strigogenys Nichols, 1937: 1 (Fly River, southern New Guinea). TM* (RMNH 28496), 12: 26-113 mm; TM* (WAM P27388-001), 4: 35-90 mm.

Freshwater streams of central southern New Guinea.

Hypseleotris cyprinoides (Valenciennes)

Eleotris cyprinoides Valenciennes (in Cuvier and Valenciennes), 1837: 248 (Mauritius). JV (RMNH 28497), 8: 17-38 mm.

Generally similar to *Hypseleotris guntheri* (Bleeker) as described in Koumans (1953), but lacking a dark longitudinal band on the body and having about 19 predorsal scales instead of 15. Most of our specimens show distinct spotting on both dorsal fins, caudal fin, and anal fin. Other distinctive markings include a blackish eye-size spot at the middle of the caudal fin base and a narrow blackish bar on the pectoral fin base.

Widely distributed in the Indo-West Pacific. Inhabits streams and estuaries.

Mogurnda mogurnda (Richardson)

Eleotris mogurnda Richardson, 1844: 4 (vicinity of Darwin, Australia). JL (RMNH 28498), 3: 55-72 mm; JL (RMNH 28499), 3: 35-50 mm; JL (RMNH 28500), 83 mm; JL (RMNH 25251), 4: 62-97 mm; TM* (RMNH 25908), 3: 78-97 mm; TM* (RMNH 28501), 242: 18-110 mm; TM (WAM P27388-002), 35: 32-115 mm.

Freshwater streams and lakes of southern New Guinea and northern Australia.

Ophieleotris aporos (Bleeker)

Eleotris aporos Bleeker, 1854: 59 (Halmahera). JL (RMNH 28502), 31 mm; JL (RMNH 28503), 3: 69-97 mm; JL (RMNH 28504), 6: 58-93 mm; JL (RMNH 28505), 3: 49-109 mm; JL (RMNH 25212), 50 mm; JL (RMNH 25231), 2: 70 and 83 mm; JL (RMNH 28506), 3: 27-40 mm; SL (RMNH 28507), 7: 42-72 mm; SL (RMNH 28508), 156: 11-46 mm; SL (RMNH 28509), 17: 16-42 mm; SL (RMNH 24530), 3: 135-168 mm; SL (RMNH 25081), 2: 102 and 135 mm; SL (RMNH 28510), 4: 111-127 mm; SL (RMNH 28511), 30: 9-40 mm; TR (RMNH 28512), 3: 66-82 mm; TR (RMNH 25110), 140 mm; JI (RMNH 28513), 110 mm.

Widely distributed in the tropical Indo-West Pacific from Madagascar eastward to Melanesia. Commonly found in brackish estuaries, streams, and lakes.

Oxyeleotris fimbriata (Weber)

Eleotris fimbriatus Weber, 1908: 254 (Etna Bay, southern New Guinea). AJ (RMNH 28514), 20: 57-113 mm; AJ (WAM P27387-002), 7: 78-93 mm; AJ (RMNH 28515), 11: 54-110 mm; AJ (RMNH 28516), 43 mm; AJ (RMNH 28517), 123 mm; AT (RMNH 28518), 3: 99-142 mm; AT (RMNH 24576), 3: 77-110 mm; AJ (RMNH 28519), 3: 41-45 mm; DU (RMNH 28520), 18: 31-84 mm; JL (RMNH 25219), 3: 73-114 mm; JL (RMNH 28521), 83: 24-112 mm; JL (WAM P27390-001), 10: 33-112 mm; JL (RMNH 28522), 2: 44 and 66 mm; JL (RMNH 28523), 23: 12-52 mm; JL (RMNH 24557), 7: 41-107 mm; TM* (RMNH 28528), 150 mm; TM*(RMNH 28524), 49: 24-143 mm; TM (WAMP P27388-003), 11: 30-111 mm.

We concur with Roberts (1978) who mentioned that the New Guinea *Oxyeleotris* are in need of systematic revision, particularly the members of the '*fimbriata* complex'. The material we have identified as *O. fimbriata* is probably divisable into at least two species. Specimens from the Ajamaru Lakes region of the Vogelkop Peninsula possess smaller scales (about 70-80 in lateral series and 36-42 predorsal scales) than those from Lake Jamur and Tanah Merah on the Digul River. Specimens from the latter area generally have 55 to 65 scales in lateral series and about 28 to 35 predorsal scales. In addition, the colour pattern lacks the extensive blotching characteristic of much of our Ajamaru Lakes material.

Reported from fresh waters of both northern and southern New Guinea by Koumans (1953), but further investigations may indicate that *fimbriata* is restricted to southern drainages.

Oxyeleotris lineolatus (Steindachner)

Eleotris lineolatus Steindachner, 1867: 13 (Rockhampton, Queensland). SL (RMNH 28529), 114 mm; SL (RMNH 28530), 11: 32-57 mm; SL (RMNH 28531), 156 mm; JI (RMNH 28532), 2: 78 and 79 mm; JV (RMNH 28533), 2: 54 and 63 mm; JV (RMNH 28534), 5: 31-49 mm; JV (RMNH 25099), 105 mm; JL (RMNH 28525), 4. 19-51 mm; TM (RMNH 28526), 2: 30 and 33 mm; TM (RMNH 28527), 3: 283-390 mm.

Freshwater streams and lakes of both northern and southern New Guinea.

Oxyeleotris nullipora Roberts

Oxyeleotris nullipora Roberts, 1978: 67 (Fly River, southern New Guinea). TM (RMNH 28535), 3: 23-27 mm; TM (WAM P27388-004), 2: 22 and 23 mm.

Recently described from lacustrine and semi-lacustrine habitats of the Middle Fly River.

Oxyeleotris paucipora Roberts

Oxyeleotris paucipora Roberts, 1978: 67 (Fly River, southern New Guinea). TM (RMNH 28536), 10: 28-33 mm; TM (WAM P27388-005), 2: 25 and 41 mm.

Recently described from riverine habitats of the Upper Fly River.

Oxyeleotris wisselensis sp. nov.

Figures 6 and 7; Table 3

Holotype

RMNH 28541, 111.0 mm, small streams in vicinity of Tigi Lake, Wissel Lakes, Irian Jaya, Indonesia (approximately 4°09'S, 136°13'E), M. Boeseman, 11-17 January 1955.

Paratypes

TA (RMNH 28537), 16: 18-92 mm; PL (RMNH 28532), 10: 27-91 mm; TI (RMNH 28539), 10: 32-68 mm; JR (RMNH 28540), 5: 85-96 mm; TI (RMNH 28541), 12: 73-109 mm; TA (RMNH 28542), 32: 17-85 mm; DA (RMNH 28543), 53: 20-90 mm; DA (RMNH 28544), 43: 54-95 mm; PL (RMNH 28545), 68 mm; JR (RMNH 28546), 51 mm; TA (WAM P27389-001), 17: 26-82 mm.

Diagnosis

A species of *Oxyeleotris* which is allied to *O. fimbriata,* but differs from it on the basis of a less depressed head shape and a much shorter snout (Figure 7). In addition, *O. wisselensis* is considerably darker in overall coloration and lacks the 3-4 lines which radiate from the eye of *O. fimbriata.* The fins of the latter species are pale in vivid contrast to the dark fins of *O. wisselensis.* Moreover, *O. fimbriata* has distinct spotting which covers the entire second dorsal fin, whereas in *O. wisselensis* there are wavy brown lines interspersed with white and this feature is restricted to the basal half of the fin. Finally, the dark spot at the upper caudal fin base is more clearly evident in the adults of *O. fimbriata.*

Description

Dorsal rays VI-I,11 (10 to 12); anal rays I,9 (8 to 11); pectoral rays 17 (16 to 18); gill rakers on first branchial arch 1 + 8 (1 or 2 + 7 to 9); scales in lateral series 66 (63 to 70); predorsal scales 26 (25 to 30).

Body elongate, laterally compressed in posterior portion, more or less cylindrical anteriorly; maximum depth 6.0 (4.9 to 6.1) in standard length. Head blunt with rounded snout; maximum depth of head 1.9 (1.9 to 2.2), maximum width 1.9 (1.5 to 1.9), both in length of head, which is equal to 3.1 (3.1 to 3.3) of the standard length. Interorbital convex, its width 4.0 (3.6 to 4.6) in head length. Snout 4.3 (3.1 to 4.0), eye 5.3 (5.5 to 7.1), both in head length.

Mouth terminal; edge of lips fimbriate; jaw teeth numerous in dense bands, teeth of outer row somewhat enlarged; palate endentulous; maxillary extends to level of below middle of eye. A series of 6 or 7 vertical pit organ canals below eye and area between anterior and posterior nares liberally covered with pit organs. Several conspicuous sensory pores on each side of head as follows: 2 nasal pores; 1 supraorbital pore; 5 preopercle pores; 2 pores slightly above and anterior to upper limit of opercle opening; and a single pore in middle of interorbital.

Scales of head and body cycloid. Head entirely scaled except for lips, tip of snout, preorbital region, lower jaw, and chin. Scales of interorbital and cheeks generally smaller than body scales and tend to be embedded.

Figure 6 *Oxyeleotris wisselensis*, paratype (RMNH 28541), 85.0 mm, Tigi Lake.

Figure 7 Comparison of head shapes of *Oxyeleotris wisselensis*, 62 mm (left) and *O. fimbriata*, 67 mm. Drawings made at same magnification with aid of camera lucida.

Table 3 Proportional measurements of selected type specimens of *Oxyeleotris wisselensis* (expressed as a percentage of the standard length).

	Holotype RMNH 28541	Paratypes				
Standard length (mm)	111.0	103.0	93.7	89.6	84.2	74.4
Body depth	20.4	18.7	20.4	16.7	20.1	18.8
Head length	31.9	32.3	31.5	32.5	32.1	31.6
Head depth	15.3	17.4	14.1	17.0	16.0	16.1
Head width	20.4	21.8	18.7	17.4	21.0	20.2
Snout length	8.4	10.3	8.2	7.5	8.3	7.7
Eye diameter	4.5	4.7	4.8	6.1	4.8	5.4
Interorbital width	9.0	8.9	7.5	8.0	8.6	6.9
Pectoral fin length	18.9	20.8	20.5	18.4	21.5	20.0
Pelvic fin length	16.0	15.8	16.0	16.7	15.2	17.5
Caudal fin length	20.7	21.2	21.3	20.8	20.3	20.8

Pelvic fins relatively small compared to fan-like pectoral fins; pelvic fin length 1.9 (1.8 to 2.1) and pectoral fin length 1.8 (1.5 to 1.8), both in head length. Bases of pelvic fins widely spearated. Pectoral and caudal fins rounded, length of caudal fin 1.6 (1.5 to 1.6) in head length.

Colour in alcohol: generally dark brown on upper half grading to light brown on ventral portion; dorsal fins dark brown, second dorsal with faint wavy brown lines interspersed with white on lower half; anal fin light brown basally, dark brown on outer half; second dorsal and anal fins with narrow white margin; remaining fins dark brown. Juvenile specimens generally light brown with dark brown head and series of dark chevron markings along side of body; a vague ocellus-like marking at base of upper caudal rays, this mark less evident with increasing size, but visible in adults.

Colour in life: according to field notes the general colour is greyish-brown or occasionally yellowish with shades of green or gold. Chevron markings on young are brown to light brown or greyish.

Remarks

Oxyeleotris wisselensis appears to be restricted to the Wissel Lakes and their tributary streams. These lakes are situated in the central mountain chain of Irian Jaya at elevations ranging from 1640 to 1750 m. Paniai Lake is the largest with a length of 16 km and width fo 9 km, and a maximum depth of at least 50 m. The other two lakes, Tage and Tigi have a combined area about equal to half that of Paniai Lake. Additional details of the environment of this region were provided by Boeseman (1963).

Oxyeleotris wisselensis is most closely allied and perhaps derived from *O. fimbriata,* a widely distributed species occurring in lowland areas of New Guinea on both sides of the central dividing range. Koumans (1949) discussed the great variability in fin ray and scale counts found in this species. He noted a tendency for Wissel Lakes specimens to have an additional ray in the second dorsal and anal fins compared with specimens of *O. fimbriata* from other localities. There is also a pronounced difference in the maximum size attained by the two species. The largest of our type series of 201 specimens is 111 mm SL compared with a maximum standard length of 143 mm for 258 specimens of *O. fimbriata.* Koumans (1949) recorded maximum standard lengths of 115 mm and 225 mm for the Wissel Lakes fish and lowland populations of *O. fimbriata* respectively. Additional studies are required to properly assess the taxonomic status of the many lowland populations of *O. fimbriata.* It is conceivable that this 'species' may be divisable into several distinct taxa (see Discussion section for this species). We have compared the specimens from the Wissel Lakes with 258 specimens of *O. fimbriata* from lowland streams of southern New Guinea.

The species is named in reference to the type locality.

Prionobutis microps (Weber)

Pogoneleotris microps Weber, 1908: 258 (Tawarin River and Merauke River, New Guinea). TR (RMNH 24546), 150 mm; JV (RMNH 28547), 170 mm.

Fresh and brackish waters of New Guinea (north and south), and northern Australia.

Family Periophthalmidae . . . Mud Skippers

Periophthalmus novaeguineaensis Eggert

Periophthalmus cantonensis novaeguineaensis Eggert, 1935: 67 (Merauke River, southern New Guinea). MV (RMNH 28548), 2: both 32 mm.

Fresh and brackish waters of central southern New Guinea.

Family Kurtidae . . . Nurseryfishes

Kurtus gulliveri Castelnau

Kurtus gulliveri Castelnau, 1878: 233 (Norman River, Queensland). TM (RMNH 28549), 3: 260-305 mm.

Fresh and brackish rivers of central southern New Guinea and far northern Australia.

Family Anabantidae . . . Labyrinthfishes

Trichogaster pectoralis (Regan)

Trichopodus pectoralis Regan, 1910: 784 (Siam). DU (RMNH 28550), 2: 93 and 105 mm; AJ (RMNH 28551), 12: 84-118 mm; AJ (RMNH 28552), 30: 93-114 mm; SL (RMNH 28553), 4: 105-161 mm.

An introduced species native to fresh waters of South-East Asia.

Family Soleidae . . . Soles

Aseraggodes klunzingeri (Weber)

Pardachirus klunzingeri Weber, 1908: 250 (Merauke River, southern New Guinea). TM* (RMNH 28554), 104 mm; TM (RMNH 28555), 3: 75-102 mm.

Fresh and brackish waters of central southern New Guinea and northern Australia.

Brachirus villosa (Weber)

Synaptura villosa Weber, 1908: 251 (Wagani River, western New Guinea). MV (RMNH 24695), 13: 38-57 mm.

Fresh and brackish waters of central southern New Guinea.

Family Cynoglossidae . . . Tongue Soles

Cynoglossus heterolepis Weber

Cynoglossus heterolepis Weber, 1910: 237 (Lorentz River, southern New Guinea). TGG (RMNH 28556), 88 mm; TM* (RMNH 28557), 139 mm.

Fresh and brackish waters of central southern New Guinea.

Discussion

The freshwater fishes of New Guinea continue to provide a fertile area for study. Recent collecting activity by Roberts (1978) and that of the senior author between 1977 and 1981 have revealed a wealth of both undescribed and poorly known species. Large tracts remain totally uncollected. For example, there have been no ichthyological explorations on the north coast between the Mamberamo River mouth and the western extremity of the island, an expanse of more than 800 km. Likewise, only a small number of collections have been made on the Vogelkop Peninsula, and in the central highlands of Irian Jaya. Only two previous authors, Weber (1913) and Munro (1964) have assembled comprehensive faunal lists. Both of these lists contain 145 species, but if fishes which are not strictly fresh water dwellers are eliminated, as well as various junior synonyms, the Weber list is reduced to 66 species, and that of Munro to 92 species. On the basis of our research for the present paper and also from consultation with various specialists (particularly for the Ariidae, Plotosidae, Gobiidae, and Eleotridae) we present a list of the freshwater fishes of New Guinea (Appendix Table 1). The list contains 158 species. We include only those fishes which appear to be restricted to freshwater habitats. We have eliminated various widely distributed forms, which although frequently found in pure fresh water, have a marine stage for dispersal. Therefore we include only species whose distribution is restricted to the New Guinea-northern Australia region. Thus, we have excluded approximately 80 species which regularly penetrate fresh water. A number of the excluded fishes have their main populations in tidal creeks or estuaries, for example the archerfish *Toxotes jaculatrix* (Toxotidae), the spotted scat *Scatophagus argus* (Scatophagidae), and several species of gobiids and eleotrids. Others such as the eleotrid *Ophieleotris aporos,* certain gobiids of the genus *Glossogobius,* and the eel genus *Anguilla* may spend the greater part of their life cycle in fresh water, but are evidently dependent on the sea for larval dispersal or as a breeding site.

The central dividing range of New Guinea includes a number of peaks with elevations in excess of 4 000 m and represents a formidable faunal barrier. Only 11 species of the 158 purely freshwater forms occur on both sides of the central mountains. The southern and northern populations of some of these species will no doubt prove to be specifically distinct when studied in more detail. Kailola (pers. comm.) has recently verified this phenomenon for the ariid catfish *Arius leptaspis*. Aside from the realtively few shared species the respective fish faunas of the south and north are very distinctive. The southern fauna appears to be the richest with 106 species thus far recorded compared to 61 species from the north. However, part of this difference is no doubt related to the greater amount of collecting activity in the south. Twenty-eight species or approximately 26% of the southern fishes are also found in northern Australia, primarily Arnhem Land and Cape York Peninsula. The latter area was linked to southern New Guinea by a land bridge as recently as 6 500-8 000 years ago (Allen and Hoese 1980). Thus, the faunal similarity of these regions is not surprising. Allen and Hoese (1980) reported that at least 63% of the fishes collected in the Jardine River at the northern extremity of Cape York Peninsula are also found in southern New Guinea.

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Dr Brongersma was the leader of the 1959 Star Mountains Expedition, at the conclusion of which Dr W. Vervoort (present Director of RMNH) had the opportunity to collect fishes from Tanah Merah. His efforts in this regard are gratefully acknowledged. Dr Vervoort kindly provided working facilities for the senior author during a visit to Leiden in April-May 1981.

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Appendix Table

List of the Freshwater Fishes of New Guinea

Species		Known distribution (SNG = S New Guinea NNG = N New Guinea)
Family Clupeidae (3 spp.)		
1	*Clupeoides papuensis* (Ramsay and Ogilby)	Digul and Fly Rivers (SNG)
2	*C. venulosus* Weber and de Beaufort	Lorentz and Fly Rivers (SNG)
3	*Nematalosa erebi* (Günther)	Jamur Lake, Digul and Fly Rivers (SNG); N Australia
Family Engraulidae (2 spp.)		
4	*Thryssa rastrosa* Roberts	Fly River (SNG)
5	*T. scratchleyi* (Ramsay and Ogilby)	Digul and Fly Rivers (SNG); N Australia
Family Osteoglossidae (1 sp.)		
6	*Scleropages jardinii* Günther	Digul and Fly Rivers (SNG); N Australia
Family Ariidae (27 spp.)		
7	*Arius acrocephalus* (Weber)	Digul, Fly, Purari and Laloki Rivers (SNG)
8	*A. augustus* Roberts	Fly River (SNG)
9	*A. berneyi* (Whitley)	Fly River (SNG); N Australia
10	*A carinatus* (Weber)	Lorentz, Digul, Fly and Purari Rivers (SNG)
11	*A. kanganamanensis* (Herre)	Ramu and Sepik Rivers (NNG)
12	*A. latirostris* (Macleay)	Lorentz, Purari and Laloki Rivers (SNG)

13	*A. leptaspis* Bleeker	Widespread SNG and N Australia
14	*A. solidus* (Herre)	Ramu and Sepik Rivers (NNG)
15	*A. stirlingi* (Ogilby)	Widespread SNG and N Australia
16	*A.* sp. A	Jamur Lake (SNG)
17	*A.* sp. B	Digul River (SNG)
18	*A.* sp. C	Widely distributed in NNG
19	*A.* sp. D	Sentani Lake, Sepik and Ramu Rivers (NNG)
20	*Brustiarius nox* (Herre)	Ramu and Sepik Rivers (NNG)
21	*Cinetodus froggatti* (Ramsay and Ogilby)	Digul, Merauke, Fly, Kikori and Purari Rivers (SNG); N Australia
22	*Cochlefelis danielsi* (Regan)	Lorentz, Fly and Kikori Rivers (SNG)
23	*C. spatula* (Ramsay and Ogilby)	Digul and Fly Rivers (SNG)
24	*Doiichthys novaeguineae* Weber	Lorentz River (SNG)
25	*Hemipimelodus bernhardi* Nichols	Mamberamo River (NNG)
26	*H. crassilabrus* Ramsay and Ogilby	Fly and Purari Rivers (SNG)
27	*H. macrorhynchus* Weber	Lorentz, Digul, Fly and Purari Rivers (SNG)
28	*H. papillifer* Herre	Ramu and Sepik Rivers (NNG)
29	*Nedystoma dayi* (Ramsay and Ogilby)	Lorentz, Digul, Fly and Purari Rivers (SNG)
30	*Netuma microstoma* (Nichols)	Mamberamo River (NNG)
31	*Tachysurus kanganamanensis* (Herre)	Ramu and Sepik Rivers (NNG)
32	*T. solidus* (Herre)	Ramu and Sepik Rivers (NNG)
33	*Tetranesodon conorhynchus* Weber	Lorentz River (SNG)

Family Plotosidae (10 spp.)

34	*Neosilurus ater ater* (Perugia)	Widespread SNG and NNG; N Australia
35	*N. brevidorsalis* (Günther)	Widespread SNG and N Australia
36	*N. equinus* (Weber)	Widespread SNG and NNG
37	*N. idenburgi* (Nichols)	Mamberamo, Sepik, Ramu and Markham Rivers (NNG)
38	*N. meraukensis* (Weber)	Merauke, Fly and Nami Nami Rivers (SNG)
39	*N. novaeguineae* (Weber)	Lake Sentani (NNG)
40	*Oloplotosus luteus* Gomon and Roberts	Fly River (SNG)
41	*O. mariae* Weber	Lorentz River (SNG)
42	*Plotosus papuensis* Weber	Lorentz and Fly Rivers (SNG)
43	*Porochilus obbesi* (Weber)	Lorentz, Oriomo and Laloki Rivers (SNG); N Australia

Family Anguillidae (1 sp.)

44	*Anguilla interioris* Whitley	Widespread SNG and NNG

Family Beloni

Family Belonidae (2 spp.)

45	*Strongylura kreftti* (Günther)	Widespread SNG and N Australia
46	*S. perornatus* Whitley	Sepik River (NNG)

Family Hemirhamphidae (5 spp.)		
47	*Zenarchopterus alleni* Collette	Mamberamo River (NNG)
48	*Z. caudovittatus* (Weber)	Merauke River (SNG)
49	*Z. kampeni* (Weber)	Mamberamo, Sepik and Ramu Rivers (NNG)
50	*Z. novaeguineae* (Weber)	Lorentz, Oriomo, Fly, Purari and Laloki Rivers (SNG)
51	*Z. robertsi* Collette	Kumusi River (NNG)
Family Melanotaeniidae (41 spp.)		
52	*Chilatherina axelrodi* Allen	Pual River (NNG)
53	*C. campsi* (Whitley)	Upper Sepik and Purari systems, and Markham River (SNG and NNG)
54	*C. crassispinosa* (Weber)	Mamberamo River to Markham River (NNG)
55	*C. fasciata* Regan	Mamberamo River to Markham River (NNG)
56	*C. lorentzi* (Weber)	Mamberamo River to Vanimo vicinity (NNG)
57	*C. sentaniensis* (Weber)	Lake Sentani and Sekanto River (NNG)
58	*Glossolepis incisus* Weber	Lake Sentani (NNG)
59	*G. maculosus* Allen	Omsis River (NNG)
60	*G. multisquamatus* (Weber)	Mamberamo and Sepik Rivers (NNG)
61	*G. pseudoincisus* Allen and Cross	Tami River (NNG)
62	*G. wanamensis* Allen and Kailola	Lake Wanam (NNG)
63	*Triatherina werneri* Meinken	Merauke River to Fly River (SNG); N Australia
64	*Melanotaenia affinis* (Weber)	Sermowai River to Markham River (NNG)
65	*M. ajamaruensis* Allen and Cross	Ajamaru Lakes (SNG)
66	*M. boesemani* Allen and Cross	Ajamaru Lakes (SNG)
67	*M. catherinae* de Beaufort	Waigeo Island (NNG)
68	*M. corona* Allen	Sermowai River (NNG)
69	*M. goldiei* (Macleay)	Widespread SNG and Aru Islands
70	*M. herbertaxelrodi* Allen	Lake Tebera (SNG)
71	*M. japenensis* Allen and Cross	Japen Island (NNG)
72	*M. lacustris* Munro	Lake Kutubu (SNG)
73	*M. maccullochi* Ogilby	Bensbach River to Fly River (SNG); N Australia
74	*M. misoolensis* Allen	Misool Island (SNG)
75	*M. monticola* Allen	Upper Purari system (SNG)
76	*M. ogilbyi* Weber	Lorentz River (SNG)
77	*M. oktediensis* Allen and Cross	Oktedi River (SNG)
78	*M. papuae* Allen	Port Moresby vicinity (SNG)
79	*M. parkinsoni* Allen	Port Moresby to Alotau (SNG)
80	*M. pimaensis* Allen	Pima River (SNG)
81	*M. praecox* Weber and de Beaufort	Mamberamo River (NNG)

82	*M. splendida rubrostriata* (Ramsay and Ogilby)	Digul River to Purari River and Aru Islands (SNG)
83	*M. sexlineata* (Munro)	Fly River (SNG)
84	*M. vanheurni* (Weber and de Beaufort)	Mamberamo River (NNG)
85	*Popondetta connieae* Allen	Vicinity of Popondetta (NNG)
86	*P. furcatus* (Nichols)	Musa River and Wanagela vicinity (NNG)
87	*Pseudomugil gertrudae* Weber	Digul River to Fly River and Aru Islands (SNG); N Australia
88	*P. inconspicuus* Roberts	Fly River (SNG)
89	*P. novaeguineae* Weber	Etna Bay to Fly River and Aru Islands (SNG)
90	*P. paludicola* Allen and Moore	Morehead River to Binaturi River (SNG)
91	*P.* sp. no. 1	Misool Island (SNG)
92	*P.* sp. no. 2	Cape Ward Hunt (NNG)

Family Atherinidae (4 spp.)

93	*Craterocephalus lacustris* Trewavas	Lake Kutubu (SNG)
94	*C. nouhuysi* (Weber)	Lorentz River (SNG)
95	*C. randi* Nichols	Jamur Lake to Balimo (SNG)
96	*C.* sp.	Upper Purari system (SNG)

Family Ambassidae (12 spp.)

97	*Ambassis agrammus* Günther	Bensbach River to Fly River (SNG); N Australia
98	*A. macleayi* (Castelnau)	Digul River to Balimo (SNG); N Australia
99	*A. reticulata* Weber	Lake Jamur to Merauke River (SNG)
100	*Denariusa bandata* Whitley	Bensbach River to Fly River (SNG); N Australia
101	*Parambassis altipinnis* Allen	Mamberamo River (NNG)
102	*P. confinis* (Weber)	Mamberamo and Sepik Rivers (NNG)
103	*P. gulliveri* (Castelnau)	Lorentz River to Purari River (SNG); N Australia
104	*Synechopterus caudovittatus* Norman	Kokoda vicinity (NNG)
105	*Tetracentron apogonoides* Macleay	Laloki and Kemp Welsh Rivers (SNG)
106	*Xenambassis honessi* Schultz	Buna vicinity (NNG)
107	*X. lalokiensis* Munro	Laloki River (SNG)
108	*X. simoni* Schultz	Buna vicinity (NNG)

Family Lobotidae (1 sp.)

109	*Dantinoides campbelli* Whitley	Sepik River (NNG)

Family Teraponidae (11 spp.)

110	*Amniataba affinis* (Mees and Kailola)	Morehead and Fly Rivers (SNG)
111	*Hephaestus adamsoni* (Trewavas)	Lake Kutubu (SNG)

112	*H. fuliginosus* (Macleay)	Fly and Purari Rivers (SNG); N Australia
113	*H. obtusifrons* (Mees and Kailola)	Mamberamo and Sermowai Rivers (NNG)
114	*H. raymondi* (Mees and Kailola)	Morehead River (SNG)
115	*H. roemeri* (Weber)	Lorentz and Digul Rivers (SNG)
116	*H. transmontanous* (Mees and Kailola)	Sepik and Ramu Rivers (NNG)
117	*H. trimaculatus* (Macleay)	Mimika River to Laloki River (SNG)
118	*Pingalla lorentzi* (Weber)	Lorentz, Digul, Morehead and Fly Rivers (SNG); N Australia
119	*Terapon jamoerensis* (Mees)	Lake Jamur (SNG)
120	*T. lacustris* (Mees and Kailola)	Morehead River to Balimo (SNG)
Family Apogonidae (8 spp.)		
121	*Glossamia aprion* (Richardson)	Oriomo River to Balimo (SNG)
122	*G. beauforti* (Weber)	Mamberamo River, Lake Sentani (NNG)
123	*G. gjellerupi* (Weber and de Beaufort)	Mamberamo and Sepik Rivers (NNG)
124	*G. heurni* (Weber and de Beaufort)	Mamberamo River (NNG)
125	*G. narindica* Roberts	Fly River (SNG)
126	*G. sandei* (Weber)	Wagami River to Purari River (SNG)
127	*G. trifasciata* (Weber)	Lorentz and Fly Rivers (SNG)
128	*G. wichmanni* (Weber)	Tawarin River to Markham River (NNG)
Family Lutjanidae (1 sp.)		
129	*Lutjanus goldiei* (Macleay)	Fly, Purari and Laloki Rivers (SNG)
Family Toxotidae (2 spp.)		
130	*Toxotes lorentzi* Weber	Merauke River and Balimo vicinity (SNG); N Australia
131	*T. oligolepis* Bleeker	Jamur Lake (SNG); Molucca Islands and N Australia
Family Gobiidae (8 spp.)		
132	*Acentrogobius bulmeri* (Whitley)	Upper Sepik system (NNG)
133	*Aloricatogobius asaro* (Whitley)	Upper Purari system (SNG)
134	*Ctenogobius tigrellus* (Nichols)	Mamberamo River (NNG)
135	*Glossogobius brunnoides* (Nichols)	Upper Kikori and Purari systems (SNG)
136	*G. concavifrons* (Ramsay and Ogilby)	Fly River (SNG); N Australia
137	*G. hoesei* Allen and Boeseman	Ajamaru Lakes (SNG)
138	*G. koragensis* Herre	Lake Sentani and Sepik River (NNG)
139	*Mugilogobius fusculus* (Nichols)	Distribution unknown
Family Eleotridae (16 spp.)		
140	*Bostrychus strigogenys* (Nichols)	Digul River to Balimo (SNG)
141	*Hypseleotris moncktoni* (Regan)	Agarambo vicinity (SNG)

142	*Mogurnda mogurnda* (Richardson)	Widespread SNG and NNG; N Australia
143	*M. variegata* Nichols	Lake Kutubu (SNG)
144	*M.* sp. A	Widespread SNG and NNG
145	*M.* sp. B	Kemp Welsh River (SNG)
146	*M.* sp. C	Bulolo River (NNG)
147	*Odonteleotris nesolepis* (Weber)	Widespread NNG
148	*Oxyeleotris fimbriata* (Weber)	Widespread SNG and NNG
149	*O. herwerdeni* (Weber)	Widespread SNG and NNG; N Australia
150	*O. lineolatus* (Steindachner)	Widespread SNG and NNG; N Australia
151	*O. novaeguineae* Koumans	Widespread SNG and NNG
152	*O. nullipora* Roberts	Digul and Fly Rivers (SNG)
153	*O. paucipora* Roberts	Digul and Fly Rivers (SNG)
154	*O. wisselensis* Allen and Boeseman	Wissel Lakes (SNG)
155	*Tateurndina ocellicauda* Nichols	Popondetta vicinity and Musa River (NNG)

Family Soleidae (2 spp.)

156	*Aseraggodes klunzingeri* (Weber)	Widespread SNG; N Australia
157	*Brachirus villosus* (Weber)	Wagani River to Fly River (SNG)

Family Cynoglossidae

158	*Cynoglossus heterolepis* Weber	Oetoemboewe, Lorentz, Digul and Fly Rivers (SNG); N Australia

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A New Species of Freshwater Rainbowfish (Melanotaeniidae) from Misool Island, Indonesia

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Abstract

A new species of rainbowfish (Melanotaeniidae) belonging to the genus *Melanotaenia* is described from 23 specimens collected at Misool Island off the western extremity of Irian Jaya, Indonesia. *Melanotaenia misoolensis* sp. nov. is closely related to *M. catherinae* from Waigeo Island, but differs with regard to colour pattern and by having a greater number of soft anal rays.

Introduction

The freshwater rainbowfishes of the family Melanotaeniidae are small (usually under 12 cm) inhabitants of streams, lakes, and swamps in the Australian-New Guinea region. The group contains approximately 50 species which are assigned to eight genera (see Allen 1980). *Melanotaenia* is by far the largest genus with 25 known species, of which 21 are found in New Guinea (Allen and Cross 1982). This large island still remains relatively unexplored, and therefore can be expected to yield additional new species, particularly the poorly known western half (Irian Jaya).

The present paper describes a new *Melanotaenia* which was located amongst unstudied New Guinea material at the Zoological Museum of the University of Amsterdam in the Netherlands. *Melanotaenia misoolensis* sp. nov. is described on the basis of 23 specimens collected at Misool Island in 1948. Misool is a relatively large (approximately 90 x 38 km) island lying just to the south of the western extremity of Irian Jaya and separated from the mainland by a distance of 32 kilometres. The island has a maximum elevation of 990 m. Rainbowfishes of the genus *Melanotaenia* have been reported from several other islands off the coast of Irian Jaya. *Melanotaenia catherinae* (Beaufort) from Waigeo and *M. japenensis* Allen and Cross from Japen are endemic to these islands which are situated off the north coast. The Aru Islands off the south coast are inhabited by *M. goldiei* (Macleay) and *M. splendida rubrostriata* (Ramsay and Ogilby), both of which are widely distributed on the southern New Guinea mainland. All of these insular areas were formerly connected to the New Guinea land mass and are presently separated by shallow (less than 50 fathoms) seas.

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Methods of counting and measuring follow those explained in Allen and Cross (1980). Counts and measurements are summarized in Tables 1 and 2. Data in parentheses indicate the range for paratypes when differing from the holotype. Proportional measurements are presented as percentage of the standard length. These data are based on the holotype and 12 paratypes, 42.0-56.8 mm SL. Type specimens are deposited at the National Museum of Natural History, Washington, D.C. (USNM), the Western Australian Museum, Perth (WAM) and the Zoologisch Museum, Amsterdam (ZMA).

Table 1 Proportional measurements expressed in thousandths of the standard length for selected type specimens of *Melanotaenia misoolensis* sp. nov.

Character	Holotype ZMA 116.456	Paratypes ZMA 116.457			
Standard length (mm)	56.8	58.5	52.9	51.0	50.0
Depth	335	345	342	350	336
Width	136	144	134	137	144
Head length	278	277	297	290	288
Snout to first dorsal fin origin	481	479	541	527	484
Snout to anal fin origin	502	509	493	480	504
Snout to pelvic fin origin	387	383	346	363	384
Length of second dorsal fin base	246	260	227	224	246
Length of anal fin base	396	421	384	363	404
Snout length	88	89	87	84	86
Orbit diameter	92	93	96	98	100
Bony interorbital width	106	104	112	102	104
Depth of caudal peduncle	109	115	121	122	112
Length of caudal peduncle	141	145	174	176	144
Length of pectoral fin	202	203	208	224	206
Length of pelvic fin	167	162	197	188	170
Longest ray of first dorsal fin	165	156	123	147	150
Longest ray of second dorsal fin	143	137	127	143	128
Longest anal ray	132	120	155	139	140
Length of caudal fin	218	239	246	231	270

Table 2 Fin ray counts for type specimens of *Melanotaenia misoolensis.*

First dorsal fin spines

IV	V	VI
2	21	2

Second dorsal fin soft rays

12	13	14
10	13	2

Anal soft fin rays

20	21	22	23	24	25
1	1	5	7	6	5

Pectoral fin rays

13	14	15	16
8	13	3	1

Systematics

Melanotaenia misoolensis sp. nov.

Figure 1

Holotype

ZMA 116.456 , male 58.5 mm SL, tributary of Wai Tama at Fakal, Misool Island, Indonesia (approximately 2°00′S, 130°00′E), M.A. Lieftinck, 2 October 1948.

Paratypes

USNM 227492, 3 specimens, 30.6-39.5 mm SL, collected with holotype; WAM P27279-001, 2 specimens, 52.9-58.5 mm SL, collected with holotype; AMZ 116.457, 17 specimens, 21.9-52.7 mm SL, collected with holotype.

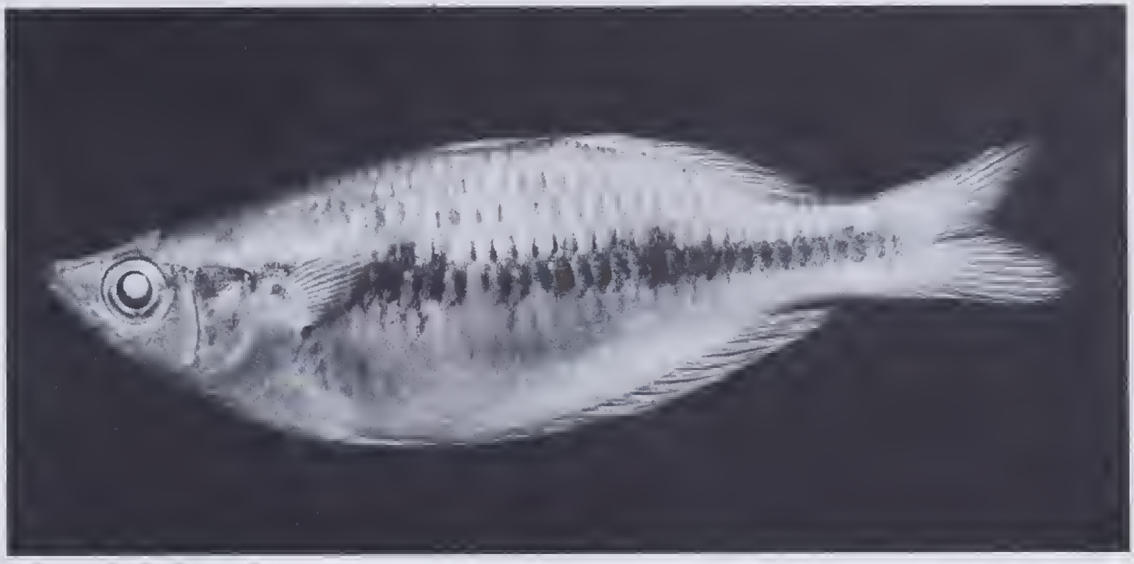

Figure 1 *Melanotaenia misoolensis*, male, paratype, 58.5 mm SL.

Diagnosis

A species of *Melanotaenia* with the following combination of characters: dorsal rays IV to VI-I,12 to 14; anal rays I,20 to 25; pectoral rays 13 to 16; horizontal scale rows 10; vertical scale rows 33 or 36; preopercle-suborbital scales 11 to 15; predorsal scales 13 to 17; colour in preservative generally pale brown on back and yellowish-tan below; a dark stripe running along middle of sides from rear edge of eye to caudal fin base, maximum width of stripe about 1½ scales.

Description

Dorsal rays V-I,12 (IV to VI-I,12 to 14); anal rays I,23 (I,20 to 25); pectoral rays 13 (13 to 16), horizontal scale rows 10; vertical scale rows 34 (33 to 36); predorsal scales 16 (13 to 17); preopercle-suborbital scales 13 (11 to 15); gill rakers on first arch 2 + 16 (2 or 3 + 14 to 16).

Greatest body depth 34.5 (32.6 to 35.0); maximum body width 14.4 (13.6 to 14.9); head length 27.7 (27.0 to 29.8); snout length 8.9 (8.4 to 9.0); eye diameter 9.3 (9.2 to 11.0); interorbital width 10.4 (10.2 to 11.2); caudal peduncle depth 11.5 (10.9 to 12.2); caudal peduncle length 14.5 (14.1 to 17.6); pectoral fin length 20.3 (20.2 to 22.4); pelvic fin length 16.2 (16.7 to 19.7); caudal fin length 23.9 (21.0 to 27.0); predorsal distance 47.9 (48.1 to 54.1); preanal distance 50.9 (45.7 to 51.0); prepelvic distance 38.3 (34.6 to 38.7).

Body ovate, laterally compressed, the snout somewhat pointed. Predorsal profile straight, the interorbital and adjacent nape flattened. Ventral, prepelvic profile rounded, the breast strongly compressed at ventral midline.

Jaws oblique, approximately equal; premaxilla with an abrupt bend between the anterior horizontal portion and lateral part; rear edge of maxilla about level with front of eye; lips thin; both jaws with dense covering of teeth arranged in irregular rows; teeth conical with slightly curved tips; teeth on anterior and lateral portions of premaxilla invading lips and distinctly visible when mouth is closed; exposed teeth also visible at front of lower jaw; vomer with narrow band of villiform teeth in 1 or 2 rows; palatines with similar teeth arranged in a single row.

Scales relatively large, arranged in regular horizontal rows; scales with smooth to scalloped margins; predorsal scales extending to rear of interorbital; preopercle-suborbital scales in two rows.

First dorsal fin originates about level with or slightly behind anal fin origin; first spine 2-3 times thickness of other spines of first dorsal fin; third spine the longest, its tip reaching base of about third soft ray of second dorsal fin when depressed. Last 2 or 3 soft rays of second dorsal fin the longest in males, anterior rays the longest in females; depressed tip of second dorsal fin extending nearly to caudal fin base in adult males and about half to two-thirds length of caudal peduncle of females. Anal spine slightly shorter than first dorsal spine which is about half head length; longest rays of anal fin in posterior part of fin in males and anterior portion in females; dorsal and anal fins with rectangular outline, pointed posteriorly with elongated rays in males; pectoral fins pointed; pelvic fin tips when depressed extending to about base of second or third soft anal ray; caudal fin moderately forked.

Colour in alcohol: light brown on upper back, yellowish-tan on ventral half; a brown stripe, slightly more than one scale wide at its broadest point, extending along middle of side from rear edge of eye to base of caudal fin; fins primarily tan with some dusky brown pigmentation; a brownish spot frequently present at base of upper pectoral rays. Live coloration is unknown.

Comparisons

Melanotaenia misoolensis is most closely allied to *M. catherinae* (Beaufort 1910), which is endemic to Waigeo, a large island lying approximately 160 km north of Misool. Both species are similar in colour; however, the mid-lateral stripe of *M. catherinae* is significantly wider, having a maximum width of about three scales compared with 1½ scales for *M. misoolensis*. Moreover, the mid-lateral stripe of *M. misoolensis* is nearly covered entirely by the pectoral fin, whereas it is broadly exposed (at least one scale row) above the pectoral fin of *M. catherinae*. In addition, the latter species lacks the dusky spot on the fin membrane behind the last dorsal spine and has a dusky soft dorsal fin which is often blackish in adult males. *Melanotaenia misoolensis*, in contrast, has a dusky spot behind the last dorsal spine and the soft dorsal fin is pale, possibly yellowish in life. The only meristic difference noted is related to counts for the soft anal rays. *Melanotaenia misoolensis* usually has 22 to 25 rays (one specimen with 20 rays) compared with 19 to 21 rays for *M. catherinae*. Comparative material included 35 specimens (ZMA 103.145, paralectotypes), 37-72 mm SL, of *M. catherinae*.

Remarks

The species is named *misoolensis* with reference to the type locality.

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Walled Rock Shelters and a Cached Spear in the Pilbara Region, Western Australia

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Abstract

In late 1977, our attention was drawn to walled rock shelters in the Pilbara Region of Western Australia where a spear was discovered behind an intact wall section. Although the age of the spear is not firmly established, we suggest that it is of post-contact origin. This paper considers walled rock shelters and their relationship to various other Aboriginal stone structures reported throughout Australia. We also describe the spear, and compare it to other pieces in the ethnographic collection of the Western Australian Museum. Finally, we suggest a possible use for walled rock shelters.

Background

In November 1977, Goldsworthy Mining Ltd personnel advised the Department of Aboriginal Sites, Western Australian Museum, that a spear and other pieces of wood had been discovered behind a man-made wall in a rock shelter on their mining lease. Subsequent investigation of the site led to the recovery of the spear and prompted search for further examples of stone walling.

Physical Setting

The vast accumulation of iron rich rocks is perhaps the best known feature of the Pilbara Region (Figure 1). At several locations these rocks are currently mined for export (Trendall 1974). One temporary mining reserve (Goldsworthy's Area 'C', also known as Packsaddle) straddles a low range (*c.* 800 m elevation above sea level) where, following uplift, erosion of cracks and joint planes has resulted in the formation of fissures, sink holes, tunnels, and small caverns. In section these latter features are usually plano-convex or flattened ovals, with the long axis aligned horizontally. Most of the gullies and steeper sided gorges contain several of these features.

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Tropical cyclones dominate the Pilbara climate with an average of two per year being recorded. They occur between December and March and result in about half the annual rainfall (average *c.* 250 mm). Summer thunderstorms and infrequent winter rains make up the remainder. Marble Bar, 225 km north of the study area and the closest settlement with adequate records, averages just less than five falls of rain greater than 20 mm per year. With daily high annual mean temperatures of 35.7°C, the humidity is correspondingly very low (Beard 1975). This semi-arid climate played a considerable part in the preservation of the spear discussed in this paper.

Within the research area, the vegetation can be characterized as tree steppe, dominated by the *Eucalyptus brevifolia-Triodia wiseana* association (Beard 1980). The lower slopes and the gullies contain riverine woodland flora, including *Eucalyptus camaldulensis, Acacia* spp., *Grevillea* spp., *Hakea* spp., etc., while valley plain habitats carry mulga formations (*Acacia aneura* low woodland).

Previous Research

A number of studies have focused upon the rock art of the Pilbara (Dix 1977; McCarthy 1962; McCaskill 1977; Virili 1977; Worms 1954; Wright 1968, 1977) and Palmer (1975, 1977*a, b, c*) has related aspects of rock art to ethnographic site data. In light of the discussion to follow, it is worth noting that spears are depicted in the rock art of the region (e.g. Wright 1968: 43, 62).

Studies into other aspects of the prehistory of the Pilbara Region include reports of archaeological sites in the Chichester Ranges (Dortch 1972), the Tom Price area (Bednarik 1977), and the Millstream area (summarized and reported in Clarke *et al.* 1978). These studies lack occupation dates and none mention the wooden artefacts of the region. Brown (1980) has analyzed stone artefact assemblages along a transect from coast to inland through the area, but once again without the benefit of dating. In addition, numerous unpublished surveys (Department of Aboriginal Sites, Western Australian Museum) further document the extent of prehistoric Aboriginal occupation in specific localities throughout the area. Maynard (1980) published the first radiometric date of 20,740 ± 345 BP (SUA 1041) for an inland site in the Pilbara (P0187, a rock shelter near Newman — Figure 1).

Tindale's (1974) map of tribal boundaries in Aboriginal Australia indicates that the site is within the territory of the Pandjima people. Population figures for this tribe are not available, but numbers around 500 are probably realistic given the semi-arid nature of this area (Radcliffe-Brown 1930: 688). Early ethnographic accounts (e.g. Withnell 1901) make no mention of walled rock shelters or spears of the type mentioned in this paper. Clement and Schmelz (1903) published ethnographical notes which include the first report of a spear of the type we describe in detail.

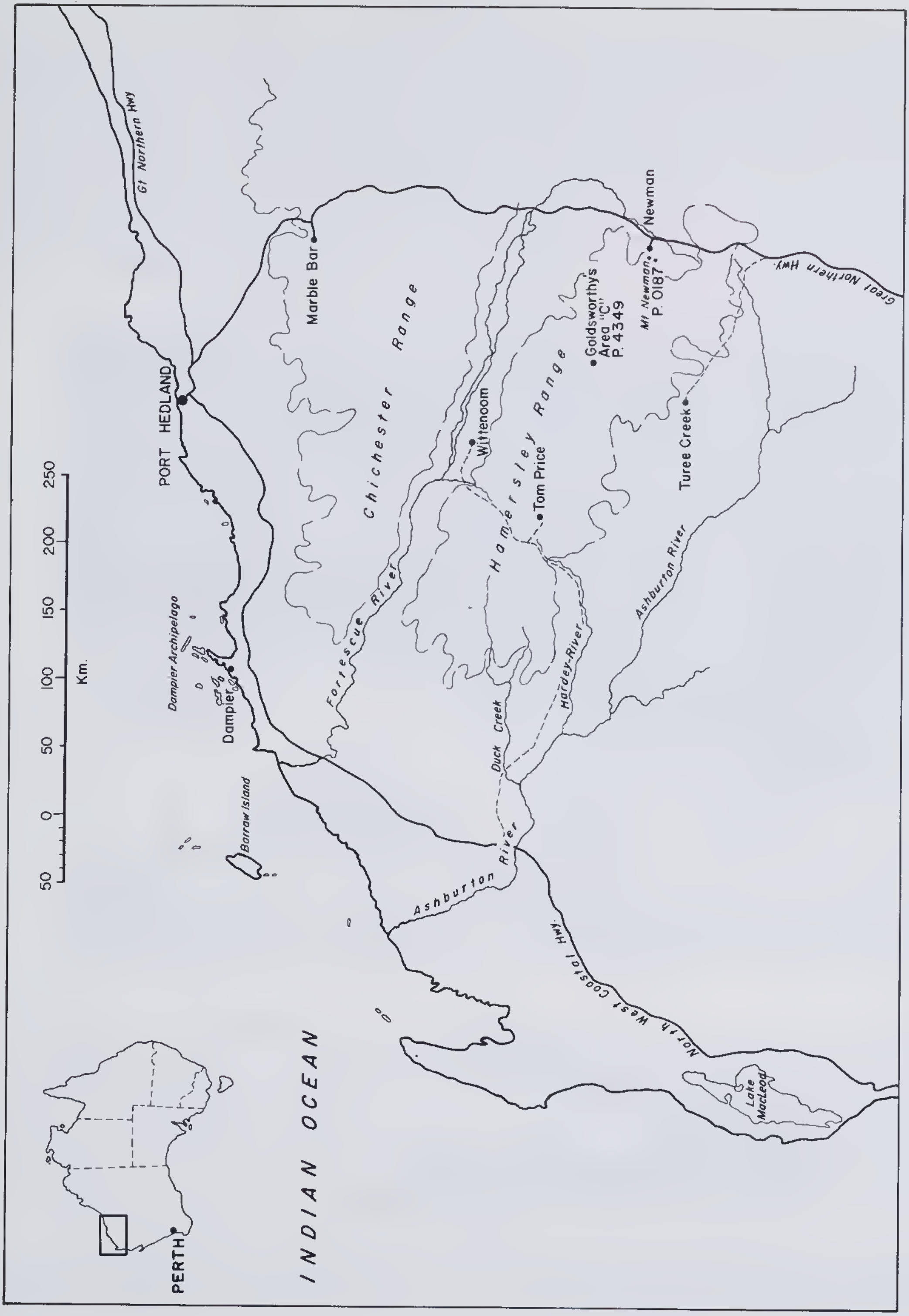

Figure 1 The Pilbara Region, Western Australia.

The Site

Located 105 km south-east of Wittenoom and 85 km north-west of Mt Newman, the rock shelter (P4349 – Figure 1) lies in a low ridge trending roughly east/west (22°59′S, 118°49′E). On this ridge, and on the adjacent plain, there are a number of other Aboriginal sites including artefact scatters, stone arrangements, and several other rock shelters, some containing dry-stone walling. The shelter described in this report faces south into a shallow but steep-sided gully (Figure 2). Other fissures, cracks and small shelters in the same strata also open into this gully. Except for stone walls and pieces of wood, none of them contain cultural material and none is large enough to provide shelter for humans.

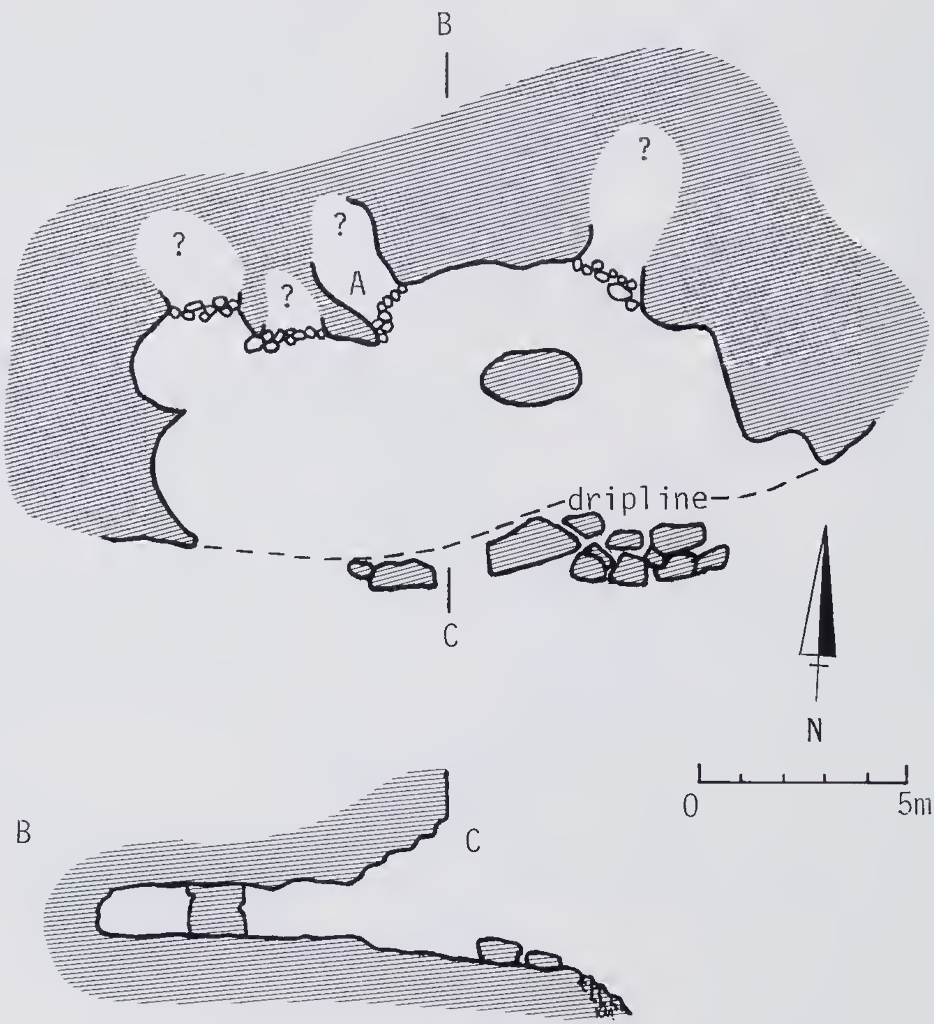

Figure 2 Sketch of floor plan and cross-section of walled rock shelter (P4349) in which the spear (A) was found.

Inside the rock shelter, all the passages at the rear and sides have been walled (Figure 3). These walls consist of flattish slabs (to 30 cm^3) of local rock, laid one slab wide, one on top of another, with random jointing patterns. Except where now broken down, the walls fill the whole space between floor and ceiling, and extend across the passages. It appears that these walls were not intended to completely seal the area enclosed behind them. In three cases, a naturally hollowed section of tree-trunk about 50 cm long and 10 cm internal diameter has been placed horizontally by the builder so as to penetrate the wall. The otherwise complete walls have one or two slabs omitted leaving an opening about 10 or 15 cm in diameter.

Figure 3 Stone walling techniques inside the rock shelter.

Behind the wall the floor is 40 cm higher than in the open part of the shelter. This enclosed floor is covered with fist-sized rocks fallen from the walls and ceiling of the shelter. It is littered with twigs and spinifex (*Triodia* sp.) leaf blades. The spear described later in this paper was lying on this surface when discovered. Some of this debris has entered the shelter through a small sink hole now choked with rubble. The walled section is too small to enter, and can only be examined from a prone position.

In a review of Aboriginal stone structures, Mountford (1940) proposed two major categories: cairn-like structures and piles of pebbles (pebble mounds). Withnell (1901: 5) mentions piles of stone with ceremonial functions. Neither of these two authors discuss walling. Kimber (1981) discusses a number of stone features including walling, but not within caves. However, stone-wall fish-traps are well known in Western Australia (e.g. Love 1936: 138), and Worsnop (1897: 108) describes walls across small gullies in the Kimberley. Stone circles, made by clearing a rocky area of stones which are then used to make a wall, have been found in the Pilbara, in other areas of Western Australia and in other places in Australia (e.g. McCaskill 1977: 184). Love (1936: 176) mentions small enclosures of stone in which dingo pups were confined. These walls, and other clearings found on rocky hillsides may have been used as hunting hides. They are in the open, not within rock shelters.

Commonly in the Kimberley and more rarely elsewhere, secondary burial chambers were constructed by wedging a few stone slabs across a suitable small crevice. Sacred material was sometimes stored in walled niches and these places marked in one way or another to warn the uninitiated not to endanger themselves by approaching too closely. The complete lack of human bone fragments or appropriate cultural material together with the absence of any of the usual markers, rules out the use of the walled shelters described here as either burial chambers or repositories.

The Spear

The spear (Figure 4) found in the walled niche, is now registered in the W.A. Museum collection as A23064. It is of composite form, 2.73 m in total length, with a single barb carved from the solid on the point section. This point (32 cm in length) appears to be made from *Acacia* sp., while the shaft (2.41 m in length) is a less dense wood of unknown genus. The spear point is affixed to the shaft with gum and sinew, and the shaft has been treated with fat and ochre at some time in the past. A crack in the main shaft has been repaired in the Museum, but no attempt has been made to straighten the curvature which has occurred due to warping. The spear weighs *c.* 300 g, and its point of balance is located 0.44 of its total length from the tip of the spear head.

Scorch marks appear on the shaft, suggesting the usual practice of heating the wood during initial construction for the purpose of straightening the shaft and to assist bark removal (e.g. Hayden 1979: 75). There is also a small scorch mark at the barb suggesting that the barb's angle of deviation from the main body of the spear head (*c.* 25°) may have been adjusted by heating. The length of the barb is 42 mm and the vertical distance from the point of the barb to the adjacent spear shaft is 15 mm.

Recently the head of a spear of this type, detached from its shaft, was found in a Pilbara rock shelter and donated to this Museum (WAM A23494, Figure 5). Although the tip and barb area is mostly lost, enough remains to indicate that again the barb was carved from the solid near a knot as in the case of the recently discovered specimen. This spear head has a series of about 30 oblique cuts running

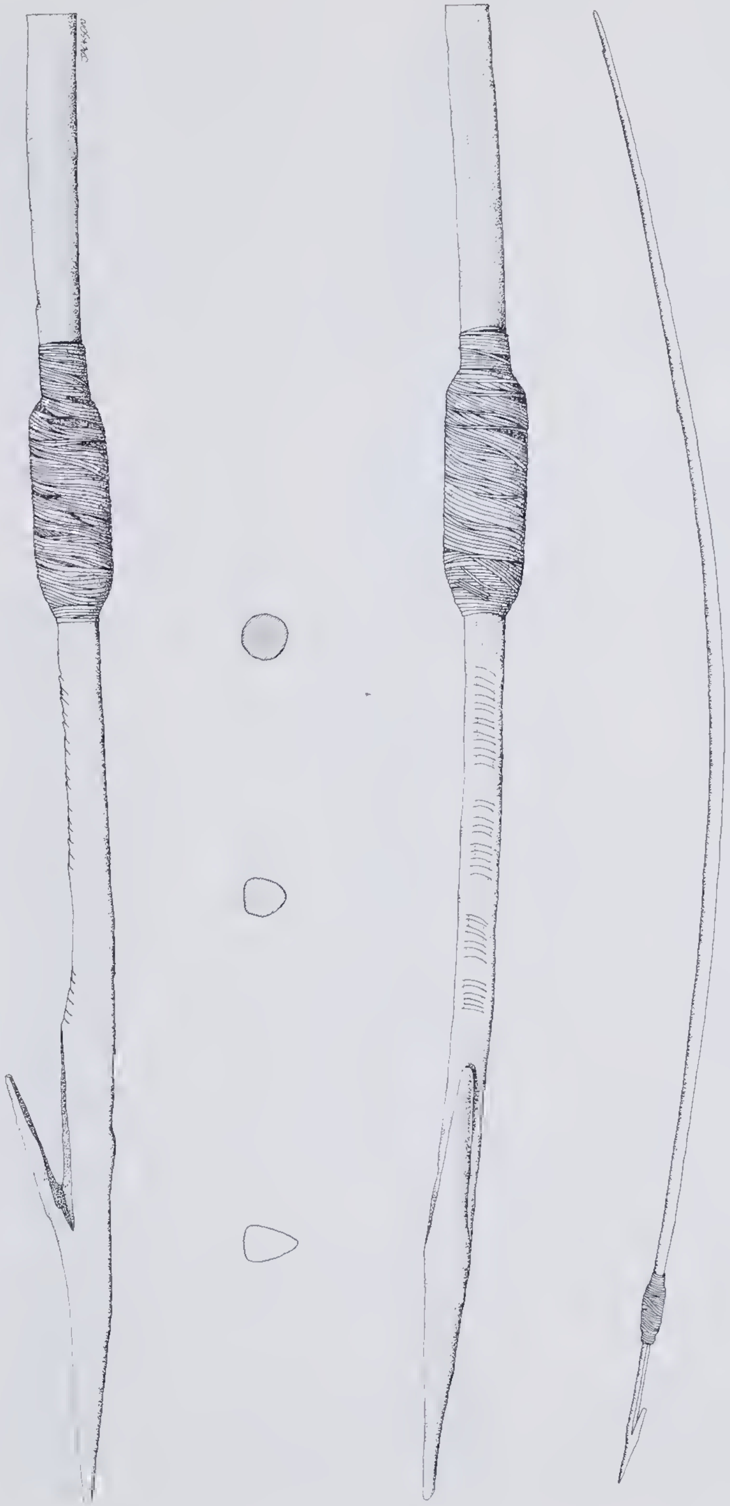

Figure 4 A23064 – the spear discovered in the rock shelter. Length = 2.73 m.

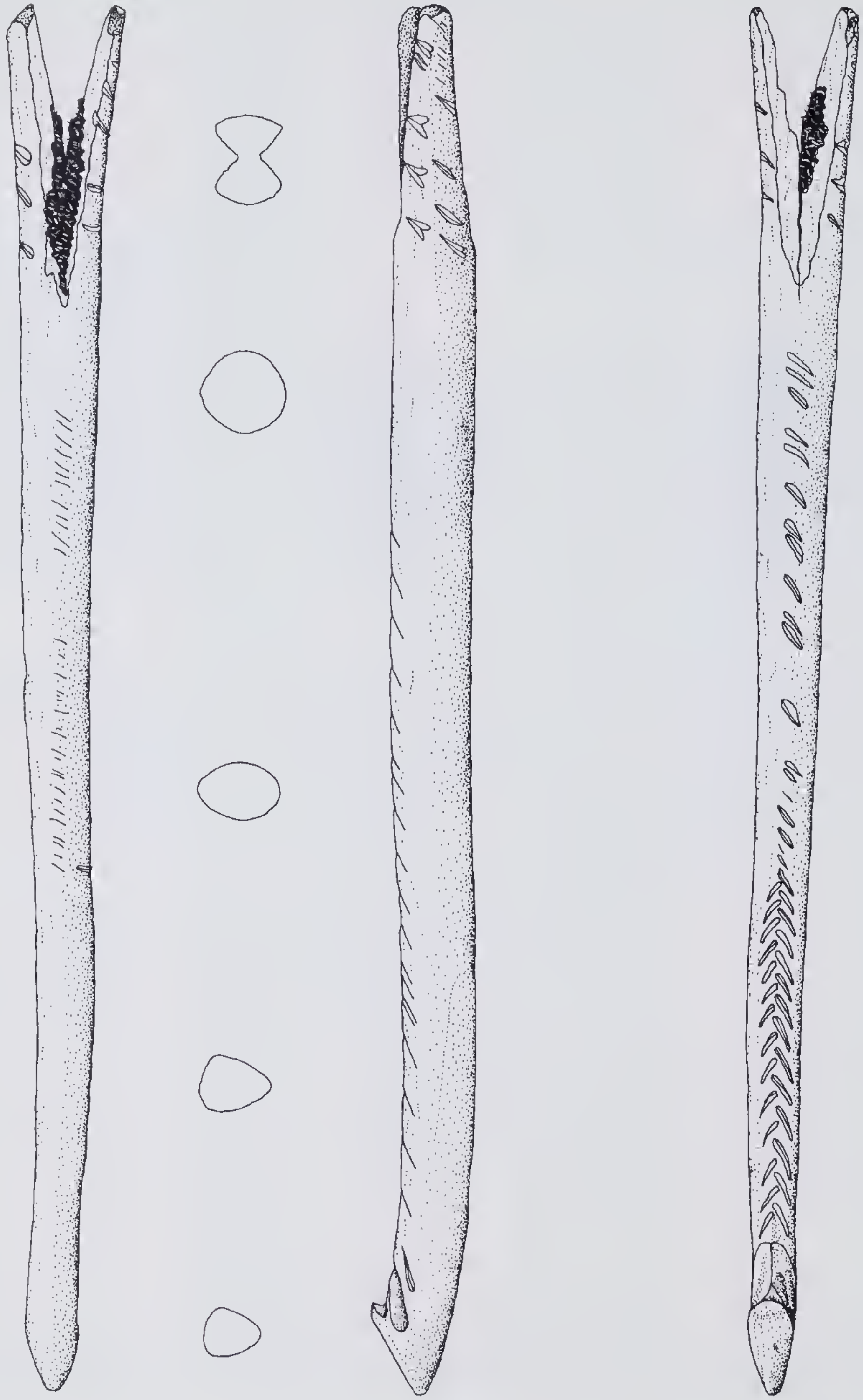

Figure 5 A23494 – head of a similar spear. Length = 24.8 cm.

along the barb side for 16 cm. Near the barb another group of 14 similarly shaped cuts join the longer series to produce a group of 'V' shapes. Both series of cuts have been produced with a thin metal blade. On the other side of this artefact is a further series of about 35 somewhat indistinct cuts three millimetres long and less than one millimetre wide. The ends and edges of these have been partly smoothed during the manufacturing process or perhaps at a later stage. Similar cuts appear on the shaft of another spear of this type in the WAM collection (A343, Figure 6) but not on other points which we have examined. We conclude that at least some of these cuts were produced during thickness reduction or paring when very short shavings were being taken from the shaft in places where long shavings might split off a wooden splinter of greater thickness than was required. We have observed this practice in contemporary Western Desert communities.

A very neat binding of tail sinew from *Macropus* sp. extends for 72 mm over the resin-cemented joint between the head and shaft of the spear found in the cave. A similar spear head (WAM A23455, Figure 7) which has been sawn from its shaft is less carefully spliced and exhibits part of the deep 'V' shaped notches used to interlock the head and shaft of such spears (Clement and Schmelz 1903: 5). This example has a rag strip binding the cemented join, but all other similar spears in the Western Australian Museum collection have sinew bound splices.

The splicing method can be clearly seen on a point removed from the shaft (Figure 5). The 'V' form of the grooves used to produce a strong joint between head and shaft is quite evident. A small patch of spinifex resin can still be seen deep in the cleft. This resin has been used to cement the point to the shaft in the first step of hafting. About ten oblique cuts on each of the horns of the splice were provided apparently to offer a more secure attachment for the resin cement. This method is at variance with that described by Clement and Schmelz (1903: 5) in which the splice is first bound together with sinew and then covered with resin.

On A2304, the spear found behind the wall, there are 35 shallow cuts on one side of the spear head, extending from the point of the barb back towards the butt. These average 1 mm wide and 5.6 mm in length. Comparative examples have cuts in a similar position, but the patterns vary (cf. Figures 4-7). These cuts are not the same as those used for thickness reduction. They serve no obvious function, but perhaps parallel the practice of identification marks and good luck tokens better known from the Western Desert (Douglas 1977: 20).

This spear shaft (A23064) appears to have been carefully finished by scraping most of the surface with either stone or glass scrapers. Many of the branches along the shaft have been broken off, while others have been cut with a sharp tool. The shape of the notches on the spear head indicates the use of a metal implement. In addition, some thinning of the shaft has been undertaken by slicing long thin slivers of wood rather than by shaving and scraping, the actions performed by stone tools. Although metal tools could have arrived in this part of the State 130 years ago, or even earlier if Dutch East India Company shipwrecks provided

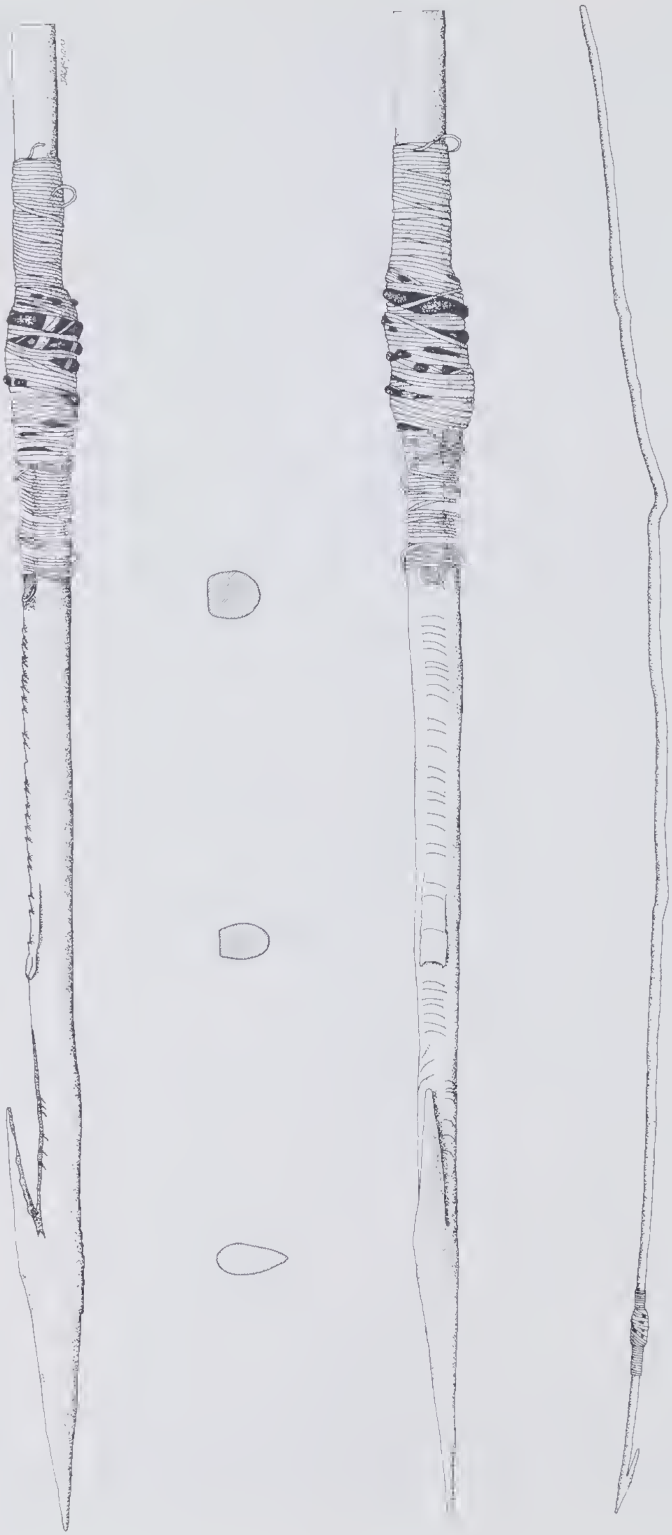

Figure 6 A343 – a similar spear from the same area now in the WAM collection.
Length = 3.5 m.

Figure 7 A23455 – a similar spear head from the WAM collection. Length = 34.3 cm.

artefact metal, we consider that the use of metal tools on this spear suggests it was made between 60 and 100 years ago.

A barb (WAM A23456) broken from a spear (similar to A23064) is illustrated in Figure 8. This barb, found adjacent to an adze flake with gum adhering (Bindon: in prep.) on the floor of a rock shelter, about 3 km from the walled shelter, along with the discovery of point A23494 confirms the use of barbed spears until relatively recently in this area.

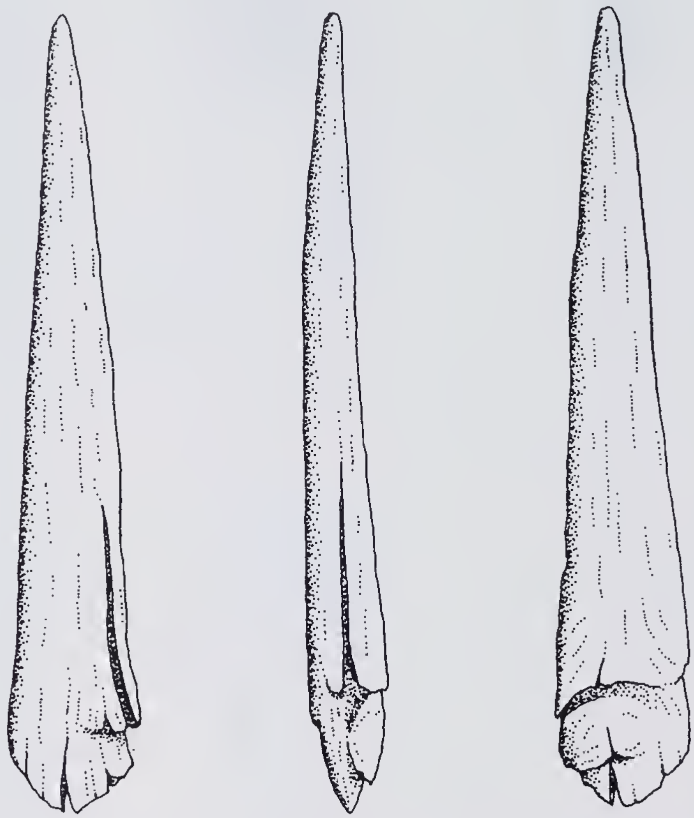

Figure 8 A23456 – the barb discovered in an adjacent rock shelter. Length = 48 mm.

Taking this and all the environmental factors into account, we consider that even in this arid climate and partially protected location, the preservation of wood for more than a century is unlikely.

Comparison with other spears in the literature (Clement and Schmelz 1903; Davidson, 1934, 1936; Gould 1970) and in the collection of the Western Australian Museum suggest that while well known, this type of spear is not the most common form collected from the Pilbara Region. Comparative measurements on a similar spear in the WAM collection (A343 – reference location 'North-West', *c.* 1902, Figure 6) show that the walled-in spear is shorter and lighter than others of its type, and is more carefully finished.

The functional nature of the recently discovered spear as determined by the criteria discussed by Palter (1977) is of interest. The length of the spear lies close to the mean of his hand-thrown sample (2.73 m vs. 2.66 m). However, the mass of this spear (*c.* 300 g) lies much closer to the mean mass of spear thrower projectiles (246.3 g) than to hand-thrown spears (740.0 g). Similarly, the point of balance (0.44) is in the region of overlap between hand-held and spear thrower projectiles. The lack of a functional indentation on the butt of the spear argues for its being a hand-thrown projectile, but it appears to be at the morphological extreme of the range of such weapons. In his study of Pilbara rock art, Wright reports spears similar to that which were described (1968: 43, 62 and Figures 1, 44, 764). None of these are being thrown or thrust by hand although future discoveries may reveal such an example.

Discussion

Ethnographic accounts of Aboriginal life in the Pilbara contain no references to walled rock shelters. In part, this reflects a lack of field observation; few early writers ventured far from the immediate environs of the white settlements. Perhaps also at the turn of the century when these writers were active, some of the traditional exploitative activities of the Aborigines were being abandoned. C. and A. Clarke (in prep.) have obtained a number of contemporary Aboriginal accounts concerning the utilization of rock shelters, including walling, as described to them by descendants of the original inhabitants of the region.

We conclude that fissures and niches were walled to encourage habitation by small game and perhaps to aid in making their capture more certain. In our interpretation the walls can be regarded both as a hunting device and as a strategy to increase the resource potential of the area.

Most of the small shelters and openings were too small for human habitation, but were easily modified with small walls to provide a large number of safe habitats for various animal species. Mammals like rats (*Rattus* sp.) and possums (*Trichosurus* sp.) as well as reptiles like pythons (*Aspledites* sp.) and goannas (*Varanus* sp.) are the most likely occupants of such environments based upon considerations of both size of apertures left in the walls and the known species for the area. The provision of passages either by the insertion into the wall of a suitable length of hollow tree-trunk, or by simply omitting to wall a niche completely suggests that access was deliberately provided. If entry to these places was being denied, then the walls would have been complete. The walls, with restricted entry passages provided an expanded safe habitat into which the invading species population was allowed to grow quickly to the carrying capacity that the niche afforded (Odum 1969: 182 ff). As a hunting strategy, the practise we describe is similar to that of placing hollow logs in streams to exploit later whatever occupant takes residency (Roth 1901). After providing an environment, the hunter leaves the area for some time allowing the animal to move in. Sometime later, the wall is broken down and any resident animals taken for food before the wall is rebuilt, providing opportunities for the remaining population to again expand into the area.

There are seven stone arrangements and numerous large surface campsites in close proximity to the low ridge which holds most of the walling discovered in this area. The concentration of stone arrangements suggests that at some stage in the prehistory of this area, large numbers of people gathered to participate in ceremonies. Such increase in density of the human population would place considerable pressure on food resources, and we suggest that this may account for the large number of walls scattered through the area. The walled shelters both increased the number of animals available and made their location more certain. There is no suggestion that the type of resource management described here would have the same importance that Bunya nuts had in the Queensland forests (Petrie 1904: 11), or Bogong moths in the Australian alps (Flood 1980). The scale of involvement is clearly at a lower level, and may suggest a correspondingly small population involved in any activities in this area.

Some of the walls found following the initial discovery had more than half their length broken down, especially the more obvious large walls. This destruction allowed sufficient space to afford human access into the chamber behind. Whether this was done by Europeans or by Aborigines is not known; however, it seems most likely that they were pulled down by inquisitive investigators.

At this stage we are unable to account for the regional localization of the hunting technique which we have proposed.

The discovery of the typical Pilbara spear behind one of these walls in a rock shelter, indicates that the walls were constructed by Aboriginal people. The spear was placed so that the removal of only two or three of the wall slabs revealed its position; whoever built the wall was certainly aware of the presence of the spear. Aboriginal artefacts have always been considered as interesting souvenirs by white settlers and this specimen would have been removed by a European if it had been seen. We suggest that the spear was cached behind the wall by the Aboriginal builder of that structure. There seems to be no further connection between these two examples of Aboriginal technology. This spear is an excellent example of one of the Pilbara spear types and is well provenanced, providing an excellent type specimen.

Aboriginal man used numerous contrivances and techniques in his hunt for game. Nets, brush fences, pit-traps, and various ambush techniques were used throughout Australia. If our assessment is correct, the technique proposed in this paper expands the range of hunting methods and underlines yet again the diverse resourcefulness of Aboriginal exploitation of the environment.

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A New Species of *Acanthistius* (Pisces: Serranidae) from Eastern Australia

J.B. Hutchins* and R.H. Kuiter†

Abstract

A new species of serranid fish *Acanthistius paxtoni,* is described from New South Wales. It is closely related to *A. cinctus* (Günther), also from eastern Australia, but is separable on the basis of colour pattern and scalation. Morphological and coloration discrepancies also distinguish it from the Easter Island species *A. fuscus* Regan, an apparent close relative previously assumed to be synonymous with *A. cinctus.*

Introduction

Australian members of the Southern Hemisphere serranid genus *Acanthistius* inhabit inshore and offshore warm temperate reefs in depths ranging from the intertidal zone to at least 64 m. They are distinguished from other Australian serranids by possessing 13 dorsal fin spines and 99 or more vertical scale rows above the lateral line. In a recent paper describing a new species of *Acanthistius* from Western Australia (Hutchins 1981), four Australian species were recognized: *A. cinctus* (Günther, 1859) and *A. ocellatus* (Günther, 1859) from eastern Australia, and *A. serratus* (Cuvier, 1828) and the new *A. pardalotus* from Western Australia. The four species are morphologically similar and best separated by their diagnostic colour patterns. The most distinctively marked is *A. cinctus* with its well defined body bars. The other three species possess spotted and/or blotched colour patterns. The present paper describes a new barred species of *Acanthistius* from New South Wales and compares it with the closely related *A. cinctus.* It is also contrasted with *A. fuscus* Regan, 1913 from Easter Island because of a previous report (Randall 1976: 336) that *A. cinctus* and the Easter Island species may be synonymous.

Measurements were made as in Hutchins (1981). Both type specimens are housed at the Australian Museum, Sydney, hereafter abbreviated AM. Other abbreviations used are BMNH – British Museum (Natural History), WAM – Western Australian Museum and SL – standard length.

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Systematics

Acanthistius paxtoni sp. nov.

Figure 1; Table 1

Holotype

AM I.21555-001, 204 mm SL, collected by fish trap at Seal Rocks, New South Wales (32°26′S, 152°32′E) at 64 m, R.H. Kuiter, 25 May 1980.

Paratype

AM I.16997-001, 258 mm SL, Watsons Bay, Sydney Harbour, New South Wales (33°51′S, 151°17′E), no other data.

Figure 1 *Acanthistius paxtoni* sp. nov., holotype, AM I.21555-001, 204 mm SL.

Diagnosis

This species is placed in the genus *Acanthistius* on the basis of the 13 dorsal fin spines and the large number of vertical scale rows above the lateral line (99 or more). Within *Acanthistius, A. paxtoni* is distinguished from other Australian members on the basis of its distinctive colour pattern of six poorly defined dark cross bars on the body and the numerous pale wavy lines on the head and body (brownish-orange in life), which may break up into spots. It is easily separated from *A. cinctus,* the only other species which possesses body cross bars, by the absence of wavy lines on the body of the latter species (see Hutchins 1981, Figure 1a). Also, the scales on the operculum and upper half of the preoperculum are cycloid in *A. paxtoni* and ctenoid in *A. cinctus*. *A. paxtoni* differs from the Easter Island species, *A. fuscus,* in colour pattern (*A. fuscus* possesses no body bars or pale wavy lines), in its longer caudal peduncle (caudal peduncle depth 1.4-1.7 in its length, 1.0 for *A. fuscus*), as well as the condition of its opercular and preopercular scales (*A. fuscus* possesses ctenoid scales).

Description

Measurements of the holotype and paratype are presented in Table 1. The following counts and proportions of the paratype are in parentheses when differing from those of the holotype.

Dorsal rays XIII, 15; anal rays III, 8; pectoral rays 18 (19); lateral line pores to caudal base 51 (53); vertical scale rows from upper origin of gill opening to base of caudal fin 114 (111); scales in diagonal row from upper origin of gill opening to base of first dorsal spine 26 (28); scales in diagonal row from origin of first anal spine to lateral line 50 (57); gill rakers (including rudiments) on lower half of first gill arch 14 (16).

Greatest body depth 2.6, head length 2.3 (2.4), snout to origin of dorsal fin 2.6, lower lip to origin of anal fin 1.3, postorbital length of head 3.9 (4.0), length of spinous dorsal base 3.0, length of soft dorsal base 4.5 (4.6), all in

Table 1 Measurements in mm of the type specimens of *Acanthistius paxtoni.*

	Holotype AM I.21555-001	Paratype AM I.16997-001
Standard length	204	258
Head length	87	109
Snout length	22	27
Eye diameter	17	19
Interorbital width	11	14
Postorbital length of head	52	65
Greatest depth of body	78	98
Least depth of caudal peduncle	25	30
Length of caudal peduncle	35	50
Snout to origin of dorsal fin	78	100
Lower lip to origin of anal fin	155	199
Length of spinous dorsal base	69	87
Length of soft dorsal base	45	56
Length of pectoral fin	51	61
Length of pelvic fin	40	48
Length of longest dorsal spine	27	33
Length of longest dorsal ray	35	37
Length of longest anal spine	30	35
Length of longest anal ray	40	50
Length of caudal fin	45	52

standard length. Snout 4.0, eye 5.1 (5.7), least width of bony interorbital 7.9 (7.8), least depth of caudal peduncle 3.5 (3.6), length of caudal peduncle 2.5 (2.2), length of pectoral fin 1.7 (1.8), length of pelvic fin 2.2 (2.3), length of longest dorsal spine (fifth) 3.2 (3.3), length of longest dorsal ray (third) 2.5 (2.9), length of longest anal spine (second) 2.9 (3.1), length of longest anal ray (fourth) 2.2, length of caudal fin 1.9 (2.1), all in head length.

Interorbital space slightly convex; maxilla reaching level below posterior half of eye; opercle with three spines, middle spine much closer to lower than upper one; opercular flap pointed; preopercular margin rounded, upper limb coarsely serrate (lowermost serration somewhat larger than rest and directed downwards), three to four strong recurved spines on lower limb (both specimens have one bifid spine), increasing in size anteriorly; scales on body and dorsal surface of head mostly ctenoid, those on sides of head and ventral surface of body cycloid; predorsal scales extend to posterior nostrils; outer row of small conical acute teeth in both jaws, and an inner band of villiform teeth separated at the symphysis (some symphysial teeth in upper jaw more cardiform); a V-shaped band of villiform teeth on vomer and a band of similar teeth on each palatine.

Colour of holotype in alcohol: ground colour greyish-brown with six poorly defined dark cross bars on body; numerous indistinct pale wavy lines on upper half of body, extending somewhat obliquely towards dorsal fin base; two indistinct broad dark bars radiate from posterior half of eye, upper reaching almost to uppermost opercular spine, lower to above angle of preoperculum (an extension of upper bar continues from front edge of eye to snout tip); spinous dorsal, pelvics and inner surface of pectorals dark brown, other fins greyish-brown; with the exception of the spinous dorsal, all fins are bordered distally by a narrow pale line. The colour of the paratype is similar to the holotype with the following exceptions: pale wavy lines on body more distinct and more numerous (about 10-11 on mid-body), those on upper two-thirds of body extending obliquely to dorsal fin base, those on lower third breaking up to spots; pale lines radiate irregularly from posterior half of eye; all fins dark brown.

Colour in life (based on a colour transparency of the freshly caught holotype, see Figure 1): head and body pale greyish-brown with many brownish-orange wavy lines, those on upper half of body extending obliquely to dorsal fin base and breaking into spots posteriorly, those on lower half also contracting to spots; lines on head radiate irregularly from posterior half of eye; body with six poorly defined dark cross bars, first from base of first dorsal spine to opercular flap, last across base of caudal fin; two indistinct broad dark bars radiate from posterior half of eye, upper one almost to uppermost opercular spine, lower to above angle of preoperculum; snout and dorsal surface of head dark brown with indications of brownish-orange spots; upper portion of maxillary groove with a dusky to brownish-orange streak; throat and breast pinkish-grey; all fins dusky, the dorsal and pectorals with irregular faint brownish-orange markings; with the exception of the spinous dorsal, all fins possess narrow pale distal borders.

Remarks

Acanthistius paxtoni is so far known only from two localities in New South Wales, Seal Rocks to the north of Newcastle, and Watsons Bay in Sydney Harbour. Its absence from intertidal rock pools, a habitat utilized by the juvenile stages of all other Australian *Acanthistius* species, suggests that this serranid is restricted to deeper reefs. Further collecting in this habitat will probably yield additional specimens from other areas along the New South Wales coastline.

Acanthistius cinctus, known from New South Wales, northern New Zealand, Lord Howe, Norfolk and the Kermandec Islands is closely related to *A. paxtoni.* Both are morphologically similar to *A. fuscus* from Easter Island, although the latter species lacks the body cross bars characteristic of the former two. Unfortunately the present shortage of specimens of both *A. paxtoni* and *A. fuscus* precludes any detailed analysis of this relationship.

This species is named after J.R. Paxton, Head of the Department of Ichthyology at the Australian Museum, Sydney, in honour of his contributions to Australian ichthyology.

Additional Material Examined

In addition to the material listed in Hutchins (1981), the following specimens were studied. *Acanthistius cinctus:* AM I.18497-012, 4 specimens, 92-218 mm SL, Emily Bay, Norfolk Island, 16 September 1975; AM I.10699, 320 mm SL, Lord Howe Island. *Acanthistius fuscus:* BMNH 1913.12.7.1, holotype, 180 mm SL, Easter Island, April 1911.

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Distribution, Status and Variation of the Silver Gull *Larus novaehollandiae* Stephens, with Notes on the *Larus cirrocephalus* species-group

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Abstract

Data on distribution, seasonal dispersal, colour of unfeathered parts and plumage stages are given for the Silver Gull (*Larus novaehollandiae*). Geographic variation within the species is analysed. Three subspecies are recognized, *L. n. novaehollandiae* Stephens of Australia (including Tasmania), *L. n. forsteri* (Mathews) of New Caledonia, and *L. n. scopulinus* Forster of New Zealand. Hartlaub's Gull (*Larus hartlaubii* Bruch) of south-western Africa is treated as a full species. The *Larus cirrocephalus* species-group comprises four species of grey-headed and white-headed gulls from the Southern Hemisphere, *L. cirrocephalus* Vieillot, *L. hartlaubii*, *L. novaehollandiae* and *L. bulleri* Hutton.

Introduction

In his monograph on the world's gulls, Dwight (1925) recognized five subspecies within the Silver Gull: *Larus n. novaehollandiae* from the coasts, islands and lakes of southern Australia north to Bernier Island in the west and the Five Islands in the east; *L. n. gunni* Mathews of Tasmania; *L. n. forsteri* of New Caledonia and coastal northern Australia from Port Darwin east and south to the Capricorn group; *L. n. scopulinus* of New Zealand; and *L. n. hartlaubii* of south-western Africa.

Although Dwight was hampered by a shortage of specimens and data on soft parts etc. his treatment of the Silver Gull has remained virtually unchanged to the present day. Peters (1934) followed Dwight and recognized all five of his subspecies. Condon (1975) recognized only two instead of three subspecies for the Australian region: *L. n. novaehollandiae* for Tasmania and Australia except northern Queensland, and *L. n. forsteri* for the south-west Pacific from New Caledonia west to Torres Strait and south along the eastern coast of Queensland to Mackay.

The main purpose of this paper is to examine geographic variation in Australia and to see if it can form the basis for the recognition of subspecies. To put the Australian variation in perspective it has been necessary to examine overseas populations of the Silver Gull and closely related species.

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Two terms used in the descriptions may need explanation. 'Mirrors' are the white areas towards the end of the primaries occurring on both webs of the first, second and in some cases the third primary (see Figure 1). 'Tongues' are the elongate areas of white or grey extending for variable distances from the bases of the primaries, usually on the outer web, sometimes on both. The primary wing patterns of gulls provide one of the most important characters used to classify them. For the purpose of this paper the primaries are numbered from the outermost inwards.

Movements are based on Carrick *et al.* (1957) and an analysis of recovery records in the *Corella* and its predecessor (*Australian Bird Bander*).

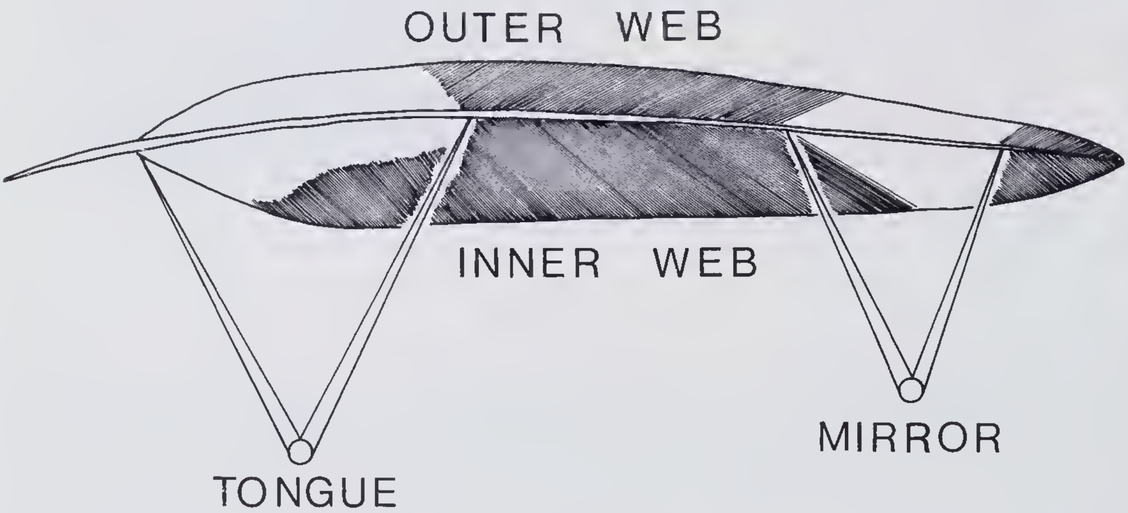

Figure 1 Primary feather showing mirror and tongue.

Materials and Methods

Two-hundred and three Silver Gulls (*Larus novaehollandiae*) held in the Western Australian Museum, South Australian Museum, National Museum of Victoria, Australian Museum, Queensland Museum, Australian National Wildlife Collection, Tasmanian Museum, Queen Victoria Museum (Tasmania), Dominion Museum (New Zealand), and American Museum of Natural History were examined in addition to 30 specimens of Hartlaub's Gull (*Larus hartlaubii*) and 50 specimens of the Grey-headed Gull (*Larus cirrocephalus*) from the British Museum, Durban Museum, Transvaal Museum, and East London Museum.

Measurements of specimens were taken as follows: length of chord of flattened wing; length of tail (along a central rectrix); length of tarsus; length of entire culmen; and bill depth at the gonys (measured vertically from point of inflection on the lower mandible to upper edge of premaxilla). The white outer bar (mirror) on the primaries was measured along the shaft on each web or vane (see Figure

1). The length of white at the base of the first three primaries (tongue) was measured along the shaft on each vane (see Figure 1), and the length of black on the fourth primary was measured from the tip to the white tongue on the outer web.

Data on unfeathered parts were taken from labels unless otherwise stated.

Variation in the Silver Gull

The Australian, New Caledonian and New Zealand populations of the Silver Gull are treated under the following geographic regions: (1) Tasmania, (2) New South Wales, (3) Victoria, (4) South Australia, (5) Archipelago of the Recherche (Western Australia), (6) Albany to Perth (Western Australia), (7) Fisherman Islands to Houtman Abrolhos (Western Australia), (8) Shark Bay to Exmouth Gulf (Western Australia), (9) Barrow Island to Broome (Western Australia), (10) Northern Territory, (11) Queensland, (12) New Caledonia, and (13) New Zealand. This facilitates comparison of the more distinctive populations, and data on soft parts and movements are more easily discussed.

(1) Tasmania

The Silver Gull is common on all coastal waters around Tasmania. It penetrates well up the major rivers and also occurs on the lakes in the Central Highlands. The breeding distribution is mapped in Figure 2.

Tasmanian birds differ from all other Australian populations in having the greatest amount of white on the primaries (on both tongues and mirrors), especially on the third primary (see Tables 1, 2 and Figure 7). Females (and in some measurements males) are slightly larger than birds from Victoria, New South Wales and South Australia (see Table 4).

Primaries in Adults

The first or outermost primary is usually tipped black and is black over most of the lower basal portion of the feather. In some birds a white tip is followed by a black bar. There is a long white mirror the full width of the feather near the tip (see Table 1) and a white tongue at the base of the feather on each web. The shaft is in most cases black through the black portions of the feather and white through the white.

The second primary is similar to the first, usually having a black tip and a large, white, subterminal mirror. The tongue is more extensive on both webs, being broader and longer (often one-third to half the length of the feather). The shaft is black in the small black portion near the tip and the remainder, in most cases, white.

The third primary is usually tipped white, followed first by a black bar, then by an irregular-shaped white mirror often continuous (especially on the outer web)

Figure 2 Map of Tasmania, King I. and Furneaux Group, showing location of breeding sites (circles) and specimens studied (dots).

with the broad, long white tongue (see Table 3). The shaft is white except through the black tip.

The fourth primary has a white tip, a black bar and black inner margin grading into grey and white on the outer web. There is less terminal black than in mainland birds; length of black averages 25 mm in males and 24 mm in females, compared to 33 mm and 32 mm in Victorian birds (see Table 3).

The fifth primary is similar to the fourth but the grey portion is decidedly greater. The remaining primaries are grey, slightly darker than the secondaries, with a blackish margin near the tip on the inner web (most noticeable on the sixth); the shafts are also grey.

Compared to other Australian populations Tasmanian birds are easily recognized by their large wing mirrors, with the mirror on the third primary often confluent with the white tongue. One adult male from Trumpeter Bay, Tasmania, has continuous white (i.e. tongue joins mirror) on first, second and third primaries, resembling closely the wing pattern of *Larus bulleri* of New Zealand.

Non-adult Plumages

Downy chicks are mottled buffy-grey to blackish-brown above and whitish-grey below. Young up to six months of age have small mirrors on the first and second primaries, and extensive light brown markings on the wing coverts and secondaries. They also have blackish-brown subterminal bars on all but the outer tail feathers. Immatures eight to ten months old still retain some brownish markings on the wings; the mirrors on the first three primaries are smaller than in adults (in some specimens there is no mirror on the third); the remaining primaries and the secondaries have broad blackish-brown subterminal bars.

Unfeathered Parts

In young up to six months of age, the bill is described on labels as black, the iris blackish-brown and the legs grey. In immatures the bill is red-brown (darker terminally) and the iris dark to white. Adults have the bill described on labels as red, vermilion-red or orange-brown; the iris white; the orbital ring red; the legs and feet cadmium red, red or orange-brown.

Movements

Two banded Tasmanian birds have been recovered in South Australia 950 km to the north-west. Tasmanian birds have been collected in Victoria and New South Wales.

(2) New South Wales

The Silver Gull is common in coastal New South Wales and is found on many islets and lakes along or near the coast. The breeding distribution in New South Wales is mapped in Figure 3.

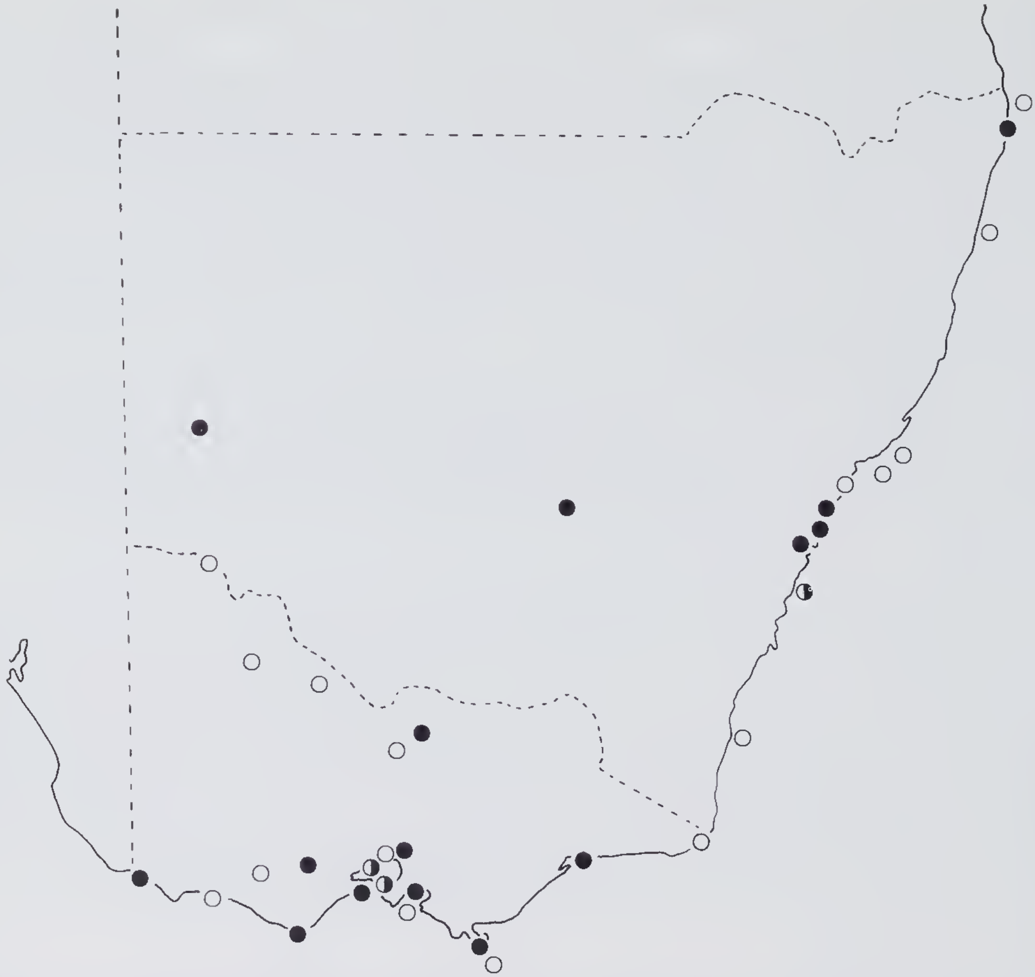

Figure 3 Map of New South Wales and Victoria showing location of breeding sites (circles) and specimens studied (dots).

In size, birds from this region match fairly well with Tasmanian specimens (see Table 4), but on average are slightly shorter in the bill in both sexes. In coloration, birds from New South Wales differ from Tasmanian birds in having reduced white on the first four primaries, in both the mirrors and the tongues.

Primaries in Adults

The first primary has little or no white tongue, and the mirror is often margined with black on the inner web. The second primary also has a narrow reduced white tongue (compared to Tasmanian birds) occupying a third to a half the length of the feather, and the mirror is often margined with black on the inner web. The third primary has a longer and broader white tongue (over half the length of the feather) than the first and second, but this is still shorter than in Tasmanian birds.

No New South Wales specimen has the tongue meeting the mirror on the third primary as in many Tasmanian birds. The mirror on the third primary is in most cases oval-shaped or a spot, margined on both webs with black. It is absent in three out of eight adult males (all three from the Sydney area) and in one adult female from Byron Bay. It is also reduced in several other females, being absent on the outer web in six out of eleven specimens and on the inner web in three out of eleven. The fourth primary has a shorter white tongue than in Tasmanian birds.

It is of interest that the specimens with reduced white on the primaries are all from north of Sydney, indicating a decline in the number of mirrors and the extent of the white tongues from south to north (see Discussion).

Two specimens in the Australian Museum (030270 from the Grant collection labelled Sydney Harbour, and 042134 from near Sydney) have wing patterns of Tasmanian birds. The second specimen is possibly a migrant from Tasmania, but the first (like much Grant material) is probably mislabelled.

Unfeathered Parts

These are similar to Tasmanian birds, except for some specimens with a dark reddish-black tip to the bill.

Movements

Birds banded in New South Wales have been recorded in Queensland, Victoria and the Northern Territory. In New South Wales banding has shown that there is an average dispersal of young gulls in their first summer for about 400 km northwards from the breeding colonies, with some travelling up to 800 km northwards. A few birds move south for varying distances up to 370 km but the main trend is northward. After the first winter there is much less movement with no recoveries more than 400 km from the place of birth, and the majority of recoveries and observations are within 80 km.

The movement in New South Wales is nearly entirely coastal, in contrast to Victoria and South Australia where many birds move inland. Some New South Wales birds do occasionally move inland as indicated by a bird from Five Islands which was recovered on Mt Ebenezer Station (160 km south-west of Alice Springs) in the Northern Territory.

(3) Victoria

The Silver Gull is common along the Victorian coastline and is more widely distributed inland than in any other State. The breeding distribution is mapped in Figure 3.

Many adult specimens from Victoria, New South Wales and South Australia have varying amounts of grey on the head and nape. In size and coloration Victorian birds match most specimens from New South Wales, but have on average, a little more white on the third primary (see Table 3).

Primaries in Adults

Eight out of the ten adults studicd have large mirrors on the first three primarics. One adult male and one female show no trace of a mirror on the third primary. Three out of six females studied have the mirror on the second primary margined with black.

The white tongue at the base of the first primary occupies up to one-third the length of the feather (on both webs); just over one-third the length on the second primary; and up to two-thirds the length on the third.

Unfeathered Parts

These are similar to New South Wales and Tasmanian birds, but no adults were noted as having dark tips to the bill. Most were recorded as scarlet.

Movements

As in New South Wales there is a general dispersal of young gulls of one to two years old in all directions to over 1200 km from the birthplace. There is then a retraction of birds back towards the birthplace and most recoveries of birds over two years old are within 80 km of their birthplace. A substantial proportion of young gulls do, however, remain permancntly at their place of birth. Banded Victorian birds have been rccovered in Tasmania, South Australia and New South Wales. There are very few recoveries of banded Victorian birds form Tasmania, so it appears that there is little movement across Bass Strait. Unlike New South Wales where the main movement is northwards along the coast, most Victorian populations breed inland necessitating southward, eastward or wcstward movements to reach the coast hence the more varied dispersal.

(4) South Australia

In South Australia the Silver Gull is common along all coasts and on offshore islands. Apart from coastal areas, it breeds in the interior as far inland as Lake Eyre. As in Victoria this gull is part of the farming scene, birds following the plough and frequcnting piggeries, slaughter yards and rubbish tips.

The breeding distribution in South Australia is mapped in Figure 4.

In size and coloration birds from South Australia are similar to Victorian birds but have slightly less white on the third primary.

Primaries in Adults

Six out of eight adult males and three out of eleven females have reduced mirrors on the third primary (compared to Victorian specimcns), the outer web being black. One adult fcmale has no mirror at all. The white tongue at the base of the first three primaries also matches well with Victorian birds; on the first the tonguc is short (usually less than one-third the length of the feather, in most cases on both webs); on the second the tongue is over one-third the length of the

Figure 4 Map of South Australia showing location of breeding sites (circles) and specimens studied (dots).

feather on both webs; and on the third primary it is over half the length of the feather.

As mentioned, South Australian birds are similar to Victorian birds, but there is a sharp contrast between them and the easternmost breeding population in Western Australia (Archipelago of the Recherche). The South Australian specimens are larger than the latter and have longer bills and much more white on the third primary (see Tables 3 and 4).

Unfeathered Parts

In young birds the bill is described as black or dark yellow with a black tip; the legs and feet dark yellow, yellow-brown or brownish. In adults the bill is red, deep dull red, dark red, orange-red, red with dark tip, red tipped with black, or orange with a black tip. The orbital ring is red the legs and feet are red, deep dull red, orange-red or dull orange; and the iris is white.

Movements

Birds banded in South Australia have been recovered in Victoria, New South Wales and Tasmania. In April 1979 two specimens were collected from a flock of 25 at Lera Waterhole (Gregory Salt Lake), Western Australia, which are in measurements and coloration most like South Australian birds and probably came from there. The back and wings are darker grey than in Western Australian birds and the shape and size of the mirrors match South Australian specimens. Small flocks of Silver Gulls were again recorded on Gregory Salt Lake in June 1980. A specimen collected at Newman, Western Australia, in November 1981 also matches best in coloration with South Australian birds. As the Western Australian populations are fairly sedentary and almost strictly coastal, many inland records from that State (Pilbara, Nullarbor Plain, Eastern Goldfields and Wheat Belt) are probably visitors from South Australia.

(5) Archipelago of the Recherche

The Archipelago of the Recherche contains the easternmost breeding population in Western Australia. The break between this and the westernmost breeding colony in South Australia is over 1000 km. The breeding distribution in Western Australia is mapped in Figure 5.

Birds from the Archipelago of the Recherche are the smallest in Western Australia, especially in wing, bill and weight measurements (see Table 4). They have smaller primary mirrors (particularly the third) than South Australian specimens or those from the Albany to Perth region. All five specimens collected in December 1979 (the other two are old specimens) had a rosy tinge on the breast and flanks. This faded soon after death, but it has not been observed in any other western population or referred to in any eastern birds. A rosy tinge to the plumage is, however, recorded for the New Zealand race of the Silver Gull *Larus novaehollandiae scopulinus* and for the closely related Black-billed Gull *Larus bulleri*, also of New Zealand.

Primaries in Adults

The white mirrors on the first two primaries are only slightly smaller than in populations 6 and 7 (birds from Albany to Houtman Abrolhos); however, the third primary has no mirror or a greatly reduced mirror. The two adult male specimens from the area have no white on the outer web of the third primary and only a narrow strip of white enclosed by black on the inner web. Of five adult females only one has a white mirror on the outer web of the third primary (four birds having the outer web all black), and only two out of five have a white mirror on the inner web of the third primary (three having the inner web black). Six out

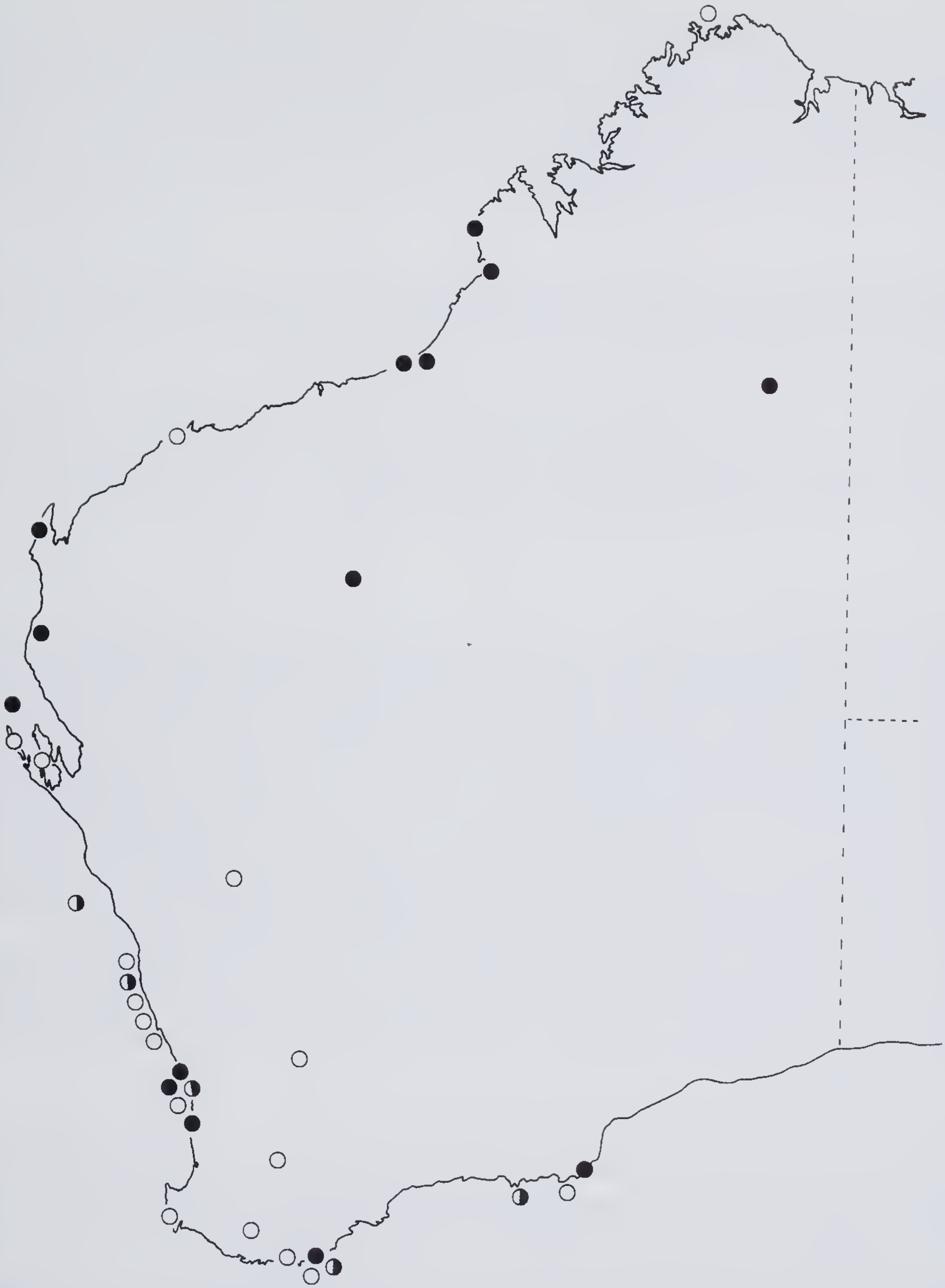

Figure 5 Map of Western Australia showing location of breeding sites (circles) and specimens studied (dots).

of seven birds have no mirror on the outer web of the third primary, and three out of seven no white mirror on the inner web. An adult male collected near Cape Arid on the mainland has no trace of a mirror on the third primary matching most island females.

The basal white tongues match specimens from Albany to Houtman Abrolhos, being long and broad and not reduced as in the north-western populations, which also have small or only two mirrors.

Unfeathered Parts

The bill is maroon, orbital ring red or bright red, legs and feet maroon, iris white and mouth bright red.

Movements

Based on the male collected near Cape Arid it appears there is some movement of birds between the Archipelago of the Recherche and the mainland. Silver Gulls commonly seen at Esperance have not been studied.

(6) Albany to Perth

The Silver Gull is common on south-western coasts. It is far more sedentary in Western Australia than in any other State, specially New South Wales, Victoria and South Australia. Occurrences inland are also much rarer than in other States. In the Perth to Fremantle area (where this species is in plague numbers) they ascend the Swan River only as far as Guildford (27 km) and are absent from many near-coastal lakes south and north of the Swan River. Although gulls have been seen on several large inland lakes such as Lake Grace, Lake Dumbleyung, the Wagin lakes, and at Northam and Rawlinna, no specimens are available from these areas and, as at the Gregory Salt Lake, the birds could be visitors from south-eastern Australia. The only permanent inland breeding colony is one of about 40 pairs that nest on islets in Lake Muir in the south-west of the State.

Specimens from the Albany to Perth region are larger than Recherche birds (see Table 4). Compared to South Australian birds, specimens from this area have slightly less white on the mirrors, and south-western females have shorter bills.

Primaries in Adults

Five out of nine males have no mirror on the outer web of the third primary, and in three others the white is narrow; five have all black inner webs, and in two others the white is very narrow. Two out of six females have no mirror on the third primary, and in the other four the white is narrow.

Nearly all the specimens with only two or greatly reduced mirrors are from the northern part of this region, the Perth area. A small proportion of breeding specimens from Carnac I. (near Perth) have only two mirrors, and some individuals have just a faint white spot on the third primary. Along the west coast it is within this and the following population that the change from three to two mirrors occurs.

The white tongue on the first primary is short and narrow; on the second longer and wider (up to half the length of the feather on both webs); and on the third long and broad (to almost two-thirds the length of the feather on both webs) (see Figure 7).

Non-adult Plumages

Birds five weeks old have the entire underparts white; the facc and crown grey, with a blackish-brown spot in front of the eye; head grey; cheeks whitish; mantle, back and wing coverts light grey to greyish-white, each feather with a subterminal blackish-brown band (darkest on wings) and fringed pale reddish-brown. The primaries are black with small mirrors on the first and second. The secondaries have black subterminal bars. The rump is light bluish-grey, and the tail white with blackish-brown to buff subterminal band on all but the outer two rectrices. At fivc weeks they still have traces of brown on wings and tail. The tail band is lost first, then the speckled coverts and finally the black bar on the secondaries. Adult plumage is attained in 10 months.

Unfeathered Parts

Adult breeding specimens from Carnac I. have the bill red, dark maroon with tip tinged black, orange-brown with blackish-brown tip, brick-red with reddish-brown tip or maroon to brick red with tip tinged brown. The iris is white. The orbital ring is reddish-orange, orange or orange-yellow. The mouth is orange or reddish-orange. Thc legs are brick-red, dark reddish-brown, reddish-brown, reddish-orange or orange-yellow.

Nicholls (1964) noticed that in her captive colony the adult birds showed a waxing and waning in the coloration of the bill, legs, feet, mouth and eyelids, with peaks in late autumn and mid-spring. This is consistent with the breeding pattern on Carnac I. which Wooller and Dunlop (1979) have shown to be trimodal with peaks in autumn (March to May), winter (June) and spring (September to November).

In immature birds the iris is dark brown; orbital ring greyish-black; legs grey; basal half of bill greyish-brown, the rest blackish-brown; and the mouth pink.

Movements

The largest populations of Silver Gulls in Western Australia occur near Perth and Albany, but there appears to be less movement along the south coast than along the lower west coast. Despite large numbers banded in Western Australia, none have becn recovered in any other Statc. The longest recorded distance travelled by a banded bird is of one ringed near Perth and recovered at Busselton, 195 km to the south. Young birds banded on Carnac I. have been recovered breeding on Seal I., Lancelin I. and Rottnest I. There is little evidence supporting the view of Serventy *et al.* (1971), that there is a mainly southern movement in this State. In fact the above-mentioned birds recovered on Lancelin I. show the opposite trend. Furthermore I have seen no birds from south of the Houtman Abrolhos that could be ascribed to populations to the north. Banding records combined with geographic variation indicate that there is local movement up to about 200 km along the coast. As mentioned earlier, movements inland seem to be on a still smaller scale.

(7) Fisherman Islands to Houtman Abrolhos

In size and coloration this population is generally similar to population 6 (see Tables 1, 2, 3 and 4). There is a slight increase in the amount of white on the first two mirrors, but a slight decrease in the amount of white on the third mirror, it being more deeply enclosed by black.

Primaries in Adults

In one of three males the mirror on the third primary is not present on the outer web, and in the other two males the white mirror is narrow (enclosed by black) on both webs. One of four females has no mirror on the third primary, and in the other three the white is very narrow on both webs.

Unfeathered Parts

These are as in population 6.

(8) **Shark Bay to Exmouth Gulf**

Primaries in Adults

Specimens from this region (Dorre I., Lake MacLeod and Mangrove Bay) show a marked decrease of about 20 mm in the size of the mirror on the first primary on both webs. In females there is no overlap in the size of the mirror with population 7, and in males very little overlap (see Table 1 and Figure 7). On the second primary the mirror is similarly 20 mm shorter than in population 7. The third primary has no white mirror, and no specimens from Lake MacLeod northwards in Western Australia have any trace of a white mirror on this feather.

The white tongues on the primaries, particularly on the second and third, are also reduced. On the first primary there is a little white at the base or no white at all; on the second it is on both webs but narrow and under one-third the length of the feather; and on the third it is a little longer and wider but less than half the length of the feather (see Figure 7).

The length of black on the fourth primary is greater than in population 7, but it compares well with more northern birds (see Table 3).

Unfeathered Parts

These are similar to populations 6 and 7.

(9) Barrow Island to Broome

The Silver Gull is generally scarce along the Pilbara and Kimberley coasts but is locally common in these regions about coastal towns and ports and at breeding colonies of Brown Boobies and Lesser Frigate-birds (Bedout I. and Lacepede Is). There are few records from northern coasts fringed with mangroves, the gulls preferring the sandy beaches.

Specimens from this region match well with population 8, but females have a slightly longer bill than elsewhere in the State (see Table 4).

Primaries in Adults

There is a slight decrease in the size of the mirrors on the first two primaries. The inner webs of both are usually fringed with black. As in population 8 there is no mirror on the third primary and the white tongues are short.

Unfeathered Parts

The bill is red with a blackish-brown tip, iris white, orbital ring grey-brown, legs deep red and mouth red.

Movements

In both the Pilbara and Kimberley this species is almost purely coastal and rarely wanders more than a few kilometers inland. Storr (1980) gives the status of the Silver Gull in the Kimberley as very common at certain ports (Broome, Cockatoo I., Koolan I.); uncommon elsewhere.

Breeding probably occurs on the Lacepede Is but at present the only known breeding locality in the Kimberley is Jones I., but this island is possibly not currently used, for gulls are scarce in this area and there are no other breeding records since 1901. The main Kimberley population is centred around the Lacepede Is. There is thus a huge break in the breeding range from south-west Kimberley to the north coast of the Northern Territory.

(10) Northern Territory

According to Storr (1977) the Silver Gull occurs along northern coasts and islets including Melville I., Goulburn Is and Groote Eylandt. It is locally common, e.g. on Groote Eylandt, but is generally uncommon. It favours blue-water seas off rocky and sandy coasts and islands. Breeding is recorded on Haul Round I. and in Melville Bay.

Only five specimens are available from this area, and on measurements and coloration they appear not to be visitors from elsewhere and are probably resident birds. They match better with specimens from north Queensland than Kimberley.

Primaries in Adults

The mirrors on the first two primaries are slightly larger than in Kimberley birds, and the two males have a small white spot or small mirror on the inner web of the third primary. On one specimen the spot on the third primary is only present on one wing.

The white tongue on the first primary is short and narrow and only on the extreme basc of the feather. On the second primary the tongue is over one-third the length of the feather and on the third over half the length of the feather. On both the second and third the tongues are narrow, especially on the inner web.

Unfeathered Parts

The bill is recorded as dark scarlet, dull scarlet, dull dark red, or blood-red. The iris is white or ash grey. The orbital ring scarlet-orange. The legs scarlet-orange, pale scarlct, orange-red or blood-red. The tip of the bill is not recorded on any specimens as being darker than the base as in most Western Australian populations.

Movements

The Northern Territory population appears to be sedentary with some local movement away from the coast to outer islands especially in the breeding season. This area could also expect migrants from south-eastcrn Australia (particularly South Australia); which could be distinguished by their three large wing mirrors.

(11) Queensland

The Silver Gull is fairly common along the Queensland coast as far north as Cairns. Gulls are occasionally reported well inland, particularly after cyclones. Storr (1973) gives the range of *Larus novaehollandiae forsteri* in Queensland as northern and mid-eastern coasts and islands, south to Mackay and Lady Elliot I.; and the nominate subspecics as south-east coast, estuarics, and islands, north certainly to Bribie I., and in the western and southern interiors. The breeding distribution in Queensland is mapped in Figure 6. There are two large breaks in the breeding range. (1) between Cook Island New South Wales and the Bunker Group (Queensland) a distancc of about 470 km, and (2) between Holbourne I. and the Low Is, a distance of 450 km.

Six of the 17 specimens available from Queensland are probably migrants from New South Wales, having three large mirrors or in the case of immatures larger mirrors than Queensland birds of the same age. In all, only ten adults were studied that probably came from the Queensland breeding population: two from Litel I. (Torres Strait), three from Purangi I. (Cape York), one from Tukna Creek (Cape York), two from the Endeavour River, one from Mt Inkerman and one from near Sarina.

Primaries in Adults

The Queensland birds match well with Northern Territory specimens. They have less white on the primaries than most New South Wales birds but more than Kimberley birds. One Queensland malc has a small white spot on the outer web of the third primary and only two have small white spots on the inner web. The basal white tongues are slightly narrower and shorter than in Northern Territory specimens.

An immature female from Rennell I. (Torres Strait) has a small white spot on the outer web of the first primary and on both webs of the second primary.

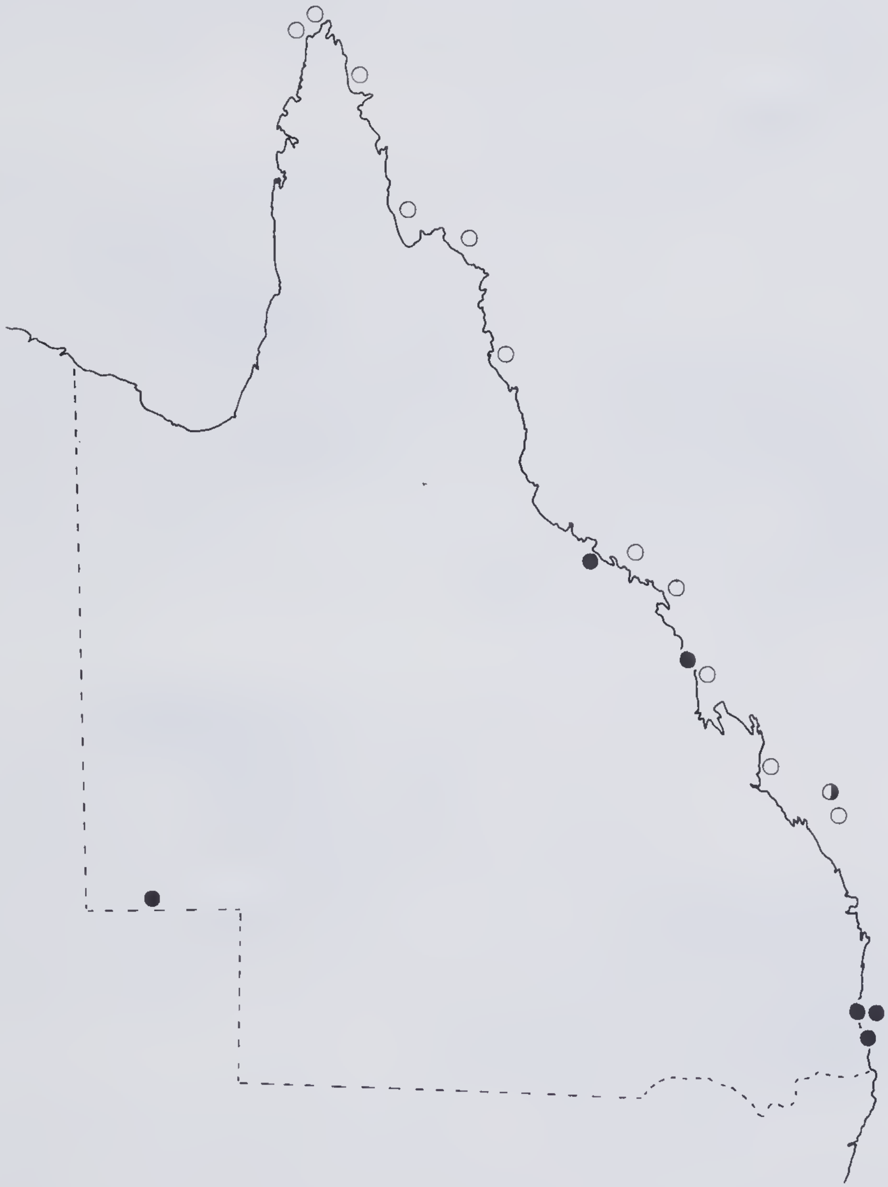

Figure 6 Map of Queensland showing location of breeding sites (circles) and specimens studied (dots).

Unfeathered Parts

Queensland specimens have the bill described as purplish-red or vermilion red, the iris pale grey or chrome yellow and the legs scarlet or vermilion red.

Movements

Little is known about the movements of Queensland birds. The similarity in colour pattern and size between Northern Territory and Queensland birds suggests that the Northern Territory has been colonized from Queensland.

(12) **New Caledonia**

An adult male from New Caledonia is the only specimen examined from within the range of *forsteri* (*sensu stricto*). Usually Queensland and coastal Northern Territory birds are placed in *L. n. forsteri* (type locality New Caledonia). However the single specimen examined from New Caledonia differs from all adult Australian birds in having only one wing mirror. It also has a greyish crescent on the nape and broad white tips on the second, third, fourth, fifth and sixth primaries. The mirror on the first primary matches well with north Queensland specimens in size and shape. The second primary is a new feather and shows no trace of a white mirror, nor does the third primary which is also new. Judging from this specimen and Mathews' (1912) description of *forsteri* the New Caledonian birds have much less white on the primaries, and in this respect differ markedly from Queensland birds.

Further collecting within this region is necessary for clarifying the status of *L. n. forsteri.*

(13) **New Zealand**

The Red-billed Gull (*Larus novaehollandiae scopulinus*) occurs on North and South Islands, and on Three Kings and Chatham Islands, Stewart, Great, Little Barrier, Kapiti, Snares, Auckland and Campbell Islands. It is a straggler to the Kermadec Islands. It is very common along the coasts, especially about harbours, but is also found on inland lakes, breeding inland at Rotorua. Mills (1969) maps the breeding distribution in New Zealand.

New Zealand birds are smaller than those from all Australian populations (see Table 4), especially in wing and bill measurements. Most of them have only two mirrors, which are smaller than in Australian birds (see Tables 1, 2, 3 and Figure 7), and the mirrors run out on the inner web at right angles to the feather shaft (the angle is more acute in Australian birds).

The basal white tongues on the first three primaries, especially the third, are longer and broader than in most Australian populations. In this respect they differ markedly from Hartlaub's Gull of Africa, which also has only two mirrors but greatly reduced tongues. Several New Zealand specimens show a faint greyish tinge to the nape, and Buller (1888) mentions that some birds in nuptial plumage have the breast and sides suffused with a delicate roseate tint. The white mantle

Figure 7 Typical wing patterns of adult Silver Gulls from (left to right) New Zealand, Tasmania, Victoria, Archipelago of the Recherche, Albany to Perth and Shark Bay to Exmouth Gulf.

merges into the pale grey back. The back and wings are pale grey or blue-grey as in Australian birds, and in most specimens are lighter than in Hartlaub's Gull.

Primaries in Adults

The first primary has a short to moderately long white tongue, usually on both webs but longest on the inner web (up to just over one-third the length of the feather). The white mirror runs out on the inner web at right angles from the shaft (see Figure 7). The rest of the feather is black except for a white tip in specimens showing no wear.

The second primary has a broad white tongue, longest on the inner web and up to half the length of the feather. The outer edge of the tongue is occasionally margined with black. The mirror again runs out from the shaft at right angles on the inner web (on the outer web the angle is more acute). The tip is white in unworn plumage.

The third primary has a long broad white tongue up to two-thirds the length of the feather. The tongue is edged on the inner web with greyish-white or greyish-black. The rest of the feather in 12 out of 14 specimens is black, i.e. lacking a mirror but tipped white in unworn plumage. Two adults, one from Lower Hutt (No. 13384) and the other a male from Stewart I. (No. 15227), have a fairly large white spot or small mirror on the inner web of the third primary. Although the nominate form has been recorded in New Zealand, the above specimens are certainly not Australian, for they have the square-cut mirrors on the first two primaries characteristic of *scopulinus.* Oliver (1930: 267) depicts a bird from Kapiti I. with three primary mirrors.

The fourth primary has a white tongue on the outer web. The inner web is grey and white margined with black the rest of the feather is black except for a white tip in unworn plumage.

Unfeathered Parts

The bill is dark red, lighter on the ridge and towards the tip, iris silvery white, orbital ring red, and legs and feet red.

Movements

No New Zealand birds have yet been found in Australia. Dwight's (1925) records of the Australian form as casual in New Zealand could be based on the odd New Zealand bird with three primary mirrors. At any rate they are not accepted by the Checklist Committee of the Ornithological Society of New Zealand (1970).

Variation in Hartlaub's Gull

Hartlaub's Gull (*L. hartlaubii*) breeds on islands off south-western Africa from Walvis Bay south at least to Cape Agulhas (Clancey 1964). It favours the cold coastal waters of western South Africa but ranges occasionally as far east as Natal.

Hartlaub's Gull has long been treated as a race of the Australian Silver Gull. African birds are smaller and darker than all Australian populations and match best in size with New Zealand birds. They average slightly longer in the wing than New Zealand specimens and have longer and narrower bills. The upper and under wing and the back are darker grey than in Australia and New Zealand.

Primaries in Adults

Most *L. hartlaubii* have only two white mirrors in the wing (two females have a small white spot on the inner web of the third primary), and the mirrors average smaller than in New Zealand specimens (see Tables 1, 2, 3 and 5). The basal white tongues on the first three primaries are much shorter and narrower than in all populations of *novaehollandiae.*

In 15 of 18 adult *hartlaubii* there is no white tongue at the base of the first primary, and in the two that have a short tongue it is greyish-white rather than white. The mirror on the first primary is in most specimens margined with black on the inner web.

On the second primary the tongue is longer (up to half the length of the feather) on the outer web. On the inner web the tongue is absent or greatly reduced and is often only present as a greyish-white line along the shaft. The mirror is broadly margined with black on the inner web in 12 out of 18 adults.

The third primary has a long white tongue on the outer web, usually about half, but up to two-thirds the length of the feather. Where present on the inner web the tongue is narrow (1-4 mm wide) and merges with the grey (in other words scarcely crossing the shaft on to the inner web). In 16 of 18 adults there is no mirror on the third primary. The exceptions are two females (one from Port Nolloth, the other from Berg River); which have a small white spot on the inner web of the third primary.

The fourth primary has a long white tongue on the outer web. On the inner web the tongue is reduced to a thin greyish-white line running along the shaft and widening near the end. The black on the inner web is in most specimens more extensive than in Australian and New Zealand birds; i.e. there is less grey or white. In this character some *L. hartlaubii* match with Grey-headed Gull (*L. cirrocephalus*); however the amount of black is variable, some specimens having a fairly broad greyish area on the inner web.

In several other characters *L. hartlaubii* is more like *L. cirrocephalus* than *L. novaehollandiae.* The white mantle in adult *hartlaubii* and *cirrocephalus* is well defined and contrasts sharply with the dark grey back (in *novaehollandiae* the white mantle grades into the light grey back). Breeding *hartlaubii* assume a grey bar on the nape that commonly extends to the side of neck and less frequent across the throat. This collar is usually most distinct on the hind neck. It is here that the dark hood of *cirrocephalus* meets the white of the neck and it is here that the margin of the hood is darkest.

Unfeathered Parts

The bill is cherry red (3), reddish-black (3), reddish-brown (2), flesh (1). The iris is brown (10), greyish-brown (4), yellowish-brown (2). The orbital ring is red (2), dark maroon (1), cherry red (1). The legs are red (6), cherry red (2), brownish (2), reddish-brown (1), tan brown (1), flesh (1), black (1).

Variation in the Grey-headed Gull

The Grey-headed Gull (*Larus cirrocephalus*) is divided into two subspecies, separated by the Atlantic Ocean. The nominate subspecies occurs in South America north to Ecuador and north-eastern Brazil, and *L. c. poiocephalus* in Africa (north to Gambia and Ethiopia) and Madagascar. On both continents it occurs on fresh waters and coasts.

The African subspecies *L. c. poiocephalus* is smaller than the nominate form and has smaller mirrors (see Tables 5 and 6). The mantle is purer white and well demarcated from the back, rather than being tinged with grey as in many South American specimens.

Grey-headed Gulls differ from Hartlaub's Gull in their larger size, more extensive grey on the head (even in immature and non-breeding plumages), smaller mirrors on the first two primaries and less white or greyish-white on the fourth primary. The iris is yellow in most *cirrocephalus* and brown in most *hartlaubii*. The Grey-headed Gull favours fresh waters, *hartlaubii* cold coastal waters; though each may be found in the preferred habitat of the other species (Clancey 1964).

Primaries in Adults

The colour pattern of the primaries is much the same as in *L. hartlaubii*. The first primary is black with no trace of a tongue and with a squarish white subterminal mirror, margined with black on the inner web. The second primary is mostly black with a narrow white tongue on the outer web and a small white mirror margined with black on the inner web. The third primary is black, without a mirror and with a moderately long tongue (usually only on the outer web; sometimes a trace of white on the inner web). The fourth primary has a long white tongue on the outer web, the rest of the feather being mostly black but becoming blackish-grey at the base on the inner web. The length of the subterminal black bar on the outer web averages 70 mm in the nominate form and 71 mm in *poiocephalus*.

Unfeathered Parts

The bill is red (3), dark red (2), light red (1), dull crimson (1), dark coral (1), dull red (1) and dark brown (1). The iris is yellow (3), maple yellow (2), light yellow (1), pale (2), white (1), brown (2). The orbital ring is light red (1). The legs are red (4), light red (1), coral (1), brown (2), dull vermilion (1), dull red (1), dark brown (1).

Movements

Generally the breeding ranges of Hartlaub's Gull and the Grey-headed Gull do not overlap. In southern Africa *cirrocephalus* breeds regularly and in good numbers in the southern Transvaal, and occasionally elsewhere in the interior if conditions are suitable. They disperse widely from their breeding grounds, covering all of South Africa and commonly reaching southern Mozambique and southern Angola in the north.

Hybridization

Each year small numbers of Grey-headed Gulls enter the range of *L. hartlaubii* and occasionally form mixed pairs or pair themselves among breeding *hartlaubii.* Hybridization between *Larus cirrocephalus* and *Larus hartlaubii* has been recorded from time to time (Sinclair 1977), but obvious hybrids are rare in collections. It would be interesting to note the iris colour of a mixed pair, as some breeding *cirrocephalus* have the iris described as brown (rather than yellow) and odd *hartlaubii* have it yellowish-brown (rather than brown). In many gulls unfeathered part coloration and calls play an important part in species recognition and pair bond formation, and it can be seen from the unfeathered part data that some *cirrocephalus* and some *hartlaubii* could match.

Judging from descriptions, the breeding displays of *L. cirrocephalus, L. hartlaubii* and *L. novaehollandiae,* are almost identical.

Table 1 Measurements (mm) of *Larus novaehollandiae* showing the length of the white mirror on the first primary, with means and sample size in parentheses.

First primary				Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black
1	Tasmania	♂	(N10)	58-86 (71)	1		53-72 (61)	1	
		♀	(N6)	65-91 (70)			55-74 (61)		
2	New South Wales	♂	(N7)	40-64 (54)			39-55 (48)		
		♀	(N11)	43-76 (62)			29-68 (54)		
3	Victoria	♂	(N4)	42-68 (55)			41-61 (50)		1
		♀	(N6)	53-65 (59)			46-56 (53)		2
4	South Australia	♂	(N6)	43-60 (53)			46-53 (49)		
		♀	(N12)	47-70 (58)			42-65 (52)		
5	Archipelago of the Recherche Western Australia	♂	(N2)	52, 62			44, 45		
		♀	(N5)	53-64 (57)			32-50 (43)		
6	Albany to Perth Western Australia	♂	(N8)	41-64 (55)			23-56 (46)		
		♀	(N5)	40-61 (53)			32-53 (45)		

Table 1 (cont.)

First primary			Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black
7	Fisherman Islands to Houtman Abrolhos Western Australia	♂ (N3)	46-71 (60)			41-57 (50)		
		♀ (N5)	55-69 (63)			48-54 (51)		
8	Shark Bay to Exmouth Gulf Western Australia	♂ (N4)	36-50 (41)			31-46 (35)		
		♀ (N4)	28-48 (38)			19-38 (30)		
9	Barrow Island to Broome Western Australia	♂ (N6)	0-51 (31)		1	17-32 (26)		
		♀ (N4)	32-50 (40)			17-36 (30)		
10	Northern Territory	♂ (N4)	47-53 (50)			37-42 (40)		1
		♀ (N1)	37			36		
11	Queensland	♂ (N4)	37-49 (38)			30-39 (36)		3
		♀ (N5)	30-48 (40)			32-46 (37)		4
12	New Caledonia	♂ (N1)	40			41		
13	New Zealand	♂ (N7)	27-56 (44)			31-50 (42)		
		♀ (N3)	31-62 (46)			34-57 (45)		

Table 2 Measurements (mm) of *Larus novaehollandiae* showing the length of the white mirror on the second primary, with means and sample size in parentheses.

Second primary		Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Mirror outer web enclosed by black	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black	Inner web black
1 Tasmania	♂ (N9)	49-70 (61)	1			45-66 (54)	1		
	♀ (N6)	49-78 (58)				46-63 (51)			
2 New South Wales	♂ (N8)	24-55 (44)				33-48 (41)			
	♀ (N12)	32-59 (49)				28-54 (44)			
3 Victoria	♂ (N4)	33-61 (47)				32-51 (41)		3	
	♀ (N6)	44-60 (50)				40-51 (45)			
4 South Australia	♂ (N7)	37-51 (43)				35-47 (40)			
	♀ (N12)	39-61 (49)				36-54 (43)			
5 Archipelago of the Recherche Western Australia	♂ (N2)	45, 46				39, 39			
	♀ (N5)	37-54 (43)				30-38 (34)			
6 Albany to Perth Western Australia	♂ (N8)	29-55 (46)		1		26-49 (41)		1	
	♀ (N5)	33-54 (45)				30-58 (41)			

Table 2 (cont.)

Second primary			Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Mirror outer web enclosed by black	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black	Inner web black
7	Fisherman Islands to Houtman Abrolhos Western Australia	♂ (N3)	41-61 (50)				33-44 (40)			
		♀ (N5)	37-60 (48)				34-51 (42)			
8	Shark Bay to Exmouth Gulf Western Australia	♂ (N3)	25-40 (33)				24-39 (29)			
		♀ (N5)	13-38 (27)				15-31 (24)			
9	Barrow Island to Broome	♂ (N6)	0-29 (16)		3	2	0-26 (15)		3	2
		♀ (N4)	21-30 (25)				20-27 (23)			
10	Northern Territory	♂ (N4)	34-42 (36)				29-37 (33)			
		♀ (N1)	26				26		1	
11	Queensland	♂ (N4)	33-42 (38)				30-36 (33)			
		♀ (N5)	20-39 (29)				22-34 (28)		4	
12	New Caledonia	♂ (N1)	0			1	0			1
13	New Zealand	♂ (N7)	0-43 (28)			2	14-41 (31)			
		♀ (N3)	13-43 (29)				22-45 (33)			

Table 3 Measurements (mm) of *Larus novaehollandiae* showing the length of the white mirror on the third primary, and the length of the black subterminal bar on the fourth primary, with means and sample size in parentheses.

Third primary		Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Mirror outer web enclosed by black	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black	Inner web black	Length of black sub-terminal bar on fourth primary
1 Tasmania	♂ (N9)	21-44 (34)	6			30-49 (38)	3			17-31 (25)
	♀ (N6)	28-40 (36)	3			27-40 (34)	3			21-26 (24)
2 New South Wales	♂ (N8)	0-29 (13)			3	0-32 (15)			3	27-35 (31)
	♀ (N11)	0-34 (12)			6	0-36 (18)			3	25-43 (32)
3 Victoria	♂ (N4)	0-31			1	0-33			1	27-40 (33)
	♀ (N6)	0-34 (24)			1	20-32 (27)				29-33 (32)
4 South Australia	♂ (N8)	0-27 (5)			6	8-25 (17)				25-40 (32)
	♀ (N11)	0-34 (18)			3	0-37 (22)			1	25-38 (31)
5 Archipelago of the Recherche Western Australia	♂ (N2)	0			2	11, 15			2	32, 39
	♀ (N5)	0-25			4	0-16 (5)			3	32-36 (34)
6 Albany to Perth Western Australia	♂ (N9)	0-29 (10)		3	5	0-30 (12)		2	5	29-45 (37)
	♀ (N6)	0-25 (13)				0-31 (15)		4	2	31-37 (34)

Table 3 (cont.)

Third primary		Length of white mirror outer web	Tongue joins mirror Continuous white outer web	Mirror outer web enclosed by black	Outer web black	Length of white mirror inner web	Tongue joins mirror Continuous white inner web	Mirror inner web enclosed by black	Inner web black	Length of black sub-terminal bar on fourth primary
7 Fisherman Islands	♂ (N3)	0-14 (8)		2	1	9-23 (16)		2		30-34
to Houtman Abrolhos	♀ (N4)	0-27 (17)		3	1	0-21 (14)		3	1	29-42 (36)
Western Australia										
8 Shark Bay to	♂ (N4)	0			4	0			4	45-54 (50)
Exmouth Gulf	♀ (N4)	0			4	0			4	41-52 (45)
Western Australia										
9 Barrow Island	♂ (N5)	0			5	0			5	38-62 (50)
to Broome	♀ (N5)	0			5	0			5	45-58 (50)
Western Australia										
10 Northern Territory	♂ (N4)	0			4	0-17 (6)			2	
	♀ (N1)	0			1	0			1	
11 Queensland	♂ (N4)	0-12 (3)			3	0-17 (8)			3	
	♀ (N5)	0			5	0-15 (5)			2	
12 New Caledonia	♂ (N1)	0			1	0			1	
13 New Zealand	♂ (N7)	0			7	0-13 (2)			6	33-42 (36)
	♀ (N3)	0			3	0			3	31-38 (34)

Table 4 Measurements (mm) of *Larus novaehollandiae* with means and sample size in parentheses.

			Wing	Culmen length	Culmen depth	Tail	Tarsus	Length	Weight
1	Tasmania	♂ (N11)	279-309 (293)	48.0-51.0 (49.3)	9.4-10.9 (10.1)	112-121 (116)	45-51 (48)		
		♀ (N6)	268-304 (287)	43.0-47.0 (47.7)	8.4-10.3 (9.2)	108-118 (114)	42-48 (45)		
2	New South Wales	♂ (N7)	282-305 (290)	44.0-49.0 (47.3)	9.6-11.0 (10.2)	108-122 (115)	44-50 (47)	384-415 (400)	246-397 (333)
		♀ (N10)	272-295 (284)	41.5-48.0 (44.6)	8.4-10.0 (9.0)	105-114 (109)	42-49 (45)	368-395 (381)	195-311 (261)
3	Victoria	♂ (N4)	295-306 (301)	46.0-50.0 (47.2)	10.0-10.5 (10.2)	117-127 (121)	47-50 (49)	400-434 (413)	311-350 (338)
		♀ (N6)	271-295 (284)	42.0-45.0 (44.0)	8.2-9.2 (8.8)	107-114 (111)	38-46 (44)	382-429 (399)	220-367 (284)
4	South Australia	♂ (N8)	292-305 (298)	46.5-52.0 (48.2)	8.8-11.2 (9.7)	108-127 (116)	42-52 (49)	418-444 (431)	343-399 (372)
		♀ (N15)	274-310 (286)	41.0-49.0 (46.8)	8.1-10.6 (9.2)	100-126 (113)	43-52 (46)	368-419 (399)	295-340 (310)
5	Archipelago of the Recherche Western Australia	♂ (N2)	290, 291	45.0, 48.0	9.7, 10.0	108, 115	46, 49	380, 402	250, 270
		♀ (N5)	283-289 (286)	41.0-47.0 (43.7)	9.0-10.0 (9.4)	111-119 (115)	44-48 (45)	382-390 (386)	240-310 (267)
6	Albany to Perth Western Australia	♂ (N8)	286-309 (300)	51.0-53.0 (51.5)	9.9-12.1 (10.9)	116-128 (121)	46-51 (48)	372-427 (403)	330-380 (348)
		♀ (N8)	276-305 (288)	43.5-48.0 (45.7)	9.4-10.5 (9.9)	107-125 (114)	42-47 (45)	355-399 (386)	266-368 (307)
7	Fisherman Islands to Houtman Abrolhos Western Australia	♂ (N3)	300-313 (306)	50.0-51.5 (50.8)	10.3, 12.1	110-125 (119)	47-52 (50)	410, 430	335, 340
		♀ (N5)	273-306 (291)	45.0-47.0 (45.8)	10.1-10.7 (10.4)	110-121 (116)	44-48 (46)	380-390 (385)	299-320 (310)
8	Shark Bay to Exmouth Gulf Western Australia	♂ (N5)	301-309 (304)	48.0-56.5 (51.4)	10.0-11.2 (10.7)	116-122 (120)	45-53 (49)	380-425 (404)	350-420 (382)
		♀ (N5)	289-298 (293)	46.0-49.5 (47.8)	9.1 10.0 (9.4)	106-117 (111)	47-50 (48)	386-425 (401)	280-330 (304)
9	Barrow Island to Broome	♂ (N6)	292-319 (305)	49.0-54.0 (51.3)	9.7-10.9 (10.3)	110-127 (120)	51-54 (52)	412, 423	300, 340
		♀ (N5)	281-299 (288)	47.5-52.5 (49.5)	9.1-9.5 (9.3)	103-116 (111)	48-54 (50)	406-413 (409)	260-320 (296)
10	Northern Territory	♂ (N4)	292-296 (294)	47.5-53.5 (50.6)	10.0-10.7 (10.4)	112-118 (115)	50-52 (51)		315-355 (337)
		♀ (N1)	304	44.0	9.5	121	48		340
11	Queensland	♂ (N4)	297-306 (300)	49.5-50.0 (50.6)	10.4-11.5 (10.9)	116-121 (117)	48-52 (50)		
		♀ (N5)	281-293 (284)	46.5-49.0 (47.9)	9.4-10.4 (9.8)	107-115 (110)	44-51 (47)		
12	New Caledonia	♂ (N1)	287	52.0	10.1	108	44		
13	New Zealand	♂ (N6)	258-291 (275)	39.0-44.5 (41.5)	9.6-10.0 (9.8)	100-119 (109)	38-44 (41)		
		♀ (N3)	264-265 (265)	41.0-42.5 (41.8)	8.7-9.3 (9.0)	103-109 (106)	37-41 (39)		

Table 5 Measurements (mm) showing the extent of the white mirrors of *Larus hartlaubii* and *Larus cirrocephalus.*

First primary			Length of white mirror outer web	Mirror outer web enclosed by black	Length of white mirror inner web	Mirror inner web enclosed by black
Larus hartlaubii	♂	(N9)	25-50 (40)		26-41 (34)	5
	♀	(N9)	31-45 (43)		21-38 (29)	7
Larus c. cirrocephalus	♂	(N3)	36-44 (40)		24-38 (33)	3
	♀	(N4)	23-49 (40)		11-37 (27)	4
Larus c. poiocephalus	♂	(N13)	20-40 (32)		17-29 (23)	12
	♀	(N9)	22-39 (30)		16-26 (21)	9
Second primary						
Larus hartlaubii	♂	(N9)	21-39 (27)		19-33 (26)	6
	♀	(N9)	13-34 (26)		11-33 (22)	8
Larus c. cirrocephalus	♂	(N3)	23-39 (31)		9-34 (23)	2
	♀	(N3)	31-37 (35)		22-30 (26)	
Larus c. poiocephalus	♂	(N12)	16-32 (24)	2	7-28 (20)	10
	♀	(N9)	9-27 (20)	1	12-22 (17)	4

Table 6 Measurements (mm) of *Larus hartlaubii, Larus cirrocephalus cirrocephalus* and *Larus cirrocephalus poiocephalus* with means and sample size in parentheses.

			Wing	Culmen length	Culmen depth	Tail	Tarsus
Larus hartlaubii	♂	(N9)	274-291 (283)	45.0-50.5 (47.8)	8.2-9.3 (8.8)	104-114 (108)	39-44 (42)
	♀	(N9)	265-293 (276)	42.0-47.0 (44.5)	7.5-9.4 (8.0)	102-112 (106)	38-43 (40)
Larus c. cirrocephalus	♂	(N4)	313-338 (325)	49.5-56.0 (54.1)	9.9-11.1 (10.5)	116-134 (125)	50-55 (51)
	♀	(N8)	300-328 (312)	48.0-53.5 (49.9)	8.9-9.4 (9.2)	110-132 (118)	44-50 (48)
Larus c. poiocephalus	♂	(N18)	283-330 (313)	46.5-57.5 (52.1)	7.9-10.7 (9.5)	102-124 (117)	44-51 (47)
	♀	(N13)	290-317 (302)	45.0-51.0 (47.4)	8.0-9.9 (8.8)	111-120 (114)	40-48 (44)

Discussion

Most of the variation within Australian Silver Gulls is clinal, e.g. increasing white on the primaries from Queensland to Tasmania and from Western Australia to Tasmania. As expected the cline down the east coast is not smooth due to large breaks in the breeding range. The situation is also complicated by long-distance movements of many south-eastern birds and the lack of specimens from breeding localities. In contrast, the Western Australian populations are far more sedentary and show a more gradual increase in mirror size and number from north to south (two mirrors in the north, three in the south). The cline along the south coast would also be relatively smooth except for the peculiar population in the Archipelago of the Recherche; these birds are small, have only two mirrors or a greatly reduced third mirror, and in life have a rosy tinge to the under parts.

Using a combination of measurements and coloration the region of origin of most suspected vagrants and migrants can be detected. In Australia, Tasmanian birds appear to be the most distinctive and the name *gunni* is available for them. However, the unnamed populations from the Archipelago of the Recherche and from northern Western Australia (Carnarvon to Kimberley) have diverged at least as far. Nevertheless in view of the predominantly clinal variation within Australia it seems pointless to add names to those already available.

The *Larus cirrocephalus* species group is made up of four species: *L. cirrocephalus, L. hartlaubii, L. novaehollandiae* and *L. bulleri,* and is entirely restricted to the Southern Hemisphere. The evolution of this group could be explained by the following steps: (1) an early form of Southern American *cirrocephalus* invaded South Africa and in isolation evolved into *L. hartlaubii*; (2) an early form of *hartlaubii* spread east to Australia and New Zealand, evolving into *novaehollandiae* in the first region and *bulleri* in the second; (3) Australian *novaehollandiae* subsequently re-invaded New Zealand and evolved into *scopulinus*; (4) recently Southern American *cirrocephalus* re-invaded Africa and evolved into *poiocephalus.*

Conclusion

The following nomenclature for the *Larus cirrocephalus* species group is proposed: *Larus cirrocephalus cirrocephalus* Vieillot of South America, *Larus cirrocephalus poiocephalus* Swainson of Africa, *Larus hartlaubii* Bruch of south-west Africa, *Larus novaehollandiae novaehollandiae* Stephens of Australia and Tasmania, *Larus novaehollandiae forsteri* (Mathews) of New Caledonia, *Larus novaehollandiae scopulinus* Forster of New Zealand, and *Larus bulleri* Hutton of New Zealand.

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Addendum

On 13 October 1982 a female Silver Gull was collected from a flock of 200 at Wyndham, east Kimberley, Western Australia. It has three primary mirrors and the bill was red, slightly darker at the tip. In wing pattern and bill coloration it matches birds from the Northern Territory rather than west Kimberley. Several immature gulls still begging for food were also seen at Wyndham; so it appears that the species breeds in this area.

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Taxonomy and Evolution of Living Species of *Breynia* (Echinoidea: Spatangoida) from Australia

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Abstract

Three living species of *Breynia* are described: *B. australasiae* (Leach, 1815) from eastern Australia; *B. desorii* Gray, 1851 from western and northern Australia; and *B. neanika* sp. nov. which is described on the basis of specimens from north-eastern Australia and from the Arafura Sea. Speciation is shown to relate to variation in rates of morphological development, *B. desorii* undergoing most morphological change during its ontogeny, *B. neanika* the least. The post-larval ontogeny of *Breynia* is described in detail for the first time. A revised key for the living species of *Breynia* is presented.

Introduction

The spatangoid echinoid *Breynia,* although being one of the commonest of the larger heart urchins around the coast of Australia, has been little studied. Indeed, surprisingly few detailed taxonomic studies have been carried out on any of the living irregular echinoids of Australia apart from recent papers by McNamara and Philip (1980) and McNamara (1982*a*). These authors established that in living Australian schizasterid echinoids it is important to examine large collections as there is often a high degree of intraspecific variation. This is the case with eastern and Western Australian forms of *Breynia* in which a certain amount of confusion over the taxonomic status has occurred during the last hundred years.

Gray (1851, 1855) originally distinguished the Western Australian *B. desorii,* from the eastern species, *B. australasiae* (Leach, 1815). However, many later workers (Agassiz 1872-74; Studer 1880; H.L. Clark 1914, 1917, 1925, 1938, 1946; Alexander 1914; Mortensen 1918) synonymized *B. desorii* with *B. australasiae* without having examined adequate material. Some workers (Mortensen 1951; James 1966; A.M. Clark and Rowe 1971) have considered *B. desorii* to be specifically distinct from *B. australasiae,* although for different reasons.

The aim of this paper is to describe the western form of *Breynia* in detail, on the basis of a large collection from Norbill Bay, Rosemary Island, Western Australia, in order to re-evaluate its taxonomic status. The range of variation between

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adults, both within and between populations, and the ontogeny of *Breynia* are described, and the relationship between ontogeny and phylogeny within the genus is assessed. Furthermore, examination of the eastern Australian form, largely on the basis of material from Lord Howe Island, and a collection recently made from the Arafura Sea by the CSIRO vessel *Soela*, reveals the presence of two species, both distinct from the western species; one of these is described as new.

Specimens used in this study are housed in the Western Australian Museum (WAM), Australian Museum (AM), Queensland Museum (QM) and British Museum (Natural History) (BM). In species descriptions 'percentage of test length' is abbreviated to % TL. All measurements made are self-evident, except for width of internal fasciole; this is measured across the apical system.

Key to Living Species of *Breynia*

1 Test with flattened aboral surface; short petals 2
Test with vaulted aboral surface; long petals 3

2 Internal fasciole narrow; periproct oval . . . . *B. neanika*
Internal fasciole narrow; periproct circular . . . . *B. vredenburgi*

3 Many primary tubercles 4
Few primary tubercles . . . . *B. australasiae*

4 Internal fasciole long; plastron long . . . . *B. desorii*
Internal fasciole short; plastron short . . . . *B. elegans*

Systematics

Order Spatangoida Claus, 1876
Family Loveniidae Lambert, 1905
Genus *Breynia* Desor, 1847

Type Species
Spatangus australasiae Leach, 1815: 68.

Breynia australasiae (Leach, 1815)

Figures 1, 2

Spatangus australasiae Leach, 1815: 68, Pl. 82.
Breynia australasiae – Mortensen 1951: 132-139, Pl. 10, figs 1-5, Pl. 12, figs 8, 9, 11, 13, Pl. 14, figs 3-5, Pl. 49, figs 1-5, 20, 25-30, 32; with full synonymy.
Breynia desorii Gray, 1851; – Mortensen 1951, Pl. 12, fig. 7, Pl. 14, figs 6, 7.

Diagnosis (emended herein)

Aborally test bears up to 15 primary spines and tubercles in each of the anterior interambulacra, 2 and 3, and up to 25 in 1 and 4. Peripetalous fasciole only close to ambitus anteriorly; broad and relatively short internal fasciole. Peristome broad and sunken; periproct large. Generally between 5 and 6 subanal pore pairs.

Remarks

This species has been described by a number of authors (see Mortensen [1951] for detailed synonymy) and in detail by Mortensen (1951). Further general description would be superfluous. However, a number of further observations can be made, amplifying, in particular, characters hitherto not considered to be of great taxonomic significance, but in this study shown to be important in characterizing the species.

Compared with other species of *Breynia* the peristome is wide (Figure 5) occupying up to 16% TL. In large adults the labrum may project slightly anteriorly giving a slight lunate shape to the peristome, in contrast to the semicircular shape in juveniles and young adults. Mortensen (1951) characterized *B. australasiae* as having a labrum which reaches only to the second ambulacral plate, although rarely just approaching the third. Examination of almost 100 specimens has revealed that the labrum reaches the second ambulacral plate in only 40% of the specimens; in the remaining 60% it reaches the third.

The periproct is large for the genus, its long axis reaching almost 15% TL. It is enclosed by plates 4-8 of interambulacrum 5. Although Mortensen (1951) observed no more than 6 pore pairs either side of the mid-line within the subanal fasciole, specimens are known which have 7; others have as few as 4. Generally there are 5 or 6.

The internal fasciole is relatively broad (Figures 1, 7) occupying generally 20-24% TL, but up to almost 30% in some large individuals. It is relatively short (Figure 6), between 36 and 44% TL. As a result of the peripetalous fasciole being set well in from the ambitus anterolaterally, the width across the anterior petals is only about 56-60% TL (Figure 9). The smaller interambulacral area within the peripetalous fasciole results in fewer primary tubercles than in species in which the peripetalous fasciole approaches closer to the ambitus (Figure 7). In anterior interambulacra 2 and 3 there are no more than 15 primary tubercles, while in the lateral interambulacra 1 and 4 there are up to 25. Rate of production of primary tubercles through ontogeny is slow compared with *B. desorii* (Figure 8).

Examination of an ontogenetic suite shows similar morphological development to *B. desorii* (described below), although rate of development is reduced. The significance of this is discussed below in the section dealing with the phylogenetic relationships between the Australian species. Opening of genital pores is thought to correspond to onset of maturity. This generally occurs between test lengths of 38 and 44 mm.

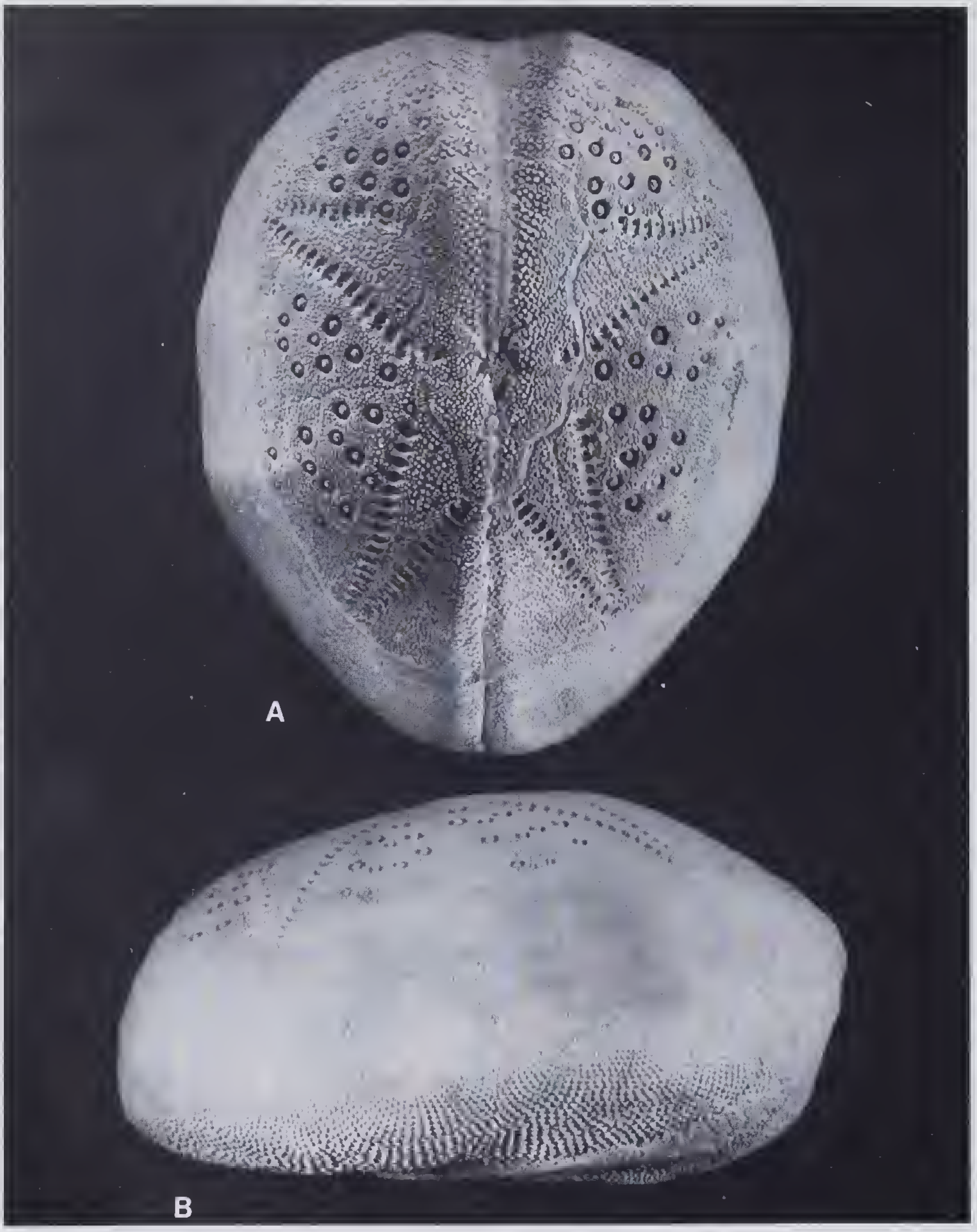

Figure 1 *Breynia australsasiae* (Leach, 1815); AM G12604, from Lord Howe Island; (A) aboral view; (B) lateral view; both x 1.

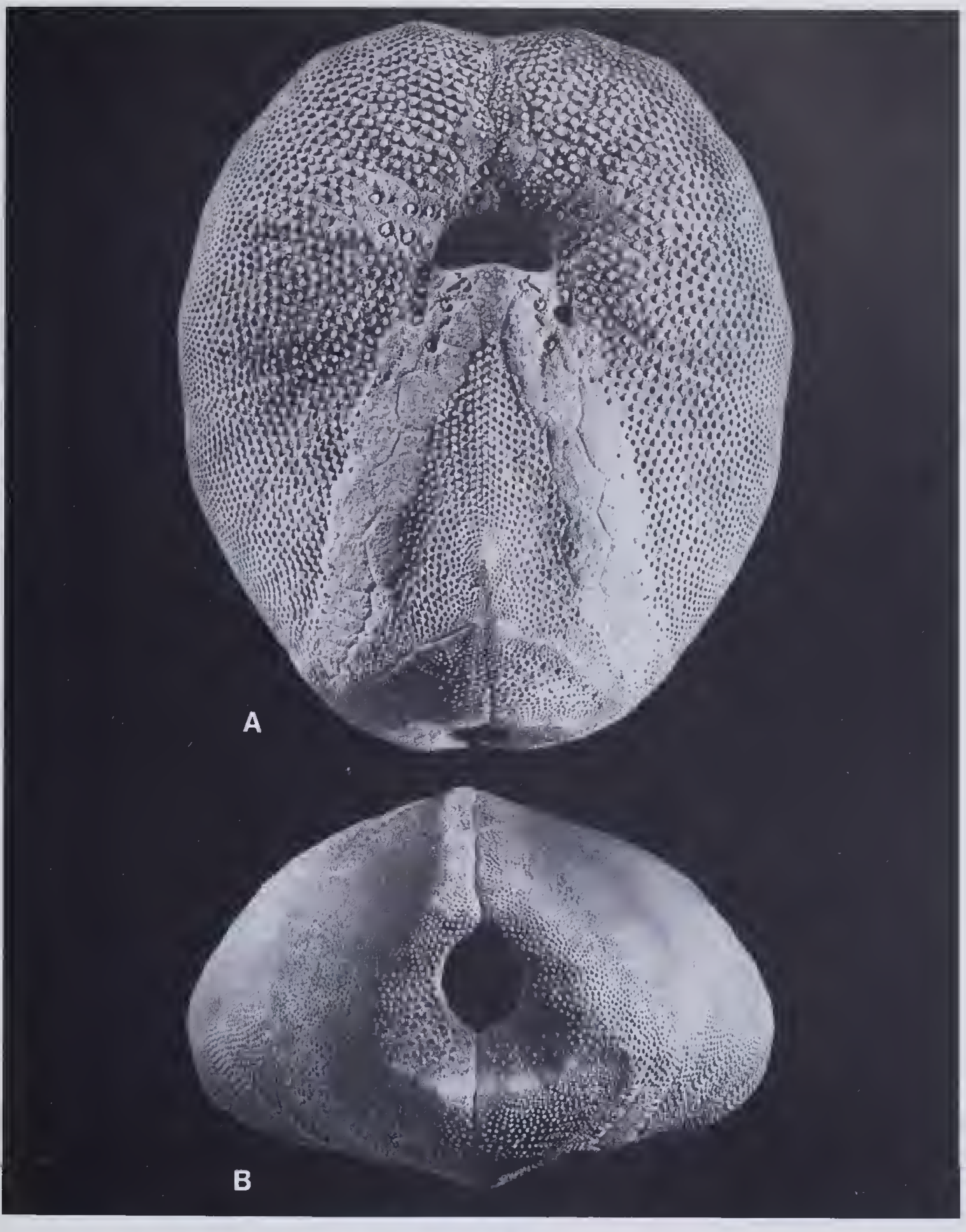

Figure 2 *Breynia australasiae* (Leach, 1815); AM G12604, from Lord Howe Island; (A) adoral view; (B) posterior view; both x 1.

Distribution

H.L. Clark (1946) and Mortensen (1951), following Tenison Woods (1878), recorded *B. australasiae* along the entire Queensland coast from 'Cape York to Port Jackson'. It does not appear, however, to be common from the Queensland coast on the basis of material held in Museum collections. Single specimens are known from East Tongue Reef, north of Cairns; Lindeman Island; Swain Reef and Turtle Head Island, Cape York (all Australian Museum specimens); north Wistari Reef; Bowen; Yepoon (all Queensland Museum specimens); and Hervey Bay (Endean 1961). Four specimens from Torres Strait are in the British Museum (Natural History) collection.

B. australasiae is particularly common around Lord Howe Island in the Tasman Sea, where it burrows in sand in shallow water depths. Although Tenison Woods (1878) recorded the species from Port Jackson there are no specimens from N.S.W. in the collections of the Australian Museum or any other collections examined. There is no record of *B. australasiae* from either the Victorian or South Australian coasts (Figure 14).

Although Mortensen (1951: 137) considered *B. australasiae* to be restricted to the eastern coast of Australia and *B. desorii* to the west, three of the specimens he figured from eastern Australia, one from Bowen (Mortensen 1951, Pl. 12, fig. 7) and two from 'Queensland' (Mortensen 1951, Pl. 14, figs 6, 7) he called *B. desorii,* contrary to his opinion on their distribution expressed in the text. These specimens appear to be *B. australasiae.*

Breynia desorii Gray, 1851
Figures 3, 4, 10

Breynia desorii Gray, 1851: 131; – Gray 1855: 46; – Mortensen 1951: 129-131, 139-141, Pl. 11, figs 3-5, Pl. 12, figs 1, 12, *non* 7, Pl. 14, figs 1, 2, *non* 6, 7; – James 1966: 79; – A.M. Clark and Rowe 1971: 146-149, 165, fig. 81b.

Breynia australasiae – Agassiz 1872-74: 578 (pars.); – Studer 1880: 881; – Alexander 1914: 112; – H.L. Clark 1914: 169; – H.L. Clark 1917: 250 (pars.); – Mortensen 1918: 20, Pl. 5, figs 2, 18, 19, 22; – H.L. Clark 1925: 228; – H.L. Clark 1938: 438-439; – H.L. Clark 1946: 381.

?*Breynia australasiae* var. *aroensis* Currie, 1924: 63-66, Pl. 4.

Holotype

British Museum (Natural History) specimen 39.6.10.36, a dry test lacking spines; probably female. Purchased from a Mr Turner prior to 1839 when it was registered. Miss A.M. Clark of the British Museum informs me (litt. comm. 21.10.80) that the specimen is the only one in the collections registered as coming from 'Swan River, Western Australia', the type locality, even though Gray (1851: 131) recorded several specimens being in existence at the time of his description of the species. It must therefore be regarded as the holotype as it is the sole remaining specimen from the type series. It had earlier been considered by A.M. Clark and Rowe (1971) that all of Gray's original series was lost.

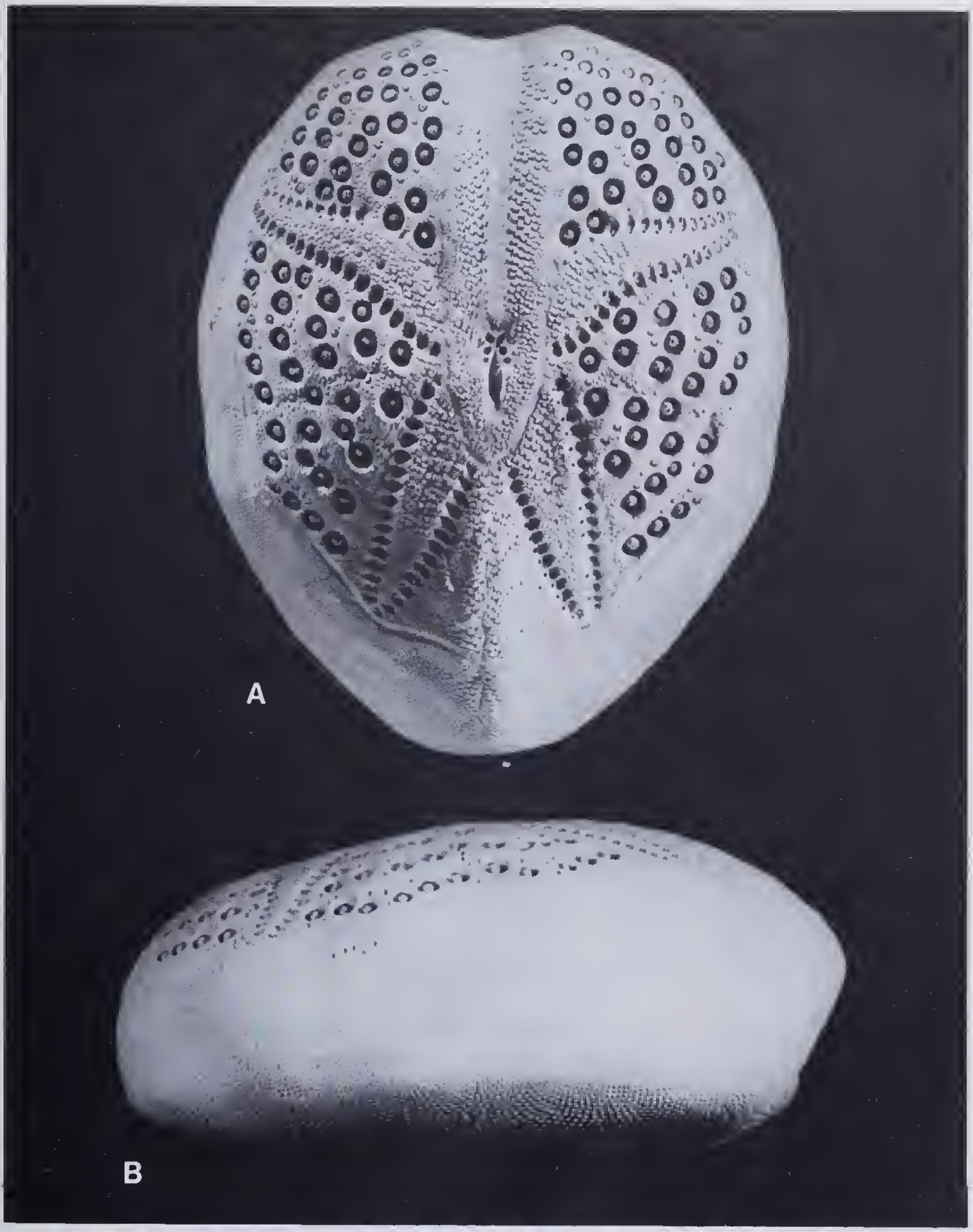

Figure 3 *Breynia desorii* Gray, 1851; BM 39.6.10.36, holotype, from 'Swan River, Western Australia'; (A) aboral view; (B) lateral view; both x 1.

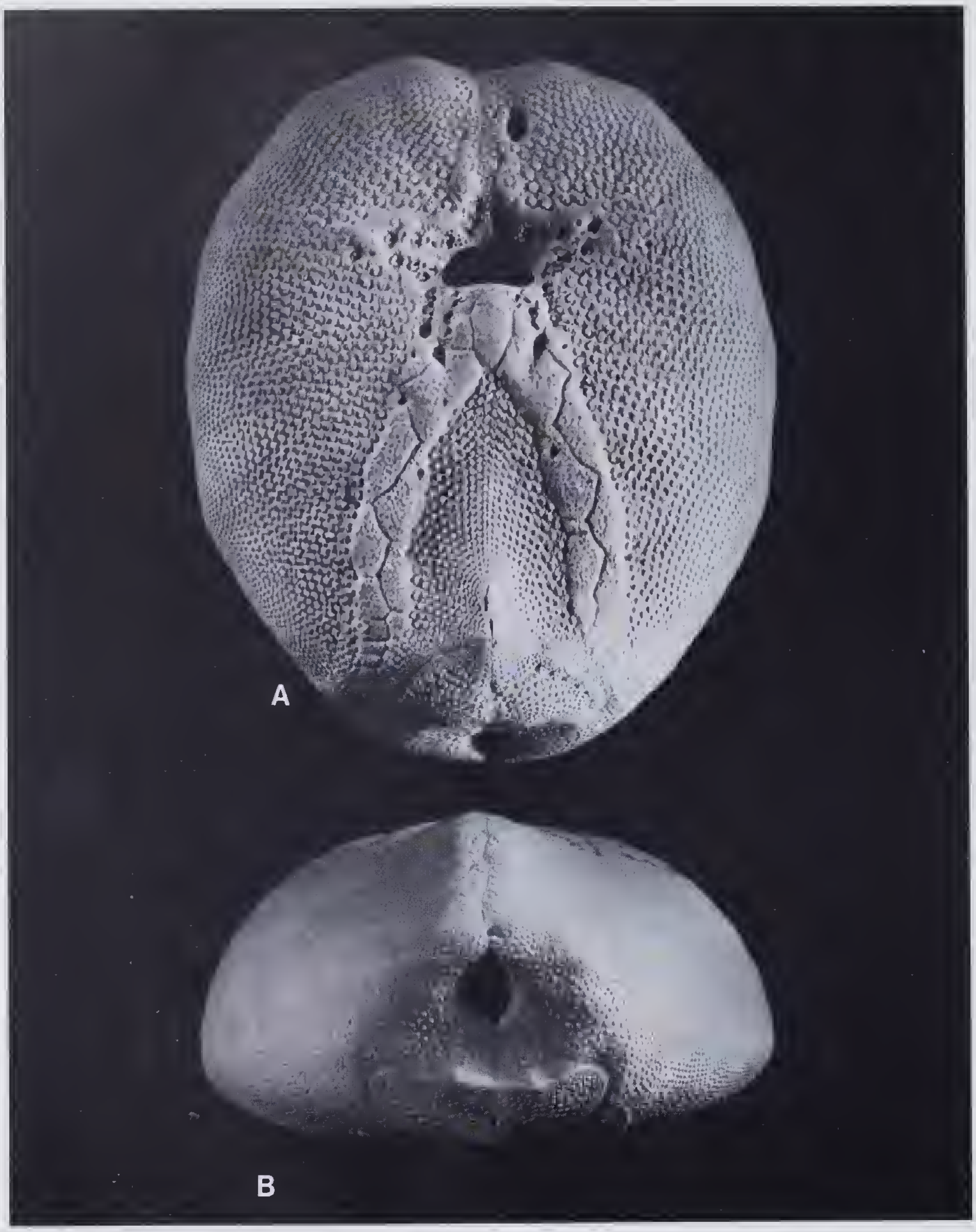

Figure 4 *Breynia desorii* Gray, 1851; BM 39.6.10.36, holotype, from 'Swan River, Western Australia'; (A) adoral view; (B) posterior view; both x 1.

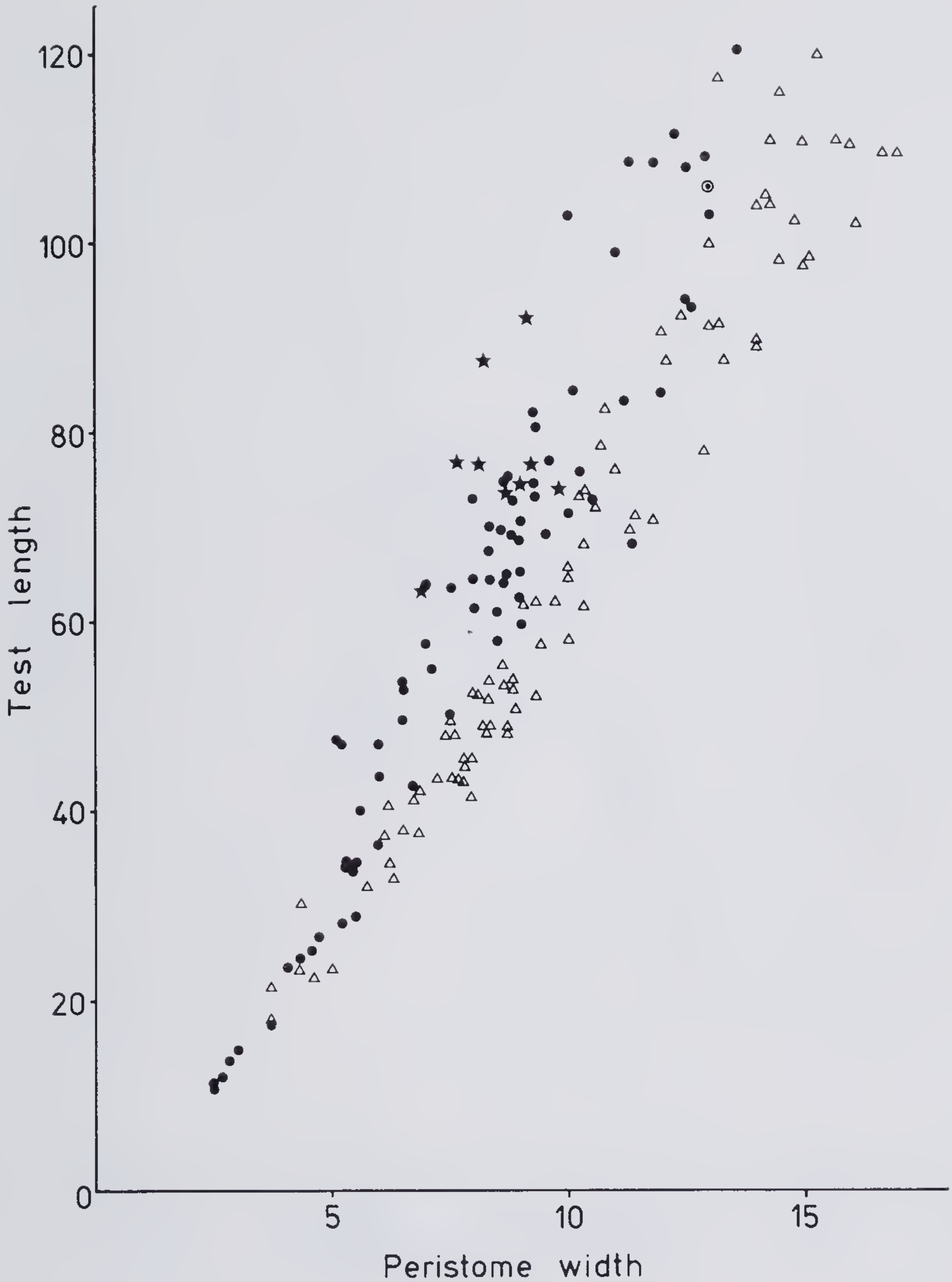

Figure 5 Plot of test length against peristome width for *B. australasiae* (triangles), *B. desorii* (circles) and *B. neanika* (stars).

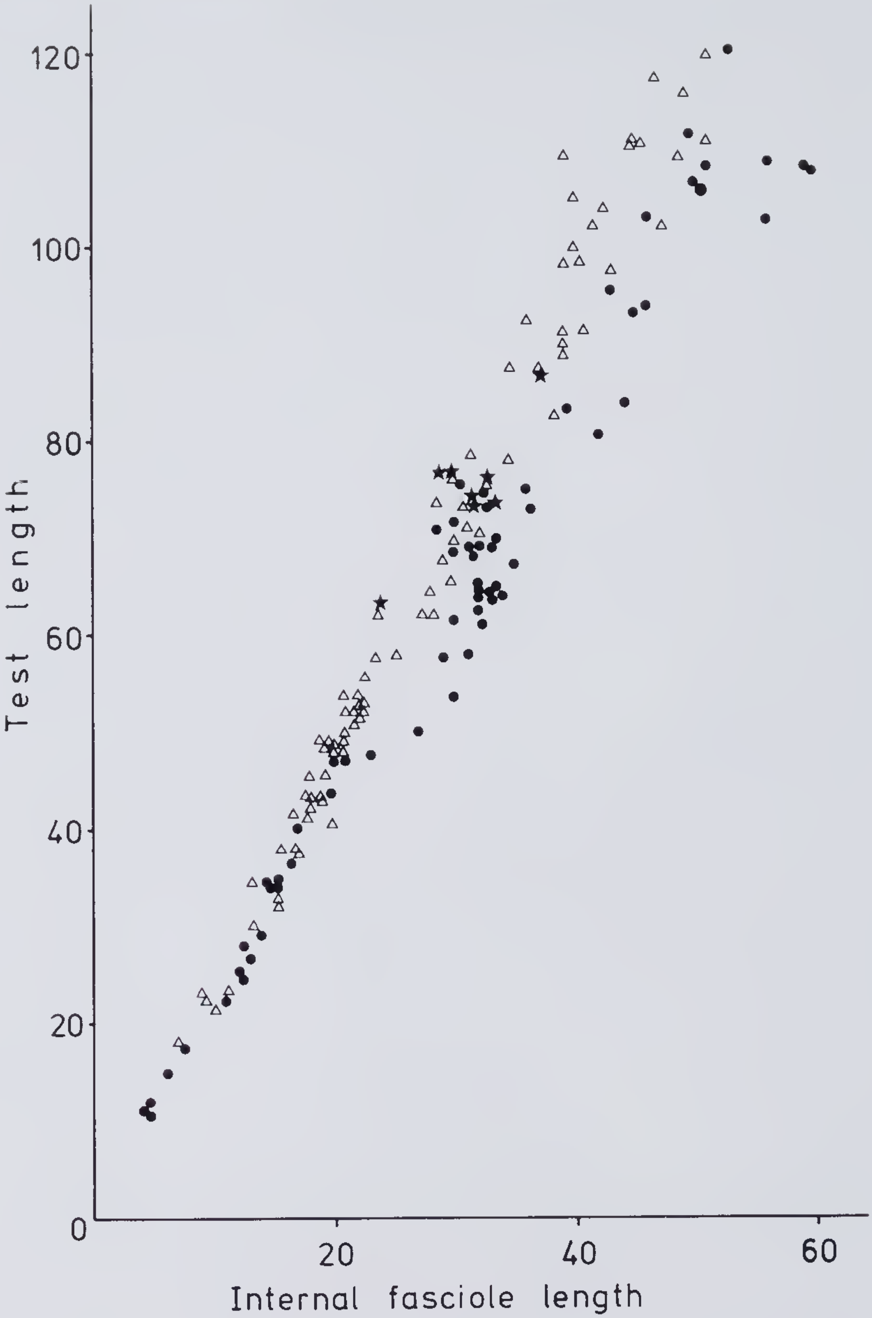

Figure 6 Plot of test length against internal fasciole length for *B. australasiae* (triangles), *B. desorii* (circles) and *B. neanika* (stars).

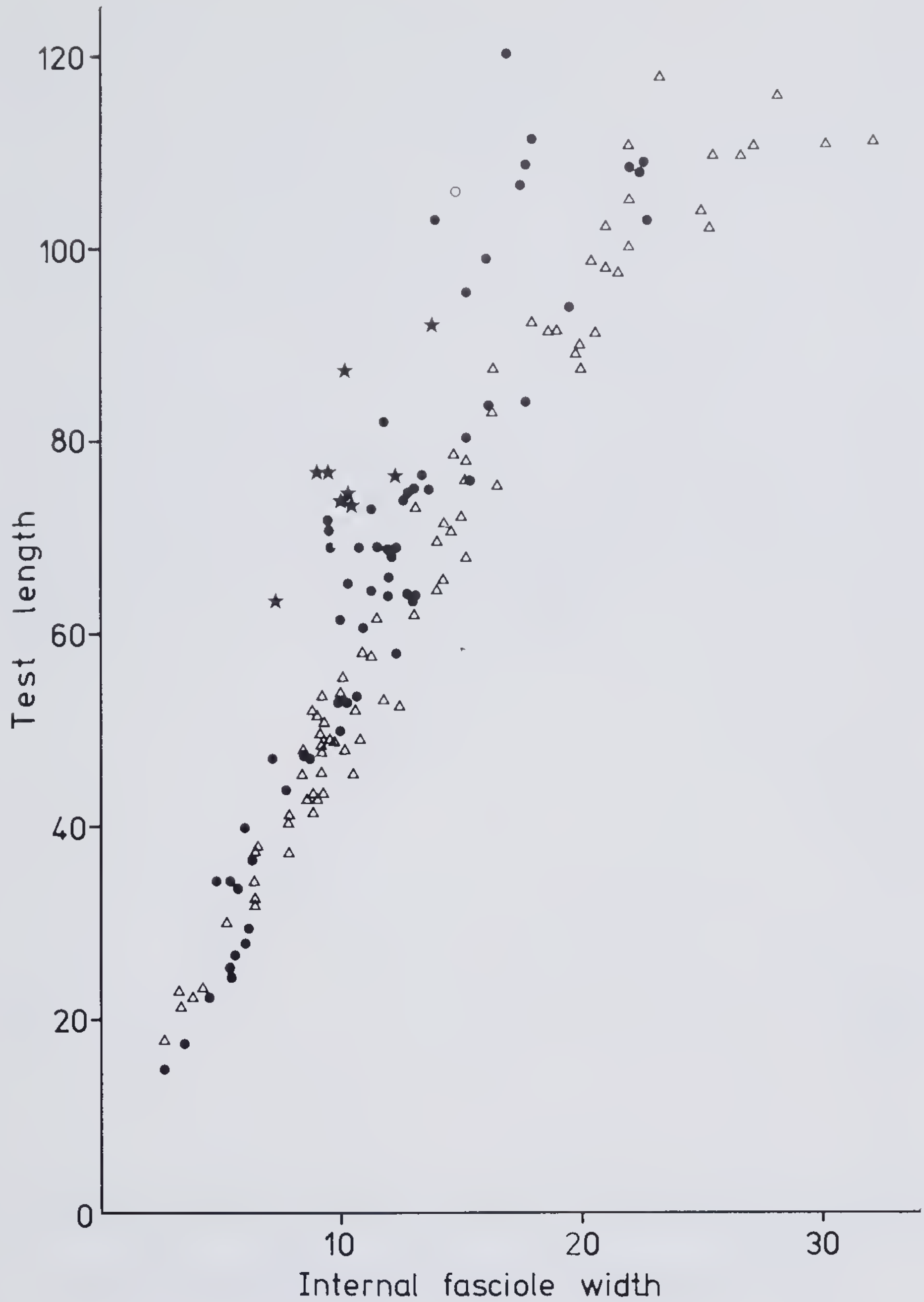

Figure 7 Plot of test length against internal fasciole width for *B. australasiae* (triangles), *B. desorii* (circles) and *B. neanika* (stars).

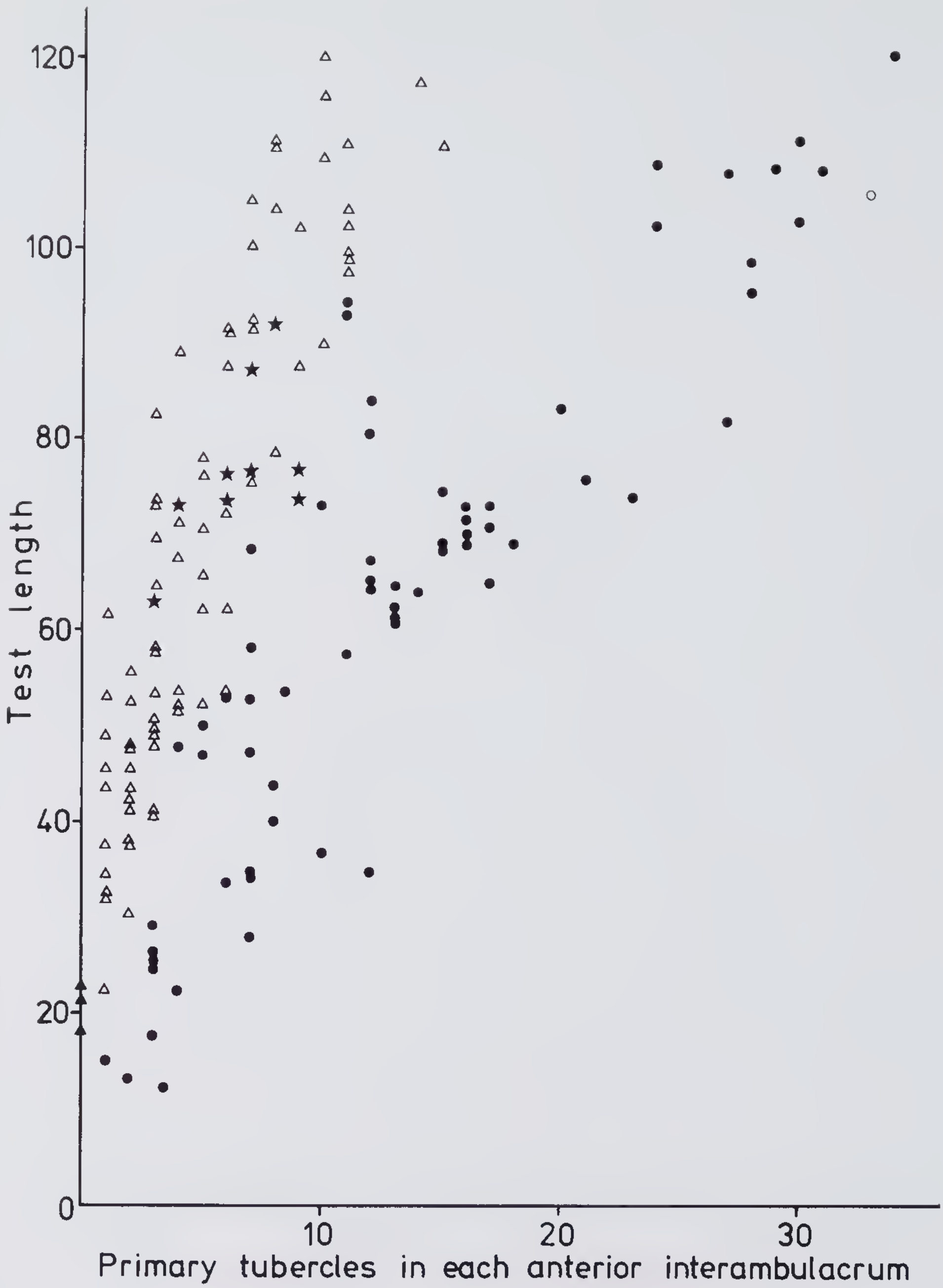

Figure 8 Plot of test length against number of primary tubercles in anterior interambulacra for *B. australasiae* (triangles), *B. desorii* (circles) and *B. neanika* (stars).

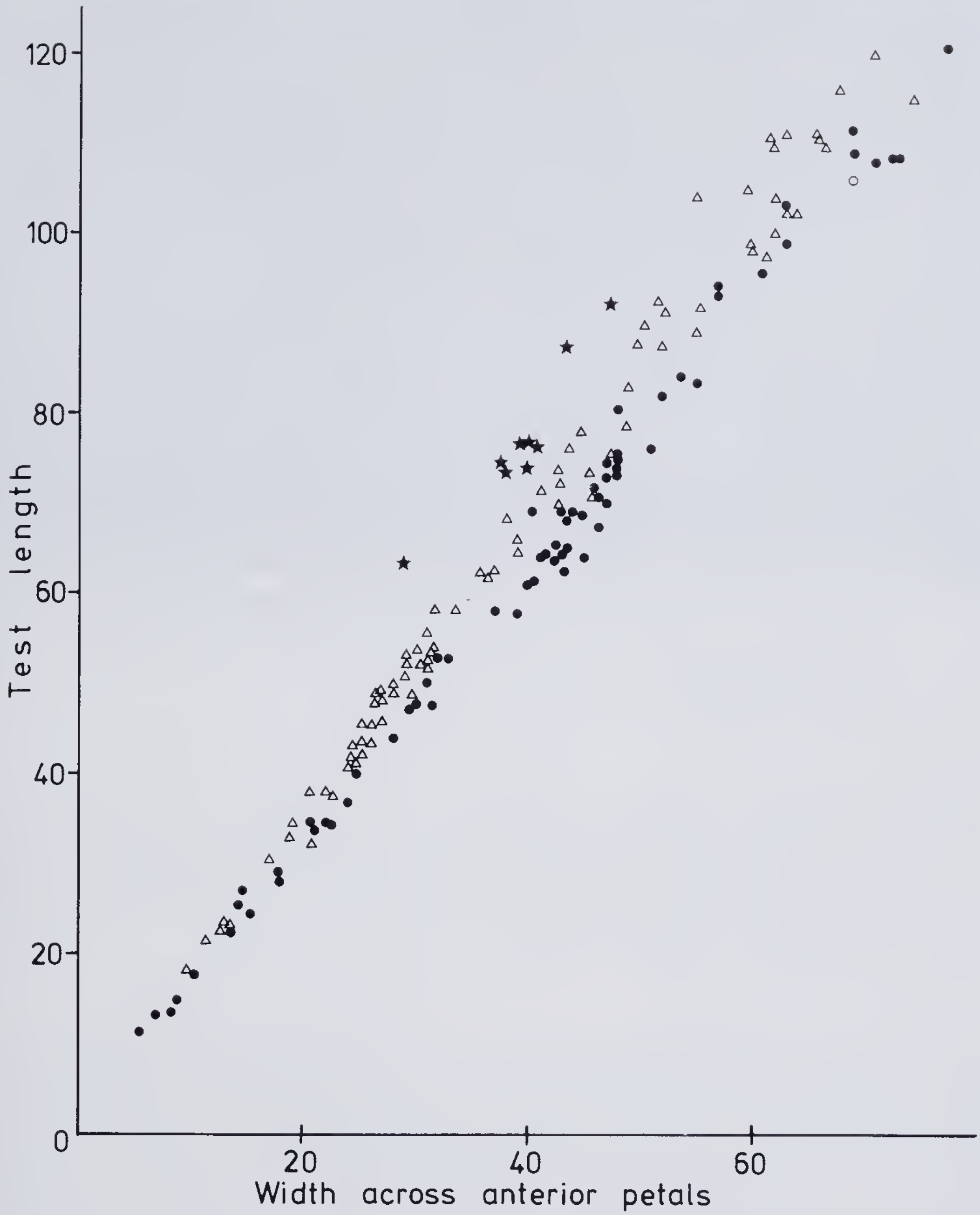

Figure 9 Plot of test length against width across anterior petals for *B. australasiae* (triangles), *B. desorii* (circles) and *B. neanika* (stars).

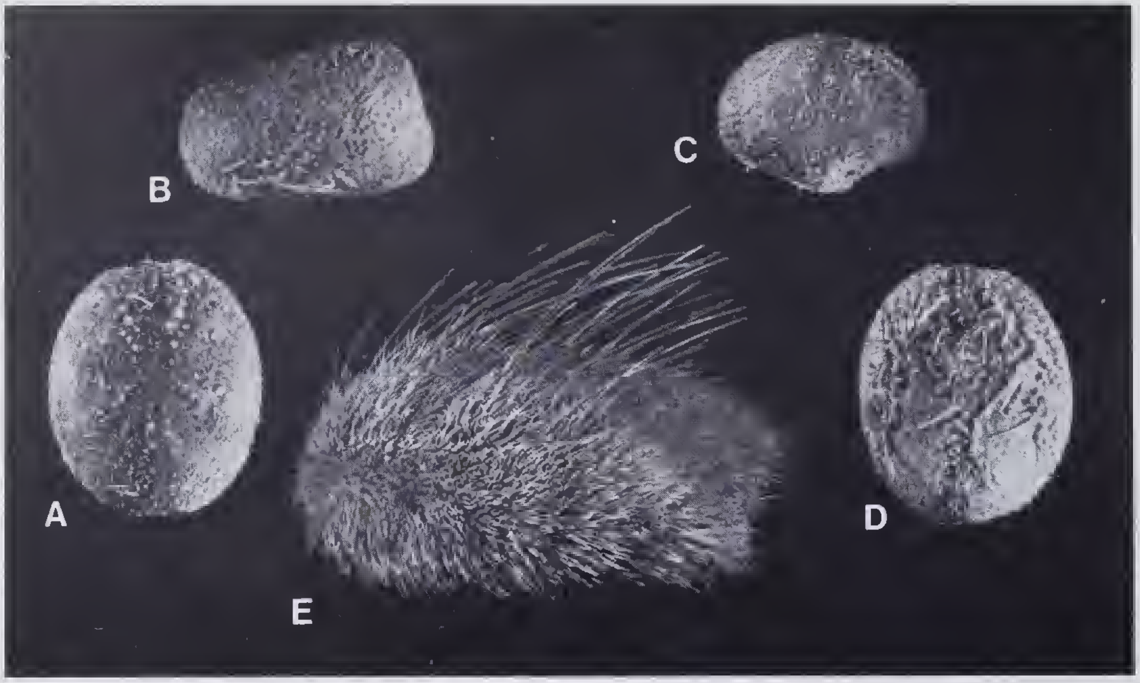

Figure 10 *Breynia desorii* Gray, 1851; WAM 50-82, juvenile (A) aboral view; (B) lateral view; (C) posterior view; (D) adoral view; all x 3; (E) WAM 51-82, lateral view of specimen with spines, x 1. Both specimens from Norbill Bay, Rosemary Island, Western Australia.

Diagnosis (emended herein)

Aborally test bears up to 42 primary spines and tubercles in each of the anterior interambulacra, 2 and 3, and up to 45 in lateral interambulacra 1 and 4. Peripetalous fasciole close to ambitus anteriorly and laterally; long and generally narrow internal fasciole. Peristome narrow and sunken. Generally between 6 and 7 subanal pore pairs.

Description

Test reaches a maximum known length of 120 mm; widest slightly anterior to mid-test length, width varying between 73 and 85% TL (holotype 82% TL). Test generally highest at two-thirds test length in keel formed by swelling of interambulacrum 5; often, however, test swollen apically; height varies between 44 and 55% TL (holotype 46% TL). Test has broad, shallow anterior notch and tapers gently posteriorly. Posterior keel overhangs periproct. Apical system tetrabasal; depressed and set anterior of centrc, about 40% TL from anterior; ethmolytic with four genital pores; a bimodal size distribution of pore size probably reflects sexual dimorphism; posterior pair more widely spaced than anterior pair, which are almost in contact; occasionally some specimens possess only 3 pores due to failure of one to open at onset of maturity. Madreporite very long, up to 6% TL. Ocular plates very small.

Aborally ambulacrum III shallow, deepening slightly abapically; bears very small pore pairs which decrease in size and become more widely spaced abapically; pores within each pair aligned abaxially; ambulacral plates bear many, relatively large, secondary tubercles abaxially, largest being close to pore pairs; adaxially covered by dense accumulation of very small, granular tubercles.

Anterior petals broad adapically, narrowing abapically to terminate close to ambitus; anterior rows of pore pairs run almost transversely; posterior rows diverge anteriorly at about 115°; pore pairs large in ambulacra between the peripetalous and internal fascioles; width across anterior petals 64% TL (Figure 9); anterior row of large pore pairs relatively short, extending for only two-thirds distance between peripetalous and internal fascioles; large pore pairs replaced by very small pore pairs which extend directly to apical system, the two rows of small pore pairs in ambulacra II and IV diverging at about 90°. Posterior row straight to gently sinuous, almost twice as long as anterior row and reaching much closer to apical system, terminating in transverse line with it at internal fasciole; very small pore pairs extend inside internal fasciole transversely to apical system; rarely one or two of the pore pairs within the internal fasciole may be large. Large pore pairs in petals deeply sunken and conjugate, outer pore of each pore pair slightly larger than inner; abapically pores diminish in size slightly close to ambitus; 10-13 pore pairs in anterior rows of petals; 16-20 in posterior rows; frequently 11 in anterior, 17 in posterior (as in holotype). Plates 13 or 14 of the anterior ambulacra have first petaloid pore pairs. Ambulacra between pore pairs covered by numerous small, granular tubercles.

Posterior petals with outer poriferous rows being much longer than inner (16-20 pore pairs, compared with 13-16); rows straight, widely spaced anteriorly, converging posteriorly at peripetalous fasciole. Within internal fasciole inner row continues its course as very small pore pairs; very small pore pairs in outer row run transversely within internal fasciole. Plates 21 of each of the posterior ambulacra have first petaloid pore pairs. This plate is occluded by plates 20 and 22, and so fails to touch the interambulacra.

Within peripetalous fasciole, interambulacra 1 to 4 bear large, sunken, primary tubercles; larger adapically, diminish in size toward peripetalous fasciole. Number of tubercles is quite variable (Figure 8), a test 109 mm in length having only 24 in interambulacrum 2, but one 106 mm in length having 42. Tests 100 to 120 mm test length generally have 28-33 in the anterior interambulacra 2 and 3. There are generally a few more tubercles in posterolateral interambulacra than in anterolateral interambulacra. Tubercles bear large spines which may reach up to half test length (Figure 10E). One aberrant specimen (WAM 631-71), which has the highest known number of tubercles in interambulacra 1 to 4, has, contrary to generic diagnosis, six tubercles in interambulacrum 5.

Peripetalous fasciole may extend to ambitus anteriorly and close to ambitus laterally; posteriorly it reaches to within almost 90% TL of posterior; frequently branched anteriorly, branches running parallel to main fasciole, but often discontinuous; indeed it is unusual for fasciole not to have many branches anteriorly. Laterally it passes across plate 6 of interambulacra 1 and 4. Internal fasciole long and generally narrow (Figures 3, 6, 7); parallel-sided throughout most of its length; length 45-55% TL; width 14-20% TL (though higher in a Shark Bay population – see below); also often branched anteriorly; extends a long distance, up to 20% TL behind apical system.

Peristome lunate, sunken and narrow (Figures 4, 5), width being only 9-13% TL. Oral unipores, with tube feet being terminated by a disc which bears many fine papillae, arranged in phyllode around peristome: 9 or 10 in ambulacra II and IV; 6 in ambulacrum III; 7 or 8 in ambulacra I and V. Although pores are generally unipores, occasionally anisopores are present. Labrum very long, up to 15% TL; broad anteriorly, constricting at one-quarter length, then approximately parallel-sided until tapers posteriorly almost to point; reaches plastron except in eight specimens: two (WAM 1788-74, 192-78) from Wallabi Island, Abrolhos; three from the southern end of Eighty Mile Beach; and three from Louisa Bay, Dirk Hartog Island. In these specimens third plates of ambulacra I and V are in contact, thus labrum and plastron are separated (Figure 11C). In about 80% of specimens labrum extends posteriorly to be in line with third ambulacral plate; in remainder extends only to second plate (Figure 11A). This is not a function only of varying length of labrum, but is largely a consequence of great variability in size of second ambulacral plate. Generally it is only about one-quarter the size of third ambulacral plate, but in some individuals it is at least half the size and extends posteriorly. Anteriorly labrum is transverse to anteriorly projecting, particularly in large adults.

Plastron triangular and widest posteriorly; width half to one-third length; posteriorly forms a slightly raised keel; plastron covered by tubercles which increase in size abaxially; areole around tubercles extends postero-adaxially. Ambulacra I and V smooth, swollen; width 8-11% TL. Periproct longitudinally oval; longer axis 10-12% TL. Subanal fasciole large; triangular to sub-oval; width up to 35% TL. Generally 6-7 pore pairs within each ambulacra within fasciole, though range is from 3-8; associated tube feet with disc-like termination bearing numerous fine papillae. Test between periproct and subanal fasciole sunken. Large adoral anterior and lateral interambulacral surfaces covered by large, closely spaced tubercles; areoles directed posterolaterally in lateral interambulacra, but anterolaterally in anterior interambulacra.

Pedicellariae very numerous; small ophicephalous, which are particularly common on adoral ambulacra I and V; large, 1.5 mm long, and small rostrate; 1 mm long tridentate; small triphyllous. There is no apparent difference in form of these pedicellariae from those of *B. australasiae,* but, as Mortensen (1951) observed, small globiferous pedicellariae infrequently occur in *B. desorii.*

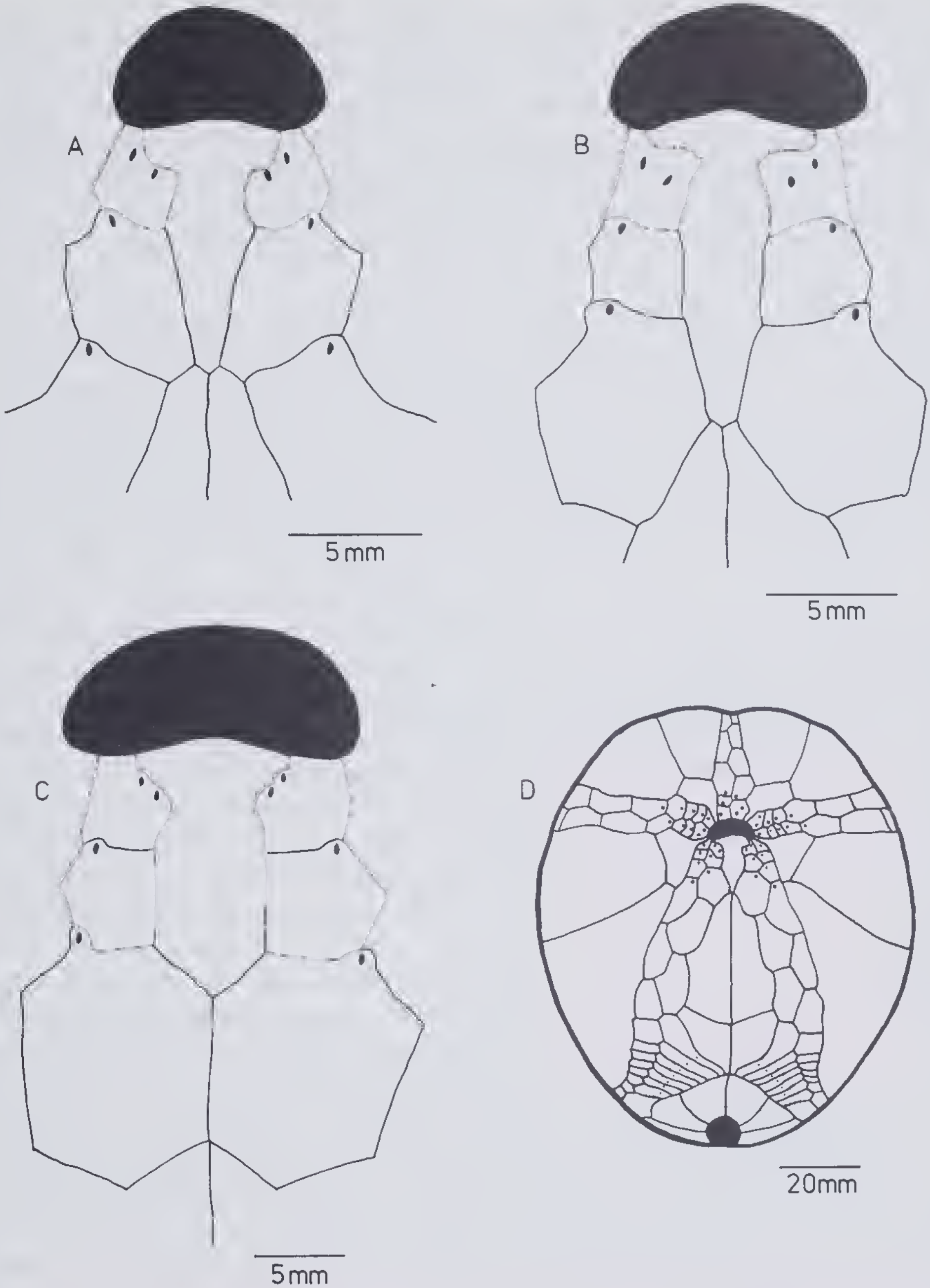

Figure 11 (A-C) Variation in plating around the labrum in *B. desorii:* (A) WAM 49-82, from Laura Bay, Dirk Hartog Island, labrum extends posteriorly to second ambulacral plates; (B) WAM 6-65, from Shark Bay, labrum extends to third ambulacral plates; (C) WAM 192-78 from East Wallabi Island, Abrolhos, labrum separated from plastron by enlarged third ambulacral plates; (D) adoral plating of holotype of *B. desorii,* BM 39.6.10.36.

Ontogeny

Smallest known specimen (Figure 10A-D) has a test length of 10.8 mm. Other specimens of test length 11.0 and 11.8 mm are known. In these small juveniles test is nearly as wide as long, being 85-90% TL. During growth test length progressively increases to adult proportions, i.e. width to as low as 73% TL. Pore pairs open when test length between 32 and 38 mm; this is thought to correspond with onset of sexual maturity. Apical system becomes relatively more anteriorly positioned with growth, from about 50% TL in smallest juveniles to about 40% TL from anterior in adults.

Smallest juveniles have short petals. In anterior pair there are 5 pore pairs in anterior row and 11 in posterior row. In posterior pair there are 8 in inner row and 9 in outer. Petals lengthen through ontogeny initially by increase in number of pore pairs until full adult complement is reachcd, then by a relative increase in size and spacing of the pore pairs. Pore pairs are neither conjugatc nor sunken in juveniles; deepening occurs with growth. The two rows of pore pairs in each petal are sub-parallel in small juveniles and interporiferous zones are a little narrower than width of pore pairs. During growth interporiferous zones of anterior petals increase greatly in width adapically, resulting in anterior rows running almost transversely in adults, and not divergent at about 120° as in juveniles. Petals lengthen such that anterior pair come to lie with distal extremities close to ambitus, width across anterior petals increasing from 50% TL in small juveniles to 66% in adults (Figure 9). Posterior pair lengthen from 25% TL to 40% TL for a ten-fold increase in test length from 10.8 mm. Lengthening of posterior petals occurs at a relatively greater rate than anterior on account of the anterior movement of the apical system; thus posterior petals lengthen both adapically and abapically, whereas anterior petals increase in length only abapically. Anterior and posterior petals of a similar length relatively through adult growth.

Internal fasciole relatively very wide anteriorly in small juveniles, occupying 32-38% TL, whereas in adults it is only half this proportion (Figure 7). With growth, inverted triangular shape of fasciole changes to parallel-sided as most lateral growth occurs posteriorly. Fasciole increases in length from as little as 32% TL to 45-55% TL in adults (Figure 6). In small juveniles fasciole close to apical system posteriorly. Moves posteriorly away from apical system during growth. In small juveniles large area of outer ambulacral plates within intcrnal fasciole carries most prominent tubercles and longest spines. In individuals of test length of 14 mm, spines up to 7 mm long. One to two primary tubercles are present in each interambulacrum between internal and peripetalous fascioles, but spines carried arc shorter than those on plates of ambulacrum III. With growth interambulacral spines lengthen relative to ambulacral spines, such that at test length of 20 mm they are of similar length. At maturity (32-38 mm) interambulacral spines are longer and continue to increase relativcly during adult growth. Production of primary tubercles and spines increases throughout adult growth.

Adorally, second plate in posterior row of interambulacrum 1 has junction with third plate meeting tenth ambulacral plate in juvenile 8 mmTL. At 34 mm TL it meets twelfth plate, whilst in adults 100 mm TL it meets the sixteenth plate.

Peristome relatively large in juveniles, length equalling nearly one-quarter test length. There is a relative size decrease during growth such that in adults peristome length half relative juvenile length; a similar relative reduction occurs in peristome width (Figure 5). Furthermore, during growth peristome becomes more sunken and in large adults labrum, which is transverse anteriorly in juveniles, may project forward. Ambulacra I and V are relatively very broad in small juveniles, width being up to 25% TL, decreasing to 8-11% TL in adults. Plastron elongates anteriorly during growth. Subanal area moves forward during growth; in juveniles it is orientated vertically at posterior of test; it moves anteriorly to lie adorally in adults, as does periproct which, in juveniles, is visible from above. Periproct large in small juveniles: long axis 25% TL in 12 mm long juvenile, decreasing to 17% TL at onset of maturity, thence to 10-12% TL in adults. Number of subanal pore pairs increases steadily from 2 at test length of 12.5 mm to full adult complement of 6-7 at onset of sexual maturity, i.e. test length between 32 and 38 mm.

Morphological Variation

The extent of phenotypic variation in *B. desorii* is best exemplified by a population collected from Laura Bay on the eastern side of Dirk Hartog Island in Shark Bay (WAM 1066.81, 1062. 81). Unlike *B. desorii* populations from Eighty Mile Beach and Rosemary Island to the north, and from the coast near Fremantle to the south, the majority of the Shark Bay specimens are characterized by possession of a narrower test, fewer primary tubercles and broader internal fasciole. In the last two characters they resemble *B. australasiae.* Of 33 specimens measured, the mean internal fasciole width (% TL) is 22.03, which is outside the range for other populations of *B. desorii* (14-20% TL). The range of the Shark Bay populations is 16.8 to 26.7% TL. In *B. australasiae* the range is 20-24% TL.

The internal fasciole length of the Shark Bay specimens is, however, characteristic of *B. desorii,* ranging from 41-58% TL (compared with 45-55% TL in other populations of *B. desorii* and 36-44% TL in *B. australasiae*).

The peripetalous fasciole is not positioned quite as close to the ambitus in the Shark Bay material. This, combined with the broader internal fasciole, restricts the production of primary tubercles. Although generally possessing fewer tubercles than specimens in other populations of *B. desorii,* the Shark Bay specimens have more tubercles than specimens of *B. australasiae* of comparable size.

The reasons for interspecific morphological differences in *Breynia* are discussed below. It may be noted here, however, that this morphological variation reflects paedomorphosis, that is retention of characters into moderate to large-sized adults which occur in juveniles and small adults of other populations of *B. desorii.* The rate of morphological change is lower in the Shark Bay material. The population is therefore a neotenic population.

It should be stressed that although the majority of specimens in the Shark Bay population have a relatively longer test than in other populations, and also have fewer primary tubercles, and a broader internal fasciole, some Shark Bay individuals are indistinguishable from individuals from other populations. Furthermore, all the Shark Bay specimens have the characteristic adoral features of *B. desorii.* Morphological variation in other populations affects similar structures to those in the Shark Bay population, but the range of variation is very much less.

Another interesting feature of morphological variation in *B. desorii* is the shape and disposition of the plates in ambulacrum I and V adorally. Variation in size of the second ambulacral plates, as already discussed, results in the labrum reaching posteriorly either to the second or third plates. In addition, a small number of specimens possess third ambulacral plates which are in contact with each other, consequently separating the labrum from the peristome. This feature has not previously been described in living species of *Breynia,* but all described fossil species invariably have the labrum separated from the plastron by greatly enlarged third ambulacral plates. This feature has been noted by Gerth (1922) in the Miocene *B. multituberculata* and by Mortensen (1951) in *B. paucituberculata* (Gerth, 1922). It also occurs in the Miocene *B. carinata* d'Archiac and Haime, 1853 and in an undescribed species from the Middle Miocene Trealla Limestone on Barrow Island and in the Gnargoo Range. It is interesting to note that in juveniles of this undescribed species the labrum and plastron are not separated, suggesting that the lack of separation of these plates in living species is a paedomorphic feature. Separation of the labrum from the plastron also occurs in the brissid *Spatangomorpha,* which occurs in Miocene-Pliocene rocks of the Indo-West Pacific region, and in the loveniid *Verbeekia* from the Eocene of Borneo.

Distribution

Although Mortensen (1951) recorded *B. desorii* from only between Swan River and Dampier, specimens in the Western Australian Museum have been collected from the entire length of the western coast of Australia (Figure 14), being particularly common between Dampier and Broome on the north-west coast. On the southern coast it has been collected from as far east as Lucky Bay (122°15'E). On the northern coast it has been collected from as far east as Darwin (131°E). One fossil specimen of *B. desorii* is known: WAM 60.17, from River Cave, Lake Arramel; this is the Pleistocene Tamala Limestone. The specimens from the Aru Islands, Papua New Guinea described by Currie (1924) as *B. australasiae aroensis* appear to be indistinguishable from *B. desorii.* They are said to be Pliocene in age (Currie 1924: 66).

Information with specimens in the Western Australian Museum collection records *B. desorii* as having been collected only from a sandy substrate. One specimen is recorded as having been found buried in sand 8 cm below the sediment/water interface. The species has been collected from water depths as great as 140 m and in intermediate depths to intertidal sandflats.

Remarks

Gray (1851, 1855) distinguished *B. desorii* from *B. australasiae* principally on the basis of the greater number of primary tubercles; he also noted the elongate, narrow nature of the internal fasciole. Following Agassiz (1872), H.L. Clark (1914, 1917, 1938, 1946), amongst others, placed *B. desorii* in synonymy with *B. australasiae* as he considered the greater number of primary tubercles to be insufficient basis on which to distinguish the western form as a separate species. The nature of the internal fasciole was not considered. Mortensen (1951) was the first worker to reinstate *B. desorii* on the basis of a number of characters. He believed that an important distinguishing character, noted also by James (1966), was the length of the labrum. He believed it extended posteriorly to the third adjoining ambulacral plate in *B. desorii,* but only to the second in *B. australasiae.* A.M. Clark and Rowe (1971) noted a marked variation in this character between species. Rather than the labrum reaching either the second or third ambulacral plate, depending on the species, it is more appropriate to note that, on the basis of examination of large samples, the labrum reaches the third ambulacral plate in *B. desorii* in about 80% of specimens and the second in 20%, whereas in *B. australasiae* the third plate is reached in about 60% of specimens and the second 40%.

Mortensen (1951) further distinguished *B. desorii* from *B. australasiae* on the basis of *B. desorii* possessing 8 pore pairs in each of the ambulacra within the subanal fasciole, whereas *B. australasiae* was said to have only 6. A.M. Clark and Rowe (1971) noted no more than 7 in the largest of the eleven Western Australian specimens of *B. desorii* which they studied; one had as few as 4. Examination of a large sample of adult specimens of *B. desorii* showed a range from 3 to 8, but generally there were 6 or 7. Frequently there will be more pore pairs in one ambulacrum than the other. In *B. australasiae* the number of pore pairs varies between 3 and 7, though generally there are 5 or 6.

The principal character noted by Gray, the greater number of primary tubercles in *B. desorii,* is particularly noticeable in large adults. Even small juveniles of *B. desorii* possess more primary tubercles than equivalent sized specimens of *B. australasiae* (Figure 8); rate of production of tubercles is greater in *B. desorii* than in *B. australasiae.*

B. desorii can further be distinguished from *B. australasiae* on its possession of longer petals, both anterior and posterior (Figures 1, 3), though there is little difference in number of pore pairs; a tendency for a slightly deeper anterior peripetalous fasciole extending closer to the ambitus laterally and posteriorly; longer and generally narrower internal fasciole (Figures 6, 7); narrower peristome (Figure 5); and smaller periproct.

Breynia neanika sp. nov.

Figures 12, 13

Holotype

AM J14324; adult ?female; dry test with some spines preserved; collected from the Arafura Sea on the CSIRO *Soela* Cruise on 14.11.80 at Station S07/80/35 (10°29′S, 132°01′E) at a depth of 80-82 m by J. Paxton.

Paratypes

AM J14325, from the Arafura Sea; collected on the CSIRO *Soela* Cruise at Station S07/80/43 (10°13′S, 133°58′E) at a depth of 72 m; AM J14326a-d, from the Arafura Sea; collected on the CSIRO *Soela* Cruise at Station S07/80/34 (10°27′S, 132°01′E).

Other Material

AM J5295, J5296 from Albany Passage, Torres Strait (10°44-47′S, 142°36-39′E), 'from 9-12 fathoms on gravelly bank'; AM J9993, from 14°24′S, 144°48′E (about 18 km ESE of Barrow Point, Queensland) at a depth of '10 m from mud with *Halimeda* and *Gracilaria*'; AM G7448, from Bowen, Queensland; BM 1881.11.23.29 from Torres Strait, collected on the *Challenger* expedition.

Diagnosis

Test flattened aborally; bears few primary tubercles, no more than 9 tubercles in interambulacra 2 and 3, and 16 in interambulacra 1 and 4. Apical system almost central. Peripetalous fasciole set far from ambitus laterally and posteriorly; internal fasciole short and narrow. Posterior petals short, same length as short anterior petals. Peristome narrow and only slightly sunken; plastron and subanal fasciole narrow; ambulacra I and V broad adorally. No more than 5 subanal pore pairs.

Description

Test reaches a maximum known length of 92 mm; widest at, or slightly posterior, to mid-test length, width generally varying between 80 and 85% TL; 91% in one specimen. Aborally surface of test flattened, but inclined gently anteriorly; highest posterior of apical system; height 44-58% TL. Test has broad, shallow anterior notch; posterior of test almost vertical. Apical system almost flush with surface of test and situated slightly anterior of mid-test length; in form like that of *B. australasiae* and *B. desorii*.

Ambulacrum III aborally very shallow, deepening slightly anteriorly; about 20 widely spaced, very small pore pairs aligned exsagittally; abaxially ambulacral plates bear few larger tubercles. Anterior petals with rows widely spaced adapically, converging abapically; anterior rows not transverse, but anteriorly divergent at 150-160°; posterior rows diverge at 90° initially, then half petal length at 110-120°; width across petals short (Figure 9), 46-54% TL; 9-12 pore pairs in anterior row, 14-16 in posterior row; pore pairs conjugate and deeply sunken. Posterior petals short, same length as anterior petals; converge anteriorly at about 50°; 15-16 pore pairs in outer row, 13-15 in inner row.

Figure 12 *Breynia neanika* sp. nov.; AM J14324, holotype from the Arafura Sea at 10°29′S, 132°01′E. (A) aboral view; (B) posterior view; both x 1.

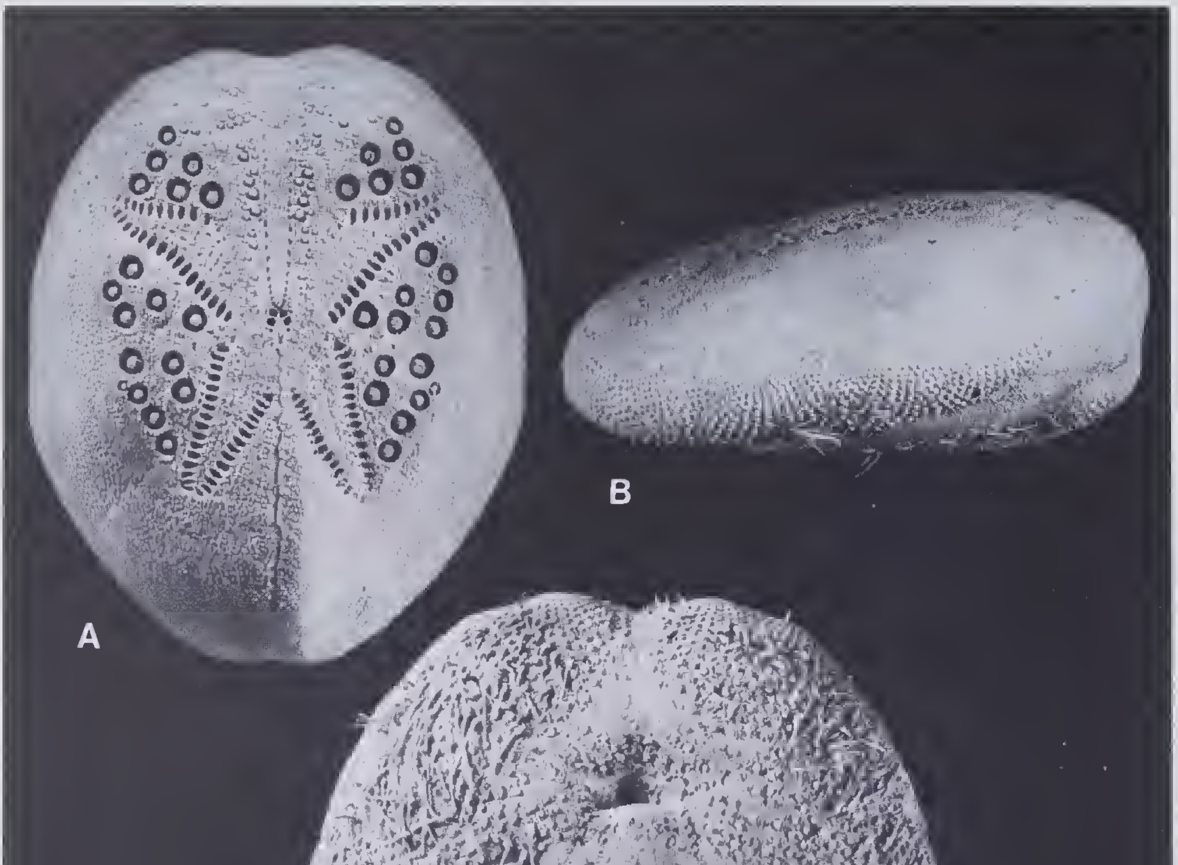

Figure 13 *Breynia neanika* sp. nov.; (A, B) AM J5295, from Albany Passage, Queensland; (A) aboral view; (B) lateral view. (C) AM J14324, holotype, from the Arafura Sea at 10°29'S, 132°01'E, adoral view; both specimens x 1.

Within peripetalous fasciole interambulacra 1 and 4 bear 9-16 primary tubercles; interambulacra 2 and 3 bear 3-9. In holotype and one other specimen (AM J5296) there is one primary tubercle in interambulacrum 5. Peripetalous fasciole is 20% TL from ambitus posteriorly; does not extend to ambitus laterally, passing across plate 7 of interambulacra 1 and 4; anteriorly in interambulacra 2 and 3 fasciole turns through almost a right angle and runs adambitally for a short distancc before turning adaxially to run close to ambitus across anterior of test. In many specimens a branch of fasciole extends line of lateral course of fasciole to run across ambulacrum III 15% TL posterior of anterior ambitus. Internal fasciole short (Figure 6) occupying 37-44% TL, and narrow (Figure 7), width being 12-15% TL across apical system; gradually broadens anteriorly.

Peristome semicircular and only slightly sunken; narrow (Figure 5), 9-13% TL. Eight unipores in phyllode in ambulacra II and IV; 6-7 in ambulacra I and V and 5 in ambulacrum III. Labrum long, 14% TL; does not project anteriorly; posteriorly extends to third ambulacral plate; tapers posteriorly. Plastron narrow, posteriorly being 35% TL; subanal fasciole also narrow, 28-30% TL; triangular to suboval; encloses up to 5 pore pairs in each ambulacrum. Ambulacra I and V flat and broad, width 16-17% TL. Periproct longitudinally oval, 12-15% TL. Test between periproct and subanal fasciole almost flat. Adoral interambulacral tuberculation relatively sparsely distributed.

Remarks

B. neanika differs from *B. australasiae* and *B. desorii* in the possession of a flatter test, the posterior of which is more vertically orientated; shorter petals, which are of equal length; anterior row of anterior petals being less transversely directed; more centrally situated apical system; peripetalous fasciole not as distally positioned laterally and posteriorly; less sunken peristome; broader ambulacra I and V adorally; narrower, more oval subanal fasciolc; sparser adoral tuberculation; and fewer phyllode unipores. It can further be distinguished from *B. australasiae* by its narrower internal fasciole and narrower peristome; and from *B. desorii* by the possession of fewer primary tubercles, shorter internal fasciole, absence of anteriorly projecting labrum, and less sunken area between the periproct and subanal fasciole.

It can be distinguished from *B. elegans* Mortensen, 1948, by its possession of a less tapering test; fewer primary tubercles; broader and shorter petals; more centrally situated apical system; longer internal fasciole; and longer plastron. *B. neanika* has more primary tubercles than *B. vredenburgi* Anderson, 1907, which also has a flattened aboral test surface. On the basis of data provided by James (1966), *B. neanika* would also appear to differ from *B. vredenburgi* in its possession of more poriferous petals; more oval periproct and narrower internal fasciole.

James' (1966) key for the separation of species of *Breynia* was bascd solely on the relationship between the position of the posterior of the labrum with respect to the adjoining ambulacral plate. It has been shown (above) that, contrary to the opinion of Mortensen (1951), there is little difference between *B. australasiae*, *B. desorii* and *B. neanika* in this highly variable character. The revised key, presented above, is based on a combination of other characters.

Etymology

Neanikos (Gr.): youthful, alluding to the possession of adult characters which occur in the juveniles of other Australian species of *Breynia.*

Phylogenetic Relationships

Many of the morphological characters which vary within populations, and which differentiate the three living Australian species of *Breynia,* are characters which undergo appreciable change during the ontogeny of the species, as their growth is allometric. The principal ontogenetic changes observed in both *B. desorii* and *B. australasiae* can be summarized as: a narrowing of the test; a relative anterior movement of the apical system; an increase in petal length and resultant abapical shift of the peripetalous fasciole toward the ambitus; an increasingly transverse orientation of the anterior row of the anterior petals; a narrowing and lengthening of the internal fasciole; an increase in the number of primary tubercles; a relative decrease in size of the peristome and periproct; development of a more deeply sunken peristome; a decrease in width of adoral ambulacrum I and V; and an increase in the number of subanal pore pairs.

B. desorii undergoes greater morphological changes in the majority of these characters during ontogeny than the other Australian species. *B. australasiae* undergoes less morphological change than *B. desorii* during ontogeny but more than *B. neanika,* which thus retains in its late adult form characters which occur only in juveniles and small adults of the other two species (paedomorphosis).

The rate of anterior movement of the apical system is similar in both *B. desorii* and *B. australasiae,* but in *B. neanika* it shows less anterior movement and remains in a more central position, like juveniles of the other two species. Both anterior and posterior petals lengthen more through ontogeny in *B. desorii* than in *B. australasiae,* which in turn has petals which lengthen more than those of *B. neanika.* Like juvenile *B. desorii* the petals of adult *B. neanika* are of similar length; the posterior becomes longer in adults of the other two species. As a consequence the peripetalous fasciole migrates out toward the ambitus most in *B. desorii* and least in *B. neanika.* This results in adults of *B. desorii* possessing larger interambulacral areas between the internal and peripetalous fascioles, so enabling a greater number of primary tubercles to be generated in *B. desorii* than in the other two species.

The anterior rows of the anterior petals change orientation during growth in *B. desorii,* from being anteriorly divergent at 120° in juveniles to almost transverse in adults. The change in orientation, which occurs as the petals lengthen, is least pronounced in *B. neanika,* the adults of which have anterior rows divergent at 150-160°.

The internal fasciole changes from being short and broad in juveniles of *B. desorii,* to long and generally narrow in the adult; in *B. australasiae* this fasciole remains broad and short, whilst in *B. neanika* it remains relatively short, but does become narrower. The peristome, which relatively decreases in size during ontogeny in proportion to the whole test, decreases at a less pronounced rate in *B. australasiae* than in *B. desorii.* Consequently adults of *B. australasiae* have a relatively larger peristome. Whereas *B. neanika* generally retains the most juvenile characters, it has a relatively small peristome, like *B. desorii.* This illustrates the potential for development of large numbers of morphotypes from a *B. desorii*-type ancestor, as decreased rates of morphological development may operate on different combinations of characters. Adults of *B. neanika* do, however, like the juvenile *B. desorii,* retain only a slightly sunken peristome in the adult. As with the peristome, the periproct also undergoes an appreciable decrease in relative size through ontogeny in *B. desorii.* This change is less pronounced in *B. australasiae,* which consequently possesses a larger adult periproct. *B. neanika* also has a relatively larger periproct than adult *B. desorii.* The adoral ambulacra I and V are very wide in juvenile *B. desorii.* They decrease in relative width through growth in *B. desorii* and *B. australasiae*; the ambulacral plates also become tumid with growth. *B. neanika* retains the juvenile flat, relatively broad ambulacral plates into the adult. Another juvenile character retained by *B. neanika* is the possession of sparsely distributed adoral tubercles.

The number of subanal pore pairs in each ambulacrum progressively increases during juvenile growth in *B. desorii* to the adult complement of 6-7. *B. australasiae* generates only 5-6, whilst *B. neanika* has no more than 5.

Consequently, speciation in *Breynia* may be considered to have occurred by selection of paedomorphic forms. *B. australasiae* evolved by selection of an extreme paedomorph of *B. desorii* which possessed a morphology which was sufficiently different from the ancestral *B. desorii* morphology to allow ecological and, subsequently, genetic isolation.

It is clear that the adaptive threshold which must be crossed in order for speciation to occur has not been reached by the Shark Bay population of *B. desorii.* Like *B. australasiae* there has been a reduced rate of morphological development of some characters, compared with the more normal populations of *B. desorii.* Fewer characters have changed in the Shark Bay population than in *B. australasiae,* however, and they are insufficient to allow ecological separation of this morphotype from the ancestral *B. desorii* morphotype.

B. neanika is neotenic with respect to *B. australasiae,* from which it is considered to have evolved by the same process as *B. australasiae* evolved from *B. desorii.* By showing increasing degrees of paedomorphosis, from the apaedomorph, *B. desorii,* though *B. australasiae,* to the most paedomorphic, *B. neanika,* the three species form a paedomorphocline (McNamara 1982*b*) (Figure 15).

Fossil species of *Breynia* have never been found in the Miocene deposits of southern Australia (principally the Murray River in South Australia and the Nullarbor in Western Australia). Neither, it would seem, was it present in south-west Australia during the Pliocene as no specimens have ever been recorded from the richly fossiliferous Roe Calcarenite, despite intensive collecting in recent years. The presence of *B. desorii* along the western part of the south coast at the present day suggests it is a relatively recent immigrant.

In addition to the occurrence of Miocene and Pliocene species of *Breynia* in the western Sind and Kachh regions of Pakistan, in Taiwan, Japan and Java, it also occurs in the Middle Miocene of north-west Australia (McNamara in prep.). Modern distribution suggests a migration from this general Indo-West Pacific region eastwards to encompass western, northern and eastern Australian coasts.

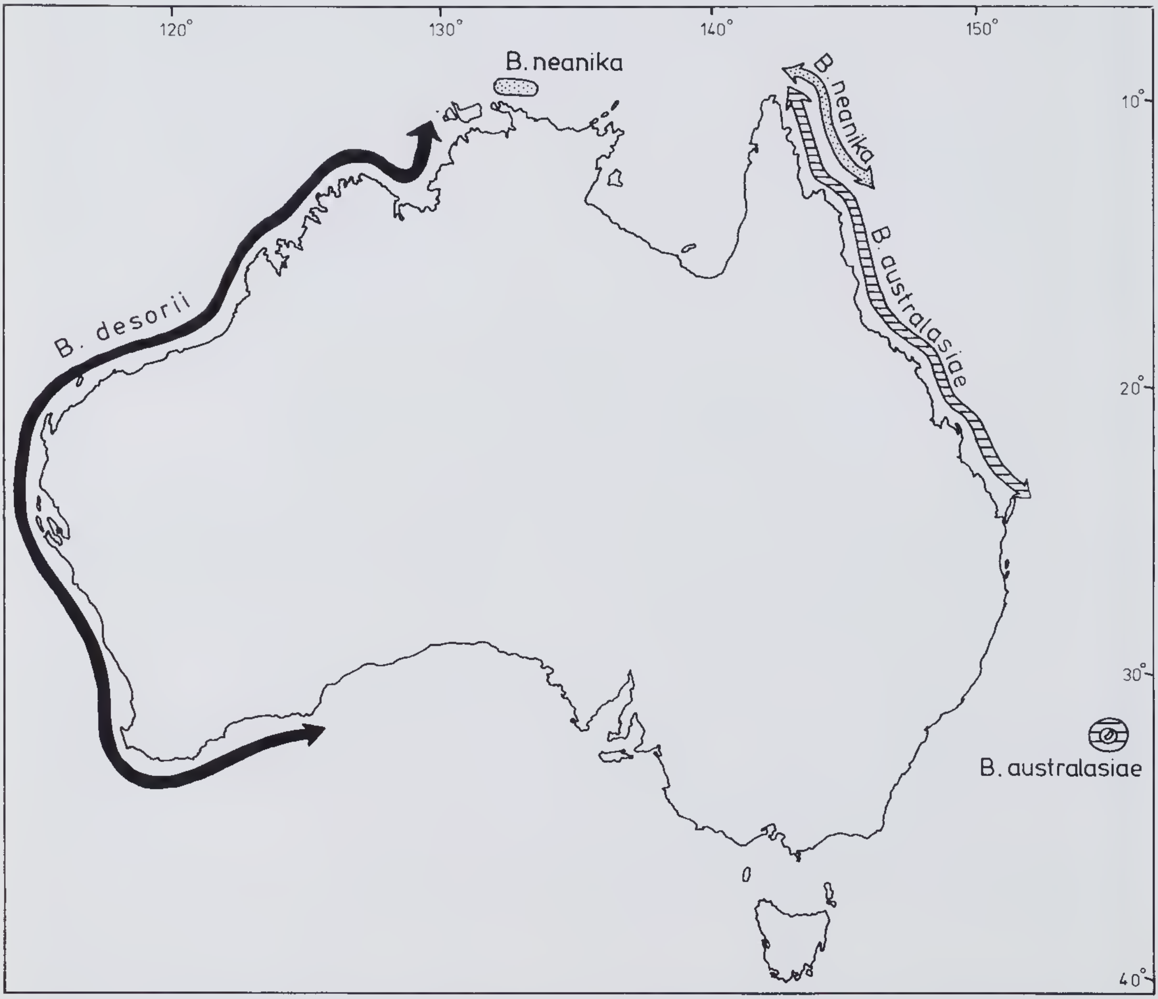

Figure 14 Map showing known distribution of species of *Breynia* around Australia.

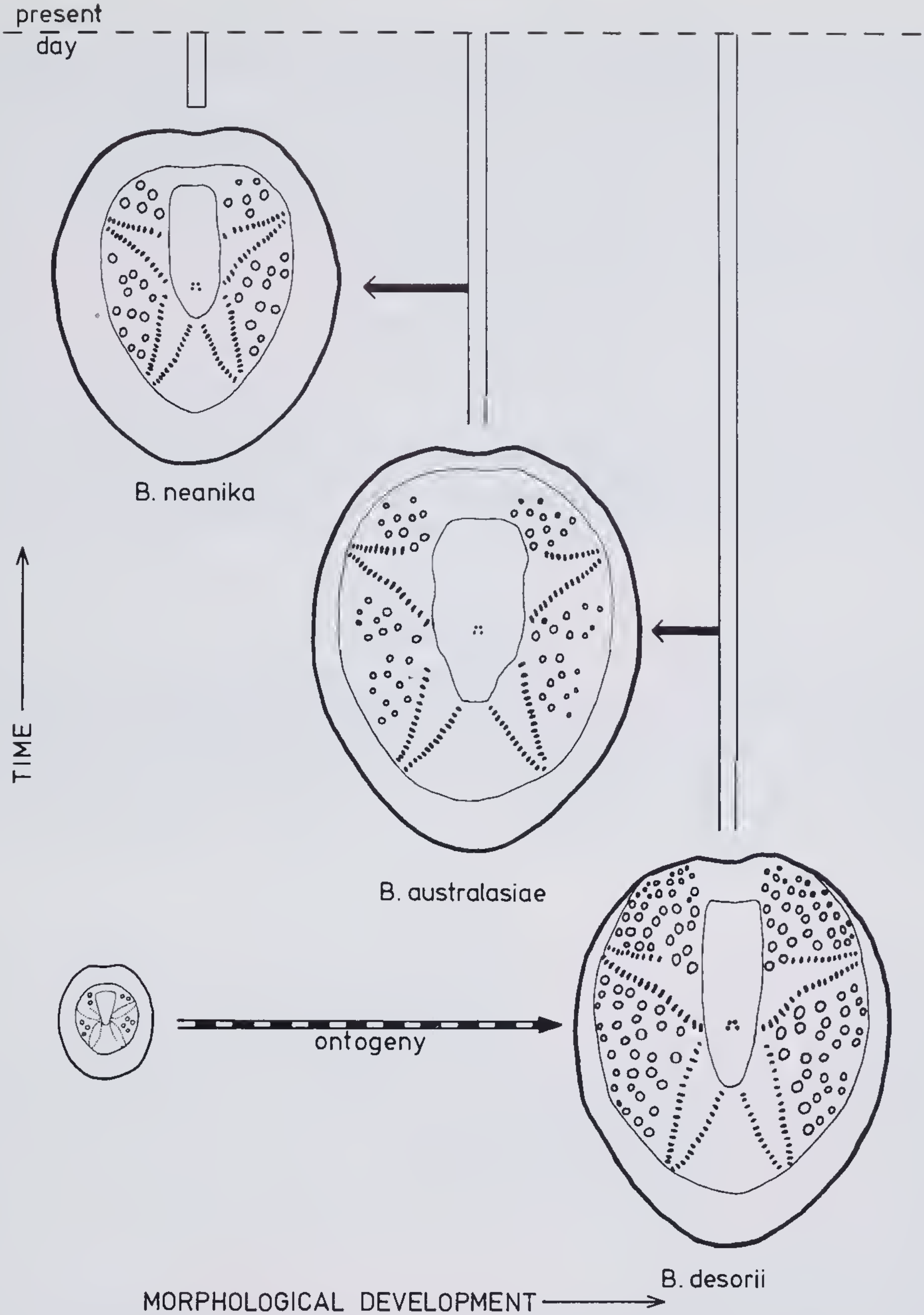

Figure 15 Suggested phylogeny of Australian species of *Breynia*. The three species form a paedomorphocline. *B. australasiae* is thought to have evolved pre-Late Pleistocene, and *B. neanika* post-Late Pleistocene. Reconstructions are x ½, except for juvenile *B. desorii* which is x 1½.

Outside of the Australian region the genus is now rare, being known only from the Kei Islands (*B. elegans*) and Andaman Island (3 specimens of *B. vredenburgi*).

The absence of *Breynia* from both the fossil and living records from much of southern Australia, suggests derivation of the eastern Australian species, *B. australasiae* and *B. neanika,* along the northern coast from species to the west. This is in keeping with the suggested paedomorphic derivation of these species from the western Australian *B. desorii.* The localized, uncommon occurrence of the paedomorphic *B. neanika* in north-east Australia (where it occurs with *B. australasiae*) and in the Arafura Sea, is consistent with a suggested development by paedomorphosis from the morphologically closest species, *B. australasiae,* perhaps in relatively recent times. The geographic spread of *B. neanika* east and west of Torres Strait, which was emergent between 80 000 and 8 000 years ago (Jennings 1972; Chappell 1976), suggests evolution of the species may have occurred after that time. Genetic isolation of *B. australasiae* in the east (it is not known west of Torres Strait) from *B. desorii* in the west, may have been facilitated by the long periods of emergence of Torres Strait during periods of Pleistocene glaciation.

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Revision of the Bearded Dragons (Lacertilia: Agamidae) of Western Australia with Notes on the Dismemberment of the Genus *Amphibolurus*

G.M. Storr*

Abstract

A new genus, *Pogona*, is proposed for the *Amphibolurus barbatus* species-group. In Western Australia it consists of *P. minor minor* (Sternfeld), *P. minor minima* (Loveridge), *P. minor mitchelli* (Badham), *P. microlepidota* (Glauert) and *P. nullarbor* (Badham). These taxa are described and keyed. The remaining species of *Amphibolurus* are transferred to *Tympanocryptis, Gemmatophora* and *Ctenophorus.*

Introduction

In preparation for a handbook on the dragon lizards of Western Australia I have had to look hard at the genera of Australian Agamidae in current usage, most of which have remained unchanged in concept for a century.

If small or compact genera like *Chlamydosaurus, Caimanops* and *Diporiphora* are recognized, it becomes necessary to split the large and highly diversified *Amphibolurus* of authors and to restrict *Amphibolurus* Wagler to its type species *A. muricatus* (Shaw) and to the species most closely related to it, including the three usually placed in *Lophognathus* Gray. The merger of *Amphibolurus* and *Lophognathus* has already been proposed by Houston (1978), but the inclusion within *Amphibolurus* of numerous other lizards is no longer tenable.

I believe that the closest relatives of *Amphibolurus (sensu stricto)* are *Chlamydosaurus, Caimanops* and *Diporiphora,* which share with it the location of pores in the perforation of an enlarged femoral or pre-anal scale. If one includes the *Amphibolurus barbatus, A. decresii, A. maculatus, A. caudicinctus, A. reticulatus* and other species-groups in *Amphibolurus,* one must also include within it *Diporiphora, Caimanops* and *Chlamydosaurus,* the last of which (having priority) would become the name of the enlarged genus. Such a genus would not only be inappropriately named but intolerably diverse.

The purpose of this paper is to begin the dismemberment of *Amphibolurus (sensu lato)* by proposing a new genus for the *barbatus* species-group and to revise its Western Australian representatives. Badham's (1976) revision was based on

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only a small part of the available material, and it has become necessary to amend some of her concepts. The present paper is based solely on specimens in the Western Australian Museum (R suffix omitted from registration numbers). Descriptions of coloration are based on preserved material.

The rest of *Amphibolurus* is distributed among three genera as follows. The *A. adelaidensis* group (of Storr 1977) is transferred to the genus *Tympanocryptis*. *A. muricatus, A. nobbi* and the genus *Lophognathus* are merged under the oldest available name, *Gemmatophora*. The remaining species, comprising the *A. maculatus, A. reticulatus* and *A. decresii* groups (of Storr 1965, Storr 1966 and Houston 1978 respectively) and *A. caudicinctus, A. scutulatus, A. mckenziei* and *A. cristatus* are transferred to the genus *Ctenophorus*, restored from the synonymy of *Amphibolurus*. These genera are now so changed in content that it becomes necessary to redefine them.

Tympanocryptis Peters, 1864

Small, short-legged, short-tailed agamids with body moderately to strongly depressed; dorsals markedly heterogeneous (small scales intermixed with large spinose scales); tympanum wholly, partly or not covered by scales; femoral and pre-anal pores few in number, each located between 3-5 scales, usually present in males only, and with alignment of pre-anal pores (when more than one present) transverse or directed slightly back towards midline.

Gemmatophora Kaup, 1827 (including *Amphibolurus* Wagler, 1830 and *Lophognathus* Gray, 1842)

Moderately large agamids with body slightly compressed to slightly depressed; scales mostly keeled; tympanum exposed; femoral and pre-anal pores few in number, each perforating an enlarged scale, and with alignment of pre-anal pores (when more than one present) directed back towards midline.

Ctenophorus Fitzinger, 1843

Very small to moderately large agamids with body slightly compressed to strongly depressed; tympanum exposed (except in *C. maculosus*); a series of enlarged tectiform scales sweeping up in a flat S-curve from below eye to above ear; and mostly with (1) dorsals small, their keels directed back towards midline; (2) numerous femoral and pre-anal pores, each located between 4 scales (anterior usually largest; (3) alignment of pre-anal pores directed forwards towards midline; and (4) black markings on breast and throat of males.

This dismemberment of *Amphibolurus* is in broad agreement with the views exprcssed by Witten (1982) on the phylogeny of Australian agamids. As only two of the numerous species hitherto placed in *Amphibolurus* will remain in that genus, I do not believe that the name is worth conserving against the older but forgotten name *Gemmatophora*.

Systematics

Genus *Pogona* gen. nov.

Type Species

Agama barbata Cuvier, 1829, Règne Animal (second edition) 2: 35.

Other Species and Subspecies

Amphibolurus barbatus microlepidotus Glauert, 1952; *A. b. minimus* Loveridge, 1933; *A. b. minor* Sternfeld, 1919; *A. mitchelli* Badham, 1976; *A. nullarbor* Badham, 1976; and *A. vitticeps* Ahl, 1926.

Diagnosis

Moderately large to very large, stout, more or less depressed agamid lizards with rows and zones of spines on head and body, including a transverse series of spines on occiput. Further distinguishable from *Amphibolurus (sensu stricto)* by pores located in notch at rear of enlarged femoral and pre-anal scales, and from other *Amphibolurus (sensu lato)* by alignment of pre-anal pores backwards towards midline.

Description

Head triangular, usually considerably narrower than long (about as wide as long in *P. vitticeps* and *P. minor mitchelli*). Body slightly to strongly depressed. Limbs and tail shorter than usual in agamids. Nostril located below sharp canthus rostralis. Tympanum distinct. Spiny scapular fold continuous with gular fold. Pores located in notch at rear of enlarged scales and counted only on one side of specimens: femoral pores 2-7, scattered along proximal half to three-quarters of thigh; pre-anal pores 1-5 (mostly 2 or 3), confined to outer part of pelvic region, their alignment orientated backwards towards midline.

Scales very variable in size but almost wholly keeled, rugose, mucronate or spinose. Occipital scales much smaller than those on rest of head. Scales on strip down centre of back much larger than ordinary scales on side of back, which are very small and intermixed with scattered spines. Elsewhere spines restricted to (1) discrete zones, namely those at ventrolateral rear of head (continuous in *P. nullarbor, P. barbata* and *P. vitticeps* with smaller but erectible spinose scales across throat – the 'beard') and 1-7 rows of spines along dorsoventral angle of body, and (2) sharply defined series of single spines: transverse series across occiput, longitudinal series above ear (absent in *P. barbata*), curving series around lateroposterior angle on top of head (terminating in transverse nuchal series), and longitudinal series on each side of nape (only present in *P. barbata, P. nullarbor* and western and southern *P. minor*).

Coloration generally dull, with dorsal and ventral pattern slightly to moderately developed in juveniles but tending to disappear with age.

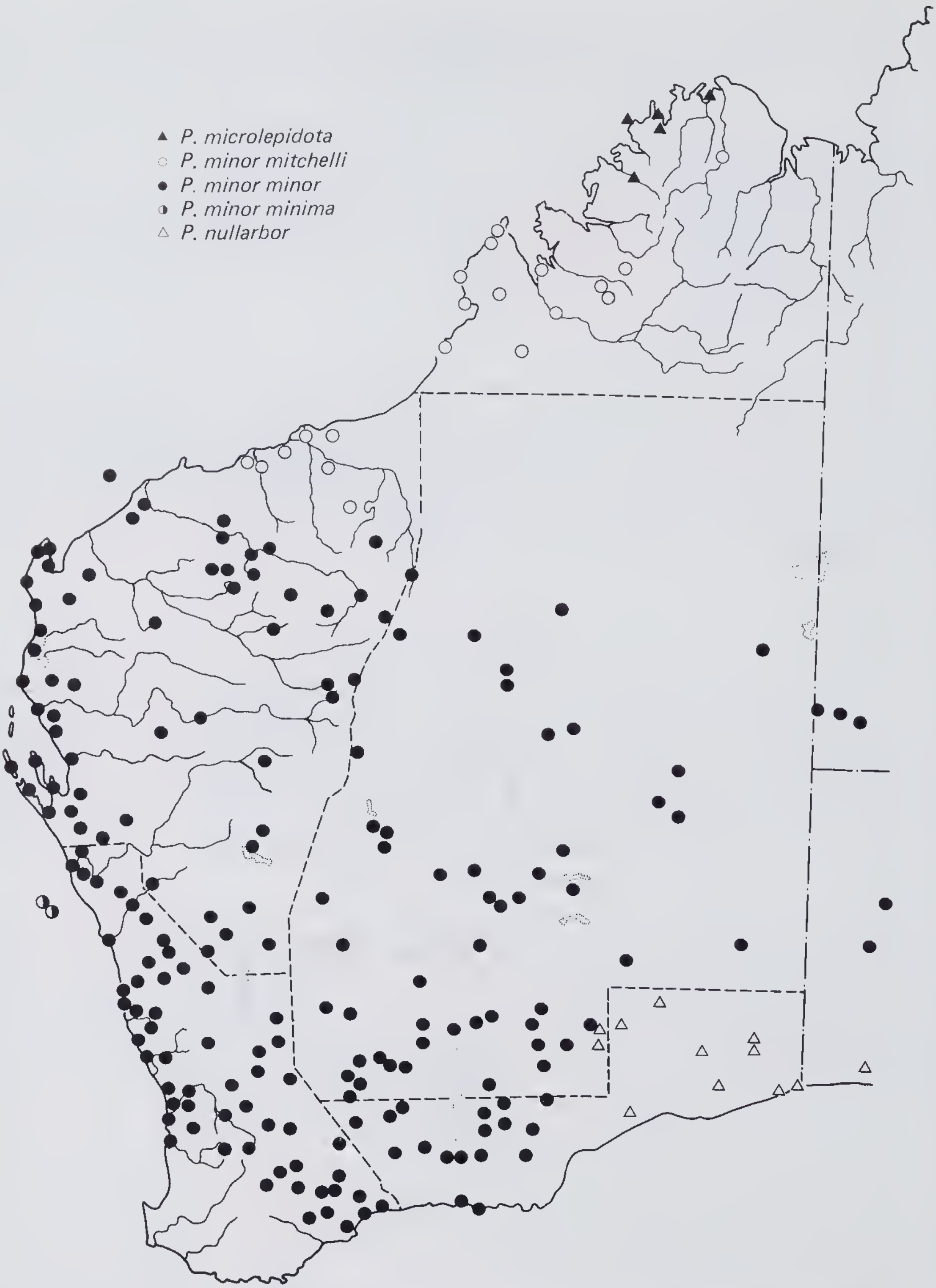

Figure 1 Map of Western Australia showing location of specimens of *Pogona*.

Distribution

Greater part of Australia but not north-east of Western Australia, north of Northern Territory, far north of Queensland, or Tasmania.

Derivation of Name

From Greek *pogon* (beard).

Key to Western Species and Subspecies of *Pogona*

1 Body not very wide or greatly depressed; dorsoventral angle of body bearing one (occasionally two) series of small, uniformly erect spines (not much larger than those of rest of back) 2

Body very wide and greatly depressed; dorsoventral angle of body bearing 3-8 contiguous series of large spines pointing in various directions 4

2 Head longer than wide; dorsal coloration predominantly greyish; spines of transverse occipital series usually weak and not contiguous; a longitudinal series of spines usually present on each side of nape 3

Head as wide as long; dorsal coloration predominantly yellowish-brown or orange-brown; spines of transverse occipital series usually strong and contiguous; no longitudinal series of nuchal spines . . . . *P. minor mitchelli*

3 Widespread in Western Australia; hindleg 47-72% of SVL . . . . *P. minor minor*

Confined to the Houtman Abrolhos; hindleg 60-77% of SVL . . . . *P. minor minima*

4 On each side of nape a longitudinal series of spines; conspicuous narrow white bands across back; confined to the Nullarbor Plain . . . . *P. nullarbor*

On each side of nape two circular clusters of spines (outer larger); dorsal pattern inconspicuous; confined to north-west Kimberley . . . . *P. microlepidota*

Pogona minor minor (Sternfeld, 1919)

Amphibolurus barbatus minor Sternfeld, 1919, Senckenbergiana 1: 78. Hermannsburg, N.T.

Diagnosis

A moderately small *Pogona* with a single series of small erect spines along dorsoventral angle of body, distinguishable from *P. minor minima* by its much shorter appendages and from *P. minor mitchelli* by its greyish coloration, narrower head and weaker spines (specially those of transverse occipital series).

Description

Snout-vent length (mm): 34-149 (N 670, mean 94.9). Length of appendages (% SVL): foreleg 33-51 (N 654, mean 41.1), hindleg 47-72 (N 642, mean 59.2), tail 138-229 (N 644, mean 179). Upper labials 12-19 (N 234, mean 15.4). Lamellae under fourth toe 16-29 (N 234, mean 22.8). Femoral pores 2-7 (N 210, mean 3.8) on each side. Pre-anal pores 1-4 (N 211, mean 2.3) on each side.

Transverse series of occipital spines meeting longitudinal series of supra-auricular spines at right angle and curving continuously forwards towards midline; occipital spines small and not contiguous. On each side of nape a longitudinal series of 2-6 spines, well separated from series of higher spines curving around rear of head behind ear. 'Beard' consisting only of large spines on ventrolateral surface of rear of lower jaw.

Upper surfaces moderately dark to very dark brownish-grey, indistinctly and variably marked with paler brownish-grey: a longitudinal streak on each side of neck, often continuous with a series of large, longitudinally elongate, paravertebral

Figure 2 A *Pogona minor minor* from Mt Bruce, W.A., photographed by R.E. Johnstone.

blotches, opposite to those of other side of body and usually connected to them by a narrow transverse band; less frequently irregular, pale greyish, narrow transverse bands on outer dorsum (these bands sometimes dominating pattern and extending right across back). Tail indistinctly banded with pale greyish-brown. A large black spot usually present on side of neck in juveniles, occasionally persisting in adults. Throat often wholly or partly black or dark grey. Venter and under base of tail grey to whitish, with or without more or less distinct ocelli (whitish, longitudinally elongate, elliptical spots with dark lateral edges).

Distribution

Much of Western Australia north to the southern Pilbara, Little Sandy Desert and Gibson Desert, including Barrow, Dirk Hartog and Salutation Is, but not the far south-west (south of Pinjarra, Wickepin, Ongerup and the Gairdner River) (see Figure 1). Also south-west of Northern Territory and west of South Australia.

Geographic Variation

Some of the foregoing description applies only to southern populations. Northwards and north-eastwards the lizards become larger, less greyish and more brownish, and the longitudinal series of spines on side of nape become shorter, then obliquely orientated (anteriorly diverging from midline), and finally a circular cluster of spines (as in *P. minor mitchelli*) at end of transverse series of nuchal spines. These changes take place further south in the interior than on the west coast. The lining of the mouth is yellow in the south, white north of the lower Murchison.

Material

North-West Division (W.A.)

Barrow I. (27731, 28668, 47350, 48862, 56692, 78232-3); 15 km SW Mardie Roadhouse (68295); Yarraloola (50049); Tambrey (20078-9) and 16 km S (27732); Yardie Creek HS (52931, 53325); Exmouth (49245); 26 km N Learmonth (25639) and 5 km S (19570); 3 km S Exmouth Gulf HS (22656); near Yardie Creek watercourse (61046, 61213, 61419); Koordarrie (30366); 11 km NE Yanrey (19376); Mt Brockman (74919); Hamersley (74927); Wittenoom (19567); Mulga Downs (74874); 7 km ENE Kurrana Well (74082); Mt Bruce (69679); Mt Tom Price (31004); Ningaloo (16867-71, 16874); Junction Well, Oakover River (42231); Ethel Creek (45274); 15 km W Marrilla (63799); 14 km N Cardabia (32602); 14 km SW The Governor (64825-7); Mt Newman (25174, 30920-1); Jiggalong (13333, 25168); Turee Creek (17687); Ullawarra (19568); Warroora (8163, 32581); 20 km ENE Gnaraloo (32611) and 5 km SE (71560); Boologooro (27730, 29998, 78246-7); Quobba (21615, 32619); Point Quobba (17315-6, 41634); 10 km SE Mardathuna (71446); Kumarina Mine (22741-2, 23952); 13 km SSW Kumarina Roadhouse (73007); 32 km N Beyonde (23937); Carnarvon (13556, 13692); Callagiddy (37890-1, 40672-3, 40695, 43995); Landor (24829, 40672); Glenburgh (28378-9); 56 km SE Carnarvon (54883-4); Trillbar (21288); Wooramel (54947); Dirk Hartog I. (42340, 45881, 57095, 58887); Peron (41635, 53744, 54622, 57598); 10 km NE Denham (54882); Woodleigh (48016); Mileura (19569); 4 km S Useless Loop (54620-1); 8 km S Nanga (55177); Overlander (29965-7); Hamelin Pool (59013) and 11 km E (55014, 71082); 24 km NW Carrarang (55151-2); False Entrance Well (55099); Monkietarra Well (41801); Editarra Well (54617);

7 km S Carrarang (54746) and 10 km SE (54618); Salutation I. (25773); Tamala (23853) and 8 km NE (18600) and 43 km ENE (23877) and 19 km S (64423-4); Coburn (64437); 36 km NW Cooloomia (66390); Cue (730) and 34 km N (28877); 5-13 km W Mungawolagudi Claypan (60635, 60639-40); 30-40 km SE Nerren Nerren (59619, 59635, 60636) and 31 km SW (64316); 12 km E Tallering Peak (52860-2); 8 km N Kirkalocka (54505); 40 km SE Yalgoo (22944); Fields Find (23812); 29 km ENE Paynes Find (37737); Rothsay State Forest (29612); Pindabunna (12617).

Eastern Division (W.A.)

64 km W Windy Corner (45275); Bobbymia (23°45'S, 120°50'E) (51044); Durba Spring (51943); Lake Anec (57070); 145 km N Carnegie (40601-2, 40607, 40610) and 130 km N (36712) and 120 km N (40613); 75 km WSW Everard Junction (60096); 5 km W Mt William Lambert (26889); 14 km N Cunyu (25275); 8 km W Yelma (21106); 13 km S Warburton Range (15140) and 70 km SSW (41586); Skipper Knob (22115); Albion Downs (19787); 20 km SE Mt Keith (62841-2); Kathleen Valley (27218, 37783); Altona (30940); 10 km SSE Banjawarn (66030, 69439, 74783); Lake Throssell (46643); 7 km NNW Erlistoun (62843); 11 km E Yamarna (53664); 18 km ESE Point Sunday (53350) and 40 km E (53566); 7-8 km W Point Salvation (79155-64); 24 km NE Laverton (16521) and 24 km ENE (79165-76); 24 km ENE Yuinmery (66064, 69018-9, 74674) and 7 km E (74715); 4 km N Mt Elvire (73413) and 13 km S (73423); Blue Hill (64823); 6-7 km NNW Mt Linden (65870, 65973, 72776-7) and 10 km SSE (65893); Linden (46628); Iltoon Rockhole (19593); Plumridge Lakes (48713, 48723); Comet Vale (66289) and 2-12 km NE (65669-70, 65786, 65809, 65831, 65846, 72607, 72627, 72641, 72657); Goongarrie National Park (72567, 72572); Mt Manning Range (73325, 73327, 73375, 73383); Mt Jackson (67020) and 18 km S (76024); 14-15 km NE Bungalbin Hill (67098, 67102, 67117, 72109, 72126) and 15 km N (76187) and 12 km N (76205) and 5 km N (67136); 8 km S Yindi (73804); Queen Victoria Spring (12969, 19588, 48661); Streich Mound (58711); near Yowie Rockhole (70894, 70898, 73224-5); 3-5 km SW Black Flag (73257, 73270); Bulong (4207); 10 km NE Cundeelee (21679-82); Kanandah (40686, 41616); Kitchener (19589-70); Zanthus (26519) and 7 km W (32677); Coolgardie (17857-8) and 52 km SSE (58092); 20 km S Woolgangie (71748, 71790) and 43 km SE (71782); Boorabbin (21705); 11 km E Karalee (30691) and 29 km S (33998); near Buningonia Spring (65523, 72465, 72480-1, 72510, 72513, 72584); 29 km S Yellowdine (37916); 21 km ENE Toomey Hills (71835) and 15-16 km E (71815, 71858); 30 km NW Heartbreak Ridge (65420, 65469, 65481) and 30 km N (72420) and 30 km NE (74496) and 20 km N (65386); Split Rock (37815).

South-West Division (W.A.)

10 km WNW Gee Gie O/C (39910); 7 km NE Carollgouda Well (34043); Mt Curious (33453); Murchison House (59675); Kalbarri National Park (18591, 33494, 33501, 33517-8, 33687, 33766, 33785, 33833, 33860-2, 33876-7, 34657, 37607, 37632, 71092-3, 78293); Ajana (29626) and 30 km N (33603, 33613, 33658); Binnu (25957); 25-32 km NE Yuna (26494), 56961, 57543, 57587); East Yuna Reserve (48118-9, 49914, 49921, 57552-3); Mullewa (22291); Wilroy (57712); Geraldton (31076-7); Gutha (2822, 78257-8); 16 km S Greenough River mouth (66229); Greenough (71926); Morawa (76235); 20 km SE Dongara (72912); 6 km NE Arrino (45697); Caron (22874-5, 22991, 24783-4); Carnamah (22877-8); 16 km N Eneabba (71994-5) and 5 km SSE (70719); 16 km N Coorow (29968) and 13 km W (13165) and 32 km W (41224); 6-7 km N Leeman (71939, 72917); Stockyard Gully (26741-2); 8 km SSW Marchagee (67432); Green Head (42591) and 5 km E (48455, 48498, 49056, 49058) and 16 km E (73000); near Mt Peron (48413-4, 48424, 49019, 49026, 49136-7, 49212); near Padbury (48483, 49026, 49057, 49114); near Mt Lesueur (48439-40, 48825); Jurien Bay (12688) and 7-16 km NE (19571, 29206-7, 30473-6); 20 km NE Dalwallinu (58214); 25 km

NNE Badgingarra (67425); Badgingarra National Park (68814-8, 68826, 68836-45, 68854-84); 42-48 km N Beacon (48365, 48395-6) and 47 km ENE (44257); Wialki (19586); Moondon (13294); 24 km N Cataby Brook (49211); Tombstone Rocks (19572); Wongan Hills (50227); Mukinbudin (32044); Lancelin (19573) and 16 km N (17699); Ledge Point (19574); Moore River National Park (59401, 59418-9); Trayning Reserve (45977); 32 km S Trayning (53727); 29 km N Kellerberrin (52294) and 25 km N (56657) and 17 km NW (49201); 13 km SE Merredin (56000); Cunderdin (19582); Neerabup National Park (62366); Quinns Rocks (30047); Burns Beach (19575, 28356, 59307, 59510); 'Red Hill Road' (29818); Mussel Pool (51534); Warbrook (12859); Sorrento (41802, 46200); Midland (4552); Bellevue (2799, 22298); Mundaring (2815); Boya (29054); Mt Yokine (19250); Wembley Downs (23917); City Beach (34650); Floreat Park (26515, 28957, 29391-2, 34574); Mt Lawley (4175); Maylands (42); Redcliffe (21220); Gooseberry Hill (4508); Kings Park (19576, 30179); Crawley (19577); South Perth (44, 368); Bentley (29720); 3 km W Kalamunda (21834) and 10 km E (17131, 21280, 21873); Piesse Brook (24087); Badjaling Reserve (52426-31); near Quairading (2481); Dangin (19591); Lesmurdie (19578-80); Wilson (32020); Bull Creek (19594); Booragoon (47716); Melville (26758); White Gum Valley (3385); O'Connor (19951); Canning Vale (52654-5); Coolbellup (66236); Spearwood (2795); Jandakot (60056-8, 60061-4, 60073-5, 60514-5, 62127-43, 62582-4, 62884); Kelmscott (19047, 51429); Roleystone (21871-2); Beverley (22851); Naval Base (57529); Bendering Reserve (43410), 43441, 43676, 52594, 52596, 57338, 67519); near Corrigin (28902); 3 km SE Mt Vincent (68115); Mandurah (21870); Pinjarra (31988); Lake Varley (21219); 25 km E Yornaning (50198); Dryandra State Forest (62239); North Tarin Rock Reserve (44437); Lake Grace Reserve (43825-6); Kukerin (6102); 29 km SE Newdegate (47607-8); Dongolocking Reserve (49620-3, 49728-9); '8 km SW Collie' (19581); Lake Chinocup (43466-70); 27 km E Pingrup (39861-3, 45299); Lake Magenta Reserve (39950); 32 km W Ravensthorpe (44870) and 26 km W (44865); Jerramungup (14493); 10 km SE Ongerup (42622); Culham Inlet (78181); 4 km W Hopetoun (56064); East Mt Barren (78228); near Woolbernup (41147); Dempster Inlet (38998-9); lower Gairdner River (52090); 'Cape Leeuwin' (299, 12784, 29984).

Eucla Division (W.A.)

Near McDermid Rock (65262, 65269, 65287, 65291, 74240, 74293); between McDermid Rock and Lake Cronin (65278); North Ironcap (71172); near Lake Cronin (65097, 65099, 65100, 65160, 68007, 68028, 68032, 68037, 68052, 74104, 74218); 8 km WNW Forrestania (71180); Frazer Range (54770-1); 30 km NNE Balladonia Hotel (46606); 20 km E Jyndabinbin Rockhole (62360) and 27 km E (62359); 38-40 km ESE Norseman (57920, 57951); 42 km ENE Clear Streak Well (59756) and 8 km N (59587-8, 59861-2); Charlina Rock (57967) and 18 km NNE (59871); 10 km SE Mt Newmont (59757-8); Frank Hann National Park (78342); Peak Charles (56884); Salmon Gums (30790) and 20 km E (22653) and 60 km E (62361, 62364-5); Esperance (19587) and 32 km E (21994) Cape LeGrand National Park (41945, 67753).

Northern Territory

Docker River (45201, 45206); 16 km E Lasseters Cave (34197-8); Armstrong Creek (34182); Ayers Rock (46634-5).

South Australia

250 km N Cook (34536) and 160 km N (31858-9); Everard (24511).

Pogona minor minima (Loveridge, 1933)

Amphibolurus barbatus minimus Loveridge, 1933, Proc. New Engl. zool. Club 13: 69. West Wallabi I., W.A.

Diagnosis

A small, relatively slender, long-limbed *Pogona,* similar in all respects to *P. minor minor* of the opposite mainland except for its longer appendages and more numerous subdigital lamellae.

Description

Snout-vent length (mm): 39-115 (N 82, mean 90.9). Length of appendages (% SVL): foreleg 42-54 (N 81, mean 47.0), hindleg 60-77 (N 81, mean 69.2), tail 175-246 (N 74, mean 203). Upper labials 12-17 (N 81, mean 14.7). Lamellae under fourth toe 20-31 (N 80, mean 25.3). Femoral pores 2-6 (N 68, mean 4.1) on each side. Pre-anal pores 2-5 (N 68, mean 2.6) on each side.

Scalation and coloration as in southern *P. m. minor.*

Figure 3 A *Pogona minor minima* from North I., Houtman Abrolhos, W.A., photographed by P. Griffin.

Distribution

The larger and more northerly islands (North, East Wallabi and West Wallabi) of the Houtman Abrolhos, off the midwest coast of Western Australia (see Figure 1).

Material

South-West Division (W.A.)

North I. (47815-8); East Wallabi I. (19547-62, 21846, 30183-9, 30201, 46554, 47826-7, 78249); West Wallabi I. (19501-46, 29496-7, 57996).

Pogona minor mitchelli (Badham, 1976)

Amphibolurus mitchelli Badham, 1976, Aust. J. Zool. 24: 435. Derby, W.A.

Diagnosis

A moderately large *Pogona,* distinguishable from *P. m. minor* by its brighter coloration (more brownish, less greyish), greater size, wider head, stronger contrast between scales in front of and behind transverse series of occipital spines, and lack of longitudinal series of spines on side of nape.

Description

Snout-vent length (mm): 37-163 (N 63, mean 109.6). Length of appendages (% SVL): foreleg 36 46 (N 62, mean 39.6), hindleg 49-64 (N 60, mean 54.6), tail 143-205 (N 58, mean 170). Upper labials 14-19 (N 53, mean 15.9). Lamellae under fourth toe 17-25 (N 54, mean 20.8). Femoral pores 4-6 (N 49, mean 4.3) on each side. Pre-anal pores 2-4 (N 49, mean 2.5) on each side.

Transverse series of occipital spines meeting longitudinal series of supra-auricular spines at less than a right angle, and only curving forwards near midline; spines usually stronger and more contiguous than in other subspecies of *P. minor.* Scales behind occipital spines smaller than in other subspecies, with a greater step down from plane of occipital scales to plane of nuchal scales. Longitudinal series of nuchal spines of other subspecies reduced in *mitchelli* (as in northernmost *P. minor minor*) to a small cluster of spines continuous with transverse series of nuchal spines. Cluster of spines on scapular fold larger than in other subspecies. Lateral scales at rear of throat (continuous with 'beard') larger and more spinose than in other subspecies.

Dorsal ground colour yellowish-brown, orange-brown or greyish-brown. Dorsal and ventral pattern in juveniles not so marked as in other subspecies and seldom persisting in adults.

Distribution

Arid and semi-arid north-western Western Australia, i.e. western Kimberley and northern Pilbara south to the Port Hedland and Marble Bar districts (see Figure 1).

Figure 4 A *Pogona minor mitchelli*, photographed by P. Griffin.

Remarks

Badham (1976) treated *mitchelli* as a full species. However it hybridizes with *P. m. minor* in southern Pilbara, but the narrowness of the hybrid zone (less than 200 km wide) permits the recognition of two mainland subspecies of *P. minor*.

Material

Kimberley Division (W.A.)

Drysdale River National Park (15°16′S, 126°43′E) (50696); Lombadina (46416) and 6 km S (60911); Martins Well (16°34′S, 122°51′E) (58527, 28532); Pender Bay (58524-5); Coulomb Point (40246-7, 58526); Point Torment (60916); Inglis Gap (27727); Derby (15182-4, 15823, 26828-30, 31037, 33624, 49986) and 24 km SSE (32166, 32189); 10 km WNW Mt North (70527) and 3 km SSW (70534); 5 km NNW Mt Percy (70655-6); 24 km E Deep Creek (68983); Broome (14109, 14135*a-i*, 58857-8); Mt Anderson (32196-8); Edgar Ranges (53999, 54011, 54070); Injudinah Creek (27723); LaGrange (3445, 13067, 46489); Cape Bossut (40536).

North-West Division (W.A.)

DeGrey (2116, 73038); Great Northern Highway, 63 km ENE of DeGrey River crossing (46068); 25 km ESE Port Hedland (46498); Mundabullangana (19556) and 23 km SE (19377); 70 km N Marble Bar (40860); Mt Edgar (13066, 45758-60).

Pogona microlepidota (Glauert, 1952)

Amphibolurus barbatus microlepidotus Glauert, 1952, West. Aust. Nat. 3: 168. Drysdale River Mission [Pago], W.A.

Diagnosis

A large *Pogona* with relatively small and narrow head and wide and strongly depressed body. Further distinguishable from *P. minor* by its 3-5 rows of large spines (rather than one row of small spines) along dorsoventral angle of body.

Description

Snout-vent length (mm): 93-180 (N 13, mean 148.7). Length of appendages (% SVL): foreleg 38-45 (N 13, mean 42.5), hindleg 59-71 (N 13, mean 65.7), tail 181-212 (N 13, mean 198). Upper labials 15-19 (N 13, mean 17.0). Lamellae under fourth toe 20-23 (N 13, mean 21.3). Femoral pores 3-5 (N 13, mean 3.8) on each side. Pre-anal pores 2-3 (N 13, mean 2.1) on each side.

Figure 5 A *Pogona microlepidota* from Crystal Head, W.A., photographed by R.E. Johnstone.

Transverse series of occipital spines well separated from longitudinal series of high supra-auricular spines; a single central occipital spine and 1-3 outer spines moderately large, remainder small. At back of nape a small circular cluster of spines close to midline; further out (in same position as in *P. minor mitchelli*) a larger, higher, oblique cluster of spines narrowly separated from transverse series of nuchal spines (posterior sector of series of high spines curving around rear of head behind ear). 'Beard' a little better developed than in *P. minor* and extending further on to ventral surface of throat. Small cluster of spines on scapular fold; parallel to and behind fold a short series of spines.

Dorsal ground colour dull yellowish-brown, becoming more greyish-brown towards middle of back. Little evidence of dorsal pattern apart from a tendency for yellowish brown and greyish-brown to be disposed in vague, narrow, alternating transverse bands of each colour. Side of rear of head (especially streak through temple) and side of neck blackish-grey. Tail greyish-brown, narrowly banded with pale dull yellowish-brown. Lower surfaces brownish-white occasionally spotted with grey.

Distribution

Far north of Western Australia, i.e. subhumid north-west Kimberley from Napier Broome Bay south-west to the Prince Regent River (see Figure 1).

Material

Kimberley Division (W.A.)

Pago (951-2, syntypes); Kalumburu (27728-9, 34075, 74943); near Crystal Head (14°30'S, 125°47'E) (43028, 56232); Mitchell Plateau (14°53'S, 125°49'E) (44258); Bigge I. (57108); Prince Regent River National Park (46847, 46962, 47246).

Pogona nullarbor (Badham, 1976)

Amphibolurus nullarbor Badham, 1976, Aust. J. Zool. 24: 440. 16 km NW Naretha, W.A.

Diagnosis

A moderately large, short-snouted, short-tailed *Pogona* with wide, strongly depressed body. Further distinguishable from *P. minor* by 3-7 rows of large spines (rather than a single row of small spines) along dorsoventral angle of body, pale narrow transverse dorsal bands, and smooth mucronate (rather than keeled) ventrals.

Description

Snout-vent length (mm): 51-141 (N 16, mean 121.7). Length of appendages (% SVL): foreleg 34-43 (N 16, mean 38.7), hindleg 51-62 (N 16, mean 56.6), tail 122-160 (N 15, mean 138). Upper labials 14-20 (N 16, mean 16.7). Lamellae under fourth toe 17-23 (N 16, mean 19.3). Femoral pores 3-5 (N 15, mean 3.9) on each side. Pre-anal pores 2-3 (N 15, mean 2.3) on each side.

Transverse series of occipital spines curving forwards towards midline, its alignment forming acute angle with that of short series of low supra-auricular spines; occipital spines small and not contiguous. On side of nape a longitudinal series of 3-6 spines (as in southern and western *P. minor* but weaker), separated from series of high spines curving around rear of head behind ear. 'Beard' weak but extending (as a band of narrow, elongate, strongly mucronate scales) right across throat. Cluster of spines on scapular fold small.

Dorsal ground colour reddish-brown, orange-brown or greyish-brown. Six or 7 narrow creamy-white cross-bands on neck and back; pale bands on tail wider and darker. Throat greyish or whitish, marked with 3 or 4 hollow chevrons, the smaller inside the larger. Ventral surfaces as in *P. minor,* i.e. greyish in juveniles with ocelli (longitudinally elongate, whitish spots laterally edged with greyish brown), whitish in adults and marked with short longitudinal greyish-brown streaks (sides of obsolete ocelli).

Figure 6 A *Pogona nullarbor* from Madura, W.A., photographed by R.E. Johnstone.

Distribution

The Nullarbor Plain of arid south-eastern Western Australia and western South Australia (see Figure 1).

Material

Eastern Division (W.A.)

Kanandah (37789); Naretha (19592, 48172) and 16 km NW (29667, holotype).

Eucla Division (W.A.)

112 km NNE Rawlinna (31964-5); 16 km W Seemore Downs (39055); 16 km S Loongana (29486); Forrest (16888, 16896) and 24 km S (41632); Wilson Bluff (28127); 40 km SW Eucla (66449); 33 km NE Madura (28901); Cocklebiddy (24655).

South Australia

75 km S Cook (31620).

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GUIDE TO AUTHORS

Subject Matter

Reviews and papers reporting results of research in all branches of natural science and human studies will be considered for publication. However, emphasis is placed on studies pertaining to Western Australia. Material must be original and not have been published elsewhere.

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Authors are advised to follow the layout and style in the most recent issue of the *Rec. West. Aust. Mus.* including headings, tables, illustrations and references.

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An abstract must be given, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and should be suitable for reprinting in reference periodicals. Contrary to Recommendation 23 of the International Code of Zoological Nomenclature it may include names of new taxa.

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Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

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Cover Male of the bee, *Ctenocolletes rufescens* sp. nov., endemic to southern Western Australia. Drawn by Jill Ruse.

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Herpetofauna of the Geraldton Region, Western Australia

G.M. Storr*, T.M.S. Hanlon† and J.N. Dunlop‡

Abstract

The study area is located on the west coast of Western Australia approximately between latitudes 28° and 30°S; it extends for 30-50 km inland to about Ajana, Eradu, Strawberry and Eneabba, and for 50-70 km offshore to the Houtman Abrolhos. The climate ranges from semi-arid in the north to subhumid in the south, most of the rain falling in the cooler half of the year. Much of the land outside reserves has been cleared for farming. Brief notes are given on the local distribution, relative abundance and habitat preferences of the 96 species of frogs, turtles, lizards and snakes recorded from the region. Some aspects of regional zoogeography are discussed.

Introduction

The present paper is one of several dealing with the herpetofauna of the west coast of Western Australia. To the immediate north of the present region L.A. Smith (pers. comm.) has studied the herpetofauna of the Kalbarri National Park, and Storr and Harold (1980) that of the Zuytdorp area; to the immediate south Dell and Chapman (1977) listed the amphibians and reptiles of the Cockleshell Gully Reserve; and to the east Burbidge *et al.* (1978) described the fauna of the Wandana Nature Reserve near Yuna.

Published information on the herpetofauna of the present region hitherto covered only the Houtman Abrolhos (Alexander 1922, Green 1972, O'Loughlin 1965, 1966 and 1969, and Storr 1960 and 1965) and the islands further south (Ford 1963). However, much information on the mainland was available in the registers of the Western Australian Museum, for the farming country between Northampton and Dongara has yielded many specimens since the turn of the century.[1] More recently naturalists have explored the sandplains, wetlands and

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[1] A collection (WAM R26304-26355) said to have been made by F.W. Pearson at Greenough between 1851 and 1881 is now believed to have come from the Eastern Goldfields.

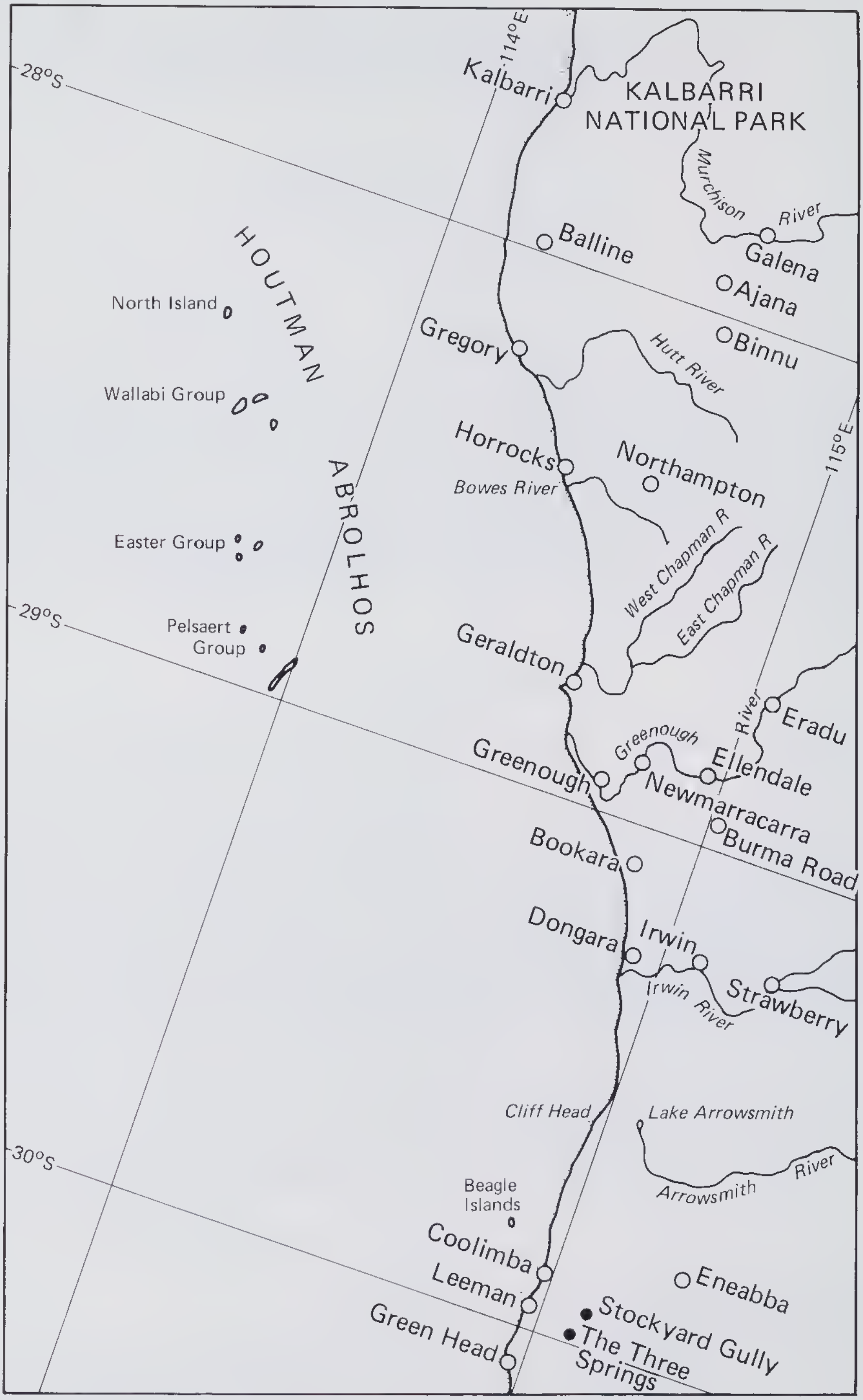

Figure 1 Map of Geraldton region, Western Australia.

caves of the region (Figure 1). To these data we have added those gathered by T.M.S. Hanlon in December 1980 and J.N. Dunlop in April 1982; the expenses of these surveys were met by generous grants from Mr and Mrs W.H. Butler to the Western Australian Museum.

The Environment

Mean annual rainfall ranges from 32 cm in the north-east to 65 cm in the far south, 73-81% of it falling from May to September. Along the mainland coast, and still more in the Houtman Abrolhos, the climate is mild. In the interior summers are much hotter (mean daily maximum temperature *c.* 35°C in January and February), and frosts are occasionally reported in winter.

The south and far north of the region consist essentially of a low sandy plateau rising gradually to 200-250 m in the east and terminating in the west in coastal dunes or low cliffs of aeolian limestone. The central and lower northern parts of the region are dissected by the Bowes, Chapman, Greenough and Irwin Rivers, and the sandy plateau has been reduced to remnants on the mesas between Geraldton and Northampton and to a much larger area between the Chapman and Greenough Rivers east of the 'Greenough Flats'. The valleys of these rivers, especially their alluvial plains, have long been cleared for farming. In this central sector, unconsolidated white sand dunes stand between the red-soil plains and the sea.

The sandy plateaux carry a rich assemblage of shrubs with scattered low trees of *Banksia, Eucalyptus, Xylomelum, Nuytsia* etc. In the dissected areas of the north-east, thickets of jam (*Acacia acuminata*) and scattered York gums (*Eucalyptus loxophleba*) occupy or used to occupy the undulating country below the residual sandplains; here the soils are generally heavy and often stony. Watercourses and lagoons are fringed with woodlands of *Eucalyptus camaldulensis* (replaced by *E. rudis* in the far south) and *Casuarina obesa* and thickets of *Melaleuca.* The seaward slopes of coastal dunes are sparsely covered with *Spinifex longifolius* and low shrubs; with increasing shelter from the sea the dunes support a higher and more varied heathland and thickets of *Acacia* (especially *A. rostellifera*) and *Melaleuca.*

The numerous islands of the Houtman Abrolhos are low-lying and consist largely of flats of marine limestone and piles of debris thrown up by storms from the fringing coral reefs. Only the largest of the northern islands (North, East Wallabi and West Wallabi) contain extensive areas of sandy beaches and dunes. On most of the islands the vegetation is sparse and the flora depauperate, but parts of East and West Wallabi are clothed in moderately rich scrub. There is no fresh surface water on any of the islands. The surrounding seas are considerably warmer than those along the mainland coast.

For further information on the physiography, soils and vegetation of the region see Beard (1976). In the following list specimens in the R series of the Western Australian Museum are cited without prefix.

Annotated List

Leptodactylidae

Heleioporus albopunctatus Gray, 1841

Throughout the mainland, wherever fresh surface water is available in winter and early spring (collected on the Hutt, Bowes, Chapman, Greenough and Irwin Rivers and at White Peak and Stockyard Gully). Begins to call in late April.

Heleioporus eyrei (Gray, 1845)

Near-coastal areas north to the lower Greenough (collected at Greenough, 12 km E of Dongara 12 km E of Irwin, 16 km E of Coolimba and the Three Springs[2]). Uncommon. Swamps that fill in late autumn or early winter.

Heleioporus psammophilus Lee and Main, 1954

One record from the lower Irwin River: three specimens (30516, 30527, 32993) collected at 2 km E of Irwin.

Limnodynastes dorsalis (Gray, 1841)

Throughout the mainland (collected on the Hutt River at 12 km ESE of Gregory, the Bowes River at 12 km W of Northampton, the Chapman River, the Irwin River at Mountain Bridge, and at the Three Springs, and heard at 2 km N of Northampton and at Lake Arrowsmith).

Myobatrachus gouldii (Gray, 1841)

One record from the eastern interior: a specimen collected under a stone in sandplain country at Eradu (Harrison 1927).

Neobatrachus pelobatoides (Werner, 1914)

Probably occurring throughout the mainland, but there is only one record, a specimen (8593) collected at White Peak. There are several records from immediately north and immediately south of our region.

Neobatrachus sp.

Two frogs (12479-80) collected at Greenough were registered in June 1957 as '*Heleioporus centralis*'. These specimens cannot be found for checking, but they were more likely to belong to *Neobatrachus sutor* Main (only then being described) than to *N. centralis* (Parker). *N. sutor* has been collected just north of our region at Galena on the Murchison River.

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[2] The soak Three Springs is referred to in this paper as 'the Three Springs' to distinguish it from the town of Three Springs to the east of our area.

Pseudophryne guentheri Boulenger, 1882

Throughout the mainland (collected on the Hutt River north of Northampton, the Chapman River, the Greenough River at Ellendale and Newmarracarra, and the Irwin River, and at Stockyard Gully and the Three Springs). Moderately common. Requiring fresh surface water in late autumn and winter.

Ranidella pseudinsignifera (Main, 1957)

Throughout the mainland (collected at East Chapman, Bookara, Pell Bridge on the lower Irwin River, and Stockyard Gully, and heard at the Three Springs). Moderately common. Requiring fresh surface water in winter.

Hylidae

Litoria moorei (Copland, 1957)

Greater part of mainland, north to the Hutt River (collected on the Hutt River at 12 km ESE of Gregory, on the Bowes River at 12 km W of Northampton, at an 'un-named cave near Eneabba', and at Stockyard Gully and the Three Springs, and observed at Ellendale Pool on the Greenough River). Common. Requiring permanent freshwater river-pools or springs.

Cheloniidae

Chelonia mydas (Linnaeus, 1758)

Common summer visitor to North I., Houtman Abrolhos, where it is said to nest (Storr 1960). Also recorded by Alexander (1922) from West Wallabi I.

Eretmochelys imbricata (Linnaeus, 1766)

A specimen was received from Geraldton in 1902.

Gekkonidae

Crenadactylus ocellatus ocellatus (Gray, 1845)

Regionally confined to the Houtman Abrolhos. In the Wallabi Group uncommon on the larger islands (East Wallabi and West Wallabi) and moderately common on the smaller islands (Seagull and Tattler); in the Easter Group common on Rat, Hut and Helsinki Is; and in the Pelsaert Group common on Middle I. Sheltering under limestone rocks and reef debris.

Diplodactylus alboguttatus Werner, 1910

Two records: a specimen in the Museum of Comparative Zoology (Harvard) from Geraldton and one in the WAM from 4 km S of Geraldton. Common in the lateritic country immediately south of our region (Dell and Chapman 1977).

Diplodactylus granariensis Storr, 1979

One record: three specimens (27397-9) collected at 12 km E of the mouth of the Hutt River. Moderately common in the lateritic uplands immediately south of our region.

Diplodactylus ornatus Gray, 1845

Coastal and near-coastal areas throughout the mainland. Uncommon. Has been collected in *Acacia rostellifera* thickets in white coastal dunes, in *Melaleuca-Acacia* scrub on near-coastal grey loamy sand, and in *Xylomelum-Banksia* scrub on inland sandplains.

Diplodactylus polyophthalmus Günther, 1867

One record from far south: a specimen (78106) collected in sandplain close to a lateritic ridge 10 km S of Eneabba.

Diplodactylus pulcher (Steindachner, 1870)

Two records of single specimens from far north-east (Ajana and Eradu).

Diplodactylus spinigerus Gray, 1842

Common on all coasts, including East Wallabi and West Wallabi Is in the Houtman Abrolhos, in thickets of *Acacia rostellifera,* open *Spinifex longifolius* and *Olearia axillaris,* and scrubs of *Melaleuca, Acacia* and *Casuarina.* Also common on inland sandplains from Binnu south to Eneabba.

Diplodactylus squarrosus Kluge, 1962

One record from far north-east: a specimen (24851) collected at Binnu.

Diplodactylus strophurus (Duméril and Bibron, 1836)

One record from far north-east: a specimen (26006) collected at Binnu.

Gehyra variegata (Duméril and Bibron, 1836)

Throughout the mainland and on some of the Houtman Abrolhos (East Wallabi and West Wallabi Is in the Wallabi Group, and Murray and Middle Is in the Pelsaert Group). Very common on the mainland in a wide variety of habitats; very common on Middle I. (O'Loughlin 1969); scarce on other islands.

Heteronotia binoei (Gray, 1845)

Northern half of mainland south to Greenough; also North and West Wallabi Is in the Houtman Abrolhos. Common on North I. and locally on the mainland but generally uncommon. A wide variety of habitats including coastal limestone.

Nephrurus levis occidentalis Storr, 1963

Northern half of mainland south to Waggrakine and Wicherina. Rare. White sandplains with relatively open vegetation.

Phyllodactylus marmoratus (Gray, 1845)

On numerous islands in the Houtman Abrolhos: North I.; East Wallabi, West Wallabi, Tattler, Pelican and Seagull Is and islet between Seagull and East Wallabi Is in the Wallabi Group; Rat, Helsinki, Morley and Wooded Is in the Easter Group; and Gun I., three islets south of Gun I., and Murray, Shark, Basile and Pelsaert Is in the Pelsaert Group. Very common on Pelican, Tattler, Wooded, Gun and Murray Is and south end of Pelsaert I.; scarce to moderately common on other islands. Sheltering under limestone and reef debris. Occurs on the mainland just south of our region (Cockleshell Gully).

Phyllurus milii (Bory, 1825)

Sparsely distributed on the mainland (collected on coast at Horrocks and Geraldton and near Greenough, and in the interior at a Stockyard Gully cave). Also the Houtman Abrolhos: East Wallabi, West Wallabi, Seagull and Pigeon Is in the Wallabi Group; and Gun I. in the Pelsaert Group. Very common on the islands; scarce on the mainland. Marine and aeolian limestone, including caves and sea-cliffs on the mainland.

Pygopodidae

Aclys concinna Kluge, 1974

One record from far south-west: a specimen (72983) found dead on road through scrubby heath on whitish sand over limestone 5 km E of Coolimba.

Aprasia repens Fry, 1914

Southern and central interiors, north to Eradu. Scarce. Sandplains.

Delma australis Kluge, 1974

Regionally known only from Rat I. in the Easter Group, Houtman Abrolhos, where it is common under slabs of limestone. In Western Australia mainly distributed east of the Darling Range; on the west-coastal mainland only found in the country immediately south of Shark Bay.

Delma fraseri Gray, 1831

Greater part of mainland north to Northampton. Uncommon.

Delma grayii Smith, 1849

Southern part of mainland north to Beagle Point and inland to Encabba; also West Wallabi I. in the Houtman Abrolhos; the specimen of *'Delma fraseri'* from East Wallabi I. (O'Loughlin 1966: 22) probably belonged to this species. Scarce. Coastal dunes and near-coastal sandplains.

Delma nasuta Kluge, 1974

One record from north-east: a specimen (47709) collected at Northampton.

Delma tincta DeVis, 1888

Northern interior south to East Chapman and Eradu. Moderately common. Mainly on heavy red soils carrying jam (*Acacia acuminata*).

Lialis burtonis Gray, 1835

Throughout the mainland; also East Wallabi and West Wallabi Is in the Houtman Abrolhos. Moderately common. A wide variety of habitats but preferring coastal dunes and limestone.

Pletholax gracilis gracilis Cope, 1864

One record from southern interior: a specimen (25071) collected at Eneabba.

Pygopus lepidopodus (Lacépède, 1804)

Throughout the mainland. Moderately common. A wide variety of habitats including near-coastal sandplains.

Pygopus nigriceps nigriceps (Fischer, 1882)

Northern interior south to the Irwin River. Known only from single specimens collected at Ajana, Binnu and Irwin. Probably restricted to heavier soils.

Agamidae

Amphibolurus adelaidensis adelaidensis (Gray, 1841)

Throughout the mainland. Common. Sandplains with heath or mallee scrub.

Amphibolurus inermis (DeVis, 1888)

Apparently confined to two discrete areas: the far north-west around Balline, and the upper south-west between Dongara and Lake Arrowsmith. Uncommon. Lightly vegetated sandy loams.

Amphibolurus maculatus maculatus (Gray, 1831)

Mainly in the south (north to Cliff Head), where it is common on sandplains. Further north largely restricted to the white coastal dunes between Dongara and Geraldton and again at Gregory, where it is moderately common among *Spinifex longifolius*; there is also a specimen from Ajana. A little east of our region, e.g. at 31 km E of Eneabba it is replaced by *A. m. griseus* Storr.

Amphibolurus minor minimus Loveridge, 1933

Endemic to the Houtman Abrolhos (North, East Wallabi and West Wallabi Is). Very common in all vegetated habitats but favouring sandy areas with clumps of

Spinifex longifolius; also among low halophytic shrubs on shell grit and in open mixed scrub on limestone. This subspecies differs from *A. m. minor* in its lesser size and relatively longer tail and hindlegs (Storr 1965: 8).

Amphibolurus minor minor Sternfeld, 1919

Mainly southern, north nearly to Geraldton, extending inland in south, but north of Dongara confined to coastal dunes. Also far north-east (single specimens from Ajana and Binnu). Common in south, where it is found in a variety of habitats including *Acacia rostellifera* thickets in white coastal dunes, low coastal heaths, mallee scrubs on grey sandy loam, and the rich proteaceous heaths of interior sandplains. In the southern population the mouth is yellow; mouth colour has not been recorded in the north-east, but to the immediate north of our region (Murchison House) it has been noted as white.

Amphibolurus reticulatus (Gray, 1845)

Northern, south to Waggrakine and Eradu, mainly in the interior but following the Hutt, Bowes and Chapman Rivers downstream nearly to their mouths. Moderately common. Preferring the heavier soils.

Lophognathus longirostris Boulenger, 1883

Regionally confined to the Greenough River. Common. Mainly the woodlands of *Eucalyptus camaldulensis* and scrubs of *Melaleuca-Casuarina* along the banks of the river.

Moloch horridus Gray, 1841

Patchily in interior (24 km W of Binnu, Eradu, Mt Fanny and Eneabba). Locally common but generally scarce. Heath on sand or laterite.

Scincidae

Cryptoblepharus carnabyi Storr, 1976

Regionally confined to the Houtman Abrolhos: East Wallabi and West Wallabi Is and islet between East Wallabi and Seagull Is in the Wallabi Group; Rat, Helsinki and Morley Is in the Easter Group; and Gun I., an islet south of Gun I., and Shark I. in the Pelsaert Group. (Specimens of '*Ablepharus boutonii*' from Seagull, Pigeon, Hut and Pelsaert Is no doubt belong to *C. carnabyi* but are not available for checking.) Locally common in the Easter and Pelsaert Groups but uncommon in the Wallabi Group. These skinks are wholly terrestrial, sheltering in limestone crevices and under reef debris. On the mainland found along the Murchison River just north of our region.

Cryptoblepharus plagiocephalus (Cocteau, 1836)

Northern interior south to the Greenough River, and southern interior north to Lake Arramall (30 km SSE of Dongara). Uncommon. Mainly trees along water-courses and around lagoons, especially *Eucalyptus rudis* in south.

Ctenotus fallens Storr, 1974

Southern half of mainland north to Arramall Farm (30 km SSE of Dongara) and inland to Eneabba; and the Houtman Abrolhos (North I.; East Wallabi, West Wallabi and Seagull Is in the Wallabi Group; Rat, Hut and Helsinki Is in the Easter Group; and Middle I. in the Pelsaert Group). Common. Open or lightly wooded sandplains, coastal dunes and coastal limestone. Has been collected in the Kalbarri National Park to the immediate north of our region.

Ctenotus impar Storr, 1969

Two records from southern interior: five specimens from Burma Road Reserve (28°55′S, 115°01′E) and two from 10 km S of Eneabba. Locally common. Sandplains. One specimen was taken from a scorpion burrow.

Ctenotus lesueurii (Duméril and Bibron, 1839)

Two records: a specimen (41658) from coastal dunes near the lower Greenough River, and one (72985) from a yellowish sandplain 15 km E of Coolimba.

Ctenotus mimetes Storr, 1969

One record from extreme north-east: a specimen (30321) collected at 3 km W of Ajana.

Ctenotus pantherinus pantherinus (Peters, 1866)

Patchily in interior (Binnu, 32 km N of Eneabba and 10 km S of Eneabba). Scarce. Heath on laterite and nearby sandplains.

Ctenotus schomburgkii (Peters, 1863)

Patchily in interior (Burma Road Reserve, 5 km SSE of Eneabba and 10 km S of Eneabba). Scarce. Sandplains.

Egernia kingii (Gray, 1839)

Mainland coast north to the Hutt River, and the Houtman Abrolhos (North I.; East Wallabi, West Wallabi, Tattler, Seagull and Pigeon Is in the Wallabi Group; and Murray, Middle and Pelsaert Is and islet south of Gun I. in the Pelsaert Group). Scarce on the mainland; moderately common to very common on the islands. Coastal dunes, cliffs and flats of broken limestone and reef debris, especially in vicinity of nesting terns.

Egernia multiscutata bos Storr, 1960

Three records from far south; a specimen (26746) collected at Stockyard Gully, and observations by G.M. Storr on *Eucalyptus todtiana* sandplains 13 km SW and 31 km E of Eneabba.

Egernia stokesii stokesii (Gray, 1845)

Endemic to the Houtman Abrolhos: East Wallabi, West Wallabi, Tattler, Seagull and Pigeon Is in the Wallabi Group; and Murray and Middle Is in the Pelsaert Group; formerly occurring on Rat I. in the Easter Group, but disappearing between 1889 and 1913, following the introduction of domestic cats (Alexander 1922). Very common. Sheltering mainly under slabs of limestone; also in hollow stems of dead shrubs.

Eremiascincus richardsonii (Gray, 1845)

Northern interior south to White Peak. Rare. Favouring the heavier soils.

Lerista christinae Storr, 1979

One record from southern interior: a specimen (70721) pit-trapped in rich proteaceous heathland 5 km SSE of Eneabba.

Lerista distinguenda (Werner, 1910)

On the mainland regionally confined to the valley of the Greenough River (collected at Eradu, Newmarracarra and Greenough); also Rat I. in the Easter Group, Houtman Abrolhos. Uncommon.

Lerista elegans (Gray, 1845)

Far south of mainland north to 16 km N of Eneabba, and East Wallabi and West Wallabi Is in the Houtman Abrolhos. Uncommon. Sandy country with low open vegetation.

Lerista gerrardii (Gray, 1864)

Northern interior south to the Greenough River (Newmarracarra). Mainly in leaf litter beneath acacias, especially jam (*A. acuminata*), on red loamy soils.

Lerista greeri Storr, 1982

A specimen (188) was collected by W.B. Alexander in the Wallabi Group, Houtman Abrolhos, in November 1913. Otherwise this skink is only known from the Kimberley.

Lerista lineopunctulata (Duméril and Bibron, 1839)

Greater part of mainland, inland to Northampton and Eradu; and West Wallabi I. in the Houtman Abrolhos. Moderately common in white coastal dunes; scarce on sandplains of interior.

Lerista macropisthopus (Werner, 1903)

Extreme north-east (Ajana and Galena). Moderately common. Mainly in leaf litter beneath acacias growing on red loamy soils.

Lerista planiventralis decora Storr, 1978

One record from southern interior: two specimens (73112-3) collected in white sand with heath and scattered eucalypts 16 km N of Eneabba.

Lerista praepedita (Boulenger, 1877)

Greater part of mainland, inland to Eradu and Eneabba; and the Houtman Abrolhos (North I.; East Wallabi and West Wallabi Is in the Wallabi Group; and Middle I. in the Pelsaert Group). Uncommon. Sandplains.

Menetia greyii Gray, 1845

Sparsely distributed on the mainland (collected at Binnu, 6 km E of Dongara and 16 km E of Coolimba); and the Houtman Abrolhos (Eastern I. in the Wallabi Group, and Leo, Suomi, Rat and Morley Is in the Easter Group). Scarce on the mainland; common on the islands.

Menetia surda Storr, 1976

One record from far north-east: a specimen (71048) collected under litter on a yellow sandplain 4 km N of Binnu.

Morethia butleri (Storr, 1963)

One record from the northern interior: a specimen (28003) collected at 12 km E of the mouth of the Hutt River.

Morethia lineoocellata (Duméril and Bibron, 1839)

Northern and central coasts south to the vicinity of Greenough; and North, East Wallabi and West Wallabi Is in the Houtman Abrolhos. Common. Well-vegetated, white coastal dunes.

Morethia obscura Storr, 1973

Sparsely distributed in the interior (collected at Northampton, Burma Road Reserve, 10 km S of Eneabba and 15 km E of Coolimba); also Gun I., an islet south of Gun I., and Pelsaert I. in the Pelsaert Group, Houtman Abrolhos, and possibly the Beagle Is (Ford 1963: 138). Rare on the mainland; common in the Pelsaert Group.

Omolepida branchialis (Günther, 1867)

Common in far south-west, north to Beagle Point and inland to Stockyard Gully, in white coastal dunes and near-coastal sandplains. Scarce further north (collected at Galena, 'presumably Geraldton' and Newmarracarra).

Tiliqua occipitalis (Peters, 1863)

Coastal areas throughout the mainland, inland to Balline and Lake Arrowsmith. Modcrately common. Mainly well-vegetated coastal dunes and ncar-coastal sandplains; also observed on a saltbush flat.

Tiliqua rugosa rugosa (Gray, 1827)

Throughout the mainland. Moderately common in farming country and near coast; scarce in uncleared parts of thc interior.

Varanidae

Varanus caudolineatus Boulenger, 1885

Extreme north-east (two specimens from Ajana).

Varanus gouldii (Gray, 1838)

Sparsely distributcd throughout the mainland. Preferring sandy country.

Varanus tristis tristis (Schlegel, 1839)

Two rccords: a spccimen (1735) collected at Newmarracarra, and one observed by T.M.S. Hanlon in *Acacia* scrub 5 km N of Leeman.

Typhlopidae

Ramphotyphlops australis (Gray, 1845)

Two records from southern intcrior: single specimens collected at Irwin House (5688) and Arrowsmith (21856).

Ramphotyphlops hamatus Storr, 1981

Two rccords from northern half of mainland: single specimens from Geraldton (32368) and Newmarracarra (1733).

Ramphotyphlops leptosoma Robb, 1972

Northcrn interior south to Newmarracarra. Moderately common. Apparently favouring the heavier soils.

Ramphotyphlops waitii (Boulenger, 1895)

Fivc of thc six regional specimcns comc from thc vicinity of Geraldton (including Wonthclla and Grccnough); thc sixth is from the southern interior (2 km N of Eneabba Spring). [Thc specimcn of *'Typhlina bituberculata'* reported by Storr and Harold (1980) for thc Zuytdorp arca was in fact an *R. waitii.*]

Boidae

Aspidites ramsayi (Macleay, 1882)

Northern interior south to Newmarracarra. Scarce. One specimen was found in a rabbit warren in sandplain country at Eradu.

Liasis 'childreni' Gray, 1842

Three records: single specimens from 30 km N of Geraldton (76412), Moonyoonooka (6142) and 5 km E of Coolimba (72984).

Python spilotus imbricatus L.A. Smith, 1981

Coastal areas of mainland north to Geraldton; and East Wallabi, West Wallabi and Seagull Is in the Wallabi Group, Houtman Abrolhos. Scarce on the mainland; common on the Wallabi Is, formerly occurring on North I. (Storr 1960).

Elapidae

Demansia reticulata reticulata (Gray, 1842)

Throughout the mainland. Moderately common. A specimen from Bookara had swallowed a frog (*Pseudophryne guentheri*).

Denisonia gouldii (Gray, 1841)

One record from far southern interior: three specimens (28087-9) collected at Stockyard Gully Cave.

Denisonia monachus Storr, 1964

Northern half of mainland south to the Greenough River (Newmarracarra). Uncommon.

Notechis curtus (Schlegel, 1837)

Far south of mainland north to the lower Arrowsmith River. Uncommon. Sandplains and coastal dunes.

Pseudechis australis (Gray, 1842)

Throughout the mainland. Moderately common in the interior; scarce or absent near the coast.

Pseudonaja modesta (Günther, 1872)

Northern interior south to the Greenough River (Walkaway). Uncommon.

Pseudonaja nuchalis (Günther, 1858

Throughout the mainland. Very common in and around towns and settlements; moderately common in coastal dunes; apparently uncommon in uncleared parts of the interior.

Vermicella bertholdi (Jan, 1858)

Southern interior north to the Greenough River (Newmarracarra). Scarce.

Vermicella bimaculata (Duméril, Bibron and Duméril, 1854)

One record from far south: a specimen (72971) collected at 10 km N of Leeman. The specimens from 'Greenough' (cited by Storr 1967: 86) are now believed to have come from the Eastern Goldfields.

Vermicella fasciolata fasciolata (Günther, 1872)

One record from extreme south-west: a specimen (62262) collected at 10 km N of Green Head.

Vermicella littoralis Storr, 1968

Coastal dunes and limestone north to Horrocks; and East Wallabi and West Wallabi Is in the Houtman Abrolhos. Moderately common.

Vermicella semifasciata semifasciata (Günther, 1863)

Northern half of mainland south to Geraldton. Moderately common.

Hydrophiidae

Pelamis platura (Linnaeus, 1766)

One record: a specimen (29609) found on the beach at Dongara after a storm in early October 1967.

Discussion

The 46 genera and 97 species and subspecies of amphibians and reptiles are distributed in 12 families as follows:

Leptodactylidae	6 genera, 9 species
Hylidae	1 genus, 1 species
Cheloniidae	2 genera, 2 species
Gekkonidae	7 genera, 14 species
Pygopodidae	6 genera, 11 species
Agamidae	3 genera, 8 species and subspecies
Scincidae	9 genera, 29 species
Varanidae	1 genus, 3 species
Typhlopidae	1 genus, 4 species
Boidae	3 genera, 3 species
Elapidae	6 genera, 12 species
Hydrophiidae	1 genus, 1 species

In view of the number of species regionally known from only one or two records, we expect several more reptiles to be added to the list. These additional species are most likely to be among those recorded from the area immediately north of our region, viz. *Aprasia smithi, Amphibolurus parviceps, A. scutulatus, Ctenotus severus, Lerista connivens, L. humphriesi, L. muelleri, L. 'nichollsi'* and *Varanus eremius.*

Species recorded from the immediate south are less likely to be found in our area, for their habitat (lateritic uplands with dry sclerophyll forest) ceases just before our region is reached; in this category are *Egernia napoleonis* and the mainland population of *Crenadactylus o. ocellatus.* Two species, *Chelodina oblonga* and *Notechis scutatus,* have their northern limit on the Hill River, and *Hemiergis peronii quadrilineata* extends north to Jurien Bay.

Nevertheless many south-west Australian frogs and lizards extend into the present region, eleven of them attaining their northern limit here, viz.:

Heleioporus eyrei (north to the lower Greenough)
H. psammophilus (to the lower Irwin)
Litoria moorei (to the lower Hutt)
Aprasia repens (to Geraldton)
Diplodactylus polyophthalmus (to Eneabba)
Pletholax g. gracilis (to Eneabba)
Ctenotus impar (to the Burma Road Reserve)
Egernia kingii (to the lower Hutt on the mainland; to North I. in the Houtman Abrolhos) and
Lerista christinae (to Eneabba)
Lerista distinguenda (to Greenough on the mainland; to Rat I. in the Houtman Abrolhos) and
Python spilotus imbricatus (to Geraldton on the mainland; to North I. in the Houtman Abrolhos)

To these could be added *Egernia multiscutata bos,* which extends only to Eneabba on the mainland but reappears much further north on Bernier I. in Shark Bay.

An even larger number of arid-zone reptiles have their southern limit (at least on the west coast or in its vicinity) within the present region:

Diplodactylus squarrosus (extending south to Binnu)
Diplodactylus strophurus (to Binnu)
Nephrurus levis occidentalis (to the hinterland of Geraldton)
Delma nasuta (to Northampton)
Delma tincta (to East Chapman)
Pygopus n. nigriceps (to the lower Irwin)
Amphibolurus inermis (to Lake Arrowsmith)
Amphibolurus reticulatus (nearly to Geraldton)
Moloch horridus (to Eneabba)

Ctenotus mimetes (to Ajana)
Ctenotus schomburgkii (to Encabba)
Lerista gerrardii (to the Greenough)
Lerista macropisthopus (to Ajana)
Menetia surda (to Binnu)
Morethia butleri (to the Hutt)
Varanus caudolineatus (to Ajana)
Ramphotyphlops hamatus (to the Greenough)
Ramphotyphlops leptosoma (to the Greenough)
Aspidites ramsayi (to the Greenough)
Denisonia monachus (to the Greenough) and
Pseudonaja modesta (to the Greenough)

It follows from the foregoing discussion that a high proportion of the species inhabiting the northern half of the region do not extend to the southern half, and vice versa. In previous analyses of west-coast herpetofaunas we have remarked on the high rate of latitudinal replacement of species *between* regions (Storr and Hanlon 1980). This, however, is the first time we have encountered a high rate of latitudinal replacement *within* a region, but then this is the first region studied in which there is a marked latitudinal gradient in rainfall, the annual mean doubling from north-east to south-west.

The only endemic taxa are the two lizards restricted to the Houtman Abrolhos: *Amphibolurus minor minimus* and *Egernia stokesii stokesii.*

We return to the problem of broken distributions along the mid-west coast of Western Australia. The principal disjunctions are in:

Phyllodactylus marmoratus — 460 km between Cockleshell Gully and False Entrance Well, Edel Land
Aclys concinna — 370 km between Coolimba and Tamala
Pletholax gracilis — 440 km between Encabba and Useless Loop, Edel Land
Egernia multiscutata — 600 km between Stockyard Gully and Bernier I.
Lerista elegans — 425 km between 15 km N of Eneabba and Useless Loop, and
Morethia lineoocellata — 190 km between Badgingarra and Greenough

In December 1980 T.M.S. Hanlon was only able to reduce the disjunction in two of the above species (*Aclys concinna* and *Lerista elegans*), and then only by *c.* 30 km. However the time spent in the field (three weeks) was very short in relation to the large area covered. As it is difficult to distinguish between complete absence and very low density, we feel that most of the above disjunctions are not yet proved. The exceptional species are *Pletholax gracilis* and *Egernia multiscutata.* The separability of the northern population of *Pletholax gracilis* as a distinct subspecies (*edelensis*) implies geographic isolation. As for *Egernia multiscutata,* we concede that the skinks themselves may have been overlooked by naturalists, but hardly their conspicuous burrows.

Table 1 Distribution of the reptiles of the Houtman Abrolhos by island groups.

	North	Wallabi	Easter	Pelsaert
Cheloniidae				
Chelonia mydas	X	X		
Gekkonidae				
Crenadactylus ocellatus		X	X	X
Diplodactylus spinigerus		X		
Gehyra variegata		X		X
Heteronotia binoei	X	X		
Phyllodactylus marmoratus	X	X	X	X
Phyllurus milii		X		X
Pygopodidae				
Delma australis			X	
D. grayii		X		
Lialis burtonis		X		
Agamidae				
Amphibolurus minor	X	X		
Scincidae				
Cryptoblepharus carnabyi		X	X	X
Ctenotus fallens	X	X	X	X
Egernia kingii	X	X		X
E. stokesii		X	X	X
Lerista distinguenda			X	
L. elegans		X		
L. greeri		X		
L. lineopunctulata		X		
L. praepedita	X	X		X
Menetia greyii		X	X	
Morethia lineoocellata	X	X		
M. obscura				X
Boidae				
Python spilotus	X	X		
Elapidae				
Vermicella littoralis		X		
TOTAL	9	22	8	10

Finally some comments on the Houtman Abrolhos. Geographically the islands are divided into four quarters, namely (from north to south) North I. and the Wallabi, Easter and Pelsaert Groups. North I. and the western islands of the Wallabi, Easter and Pelsaert Groups are continental remnants that were separated from the mainland by rising sea-level *c.* 11500 years ago (Main 1961). The eastern islands in each group are recent accumulations of coral fragments (O'Loughlin 1969, Green 1972).

Twenty-five species of reptile occur in the Houtman Abrolhos; their distribution by island groups is set out in Table 1. Not surprisingly the Wallabi Group is the richest; in East Wallabi and West Wallabi it contains much the largest and most varied islands in the archipelago. Generally the fauna of North I. and the Pelsaert Group are attenuated versions of the Wallabi Group fauna. However, the fauna of the Easter Group is quite peculiar in its composition. Only eight species have been found in the group, but two of them, *Delma australis* and *Lerista distinguenda,* are not known from any other group. Moreover, *Delma australis* is absent from the opposite mainland, and *Lerista distinguenda* is restricted to one small part of the Geraldton region. A third Easter Group species, *Menetia greyii,* is unknown from other Groups except for its occurrence on Eastern I. in the Wallabi Group. Now Eastern I. is one of the islands recently formed from reef debris; and *Menetia greyii,* the sole reptile on the island, must have arrived there from over the sea. Perhaps the peculiarities of the Easter Group are similarly due to transmarine dispersal.

Comprising seven families, 17 genera and 21 species of reptiles, the fauna of the Wallabi Islands is continental in its diversity. Nevertheless this fauna differs considerably from that of any comparable area on the mainland. The last 11500 years has seen not only the evolution of distinct subspecies but also the extinction of such widespread west-coast reptiles as *Diplodactylus ornatus, Amphibolurus adelaidensis/parviceps, A. maculatus, Ctenotus lesueurii, Omolepida branchialis, Tiliqua occipitalis, T. rugosa* and *Pseudonaja affinis/nuchalis.* Nor has the mainland fauna gone unchanged in this period, as indicated by the withdrawal of *Crenadactylus ocellatus, Phyllodactylus marmoratus* and *Cryptoblepharus carnabyi.*

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Human Skeletal Remains from Cheetup, Western Australia

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Abstract

This paper describes Pleistocene human skeletal material from an excavation by M. Smith in 1979 at Cheetup, Western Australia. Recovered from a hearth now dated at over 12 000 BP, these remains include fire-damaged cranial, post-cranial, and dental fragments. Analysis of the material reveals that it represents a child, possibly female, 3-9 months of age at death. The source of the material and its condition are consistent with deliberate cremation.

Background

The material described in this paper comes from Cheetup (33°52'S, 122°27'E), a rockshelter approximately 55 km E of Esperance, Western Australia (Figure 1). Excavated by M. Smith (1982), this site is listed in the catalogue of the Department of Aboriginal Sites, Western Australian Museum as W0594. These fragments (WAM registration number A23441) were recovered during the first season of excavation in 1979 at a depth of 7-33 cm in trench F12, spit 4, in a feature subsequently identified as a hearth. Radiocarbon dating of charred wood from this feature is 12 845 ± 310 BP (GX-6604). Initial sorting by J. Balme of the bone fragments recovered, indicated the possibility of some being of human origin. The following paper confirms that preliminary identification, and describes the material in detail.

Previous descriptions of Australian Aboriginal skeletal material from Western Australia include three teeth and a pelvic fragment from Devil's Lair (Davies 1968, 1973; Freedman 1976; Allbrook 1976), a study of cranial morphometrics (Margetts and Freedman 1977), the Cossack material (Freedman and Lofgren 1979*a, b*), a study of odontometrics (Freedman and Lofgren 1981), middle ear ossicles (Blumer, Freedman and Lofgren 1982), and discrete non-metric cranial traits (Milne, Schmidt and Freedman [in press]). Because of the already known length of human occupation of Australia (> 40 000 BP, Jones 1979), as well as the

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considerable variation in form demonstrated by described material, there is particular importance in all discovered Pleistocene human skeletal material. Also, problems of regional variation in space and time require the close study of all available material so that existing models may be refined. This paper offers new data pertaining to these problems.

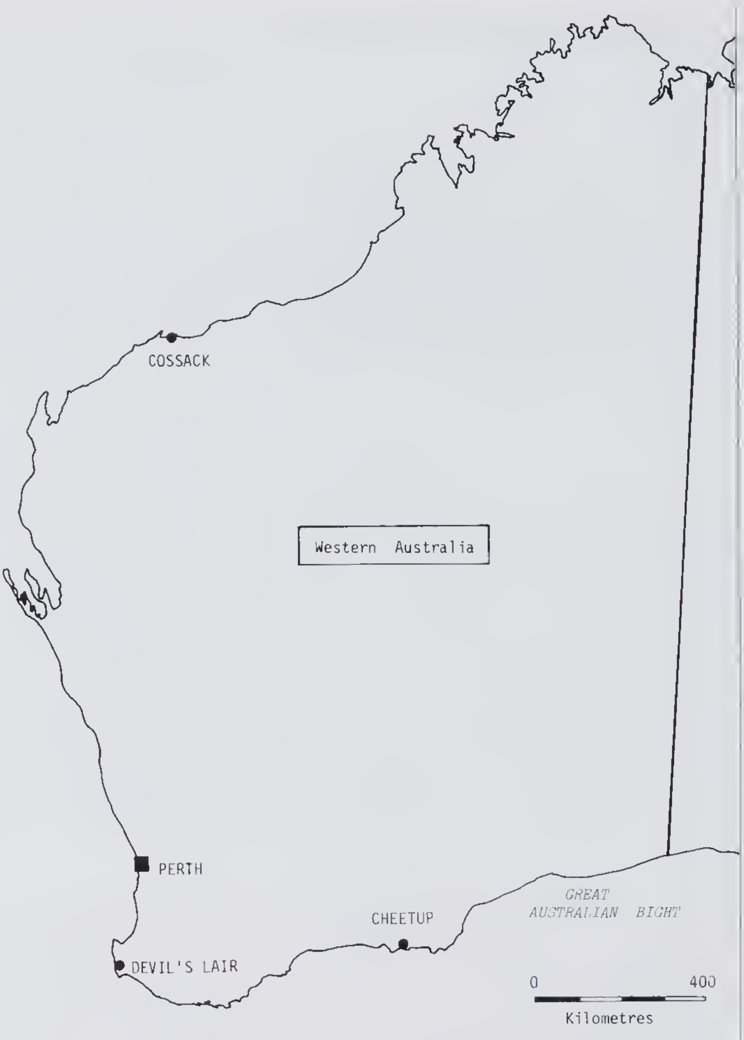

Figure 1 Location of Cheetup, W.A.

Material

The fire-damaged skeletal remains recovered from this excavation include more than 100 small bone fragments, of which the largest piece is only 25 mm x 16 mm. The identifiable fragments are primarily from the skull vault, but 5 pieces of bone are clearly from the post-cranial skeleton, and there are parts of 6 teeth also present.

Skull Bones

More than 60 small fragments of the cranial vault are present (Figure 2). Only 4 fragments are more than 15 mm x 10 mm, and no attempt has been made to reconstruct the vault. In most instances only a single table of bone (usually the outer) is present, but a few fragments include both tables and many of the others have some of the inner cancellous bone still attached. When both tables of bone are present, the thickness of the fragments vary from 1 mm to 1.5 mm, but it is not possible to identify the regions of the vault from which these fragments came.

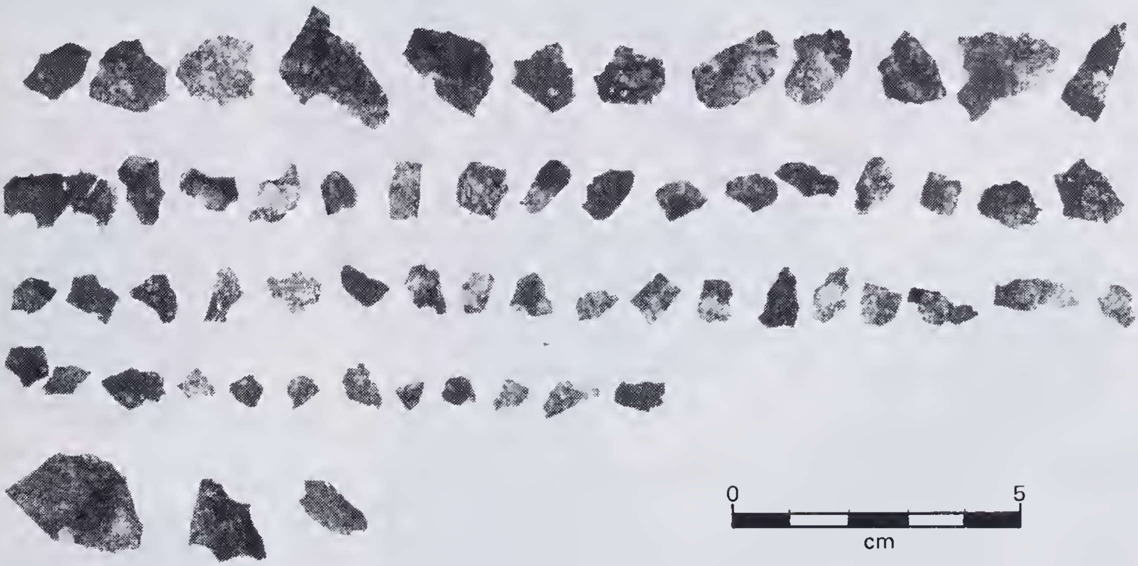

Figure 2 Cranial fragments, Cheetup, W.A.

Small Unidentified Fragments of Bone

There are over 25 small slivers and thicker pieces of bone (Figure 3). Some of the thicker pieces could come from the cranial base or face. Only one piece of these is more than a fragment. That piece is about 25 mm x 16 mm and over 7 mm at its maximum thickness, and could be part of the mastoid region of a temporal bone. Some of the other fragments could be parts of post-cranial bones, particularly long bones.

Post-cranial Bones

Of the 7 post-cranial fragments (Figure 4), 5 are identifiable. Three are proximal or distal parts of limb long bones. Two of these are probably the right and left proximal parts of the shafts of humeri (Figure 4A and B), the cross-sectional measurements of these pieces being approximately 7.8 mm x 9.1 mm

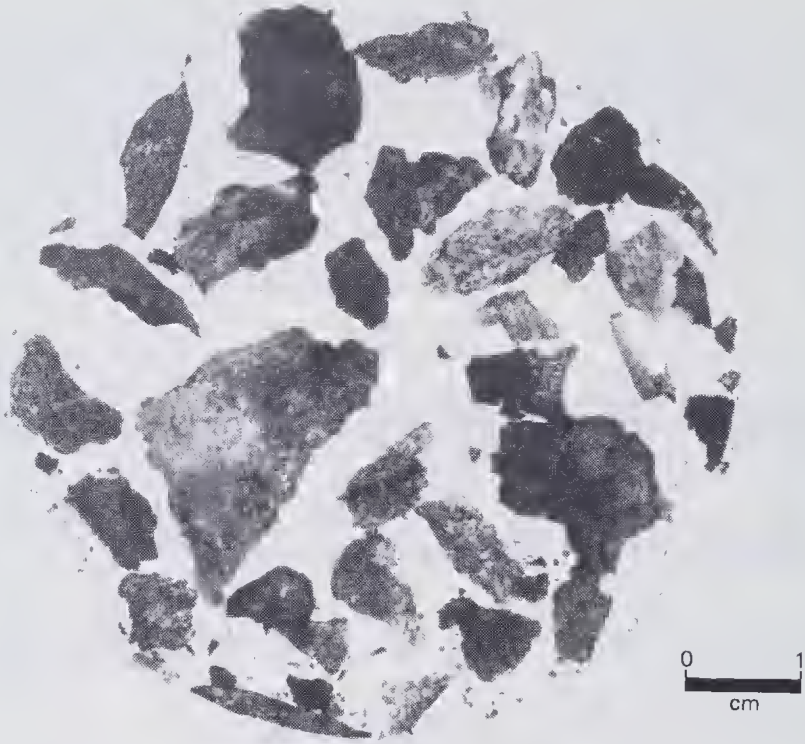

Figure 3 Unidentified fragments, Cheetup, W.A.

Table 1 Approximate dimensions of the Cheetup teeth, and comparisons with some other deciduous teeth mentioned in the text (in mm).

Tooth	Dimension	Cheetup	Devil's Lair	Mod. Aust. Ab. Means‡ ♀	♂
di[1]	height (crown)	7.2	–	–	
	length (m-d)	6.0	7.0*	7.20	7.35
	breadth (b-l)	–	5.25*	5.30	5.47
di[2]	length (m-d)	–	6.0†	5.93	6.00
dc	height (crown)	6.0	–	–	
	length (m-d)	5.7	–	6.16	6.31
	breadth (b-l)	5.2	–	5.84	6.05
dm[1]	length (m-d)	7.0	–	7.28	7.55
	breadth (b-l)	8.0 (l & r)	–	8.77	9.07

* Davies, P.L. (1968)
† Freedman, L. (1976)
‡ Margetts, B. and Brown, T. (1978)

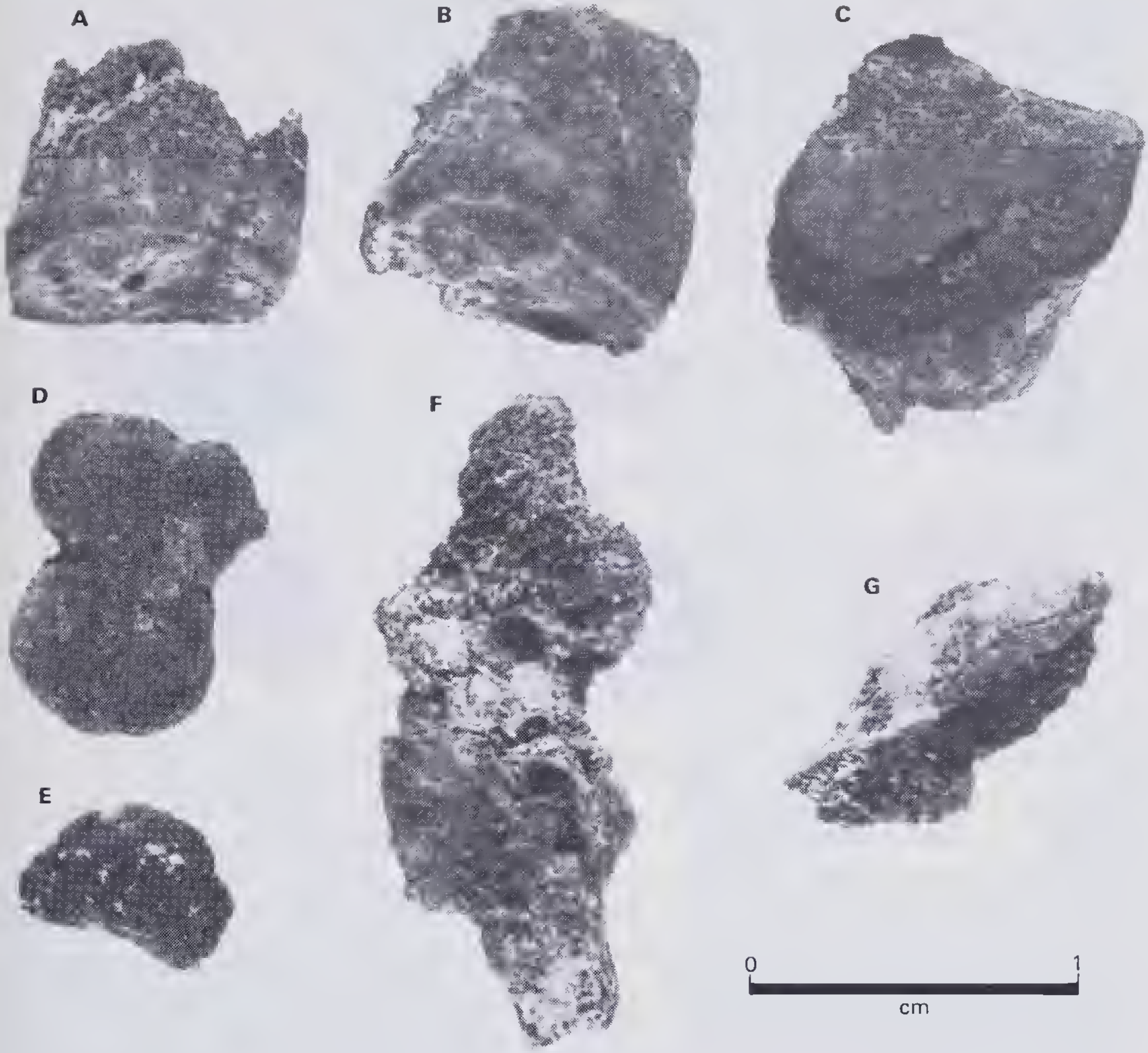

Figure 4 Post-cranial fragments, Cheetup, W.A. (see text for identifications).

and 7.5 mm x 9.1 mm. The third end fragment (Figure 4C) is damaged but might be the distal end of the shaft of a humerus. The fourth fragment (Figure 4D) is an epiphysis, probably from the distal end of a humerus and it measures about 10 mm x 7.5 mm. The fifth fragment (Figure 4E) is a small portion of the epiphysis of a long bone, but it is too small to be more specifically identified.

Teeth

There are 6 individual teeth or parts of teeth present in the remains found. The specimens are all the unworn calcified crowns, or parts of crowns, of deciduous teeth; no roots are present (Figure 5). The specimens include: (Figure 5A) the labial part of the crown of the right di^1; (Figure 5B) the crown, probably of a $\overline{dc}$; (Figure 5C and D) the whole left, and part of the right, crown of dm^1, (Figure 5E) part of the crown of a right dm_1, and (Figure 5F) another dm crown fragment, possibly the left dm_1. The approximate measurements of the teeth are given in Table 1.

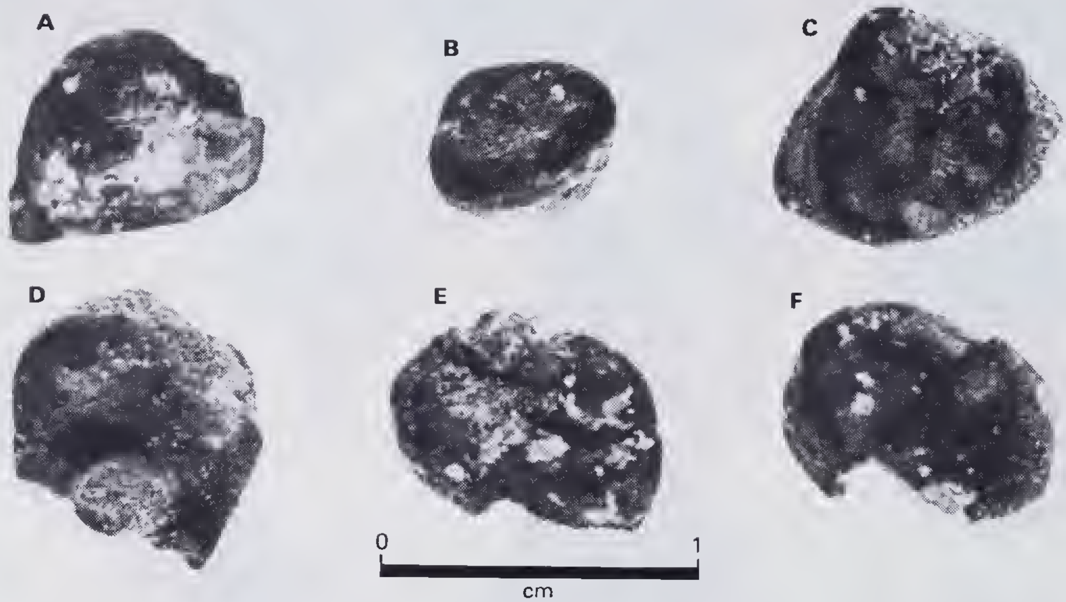

Figure 5 Deciduous teeth, Cheetup, W.A. (see text for identifications).

Conclusions

The small size and partially charred condition of the bone fragments described make reconstruction and more extensive analysis impractical. The majority of the fragments are from the cranial vault and probably represent virtually the whole of that region. The few possible cranial base and face fragments are too small for any certain assignments to be made.

Of the post-cranial skeleton, only 5 identifiable fragments were found and these are the ends of long bones or their epiphyses. The coloration of these fragments suggests extensive charring much more so than does the condition of the skull fragments, in which the colour and damage suggest less exposure to heat. These differences may account for the paucity of post-cranial remains.

The 6 teeth and tooth fragments are all of deciduous teeth lacking roots. They show no obvious signs of attrition and it does not appear as if the roots had been formed. On the basis of the apparently unworn state and lack of roots of the teeth found, an approximate age of about 6 months would seem the most reasonable assessment, using the ossification data summarized by Gabriel (1965). In view of individual variability and the fact that initially there would be little wear on the teeth, a range of 3-9 months of age is postulated. In view of these dimensions being smaller than even the female mean values of Margetts and Brown (1978), it is possible that the remains are those of a female child.

The location of the remains within a discrete feature identified as a hearth, and condition of the fragments of bone suggest some tentative conclusions. As with the Lake Mungo cremation (Bowler *et al.* 1970), the pyre did not entirely consume all bone fragments, and differential charring was the result. Charring is consistently more intense on external surfaces of individual fragments. While other explanations are possible for the presence and state of the remains, it appears most likely that the child was cremated as a complete and fully-fleshed cadaver.

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A Review of the Gudgeon Genus *Hypseleotris* (Pisces: Eleotridae) of Western Australia, with Descriptions of Three New Species

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Abstract

The five Western Australian members of the eleotrid genus *Hypseleotris* Gill are reviewed. These small fishes are inhabitants of brackish water, freshwater streams, swamps and ponds, primarily in northern Australia and New Guinea. The species treated in the present paper include *H. aurea* (Shipway) and *H. compressa* (Krefft). In addition, the following three species from the Kimberley district are described as new: *H. ejuncida, H. kimberleyensis*, and *H. regalis.* The first two species are closely allied, differing from each other primarily on the basis of coloration, body depth, and number of vertebrae. *Hypseleotris regalis* is most similar to *H. aurea,* but differs with regard to squamation and number of vertebrae. A key to Western Australian *Hypseleotris* and diagnostic illustrations are provided.

Introduction

Prior to 1970 relatively few comprehensive studies had been carried out on the taxonomy of Australian freshwater fishes. Some areas, such as the north-west, had not been sampled extensively primarily because of the inaccessibility of much of this region. Recent collections from the Kimberley district of far northern Western Australia by the Western Australian Museum has resulted in the discovery of a number of undescribed fishes, including a new genus and six new species of eleotrids.

Three of the new species belong to the genus *Hypseleotris,* which occurs in fresh and brackish waters of the Indo-west Pacific. They are small free-swimming fishes which feed mainly on tiny invertebrates. Breeding males are often colourful and make attractive aquarium fishes. Currently few species are recognized, but virtually no work has been done on species occurring outside Australia. Although not recorded from the New World, it is very likely that *Hemieleotris* from Central America will prove identical to *Hypseleotris.* Similarly, *Batanga* from Africa appears close to *Hypseleotris.*

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Although several species have been described from Australia, generally only four were previously recognized as valid: *H. compressa* (Krefft), *H. galii* (Ogilby), *H. klunzingeri* (Ogilby), and *H. simplex* (Castelnau). Recently Hoese, Larson and Llewellyn (1980) recorded two additional undescribed species from south-eastern Australia. Although we are unable to locate the type specimen of *H. simplex*, it is regarded here as a junior synonym of *H. compressa*, which is widely distributed in northern and eastern Australia. The remaining *Hypseleotris* treated herein, including *H. aurea* and three new species are apparently restricted to north-western Western Australia. Our numerous collections from streams in the Northern Territory and the Gulf of Carpentaria drainage of northern Queensland contain only *H. compressa*. Other *Hypseleotris* species are known in Australia from coastal drainages extending from the Atherton Tablelands of northern Queensland to New South Wales and Victoria, and from inland drainages, including the Murray-Darling system, of southern Queensland, New South Wales, Victoria and South Australia.

Methods

Methods for counts and measurements mainly follow those of Hubbs and Lagler (1958). The longitudinal scale count was taken from the upper pectoral base obliquely to the midline and then to the end of the hypural. The transverse scale count was taken from the origin of the second dorsal fin downward and backward to the anal base (TRDB). The postdorsal scale count is taken from the end of the second dorsal fin to the caudal base middorsally, and includes only scales on the middle of the top of the caudal peduncle. Gill raker counts include all rudiments. Counts for vertebrae, fin rays, scales and gill rakers are presented in Tables 1-6. In addition, the body depth and pelvic fin length of the five species are compared in Tables 7 and 8 respectively.

Specimens studied, including types of the new taxa, are deposited at the following institutions: Australian Museum, Sydney (AM); British Museum (Natural History), London (BMNH); Museum National d'Histoire Naturelle, Paris (MNHN); and Western Australian Museum, Perth (WAM).

Systematics

Hypseleotris Gill

Hypseleotris Gill, 1863: 270 (*Eleotris cyprinoides* Valenciennes, by original designation).
Carassiops Ogilby, 1897: 732 (*Eleotris compressus* Krefft, by original designation).
Austrogobio Ogilby, 1898: 784 (*Carassiops galii* Ogilby, by original designation).
Caulichthys Ogilby, 1898: 784 (*Asterropteryx guentheri* Bleeker, by original designation).
Shipwayia Whitley, 1954a: 155 (*Eleotris aurea* Shipway, by monotypy and subsequent designation by Whitley, 1954b: 30).

Description

Head and body distinctly compressed. Mouth small, very oblique, posterior margin under or anterior to middle of eye. Gill opening moderately broad, extending forward to below posterior end of preoperculum. Pectoral base narrow, with rays developed ventrally; a free fold of skin extending to upper attachment of opercular membrane above uppermost ray. Body scales large and ctenoid. Teeth small in several rows in both jaws. Tongue tip truncate. First dorsal VI-VIII (rarely V or IX). Second dorsal I,8-12 (rarely 13). Anal I,10-13 (rarely 14). Pectoral rays 14-17 (rarely 13). Longitudinal scale count 24-43. Transverse scale count (TRDB) 7-15. Segmented caudal rays 15. Vertebrae 25-33. Head pores present or absent, sometimes with up to 5 preopercular pores and sometimes two pores above each eye. Cheek sensory papillae normally in longitudinal rows, with few vertical rows (except in *H. klunzingeri*). Body scales ctenoid, often cycloid on belly and nape. Head scales present or absent.

Remarks

Until recently Australian species of *Hypseleotris* were placed in the genus *Carassiops* Ogilby. Examination of type material of the type species of *Hypseleotris (H. cyprinoides* at MNHN) and *Carassiops* (*H. compressa* at BMNH and AM) revealed that these two forms represent a closely related, apparently allopatric, species pair. *H. compressa* differs from *H. cyprinoides* primarily in lacking interorbital scales before the middle of the eye. *H. compressa* is known from Australia and possibly New Guinea while *H. cyprinoides* is found in fresh and brackish water throughout the western tropical Pacific outside Australia.

Whitely (1954*a*) separated *Shipwayia* from *Carassiops* (=*Hypseleotris*) only on the basis of the higher scale counts in *Shipwayia*; 45 to 50 rows versus 27 to 35. Our counts indicate scale counts of 33 to 43 for *H. aurea* compared with 24 to 34 in other Australian species. Because *H. aurea* is closely related to *H. regalis,* sp. nov., an otherwise typical member of the genus which has low scale counts, there appears to be no justification for separating *Shipwayia* and *Hypseleotris.*

The Western Australian species can be conveniently grouped into three categories on the basis of colour similarities. The first contains only *H. compressa;* the second *H. aurea* and the allopatric *H. regalis,* sp. nov.; and the third *H. kimberleyensis,* sp. nov. and the allopatric *H. ejuncida,* sp. nov. On the basis of fin coloration, it appears likely that the two complexes which are restricted to Western Australia were derived from the same stock as *H. compressa.* They do not show any close similarity to species from south-eastern Australia. *H. compressa* is the only known Australian species to occur in salt as well as fresh water, and is the only species ranging throughout tropical and subtropical Australia.

All species from Western Australia are basically similar in sensory papillae patterns (Figure 1), a feature which is often diagnostic in eleotrids.

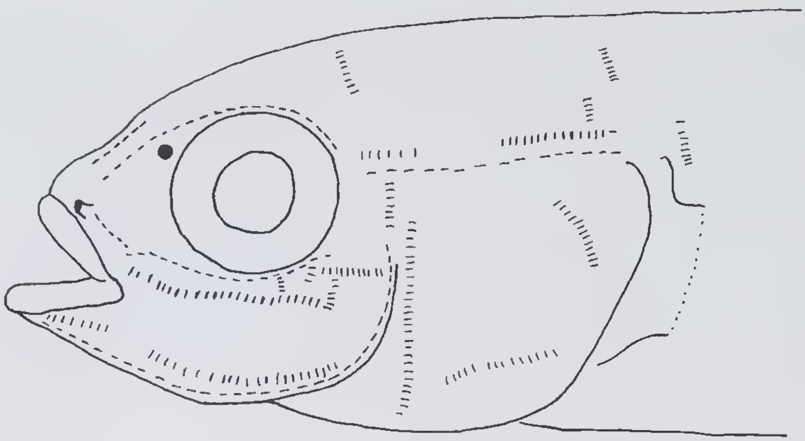

Figure 1 Diagrammatic sketch of sensory papillae on head of *Hypseleotris regalis*. The drawing is a composite, based on several specimens. Papillae numbers are approximate and the pattern shown may be incomplete as the papillae are often difficult to detect.

Key to Western Australian Species of *Hypseleotris*

1a Preoperculum with 2-4 pores. Predorsal scales reach forward to above middle of eyes. Scales from under first dorsal fin to upper attachment of opercular membrane ctenoid; nape scales often ctenoid. Second dorsal fin-rays modally I,9 (Murchison River northward to Kimberleys) .... *H. compressa* (Krefft)

1b No preopercular pores. Predorsal scales reach forward to or behind middle of eye. Scales from under first dorsal fin to upper attachment of opercular membrane cycloid; nape scales if present cycloid. Second dorsal fin-rays usually I,10 2

2a Longitudinal scale count 34-43. Postdorsal scale count 10-13. Body relatively deep, body depth at pelvic fin origin 20-23% of SL (Murchison River) ...... *H. aurea* (Shipway)

2b Longitudinal scale count 24-32. Postdorsal scale count 7-9. Body more slender, depth at pelvic fin origin 14-20% of SL 3

3a Longitudinal scale count 24-26. Body moderately slender, body depth at pelvic fin origin 16-20% of SL. Predorsal scaled completely to behind eyes. Gill rakers on outer face of second arch modally 10. Body without vertical bars, but with 15-20 chevron marks on side. Pelvic fin origin under posterior opercular margin (West Kimberley) .... *H. regalis* sp. nov.

3b Longitduinal scale count 28-32. Body very slender, depth at pelvic fin origin 14-18% of SL. Predorsal naked or partly scaled, with naked patches. Gill rakers on outer face of second arch 8-9. Body with faint vertical bars anteriorly. Pelvic fin origin under or behind pectoral fin insertion 4

4a Predorsal completely naked. Operculum naked. Second dorsal and caudal fins clear to dusky without distinct spots or wavy bands; caudal sometimes with 2 faint vertical bands. Dark bar on pectoral fin base developed dorsally only, usually only above uppermost pectoral fin ray. Body depth at anal origin 13-17% of SL. Vertebrae 25 (Central Kimberley .... *H. kimberleyensis* sp. nov.

4b Predorsal usually extensively scaled, midline sometimes with few scales. Operculum with large scales. Second dorsal fin with numerous white spots, surrounded by dark pigment forming wavy bands. Caudal fin with dark spots, forming 4-6 wavy bands. Bar at base of pectoral fin covering whole base. Body depth at anal fin origin 17-18% of SL. Vertebrae 26 (West Kimberley) .... *H. ejuncida* sp. nov.

Hypseleotris compressa

Figure 2

Eleotris compressus Krefft, 1864: 184 (Clarence River and Port Denison).
Hypseleotris simplex – Allen, 1975: 95, fig. 12 (in part, WAM P25036-003).

Material Examined

AM I.22746-001, 7 (27-35 mm SL), Lawley River, Western Australia; WAM P.16562-16563, 2 (58 mm SL), Murchison River, Western Australia WAM P25-36-003, 35 (13-37 mm SL), Prince Regent River, Western Australia.

Diagnosis

A species of *Hypseleotris* closely related to *H. cyprinoides* of the western tropical Pacific (exclusive of Australia), but differing from it by lacking interorbital scales anterior to the middle of the eyes. It differs from other Western Australian members of the genus by a combination of characters which include the presence of preopercular pores; predorsal scales extending anteriorly to above middle of eycs; presence of ctenoid scales between first dorsal fin base and upper attachment of opercular membranc; and a modal count for the second dorsal fin of I,9.

Description

Two to five preopercular pores. Adults usually with two pores conncctcd by short tube above dorsoposterior margin of eye. Predorsal scales reach forward to above middle of eye; cycloid or ctenoid. Cheek with four to six rows of small embedded cycloid scales. Operculum with medium-sized cycloid scales. Gill opening extends forward to below posterior preopercular margin. First dorsal VI. Second dorsal I,9-10. Anal usually I,10-11. Typically with 1 or 2 more anal than dorsal rays. Pectoral usually 14-15. Longitudinal scale count 25-29. Predorsal scales 14-18. Transverse scales (TRDB) 9-10. Postdorsal scales 8-9. Gill rakers on outer face of first arch 3-4+1+19-11 + 12-16. Vertebrae 26. Sides of body often with about 7 or 8 brown vertical bars, often forming X-shaped marks on midside. Base of caudal fin with a vertically elongate dark brown spot just below midside. Dorsal fins with 2 black stripes. Second dorsal with round white spots posteriorly, surrounded by black. Live and fresh adult specimens viewed from above usually have a distinct dark mark near the posterior end of the second dorsal fin.

Figure 2 *Hypseleotris compressa,* **female, 29 mm SL, Prince Regent River, Western Australia.**

Sexual Dimorphism

Males typically havc morc elongate posterior second dorsal and anal rays, a higher first dorsal fin, and the two dorsal fins are closer together. Males reach a larger size than do females, and often develop a fleshy hump on the top of the end of the head. Breeding males are often more brightly coloured than females.

Distribution and Habitat

Hypseleotris compressa is common in lower reaches of rivers from eastern Victoria, New South Wales, Queensland, Northern Territory, and Western Australia. The Western Australian distribution extends from the Murchison River (approximately 27°40′S) northwards in coastal streams and across the Kimberley region to the Northern Territory border. The species is most abundant in flowing waters and is often associated with aquatic vegetation. Juveniles are frequently found in swift-flowing water or in estuaries. The species sometimes occurs in full strength sea water, and this tolerance undoubtedly contributes to its wide distribution.

Hypseleotris aurea

Figure 3

Eleotris aurea Shipway, 1950: 75 (Murchison River).
Shipwayia aurea – Whitley, 1954a: 152 and 155 (description of new genus).

Material Examined

AM I.22743-001, 6 (43-48 mmSL), Murchison River, Western Australia; WAM P.3273 (holotype), 1 (49 mm SL), Murchison River, Western Australia; WAM P22122-004, 14 (33-40 mm SL), Murchison River, Western Australia.

Diagnosis

A species of *Hypseleotris* closely related to *H. regalis* of the Prince Regent Reserve, West Kimberley. It differs from this species by possessing an additional vertebra (26 versus 25) and smaller scales. Ranges of counts for longitudinal scales, transverse scales, predorsal scales, and postdorsal scales are 34-43 v. 24-26, 10-13 v. 8-9, 16-21 v. 14-16, and 10-13 v. 8 for *H. aurea* and *H. regalis* respectively. It differs from *H. compressa* on the basis of characters indicated in the diagnosis section for that species and from other Western Australian *Hypseleotris* on the basis of a combination of characters which include its relatively high longitudinal and postdorsal scale counts and deeper body, the depth at pelvic fin origin 14-20% of SL.

Description

No head pores. Predorsal scales reach forward to above middle of eye. Check with four rows of small embedded cycloid scales. Operculum covered with medium-sized cycloid scales. Gill opening extends forward to below posterior preopercular margin. First dorsal VI. Second dorsal usually I,10. Anal usually I,11 with 1 more anal ray than dorsal ray. Pectoral 14-16, usually 15-16. Longitudinal scale count 34-43. Transverse scale count (TRDB) 10-13. Predorsal scales 16-21. Postdorsal scales 10-13. Gill rakers on outer face of first arch 2-3+1+8-9 = 11-13. Vertebrae usually 26. Pelvic fin short, reaching half to two-thirds of distance to anus, 13-17% of SL. Body relatively deep, body depth at anal origin and at pelvic origin 20-23% of SL. Snout and head above eye dark brown in adult males. A black bar at pectoral base, entirely above pectoral rays. Body with 6-9 vertical brown bands, width about equal to eye diameter; bands more pronounced anteriorly and dorsally, often fading on caudal peduncle. A small dusky spot at base of caudal rays below midside. Second dorsal with 2 or 3 rows of small dark spots on basal half of fin, surrounding white to clear spots. Distal tip of fin dusky, sometimes whole fin dusky. Extreme tip of anal usually white.

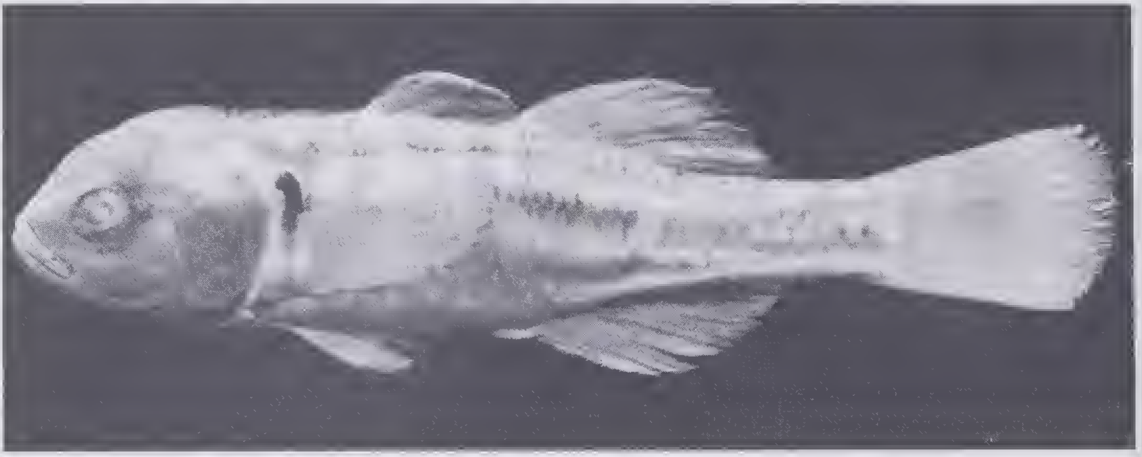

Figure 3 *Hypseleotris aurea*, male, 36 mm SL, Murchison River, Western Australia.

Sexual Dimorphism

Adult males have a prominent forehead hump extending from above the upper end of the opercular margin forward to the snout. The posterior dorsal and anal rays are not prolonged in males, nor were any other sexual differences observed.

Distribution and Habitat

Hypseleotris aurea is known only from the Murchison River, which flows into the Indian Ocean approximately 500 km north of Perth, Western Australia. It has been collected from small, quiet pools near the North-West Highway crossing at Galena (approximately 27°49'S, 114°41'E). The habitat was characterized by moderately turbid water and a boulder substratum littered with dead tree branches.

Hypseleotris regalis sp. nov.

Figure 4

Hypseleotris simplex – Allen, 1975: 95 (in part, Prince Regent Reserve).

Holotype

WAM P25028-009, male, 32 mm SL, Wyulda Creek, about 2 km above junction with Roe River (approximately 15°26'S, 125°37'E), Prince Regent Reserve, West Kimberley, Western Australia, G. Allen, 17 August 1974.

Paratypes

AM I.22744-001, 5 (26-34 mm SL), collected with holotype; WAM P25028-007, 12 (23-36 mm SL), collected with holotype; WAM P25040-004, 14 (22-37 mm SL), Youwanjela Creek (approximately 15°34'S, 125°25'E), a small tributary of the Prince Regent River, West Kimberley, Western Australia, B. Wilson, 21 August 1974.

Diagnosis

A species of *Hypseleotris* closely related to *H. aurea* from the Murchison River of Western Australia. The characters which differentiate these species are discussed in the diagnosis for *H. aurea*. It differs from *H. compressa* by the absence of preopercular pores and other features mentioned in the diagnosis for that species. Finally, it is separable from *H. kimberleyensis* and *H. ejuncida* on the basis of a combination of characters which includes a longitudinal scale count of 24-26; a moderately slender body, the depth at pelvic origin 16-20% of SL; predorsal scales extending to behind eyes; modal gill rakers on outer face of second arch 10; colour pattern consisting of about 15-20 chevron marks on side; and pelvic fin origin positioned under posterior opercular margin.

Description

No head pores. Predorsal scaled forward to above middle of eye. Cheek with 2 or 3 rows of small embedded cycloid scales. Operculum covered with medium-sized cycloid scales. Lower attachment of gill opening below posterior preopercular margin. First dorsal VI. Second dorsal usually I,9-10. Anal usually I,10. Typically an equal number of dorsal and anal rays. Pectoral usually 13-14. Segmented caudal rays 15; branched caudal rays 11, rarely 13. Longitudinal scale count 24-26. Transverse scale count (TRDB) 8-9. Predorsal scales 14-16. Postdorsal scales usually 8. Gill rakers on outer face of first arch 3-4+1+9-10 = 12-15, usually 12-14. Vertebrae 25. Pelvic fin moderately long, 18-22% of SL. Body slender, body depth at anal origin and depth at pelvic origin 16-20% of SL. Snout short, less than eye diameter. Mouth small, forming an angle of about 45° with body axis; jaws ending under posterior nostril. First dorsal origin about an eye diameter behind pelvic origin. Pelvic origin below posterior opercular margin. First dorsal fin low, with a rounded margin, height less than body depth; fourth and fifth spines longest. Second dorsal fin subequal in height to first dorsal fin, with posterior rays longest, particularly in males. Caudal short with a rounded to truncate margin. Pectoral rays, except upper 2 or 3 and lower 1 or 2, branched once. Anal rays sometimes with a second branch near tip. Pelvic fins long and pointed, reaching to anus. Caudal peduncle long, length greater than second dorsal fin base. Head dark brown, usually darker than body in males. A black bar at base of pectoral fin extending ventrally to opposite third to seventh pectoral ray. Body with 15-20 thin black chevron marks along midside. A black spot on posterior end of caudal peduncle below midside. Basal one-third of dorsal and anal fins dark brown to black (sometimes with white spots on second dorsal fin) followed distally by a thin white stripe, followed distally by a broader black stripe; extreme distal tips white.

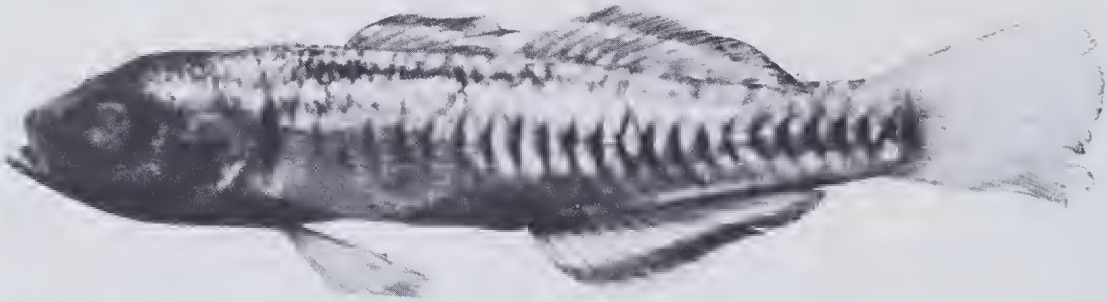

Figure 4 *Hypseleotris regalis*, male holotype, 32 mm SL, Wyulda Creek, Western Australia.

Sexual Dimorphism

Males appear to reach a larger size, although only six females were examined (23-30 mm SL) and 21 malcs (27-36 mm SL). In males the first dorsal membrane reaches almost to the base of the sccond dorsal fin, but the two fins are widely separate in females. Males have the posterior dorsal and anal rays prolonged, with the last ray longer than thc third ray. In females the last ray is about two-thirds length of the third ray. The caudal fin margin is rounded in males and truncate in femalcs. Thc latter sex is generally lightcr in colour.

Distribution and Habitat

Hypseleotris regalis is known only from the Upper Roe Rivcr and Youwangela Creek, in a remote section of the Prince Regent Rescrve. The two populations are idcntical with rcgard to coloration, although there are slight differences in fin-ray, scale, and gill raker counts. The holotype and majority of paratypes wcre collcct-ed with rotenone over rock bouldcr substratum in a quiet, clear pool approxi-mately 4 x 10 m with a maximum depth of about 2 m.

Etymology

The species is named *regalis* (Latin for 'regal' or 'royal') with refcrcnce to the name of the type locality area, Prince Regent Reserve.

Hypseleotris kimberleyensis sp. nov.

Figure 5

Holotype

WAM P25454-009, male, 34 mm SL, Barnett River near Barnett Gorge (approximately 16°32'S, 126°08'E), Central Kimberley, Western Australia, B. Hutchins and A. Chapman, 30 July 1975.

Paratypes

AM I.22742-001, 3 (31-35 mm SL), collected with holotype; WAM P25454-007, 6 (27-34 mm SL), collected with holotype; WAM P25872-006, 4 (28-34 mm SL), Manning Creek Gorge (approximately 16°38'S, 125°55'E), Central Kimberley, Western Australia, G. Allen and G. Evans, 15 September 1977.

Diagnosis

A species of *Hypseleotris* closely related to *H. ejuncida* from the Prince Regent River of Western Australia. These species differ from other Western Australian members of the genus by a combination of characters which includes the absence of preopercular pores, longitudinal scale count 28-32; body relatively slender, the depth at pelvic fin origin 14-18% of SL, and the pelvic fin origin under or behind the pectoral fin insertion. *Hypseleotris kimberleyensis* differs from *H. ejuncida* on the basis of the following combination of characters: predorsal and operculum without scales; second dorsal and caudal fins without distinct spotting or wavy bands; dark bar on pectoral fin base developed only on dorsal portion, usually above uppermost pectoral ray; body depth at anal fin origin 13-17% of SL; and vertebrae 26.

Description

No head pores, Head entirely naked. No median nape scales before first dorsal fin. Body scaled, a naked patch under first dorsal fin from upper pectoral base to second dorsal origin. Ventral surface of belly naked. Gill opening extends forward to below a point just in front of posterior preopercular margin. Pelvic origin behind pectoral insertion. First dorsal VI. Second dorsal usually I,10. Anal usually I,10. Pectoral rays 14-15. Segmented caudal rays 15; branched caudal rays 11, rarely 12. Longitudinal scale count 29-32. Transverse scale count (TRDB) usually 9. Postdorsal scales 7-9. Gill rakers on outer face of first gill arch 1-3+1+7-9 = 9-12. Vertebrae 26. Pelvic length 18-22% of SL. Body depth at anal origin 14-17% of SL. Body depth at pelvic origin 13-17% of SL. Snout short, subequal to eye. Mouth small, forming an angle of about 50° with body axis; jaws ending under posterior nostril. First dorsal origin about an eye diameter behind pelvic origin. First dorsal fin low, with rounded margin, height less than body depth; fourth and fifth spines longest. Second dorsal fin subequal in height to first dorsal fin; posterior rays sometimes prolonged ranging from two-thirds or equal to length of third ray. Caudal fin with slightly rounded to truncate margin. Pectoral rays seven to 11 branched, with one branch point each; middle rays longest. Second dorsal and anal rays branched once, except for first segmented ray, which is unbranched; other anterior rays sometimes with a second branch point near tip. Pelvic fins long and pointed, reaching about to anus. Caudal peduncle long, length greater than second dorsal base. Head dark brown, darker than tan body. Head of females lighter, often with dark brown on top of head only. A black bar at base of pectoral fin from upper margin to opposite first to fifth pectoral ray. Body with 4-7 narrow dark brown bars anteriorly from first dorsal fin to middle of second dorsal fin, more distinct anteriorly. Scales edged in dark brown, edgings darkest on midside forming a row of X-shaped marks just below midside. A small dark brown spot on posterior end of caudal peduncle just below midside. Median fins dark brown to black in males, dusky in females. Second dorsal and anal sometimes with a thin whitish longitudinal stripe just below middle of fin; distal margin usually lighter than rest of fin, but without a distinct white margin. No white spots on fins. Pectoral and pelvic fins dusky to clear. Caudal fin sometimes with two thin vertical wavy lines near base.

Figure 5 *Hypseleotris kimberleyensis*, male holotype, 34 mm SL, Barnett River, Western Australia.

Sexual Dimorphism

Adults of both sexes lack a prominent hump on the forehead. Of the five females examined the largest is 31 mm SL, and the nine males range from 30 to 30.5 mm SL. Males have the two dorsal fins separated by about 2 or 3 scale rows; in females the separation is slightly wider, about 3 or 4 scale rows. Males collected in spring (September) are characterized by prolonged posterior dorsal and anal rays, but in males collected during winter (July), these rays are not prolonged. The caudal margin is rounded in males and distinctly truncate in females. The anterior 3-4 bands on the side are distinct in males, but in females 6-7 bands are evident. In addition, males are typically darker than females.

Distribution and Habitat

This species is known only from the Barnett River system in the vicinity of Mount Barnett Station (16°40'S, 125°57'E) which is situated on the Gibb River (Derby to Wyndham) Road, approximately 260 km north-east of Derby, Western Australia. The type specimens were collected from clear, rocky pools with moderate flow.

Etymology

The species is named *kimberleyensis* with reference to the type locality, the Kimberley district of Western Australia.

Hypseleotris ejuncida sp. nov.

Figure 6

Holotype

WAM P25032-009, male, 46 mm SL, Gundarara Creek, about 2 km above junction with Prince Regent River (approximately 15°49'S, 125°37'E), Prince Regent Reserve, West Kimberley, Western Australia, G. Allen, 21 August 1974.

Paratypes (all collected with holotype)

AM I,22745-001, 4 (34-37 mm SL); WAM P25032-002, 8 (23-43 mm SL).

Diagnosis

A species of *Hypseleotris* closely related to *H. kimberleyensis*. The reader is referred to the diagnosis for the latter species for a discussion of the differences between these two species and other Western Australian members of the genus. *Hypseleotris ejuncida* differs from *H. kimberleyensis* on the basis of the following combination of characters: predorsal and operculum usually extensively scaled; second dorsal fin with white spots and wavy bands; caudal fin with dark spots forming 4-6 wavy bands; dark bar covering entire pectoral fin base; body depth at anal fin origin 17-18% of SL; and vertebrae 25.

Description

No head pores. Top of head scaled forward to just behind eyes, midline of nape often scaled at least partially. Operculum with large cycloid scales. Cheek naked. Belly covered with cycloid scales. Body scales largely ctenoid, cycloid in patch under first dorsal fin and on head. Gill opening extends forward to below posterior preopercular margin. Pelvic origin just below or behind dorsal pectoral insertion. First dorsal VI. Second dorsal I,9-10. Anal I,9-11, usually I,10. Pectoral rays 14-15. Segmented caudal rays 15; branched caudal rays 11-13, usually 11. Longitudinal scale count 28-31. Transverse scale count (TRDB) usually 8 or 9. Predorsal midline scales 2-20, scales at side of midline 14-20. Postdorsal scales usually 8. Gill rakers on outer face of first gill arch 2-3+1+8-9 = 11-13. Vertebrae 25. Pelvic length 17-22% of SL, usually 19-21%. Body depth at anal origin 17-18% of SL. Body depth at pelvic origin 16-18% of SL. Snout short, about equal to eye diameter. Mouth small, forming an angle of about 45° with body axis, jaws end under a point just in front of posterior nostril. First dorsal fin origin about an eye diameter behind pelvic origin. First dorsal fin low, height less than body depth; fourth and fifth spines longest. Second dorsal slightly higher than first; posterior rays prolonged in males, longer than third ray; short in females, about two-thirds length of third ray. Caudal fin with rounded to almost truncate margin. Pectoral fin with 8-13 branched rays, usually 11-13; middle rays often with 2 or 3 branch points. Second dorsal and anal rays (except for first segmented ray) with one branch point each in small specimens; often with a second branch point near tip in larger specimens. Pelvic fins long and with pointed tip reaching almost to anus. Caudal peduncle long, length greater than second dorsal fin base. Head dark brown in males, lighter in females, darker than tan body. Dark brown bar at base of pectoral fin darker dorsally, covering whole pectoral base. Body with 3 or 4 dark brown vertical bars between pectoral base and second dorsal fin origin. Body scales edged with dark brown, forming a diamond-shaped pattern on body. A longitudinal irregular dark brown stripe along side just below midside, formed from intense dark edges to scales; stripe often obscure in large dark males. A prominent dark brown spot at end of caudal peduncle, extending ventrally from midside. Dorsal and anal fins dusky to black. First dorsal fin with a pale whitish median longitudinal stripe. Base of second dorsal fin with 1 or 2 rows of white spots, prominent in males, sometimes obscure in females; membranes between rays with dark pigment forming almost vertical thin stripes, which cross fin rays. Second dorsal and anal fins with a pale whitish margin. Caudal fin with 4 to 6 thin dark brown wavy vertical lines, more prominent in females. Pectoral and pelvic fins clear to dusky.

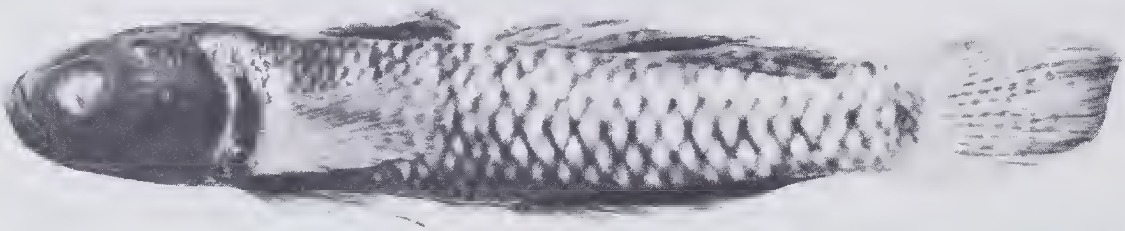

Figure 6 *Hypseleotris ejuncida*, male holotype, 46 mm SL, Gundarara Creek, Western Australia.

Sexual Dimorphism

Adults of both sexes lack a hump on the forehead. The six females examined ranged in size from 23-36 mm SL and the seven males 30-47 mm SL. The posterior membrane of the first dorsal fin of males reaches almost to the second dorsal fin origin, but in females the membrane is separated from the second dorsal fin by two scale rows. In addition, the posterior dorsal and anal rays are prolonged and the caudal fin is more rounded in males. Females are generally lighter coloured, with the anterior body bands more distinct than in males.

Distribution and Habitat

This species is known only from the Prince Regent River drainage, situated approximately 260 km north of Derby, Western Australia. The type specimens were collected with rotenone from a clear, quiet pool over sandstone bottom at depths to about 2 m.

Etymology

The species is named *ejuncida* (Latin for 'slender') with reference to the slender body shape.

Table 1 Vertebral counts of species of *Hypseleotris* from Western Australia. An asterisk indicates count of holotype.

Species	Population	Vertebral formula							Total vertebrae			
		13+12	13+13	13+14	14+10	14+11	14+12	15+10	24	25	26	27
H. compressa	Murchison R.	—	—	—	—	2	—	—	—	2	—	—
	Lawley R.	—	—	—	—	6	—	1	—	7	—	—
	Prince Regent R.	15	—	—	1	15	3	—	1	30	3	—
H. aurea	Murchison R.	—	12	2	—	—	—	—	—	—	12	2
H. regalis	Youwanjela Ck	14	—	—	—	—	—	—	—	14	—	—
	Upper Roe R.	16*	—	—	—	—	—	—	—	16*	—	—
H. kimberleyensis	Barnett R.	—	10*	—	—	—	—	—	—	—	10*	—
	Manning Ck	—	4	—	—	—	—	—	—	—	4	—
H. ejuncida	Prince Regent R.	7	—	—	—	6	—	—	—	13*	—	—

Table 2 Dorsal, anal and pectoral ray counts of species of *Hypseleotris* from Western Australia. Spine in fins included in count. An asterisk indicates count of holotype.

Species	Population	Second dorsal rays				Anal rays				Dorsal-Anal				Pectoral rays				
		9	10	11	12	10	11	12	13	+1	0	–1	–2	13	14	15	16	17
H. compressa	Murchison R.	—	2	—	—	—	1	1	—	—	—	1	1	—	1	1	—	—
	Lawley R.	—	5	2	—	—	4	3	—	—	—	6	1	—	2	3	2	—
	Prince Regent R.	—	17	5	—	1	11	10	—	1	1	14	6	—	4	16	1	1
H. aurea	Murchison R.	—	1	8*	—	—	1	7	1*	—	—	8	1*	—	1*	6*	3	—
H. regalis	Youwanjela Ck	1	2	3	—	2	4	—	—	—	4	2	—	4	2	—	—	—
	Upper Roe R.	—	2	15*	—	2	10*	3	—	1	11*	5	—	3	10*	2	—	—
H. kimberleyensis	Barnett R.	—	—	9*	1	—	6	4*	—	—	7	3*	—	—	8*	1	—	—
	Manning Ck	—	1	3	—	1	3	—	—	1	2	1	—	—	—	4	—	—
H. ejuncida	Prince Regent R.	—	3	10*	—	1	10	2*	—	1	7	5*	—	—	6	6*	—	—

Table 3 Longitudinal scale count in *Hypseleotris* from Western Australia. An asterisk indicates count of holotype.

Species	Population	Scale Count 24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
H. compressa	Murchison R.						2														
	Lawley R.				1	4	2														
	Prince Regent R.		1	3	6	4	1														
H. aurea	Murchison R.											1			1	1	3	2*			1
H. regalis	Youwanjela Ck		3	3																	
	Upper Roe R.	5	5	6*																	
H. kimberleyensis	Barnett R.						6	1	2	1*											
	Manning Ck						2		1	1											
H. ejuncida	Prince Regent R.					1	3	4*	3												

Table 4 Predorsal scale counts in species of *Hypseleotris* from Western Australia. Counts are along midline, except where noted. An asterisk indicates count of holotype.

Species	Population	Scale Count 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
H. compressa	Murchison R.																		1	1			
	Lawley R.																	3	3				
	Prince Regent R.															3	5	7	1				
H. aurea	Murchison R.																	1*	1	1	3	2	1
H. regalis	Youwanjela Ck															3	2	1					
	Upper Roe R.															7	7*	1					
H. kimberleyensis	Barnett R.	10*																					
	Manning Ck	4																					
H. ejuncida	(Midline)			1	1				1			1		2		1	2*				1	1	
	(Sides of nape)															2	2	1	1	2*	1	1	1

Table 5 Postdorsal and transverse scale counts in species of *Hypseleotris* from Western Australia. The transverse count is from the second dorsal origin backward and downward to the anal base. An asterisk indicates count of holotype.

Species	Population	Transverse Scale Count						Postdorsal Scale Count						
		8	9	10	11	12	13	7	8	9	10	11	12	13
H. compressa	Murchison R.			2						1				
	Lawley R.		1	4					3	3				
	Prince Regent R.		7	8					11	16				
H. aurea	Murchison R.			2	4	2	1*				2	1	3*	3
H. regalis	Youwanjela Ck	1	5						6					
	Upper Roe R.	9	5					2	13*					
H. kimberleyensis	Barnett R.	1	8	1				2	6*	2				
	Manning Ck		1						1					
H. ejuncida		6	4*	1					11*	1				

Table 6 Gill rakers on outer face of lower arch in Western Australian species of *Hypseleotris*. The count of the lower rakers includes the raker at the angle of the arch. An asterisk indicates count of holotype.

Species	Population	Lower Gill Rakers						Total Rakers							
		7	8	9	10	11	12	9	10	11	12	13	14	15	16
H. compressa	Murchison R.				1	1							2		
	Lawley R.				1	5	1					1	5	1	
	Prince Regent R.				4	7	5				1	3	6	5	1
H. aurea	Murchison R.			3	3	1				3	4	1			
H. regalis	Youwanjela Ck				4	2					4	1	1		
	Upper Roe R.				11*	6						7*	9	1	
H. kimberleyensis	Barnett R.		2	6*	2				5	3	2*				
	Manning Ck	1	3					3	1						
H. ejuncida	Prince Regent R.			3*	9					2*	7	3			

Table 7 Body depth at anal origin and pelvic origin, expressed as percentages of standard length, of Western Australian species of *Hypseleotris*.

Species	Body Depth at Pelvic Origin											Body Depth at Anal Origin											
	14	15	16	17	18	19	20	21	22	23	24	13	14	15	16	17	18	19	20	21	22	23	24
H. compressa				1	1	3	3	3	4	1	2							4	2	2	5	3	3
H. aurea							1	1	3	3									1	2	2	3	
H. regalis			2	5	4	7	2								3	3	10	3	1				
H. kimberleyensis	3	3	5	1								2	1	5	2	2							
H. ejuncida			1	4	7											2	10						

Table 8 Pelvic lengths, as percentages of standard length of species of *Hypseleotris* from Western Australia.

Species	Pelvic Length										
	13	14	15	16	17	18	19	20	21	22	23
H. compressa											
Lawley and Murchison R.								2	5	1	1
Prince Regent R.						1		2	1	3	4
H. aurea	1	2	3	1	1						
H. regalis						2		7	4	1	
H. kimberleyensis						2	2			2	
H. ejuncida					1		1	4	4	1	

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The Analysis of Habitat Utilization Using Broad-scale Survey Data

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Abstract

Problems associated with the use of extensive survey data to broadly define the habitat preferences of uncommon species are discussed. A robust habitat utilization index (HUI) is derived which circumvents problems associated with both differential trapping effort and distribution of individuals between habitats.

Introduction

Effective reservations of land are needed often to encourage the survival of rare or endangered species. Decisions on land reservation may be required urgently before adequate data are available on the specific habitat preferences of the species in question.

Here I discuss some of the problems involved in the analysis of broad-scale survey data to derive tentative answers to questions for which the survey was not designed. Specifically, how to derive, from broad-scale biological surveys, a measure of habitat preference for a species which is uncommon.

The Problem

By their nature regional survey data are broadly based and do not focus on single species problems. In consequence they have little resolution of the habitat or population characteristics of a single species, especially if that species is rare. They are irregular in timing with respect to season, and data from different years and areas may need to be pooled to boost the sample size of uncommon species. In addition the only quantitative data available are expressed as catch per unit effort.

Raw data from surveys can be pooled and used simply only if trapping effort is constant between habitats, the populations are stable, their proportional distribution between habitats is constant and there is no seasonal variation in trap proneness between habitats. No real surveys or populations obey these constraints.

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The Index

To overcome the variation in trapping effort, the catch for a species in each habitat is scaled as catch per unit effort.

$$PH_{ij} = IH_{ij}/EH_{ij},$$

where IH_{ij} is the number of individuals of a species trapped in habitat i of survey area j and EH_{ij} is the trapping effort (e.g. trap nights) in habitat i of survey area j.

The survey data to be pooled may come from different areas and may be sampled in different seasons or years. In addition, different numbers and types of habitat may be included in the various survey areas. Hence we derive another scaling factor, namely the catch per unit effort in all i habitats of survey area j.

$$PE_j = IE_j/EE_j,$$

where IE_j is the number of individuals of the species trapped in all i habitats of survey area j and EE_j is the trapping effort in all habitats of survey area j.

The relative importance of habitat i in survey area j is then PH_{ij}/PE_j which is summed for all survey areas and corrected for the number of survey areas considered giving the dimensionless Habitat Utilization Index

$$HUI_i = \left[\sum_{j=1}^{n} PH_{ij} \cdot \frac{1}{PE_j} \right] \frac{.1}{n}$$

The absolute importance of habitat i in all survey areas is simply

$$\left[\sum_{j=1}^{n} PH_{ij} \right] \frac{.1}{n}$$

I want to examine the robustness of the index to changes in trapping effort between reserves (survey areas) and habitats, and to changes in the distribution of individuals between habitats. Figure 1 and Table 1 include analysis of Kitchener's (1981) index AI, to be discussed later.

Consider a matrix with i rows and j columns (Table 1). Each cell contains two values: the number of individuals of the species trapped in habitat i of reserve j and the trapping effort in habitat i of reserve j. From this matrix the index HUI_i can be calculated for each habitat i. Establish a series of such matrices in which the proportional trap success stays constant between reserves but the trapping effort is increased by a constant factor α in successive reserves. In addition, the proportional distribution of individuals trapped per unit effort (β) varies between habitats. Figure 1 shows that the index HUI does not vary with changes in α and β when the real distribution of individuals is held constant.

Table 1 Matrix of 3 habitats in each of 3 reserves to illustrate discussion in the text. Each cell shows numbers trapped (e.g. $X_{1,1} = 5$) and the total trapping effort (e.g. $X_{1,1} = 100$) for each habitat (*i*) in each reserve (*j*). The calculated values of AI and HUI are given for each habitat to the right of the matrix.

	i \ *j*	Reserve† 1	2	3	HUI	AI
habitat†	1	5/100	17.5/350	61.25/1225	2.33	5.97
	2	5/200	17.5/700	61.25/2450	1.17	2.99
	3	5/400	17.5/1400	61.25/4900	0.58	1.49
		15/500	52.5/2450	183.75/8575		

† $\alpha = 3.5$ and for habitats 1 to 3, β is successively 0.05, 0.025 and 0.0125.

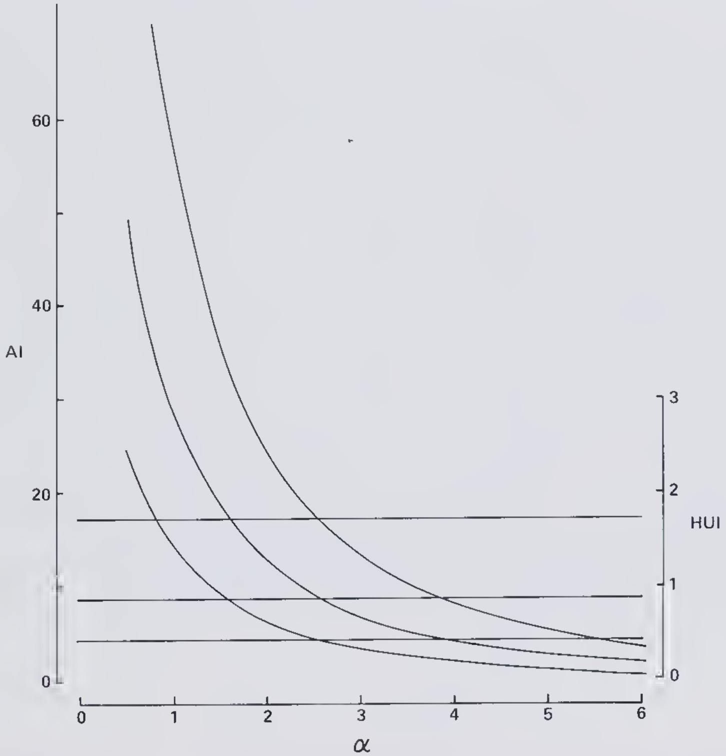

Figure 1 Graph showing the manner in which the indices A1 and HU1 vary with changes in trapping effort between habitats and the proportion of individuals caught per unit effort. The three straight lines represent HUI (right ordinate) as α (see text) varies from 0 to 6 for, from top to bottom, β values of 0.05, 0.025 and 0.0125. The three curves show the variation in AI (left ordinate) as α and β vary over the same range and sequence as for HUI.

Discussion

Kitchener (1981) analysed the habitat requirements for *Phascogale calura* (Gould), a species considered rare and endangered, using data available for a number of extensive surveys conducted over many years on nature reserves in the Wheat Belt of Western Australia. Such surveys usually provide the only data available on habitat preferences of widespread but uncommon species on which to base decisions about conservation. Kitchener (1981) derived an index to permit the pooling of survey data to delineate the habitat preference of *P. calura.* This index has been used subsequently to examine the habitat preferences of *Ningaui timealeyi* (Archer) (Dunlop and Sawle 1982).

The general case of Kitchener's (1981) abundance index is

$$AI = \sum_{i=1}^{n} \frac{P_i}{T_i},$$

where P is the proportion caught in a given habitat of all individuals in reserve (survey area) *i,* T is the total trapping effort (e.g. trap nights) in a given habitat in all reserves and n is the number of survey areas (reserves). The index is scaled in some way (Kitchener used AI x 10 while Dunlop and Sawle used AI x 10^2).

The index AI is shown, alongside HUI, in Table 1 and Figure 1 for varying values of α and β. An ideal index should show no change in value for a given β as the value of α is changed. While HUI shows no change, the index AI is extremely sensitive to changes in α (Figure 1) which are much smaller than the variation in α considered by Kitchener (1981) and Dunlop and Sawle (1982).

HUI permits one to pool survey data, where the trapping effort varies between habitats and reserves, and obtain an unbiased estimator of the habitat preference within the limitations of the data base. Interpretation of the index will depend on the spatial and temporal resolution of the survey data and the degree of synchrony of different surveys. Care in planning of surveys will eleviate some of the difficulties of interpretation. As uncommon species are rarely amenable to intensive work, these surveys may provide the only information on which to base preliminary decisions on conservation and in planning species-specific work.

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A Revision of the Bee Genus *Ctenocolletes* (Hymenoptera: Stenotritidae)

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Abstract

The endemic Australian genus *Ctenocolletes* Cockerell, 1929, is revised with recognition of eight species including four new ones: *C. centralis, C. fulvescens, C. rufescens* and *C. tricolor.* The male of *C. albomarginatus* and female of *C. ordensis* are described for the first time.

The following are new synonyms: *C. notabilis* Michener, 1965 = *C. nicholsoni* (Cockerell, 1929); *Melitribus glauerti* Rayment, 1930, and *Stenotritus speciosus* Rayment, 1935 = *C. smaragdinus* (Smith, 1868).

Ctenocolletes murrayensis Rayment, 1935, is removed to the genus *Stenotritus.* With its removal, *Ctenocolletes* as presently known becomes essentially western Australian in distribution.

Males of some species exhibit allometric variation with larger individuals showing greater convergence of the compound eyes on the vertex.

The species are described, keyed and figured and their distributions are plotted.

Introduction

Prior to about 1970, few individuals of the endemic Australian genera *Ctenocolletes* Cockerell and *Stenotritus* Smith were to be found in museum collections and revisionary studies at that time would have been premature. In more recent years, more material has come to hand especially from fieldwork in Western Australia and it has become apparent that there are several undescribed species.

These two sister genera have attracted interest because of their uncertain affinities. Until comparatively recently they were regarded tentatively as Colletidae, forming their own subfamily Stenotritinae (Michener 1944, 1965), but McGinley (1980) accorded them family status following studies of glossal morphology.

Recent field studies have also yielded the first observations of the bionomics of *Ctenocolletes* and the present revision provides a sound nomenclatural basis for publication of these observations.

Methods and Terminology

A total of 266 specimens was examined from collections for which the following abbreviations are used: AM, Australian Museum, Sydney; ANIC, Australian

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National Inseet Colleetion, CSIRO, Canberra; WADA, Western Australian Department of Agriculture, Perth; WAM, Western Australian Museum, Perth.

The morphologieal terminology employed here is largely that of Miehener (1965) with a few minor departures related to the method of obtaining eertain relative dimensions (*vide*).

Relative Dimensions

All measurements were made using a Zeiss Citoval stereomieroseope with zoom objeetive and eyepieee gratieule with 100 scale divisions. By setting the objeetive power to give a head width reading of 100 seale divisions for eaeh spceimen, all subsequent measurements obtained are equivalent to pcreentages of head width and are directly eomparable between speeimens or between species.

The abundant faeial hair of most species makes it very diffieult to obtain measurements of eertain eephalic features and thus they have been omitted from the species descriptions. The methods of obtaining most eephalic measurements used in this paper are illustrated in Figures 1 and 2 and the abbreviations for all measurements are as follows: C2L, length of spur (ealear) of mid tibia; F1L, length of attenuated first segment of flagellum; FRL, length of remainder of flagellum; HL, length of head; HW, width of head; LID, lower interocular distanee; MBW, basal width of mandible (viewed ventrally); MFW, minimum width of face (= UID in Figure 1); ML, length of mandible; MOD, diameter of median oeellus; OOD, oeelloeular distance; SL, length of scape; UID, upper intcroeular distance.

The length of the first segment of the flagellum is measured on the anterior surface (Figure 2) beeause the distal end is oblique viewed dorsally.

Propodeal Enclosure

The relative size of the enelosure varies markedly between speeies and is compared here to the size of the median oeellus. The enelosure's eurved margins and tapering extremities preelude easy measurement by other means.

Terminalia

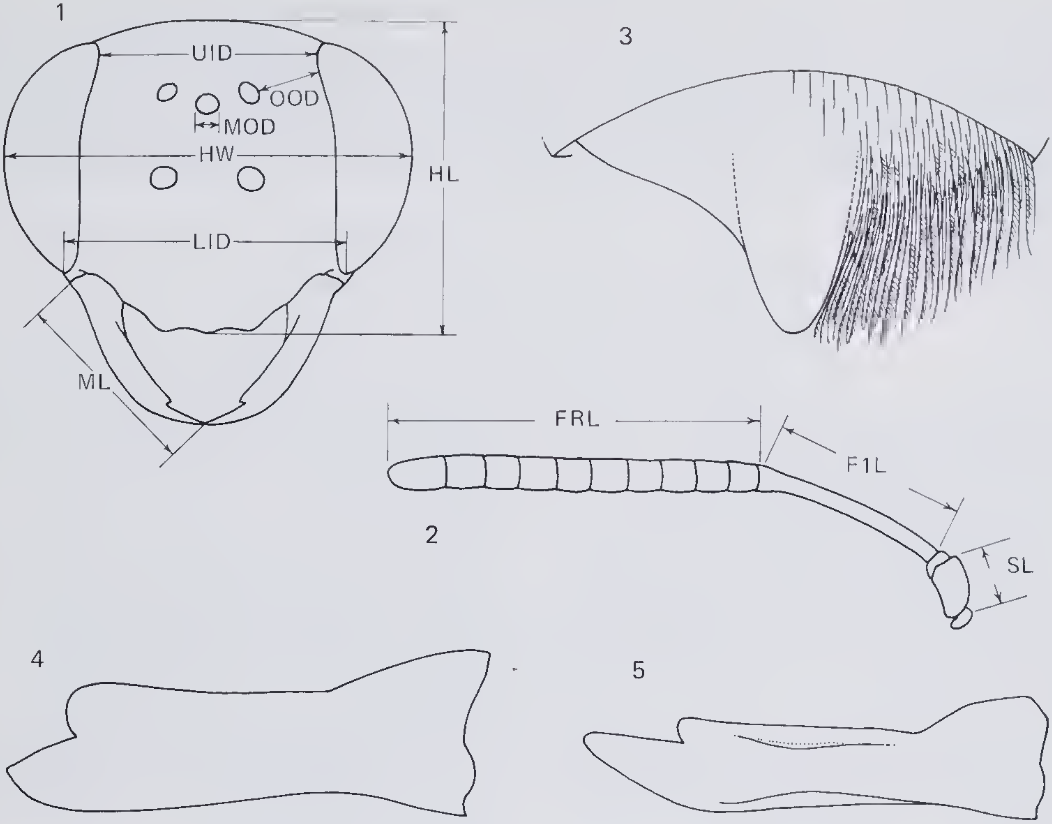
The genital eapsule, seventh and eighth metasomal sterna were eleared and immersed in glyeerine prior to being drawn.

Tibial Spurs

Counts of spur teeth inelude only the eoarse teeth and exelude the additional fine teeth that frequently oeeur proximally. Counts were made on both sides of eaeh bee so that two numbers were obtained from eaeh.

Vertex

This term is used as is customary for Hymenoptera to mean the summit of the head between the compound eyes even though the oeelli have shifted forward and downward on to the frons.



Figures 1-5 *Ctenocolletes*: (1) head of female and (2) antenna of male of *C. nicholsoni* (anterior views) showing various measurements; (3) apical (7th) metasomal tergum of *C. smaragdinus* male (dorsal view; vestiture omitted from left side); (4) left mandible of *C. fulvescens* female (ventral view); (5) same of *C. nicholsoni* female.

Systematics

Family Stenotritidae

Genus *Ctenocolletes* Cockerell

Ctenocolletes Cockerell, 1929: 358. Type-species *Stenotritus nicholsoni* Cockerell, 1929 (monobasic).

Originally established as a subgenus of *Stenotritus* and based solely on female characters, *Ctenocolletes* was first accorded generic status by Rayment (1935: 683; earlier in this book he treated it as a subgenus). Michener (1965) gave it generic status and differentiated it from *Stenotritus* on the basis of both male and female characters. While some of these have proved reliable, others have not. For example, the number of teeth on the inner hind tibial spurs of females and the size of the propodeal triangle are too varaible and sometimes do not differ from those of some *Stenotritus*. The character states listed in Table 1 distinguish the genera.

Table 1 Character states diagnostic for *Ctenocolletes* and *Stenotritus*.

Ctenocolletes	*Stenotritus*
1 Apical metasomal tergum of male with pygidial plate defined laterally and apically by a carina (Figure 3).	1 Apical metasomal tergum of male with only a bare area not defined by a carina.
2 Hidden 7th metasomal sternum of male a transverse band (Figures 42, 45, 48), not divided into slender anterior apodemes and setose posterior lobes.	2 Hidden 7th metasomal sternum of male divided into a pair of slender anterior apodemes and a pair of setose posterior lobes.
3 Labrum of female with an undivided basal elevation (Figures 9-15).	3 Labrum of female with basal elevation strongly bilobed or grooved medially (Figure 8).
4 Inner hind tibial spur of female with very long coarse teeth and shaft thickest near middle (Figures 22, 23).	4 Inner hind tibial spur of female with short to moderately long teeth and shaft thickest at base or uniformly thick basally, tapering distally (Figure 21).
5 Apical spine of strigilis of female with long coarse teeth (Figure 17).	5 Apical spine of strigilis of female with short fine teeth (Figure 16).

Species

Michener (1965: 83) listed eight species names under *Ctenocolletes*. Of these, three are here synonymized and one, *C. murrayensis* Rayment, 1935, is removed to the genus *Stenotritus*. The type of the latter in ANIC is a female in poor condition but clearly exhibits the character states for *Stenotritus* given under 3-5 in Table 1. Description of four new species brings the total number of species of *Ctenocolletes* to eight.

Distribution

Western Australia, extreme west of South Australia and probably also western Northern Territory. In Western Australia the genus is mainly confined to the southern portion of the State although *centralis* extends at least as far north as 23°S and *ordensis* is recorded (though dubiously) from the far north. Figures 6 and 7.

Key to the Species of *Ctenocolletes*

1 Head, body and appendages largely bright metallic green .... *C. smaragdinus*
Head, body and appendages non-metallic, largely black or brown 2

2 Males (antennae 13-segmented) 3
Females (antennae 12-segmented) 8

3 Fore tarsal claws unequal, inner one modified (Figures 27-30); pubescence of mesosoma and metasoma black and white, not buff to rufous 4
Fore tarsal claws equal and alike; pubescence of mesosoma and metasoma chiefly buff to rufous, sometimes partly black and/or white 5

4 Inner fore tarsal claw narrowest at mid section viewed posteriorly (Figure 27); apical (eighth) metasomal sternum not concave near apex (Figure 41); facial pubescence off-white to pale buff .... *C. albomarginatus*
Inner fore tarsal claw not narrowest at mid section (Figure 29); apical (eighth) metasomal sternum concave near apex (Figure 44); facial pubescence golden .... *C. tricolor*

5 Fore basitarsi arcuate (Figures 32, 34); fore trochanters with prominent shiny projections ventrally (Figures 35, 36).......... 6
Fore basitarsi straight; fore trochanters without ventral projections 7

6 Fore trochanters with ventral projections broad basally (Figure 36); hind trochanters without ventroapical projections; mid tibial spur and two hind tibial spurs present .... *C. nicholsoni*
Fore trochanters with ventral projections constricted basally (Figure 35); hind trochanters each with a slender ventroapical spine (Figure 39); mid tibial spur absent; only one hind tibial spur .... *C. centralis*

7 Compound eyes converging slightly to strongly above (Figures 53, 54); pubescence of metasomal terga forming distinct bands (Figure 52) .... *C. rufescens*

Compound eyes not at all converging above; pubescence of metasomal terga not banded, rufous on 1 and 2, black on 3-7 (Figure 51) . . . . *C. ordensis*

8 Pubescence of metasomal terga 3-6 entirely black . . . . *C. ordensis*

Pubescence of metasomal terga 3-6 not entirely black 9

9 Pubescence of metasomal terga 5 and 6 rufous, contrasting sharply with pure white apical bands on preceding terga 10

Pubescence of metasomal terga 5 and 6 golden to rufous but not contrasting with that of previous segments 11

10 Facial pubescence whitish; labral elevation black; metasomal terga 1-4 with white apical hair bands . . . . *C. albomarginatus*

Facial pubescence rufous; labral elevation orange-brown; metasomal terga 1-3 (but not 4) with white apical hair bands . . . . *C. tricolor*

11 Mid tibial spur relatively slender with 18-22 short teeth (Figure 19); metasomal terga 2-4 with uniform adpressed golden setae, not conspicuously banded (Figure 49) . . . . *C. fulvescens*

Mid tibial spur relatively broad with less than 18 teeth (Figure 20); metasomal terga 2-4 with mainly erect pubescence forming distinct bands (Figures 50, 52) 12

12 Apical plate of hind femur almost entirely covered by dark brown hair (Figure 24); attenuated first segment of flagellum only as long as next 4.5 segments together . . . . *C. rufescens*

Apical plate of hind femur only about half-covered by buff or golden setae (Figure 25); attenuated first segment of flagellum at least as long as next 5 segments together 13

13 Ventral margin of clypeus with median prominence (Figure 11); pubescence of scutum and metasomal terga 2-4 usually with patches of blackish setae amongst buff areas (Figure 50) . . . . *C. nicholsoni*

Ventral margin of clypeus evenly convex (Figure 10); pubescence of scutum and metasomal terga 2-4 uniformly buff without patches of black setae . . . . *C. centralis*

Figure 6 Map of south-western Australia showing collection localities of three species of *Ctenocolletes* (fine lines represent major roads; composite symbols represent coincident records for two species).

Ctenocolletes albomarginatus Michener, 1965
Figures 6, 26-28, 40-42

Ctenocolletes albomarginatus Michener, 1965: 266, pl. 5 (1, 2) (female; male only figured).

Holotype

♀, '6 miles N of Watheroo [30° 18'S, 116°03'E], W.A., 11.9.1952, McIntosh & Calaby', in ANIC.

Paratypes

Michener designated three female paratypes. Two that I have examined (from Moorine Rock and Merredin) are referable to the new species *C. tricolor*.

Diagnosis

Agrees with *tricolor* and differs from all other species in the following features: fore tarsal claws of male unequal and dissimilar (inner claw modified — Figures 26-28); metasomal integument largely black with white pubescence forming narrow apical bands on terga 1-4 and, in females, contrasting sharply with rufous pubescence of terga 5 and 6.

Distinguishable from *tricolor* as follows: male with inner fore tarsal claw more strongly modified, constricted at midsection viewed posteriorly (not constricted in *tricolor*; cf. Figures 27, 28 with 29, 30), and apical (eighth) metasomal sternum not concave near apex (concave in *tricolor*); female with glossy black labral elevation (matt orange in *tricolor*); both sexes with off-white to buff facial pubescence (golden in *tricolor*) and a narrow white hair band across metasomal tergum 4 (absent from *tricolor*); size smaller.

Description

Male

This sex has not previously been described.

Body length 14-16 mm; head width 4.2-4.9 mm (n 8).

Relative dimensions: HW 100; HL 78-83; UID 32-48; LID 60; MOD 8; OOD 7-11; SL 12-14; F1L 22-23; FRL 77-82; ML 42.

Inner orbits approximately parallel in smaller specimens to slightly converging above in larger ones; vertex varies correspondingly from gently convex and higher than tops of eyes to level and slightly lower than tops of eyes; attenuated first segment of flagellum about as long as next 3.2 segments together; labrum rather semicircular, about two-thirds as long as wide, its basal elevation triangular and defined only by a line of setae; first recurrent vein distal to first intercubitus by about one-third posterior length of second cubital cell; propodeal enclosure small, barely large enough to accommodate an ocellus; trochanters lacking projections; fore basitarsus unmodified, straight and about 70% as long as tibia; fore tarsal claws unequal, the inner much longer than the outer and strongly modified (Figures 26-28); hind tibia straight and of elliptical cross-section; hind basitarsus slender with very slightly concave ventral margin; hind distitarsus (excluding claws) about 75-80% as long as distance from its insertion to base of segment 2; base of seventh metasomal tergum not usually exposed; apical (eighth) sternum without a strong subapical concavity (Figure 41).

Integument predominantly black with the following orange-brown: mandibles distally, labrum (sometimes), tibiae ventrally (to variable extent) and pygidial plate. Tarsi dark brown.

Facial hair including narrow fringe below labral elevation buff; that of anterior margin of scutum white to faintly buff; white hair on head posteriorly, scutum laterally and posteriorly, metanotum, propodeum, thoracic pleura and sterna (except for darker patches on mesopleura and mesosternum), legs proximally to apices of femora and ventrally on mid and hind tibiae, metasomal sterna 1-4, tergum 1 and base of 2; apical margins of metasomal terga 2-5 with narrow bands of short white tomentum (weak or incomplete medially); black to dusky grey or brown hair on vertex, scutum except margins, mesonotum from axilla to axilla, tegulae, mesopleura (extent variable), mesosternum and terga 2-6.

Terminalia: see Figures 40-42.

Female

Body length 18.0-18.7 mm; head width 5.1-5.7 mm (n 12).

Relative dimensions: HW 100; HL 74-77; UID 51-55 (37 in one); LID 68-70; MOD 7; OOD 15-17 (12 in one); SL 13; F1L 21-22; FRL 54-57; ML 45-52; MBW 14; C2L 24-26.

Form, coloration and pubescence much as described for *tricolor* female except as noted in the diagnosis above and with the following additional differences: mid tibial spurs relatively slender with 16-24 coarse teeth (n 22) most of which are shorter than the shaft is thick; inner hind tibial spurs with 4-10 coarse teeth (n 18); second metasomal tergum with white hair confined to margins, greater part with short black setae; lateral portions of metasomal terga 3 and 4 rather bulbous, translucent dark brown and frequently concealing mites underneath.

Variation: specimens from eastern portion of range (Sandstone, Laverton) have less or no sooty pubescence on scutum and scutellum.

Distribution

Southern Western Australia (Figure 6).

Remarks

Although Michener (1965) figured a male, he made no reference to this sex in his description. The sexes are associated here on the basis of their morphological similarities.

Material Examined

The holotype and the following.

Western Australia

12.5 km ENE of Anketell HS (28°02'S, 118°51'E), 6-7 Sept. 1981, T.F. Houston, on flowers of *Baeckea stowardii*, 1 ♀, WAM; 2.5 km NE of Comet Vale (29°57'S, 121°07'E), 9 Sept. 1982, B. Hanich and T.F. Houston, 1 ♂, WAM; Dalwallinu, 11 Oct. 1975, R.P. McMillan, 1 ♀, WAM; 13 miles N of Geraldton, 19 Aug. 1971, T.F. Houston, on flowers of *Scholtzia spathulata*, 2 ♂, WAM; Goongarrie (29°55'S, 121°08'E), Oct. 1980, W.F. Humphreys *et al.*, ex pit fall trap, 1 ♂, WAM; 37 km NE of Laverton, 28°21'S, 122°37'E, 10-12 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 2 ♀, WAM; Merredin, A. Douglas, 2 ♀, WAM; Morawa, 3 Sept. 1978, A.M. and M.J. Douglas, on flowers of *Hakea coriacea*, 1 ♂, WAM; Mullewa, 1 ♂ (19 Aug. 1940, Mules), 2 ♀ (Sept.), WADA; 30 km W of Sandstone (27°59'S, 119°18'E), 7 Sept. 1981, T.F. Houston, 1 ♂ (on flowers of *Eucalyptus oldfieldii*), 1 ♀ (entering burrow in road drain soil), WAM; Watheroo, 1 Sept. 1954, C.F.H. Jenkins, 1 ♀, WADA; Yelbeni, Sept., B. O'Connor, 2 ♂, 1 ♀, WADA; 40 km N of Yuna, 5 Sept. 1981, G.A. Holloway, 1 ♂, AM.

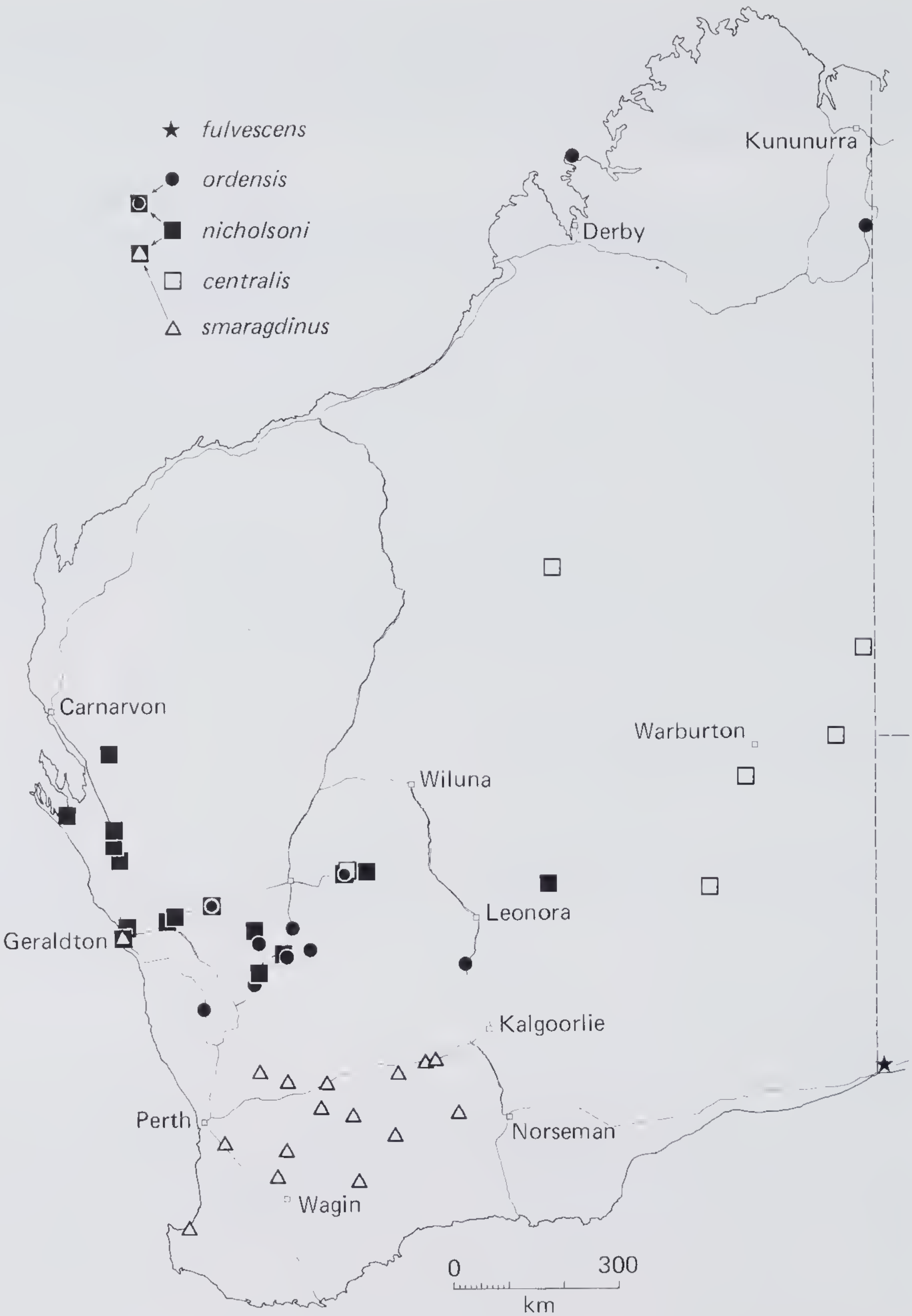
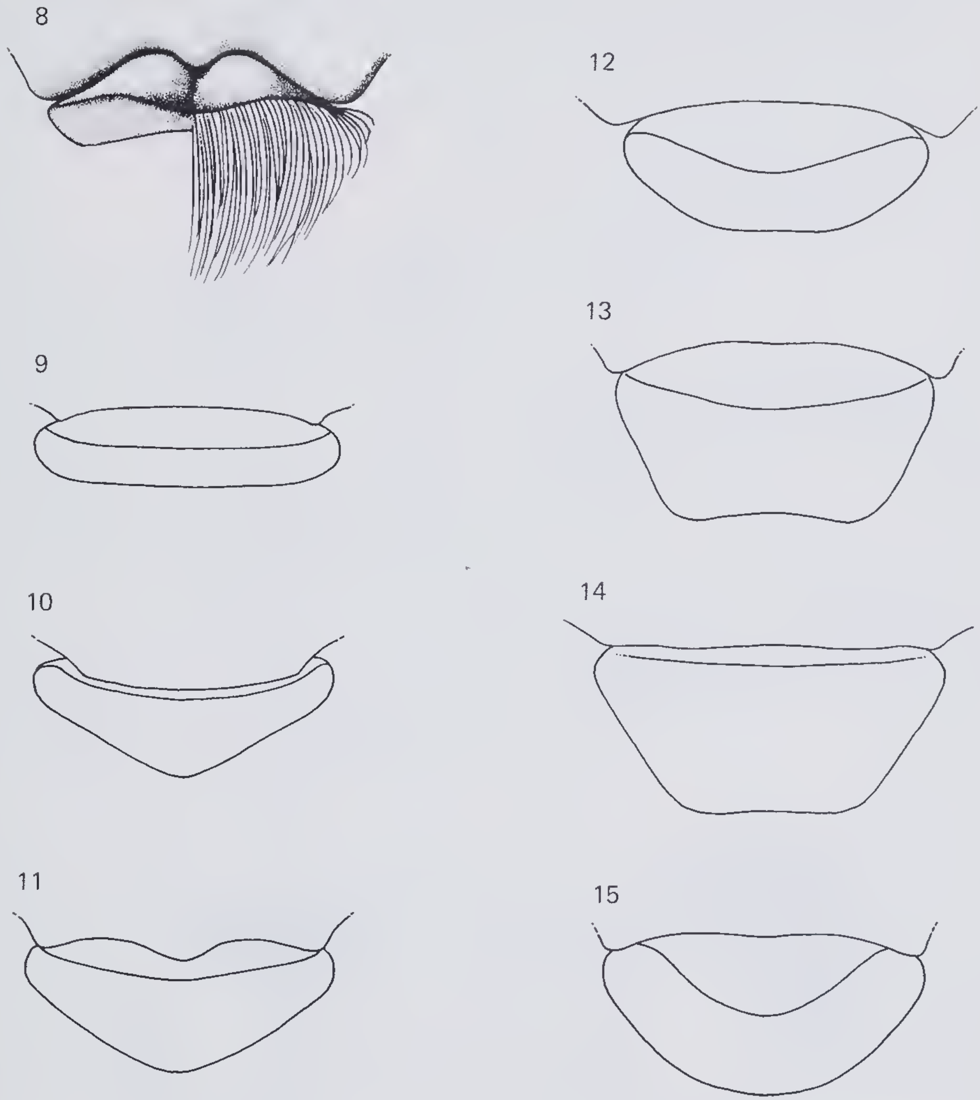
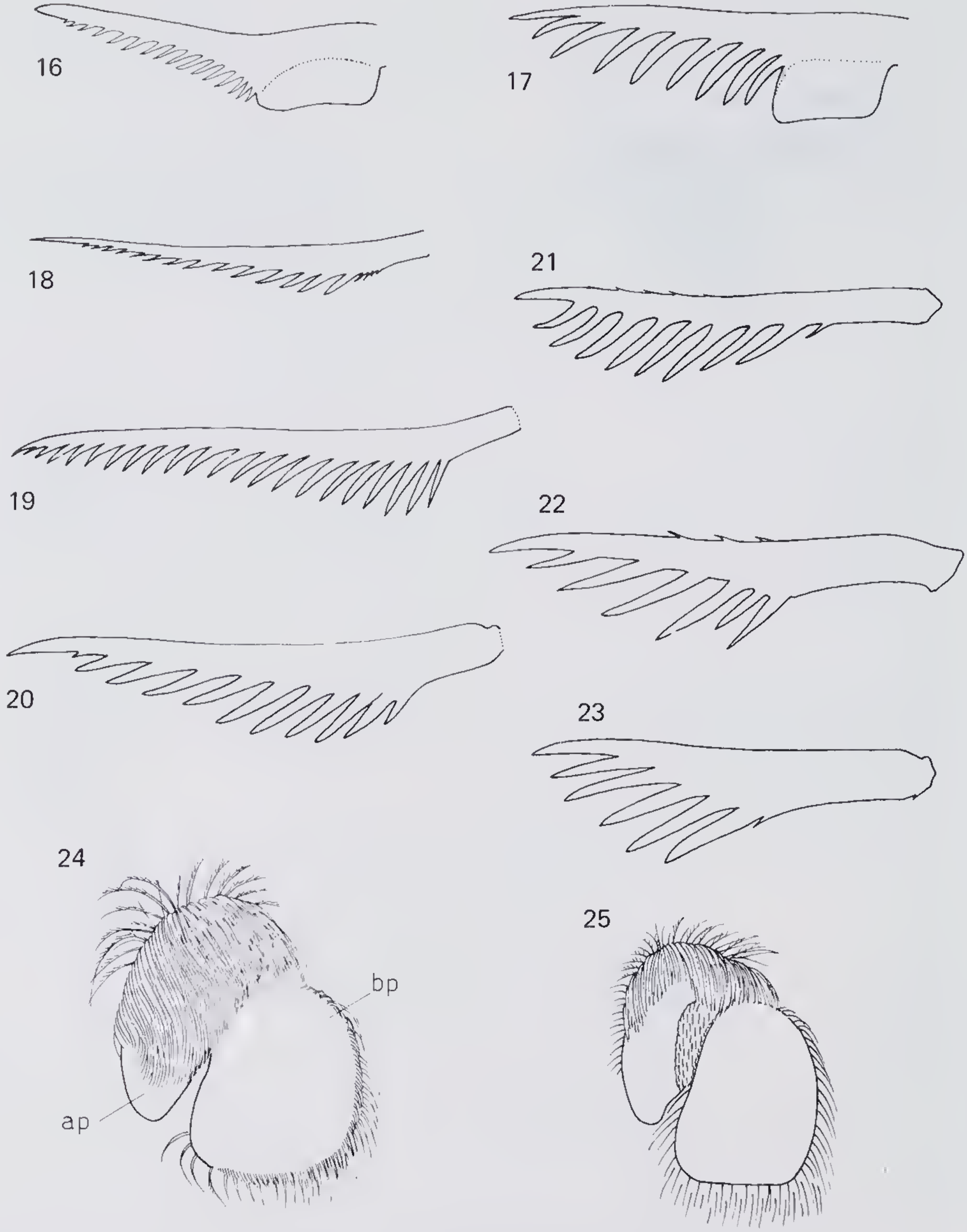


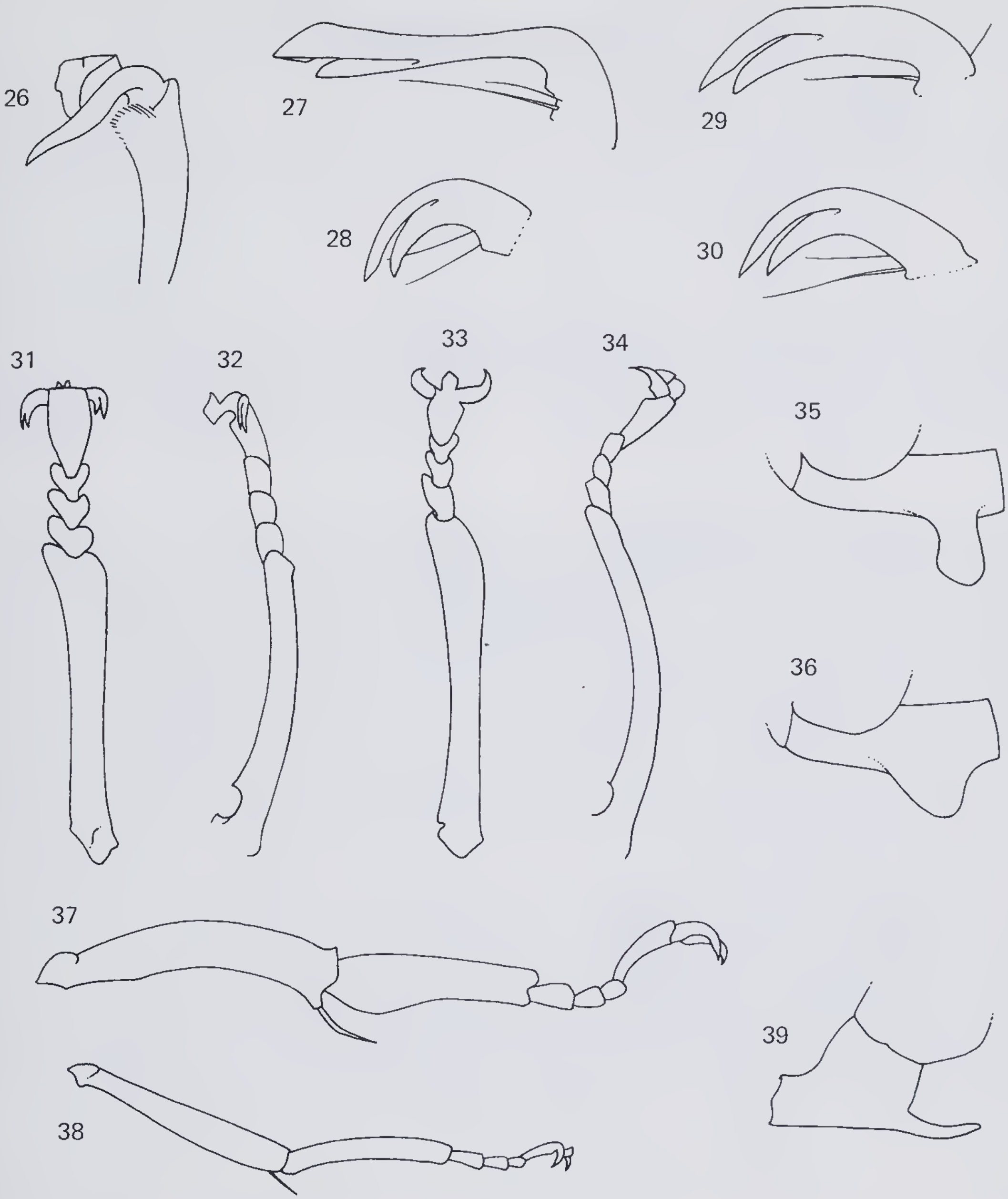
Figure 7 Map of Western Australia showing collection localities of five species of *Ctenocolletes* (fine lines represent major roads; composite symbols represent coincident records for two species).



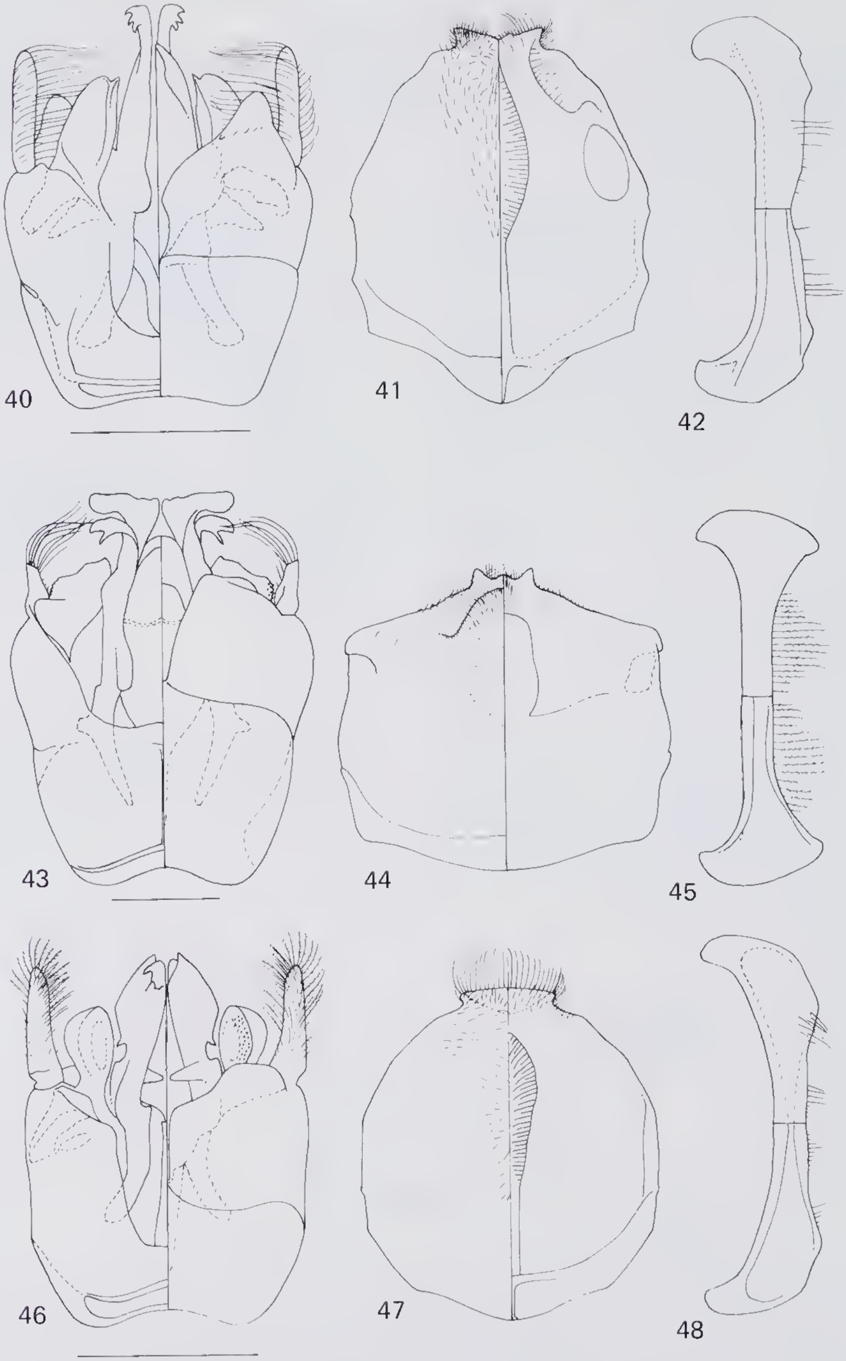
Figures 8-15 Labrum and midventral margin of clypeus of females (anterior views; vestiture omitted except on right-hand side of Figure 8): (8) *Stenotritus greavesi* (Rayment); (9) *Ctenocolletes fulvescens*; (10) *C. centralis*; (11) *C. nicholsoni*; (12) *C. rufescens*; (13) *C. ordensis*; (14) *C. smaragdinus*; (15) *C. tricolor.*



Figures 16-25 Features of legs of females: (16) fore tibial spur of *Stenotritus greavesi*; (17) same of *Ctenocolletes nicholsoni*; (18) mid tibial spur of *C. smaragdinus*; (19) same of *C. fulvescens*; (20) same of *C. nicholsoni*; (21) inner hind tibial spur of *Stenotritus pubescens* Smith; (22) same of *C. ordensis*; (23) same of *C. nicholsoni*; (24) apical plate (ap) of femur and basitibial plate (bp) of left hind leg of *C. rufescens*; (25) same of *C. nicholsoni.*



Figures 26-39 Features of legs of *Ctenocolletes* males: (26) distitarsus of *C. albomarginatus* (inner view); (27, 28) inner and outer fore tarsal claws of same (drawn to same scale); (29, 30) same of *C. tricolor*; (31, 32) dorsal and inner aspects of right fore tarsus of *C. centralis*; (33, 34) same of *C. nicholsoni*; (35) left fore trochanter of *C. centralis* showing ventral process (anterior view); (36) same of *C. nicholsoni*; (37) left hind tibia and tarsus of *C. ordensis* (outer view); (38) same of *C. nicholsoni*; (39) left hind trochanter of *C. centralis* showing ventroapical spine (outer view).



Figures 40-48 From left to right: genital capsule, 8th and 7th metasomal sterna of *Ctenocolletes* males: (40-42) *C. albomarginatus*; (43-45) *C. tricolor*; (46-48) *C. rufescens*. Dorsal aspect shown on right half of each figure and ventral aspect on left half; 7th sterna rotated 90° clockwise. Scale lines = 1 mm.

Ctenocolletes centralis sp. nov.

Figures 7, 10, 31, 32, 35, 39

Holotype

In ANIC, ♂, '3 miles Sth Neale Junction' [28°18'S, 125°49'E], Western Australia, 16 July 1974, K.T. Richards.

Paratypes

Western Australia

12.5 km ENE of Anketell HS (28°02'S, 118°51'E), 6-7 Sept. 1981, T.F. Houston, on flowers of *Baeckea stowardii*, 2 ♀, WAM; Blackstone Range, 17 July 1967, K.T. Richards, 4 ♀, WADA; Canning Stock Route Well 24, Sept. 1971, R. House, 1 ♀, WADA; same data as for holotype, 4 ♂, WAM, WADA; 130 miles N of Neale Junction, 18 July 1974, K.T. Richards, 5 ♀, ANIC, WADA, WAM.

Diagnosis

Agrees with *C. nicholsoni* and differs from all other species in the following features: male with fore basitarsi attenuated and arcuate (Figures 31, 32) and fore trochanters with hairless ventral projections (Figure 35); female with apical plate of hind femur only about half-covered with golden pubescence (as in Figure 25); both sexes with attenuated first segment of flagellum at least as long as next five segments together, metasomal terga largely black with erect plumose setae generally and dense, buff bands of pubescence across their hind margins (this last character shared with *C. rufescens*), and first recurrent vein distal to first intercubitus by only one-tenth to one-fifth posterior length of second cubital cell.

Distinguishable from *nicholsoni* as follows: male with ventral projections of fore trochanters relatively longer and more slender, almost clavate (cf. Figures 35, 36), hind trochanters with slender ventroapical spines (Figure 39; absent in *nicholsoni*), mid tibial spur absent and hind tibia with only one spur (mid tibia with one and hind tibia with two spurs in *nicholsoni*); female with mid ventral margin of clypeus evenly convex, not trilobed (cf. Figures 10, 11); both sexes with almost uniformly buff pubescence, lacking conspicuous patches of black or dusky setae (except perhaps on scutellum and axillae).

Description

Male (holotype)

Body length 16 mm; head width 5.3 mm.

Relative dimensions: HW 100; HL 82; UID 23; LID 62; MOD 7; OOD 7; SL 10; F1L 32; FRL 68; ML 40; MBW 11.

Eyes strongly converging above; vertex relatively narrow and depressed below level of tops of eyes (much as in Figure 54); attenuated first segment of flagellum about as long as next 5.5 segments together; first recurrent vein distal to first intercubitus by only about one-tenth posterior length of second cubital cell;

propodeal enclosure relatively large (broad enough to accommodate three ocelli side by side) and extending broadly downwards to propodeal pit; fore coxa with small median ventral projection; fore trochanter with large spathulate ventral projection (Figure 35), hairless at apex, and hind trochanter with slender curved ventroapical spine (Figure 39); fore basitarsus little shorter than tibia, slender proximally, expanded distally and gently arcuate (Figures 31, 32); fore tarsal claws symmetrical; mid tibia lacking spur; hind tibia slender and straight with only one spur and hind basitarsus long and gently arcuate (much as in Figure 38); hind distitarsus (excluding claws) only about 66% as long as distance from its insertion to base of segment 2 (which has a strong ventroapical spine); pygidial plate with slightly elevated carinate margin.

Integument black except as follows. The following are yellow-brown: first segment of flagellum, labrum ventrally, tegulae, wing veins proximally, all tibiae and tarsi. Posterior and lateral margins of metasomal terga hyaline.

Pubescence almost wholly buff to golden-buff, long, erect, plumose, and obscuring underlying integument of most of head and body, densest on face but sparse on vertex and lateral to ocelli; dusky setae occur sparsely on mid scutum, axillae and scutellum and form a distinct transverse band across third and fourth metasomal terga; hind legs have especially long erect pubescence, densest on trochanters.

Terminalia: not significantly different from those of *C. nicholsoni.*

Variation: slight in the small sample available. Head width range 5.25-5.45 mm (n 5), upper interocular distance 16-23% of head width. Eyes in all males strongly convergent with vertex depressed below their summits. Dusky setae are sparse in (or absent from) the mesonotal pubescence of some specimens.

Female

Body length 16.5-19.0 mm; head width 5.5-6.0 mm (n 13).

Relative dimensions: HW 100; HL *c.* 75; UID 53-57; LID 65-70; MOD 6; OOD 17-18; SL 11-12; F1L 25-27; FRL 54-56; ML 48; C2L 22-25.

Head distinctly wider than long; face between eyes slightly broader than long; inner orbits parallel to slightly converging above; mid ventral margin of clypeus produced and evenly convex; labrum relatively short with basal elevation hidden beneath clypeus (Figure 10); mandibles slender with acute posterior tooth and small anterior tooth (as in Figure 5); attenuated first segment of flagellum equal in length to next five segments together; propodeal enclosure relatively large as in male; mid tibial spur relatively short (much as in Figure 20) with 8-15 long coarse teeth (n 22); inner hind tibial spur (much as in Figure 23) with 3-7 very long coarse teeth (n 21); pygidial plate broadly triangular with even surface.

Integument predominantly black. The following are brown: tegulae, wing veins proximally, fore and mid distitarsi, hind tibiae and tarsi, tibial spurs, swollen translucent lateral portions of metasomal terga 3 and 4 (which often conceal mites underneath), and pygidial plate. Hind margins of metasomal terga hyaline.

Pubescence generally moderately dense, erect, grading from white on lower face and posterior of head, through pale buff on lateral and ventral areas of thorax and propodeum, buff on upper face, dorsum of thorax, tegulae and most of metasoma, to golden on fifth and sixth terga. Blackish setae occur moderately densely across vertex, on axillae and scutellum but only very sparsely on central scutum and do not form a colour patch on the latter. A band of dense buff pubescence occupies full width of vertex above ocelli. Labrum lacks pubescence. Apical plate of hind femur at least half bare (as in Figure 25), remainder covered by golden setae. Metasomal terga 1-4 with dense apical bands of pale buff pubescence contrasting with sparser more erect setae elsewhere.

Distribution

Central desert region of Western Australia (Figure 7).

Remarks

This species is sympatric with its nearest relative, *nicholsoni,* near Sandstone but no evidence of hybridization has been noted. The sexes are associated on the basis of morphological similarity and correlation of characters with those of *nicholsoni.*

The specific epithet alludes to the distribution of the species.

Ctenocolletes fulvescens sp. nov.

Figures 4, 7, 9, 19, 49

Figure 49 *Ctenocolletes fulvescens* female (holotype).

Holotype

In WAM (82/818), ♀, '20 mi. NE of Eucla [Western Australia, 31°41'S, 128°54'E] ', South Australia, 21 January 1970, T.F. Houston, on flowers of *Eucalyptus oleosa* at sunrise. The type locality is in S.A. about 18 km from the W.A. border.

Diagnosis

Female (male unknown) distinguishable from those of all other species by the following features: dorsum of thorax covered by dense erect tomentum imparting an overall buff colour, each seta white with dark brown tip; metasomal integument yellow-brown dorsally, second to fourth terga with adpressed golden simple setae, others with longer golden pubescence but conspicuous banding absent (Figure 49); inner hind tibial spurs with ten coarse teeth.

Description

Female (holotype)

Body length 18 mm; head width 6.2 mm.

Relative dimensions: HW 100; HL 81; UID 46; LID 70; MOD 7.5; OOD 15; SL 14; F1L 22; FRL 55; C2L 35.

Head appearing only slightly wider than long and face longer than wide; compound eyes converging slightly above; mid ventral margin of clypeus fairly straight; labrum relatively very short, basal elevation occupying half its length (Figure 9); mandible relatively stout with broad anterior tooth (Figure 4); attenuated first segment of flagellum as long as next four segments together; mid tibial spurs relatively long, moderately slender and with 18-22 stout teeth (Figure 19); inner hind tibial spurs very broad with ten long stout teeth; first recurrent vein distal to first intercubitus by about one-third posterior length of second cubital cell; propodeal enclosure moderately large, more than ample to accommodate an ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous); pygidial plate with a strong median convexity.

Integument black to dark brown except for the following areas of yellow-brown: transparent tegulae, metasomal tergum 1 apically and terga 2-4 dorsally, flagella ventrally, distal tarsal segments and hind basitarsi, and all tibial spurs.

Long white plumose setae generally dense enough to obscure underlying integument (except upper portion of clypeus) occurs as follows: face up to ocelli, head posteriorly, fringe beneath labral elevation, lateral, ventral and posterior surfaces of mesosoma (posterior surface of propodeum has much shorter setae contrasting sharply with very long setae of posterolateral areas), proximal portions of legs and metasomal sterna 1-5. Vertex with sparse dusky brown setae. Dorsum of thorax with short, dense, erect tomentum, each seta white with a dark brown apex, colour overall appears buff; scutellum with two bare areas (possibly worn). Metasomal terga with golden pubescence (except bare anterior face of first); dorsal surface of tergum 1 with short erect plumose setae, terga 2-4 with adpressed simple setae not obscuring integument, 5 and 6 with long dense plumose setae· apical margins of terga 1-4 have very narrow fringes of paler plumose setae but metasoma does not appear banded (Figure 49); foveal areas of tergum 2 covered by short buff tomentum. Apices of hind femora covered by dense buff setae. Hind tibiae and tarsi with predominantly white setae on outer sides (brownish near basitibial plates), yellow-brown on inner sides of basitarsi.

Remarks

Known only from the type specimen.

Because of its relatively large propodeal enclosure and numerous teeth on the inner hind tibial spurs, this species would run to *Stenotritus* by Michener's (1965) diagnosis and key. However, the form of its tibial spurs and labrum clearly ally it with other *Ctenocolletes*.

The specific epithet is Latin for 'becoming golden' in allusion to the metasomal pubescence.

Ctenocolletes nicholsoni (Cockerell, 1929)

Figures 1, 2, 5, 7, 11, 17, 20, 23, 25, 33, 34, 36, 38, 50

Stenotritus (Ctenocolletes) nicholsoni Cockerell, 1929: 358-359.
Ctenocolletes nicholsoni (Cockerell) Michener, 1965: 83.
Ctenocolletes notabilis Michener, 1965: 266-267, pl. 5 (3), text figures 220-222. Syn. nov.

Figure 50   *Ctenocolletes nicholsoni* male (left) and female.

Types

Holotype of *nicholsoni:* ♀, Kojarena [28°44'S, 114°52'E], Western Australia, 8 September 1926, Nicholson, in AM.

Holotype of *notabilis:* ♂, Geraldton [28°46'S, 114°37'E], Western Australia, 1917, W.W. Froggatt, in ANIC.

Diagnosis

Most like *C. centralis* and rather similar to *C. rufescens.* For differences refer to diagnoses of those species.

Description

Male

Body length 17-19 mm; head width 5.1-5.5 mm (n 11).

Relative dimensions: HW 100; HL 80-82; UID 20-24; LID 60-62; MOD 7; OOD 6.0-7.5; F1L 34; FRL 66-70; SL 10; ML 43.

Form and pubescence much as described for male of *C. centralis* differing as noted in diagnosis of that species and in the following additional ways.

Fore basitarsi more strongly arcuate and not quite as expanded distally (Figures 33, 34); no ventroapical spine on second segment of hind tarsus.

Pubescence more varied in coloration than in *centralis.* Rich buff on face and anterior portion of scutum, contrasting with whiter hair on posterior of head, posterior of scutum, metanotum, propodeum and first metasomal tergum. Black or dusky brown setae form dark patches as follows: a pair of rounded patches on mid scutum, smaller patch posteriorly on tegula and on mesopleuron below tegula, band across scutellum and axillae, dorsolateral patches on propodeum and wide transverse bands across metasomal terga 2-5 (that on 2 sometimes faint to virtually absent); dense buff more adpressed pubescence forms conspicuous cross-bands on hind margins of terga 2-5; pubescence of hind trochanters no denser than elsewhere and hind tibiae with dusky brown setae dorsally.

Terminalia: figured by Michener (1965: 84).

Female

Body length 18.0-20.5 mm; head width 5.7-6.3 mm (n 22).

Relative dimensions: HW 100; HL 75-77; UID 51-55; LID 67-69; MOD 5.5-6.5; OOD 16-17; SL 12-13; F1L 26-27; FRL 53-56; ML 44-49; C2L 22.

Form, coloration and pubescence as described for *centralis* female except as noted in the diagnosis of that species and with the following additional differences.

Labrum sub-triangular with basal elevation exposed (Figure 11); mid tibial spur (Figure 20) with 8-13 coarse teeth (n 42), inner hind tibial spur (Figure 23) with 3-5 coarse teeth (n 36).

Pubescence white on lower face, posterior of head, lateral and ventral areas of thorax (except sooty patch on mesosternum), propodeum and proximal portions of legs; vertex with buff pubescence usually confined to area above ocelli and not obscured by it from front; black or sooty brown setae form patches as follows — band across vertex, wide band across scutum extending laterally narrowly in front of tegulae, band across scutellum and axillae, patch on mesopleuron below tegula, faint dorsolateral patches on propodeum, and all but apical margins of metasomal terga 2-4; dense apical fringes of metasomal terga grading from pale buff on 1 to fulvous on 5 and 6.

Variation: sooty areas of pubescence decrease in extent and intensity towards eastern part of range; almost absent form thorax and metasoma of Laverton specimens.

Distribution

Southern Western Australia (Figure 7).

Remarks

The sexes have been confidently associated on the basis of morphological similarities, coincident collection records and correlation of characters with those of the closely related *C. centralis.*

Material Examined

The holotypes of *nicholsoni* and *notabilis* and the following.

Western Australia

11 km ENE of Anketell HS (28°02'S, 118°51'E), 4-6 Sept. 1981, T.F. Houston, on flowers of mulga *Acacia,* 1 ♀, WAM; 12 km NNE of Eurardy HS (27°34'S, 114°40'E), 19 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Acacia blakelyi,* 1 ♀, WAM; 126 miles N of Geraldton, 20 Aug. 1971, T.F. Houston, on flowers of *Baeckea pentagonantha,* 2 ♂, 7 ♀, WAM; 37 km NE of Laverton, 28°21'S, 122°37'E, 10-12 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides,* 2 ♀, WAM; 10 km ESE of Meedo HS (25°40'S, 114°37'E), 23-26 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Calytrix oldfieldii,* 1 ♂, 1 ♀, WAM; Meleya Well (28°58'S, 117°12'E), Thundelarra Stn, 28 Aug.-2 Sept. 1981, T.F. Houston, on flowers of *Acacia tetragonophylla,* 3 ♀, WAM; Moresby Range, Geraldton, 7 Aug. 1974, N. McFarland, 2 ♂, 1 ♀, WADA; Mullewa, L.J. Newman, 3 ♀, WADA; 10 km E of Mullewa, 17 Aug. 1981, P.G. Kendrick, 2 ♂, WAM; 16 km S of Nerren Nerren HS (27°08'S, 114°38'E), 19 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii,* 2 ♂, 1 ♀, WAM; 10 km SW of Paynes Find, 29 Aug. 1981, G.A. Holloway, 2 ♂, 2 ♀, AM; RP[?], 3 Aug. 1973, D. and N.F. McF[arland], 1 ♂, WADA; Sandstone, 28 Aug. 1974, A.M. and M.J. Douglas, 10 ♀, WAM; 8 km NE of Tamala HS (26°42'S, 113°43'E), 21-23 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii,* 4 ♀, WAM; same as preceding but on flowers of *Ptilotus obovatus,* 1 ♂, WAM; 70 km NE of Wubin, 28 Aug. 1981, G.A. Holloway, at light, 1 ♀, AM; 28 km W of Yalgoo, 1-2 Sept. 1981, G.A. Holloway, 2 ♂, AM.

Ctenocolletes ordensis Michener, 1965

Figures 7, 13, 22, 37, 51

Ctenocolletes ordensis Michener, 1965: 267, pl. 5 (4), figures 217-219.

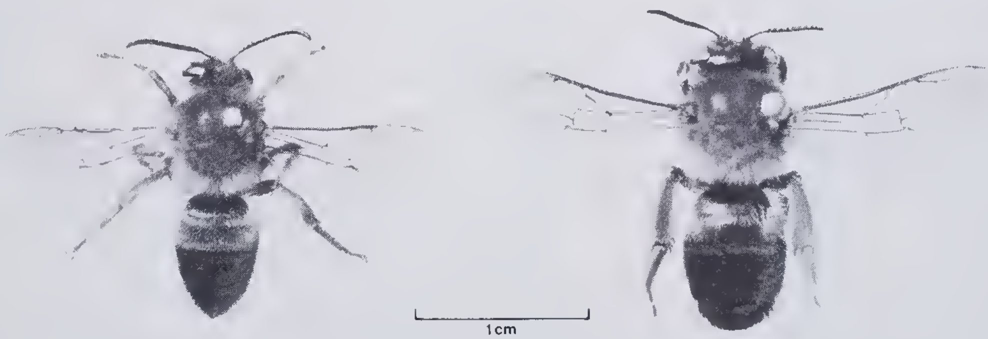


Figure 51 *Ctenocolletes ordensis* male (left) and female.

Type

Holotype: ♂, 'Wotjulum' [16°07'S, 123°43'E], Western Australia, 3 October 1955, A.M. Douglas, in WAM (65/728).

See under Remarks concerning veracity of type locality.

Diagnosis

Readily distinguished from all other species by the following features: pubescence of head, mesosoma, first two metasomal terga and legs predominantly orange-brown without patches of darker setae; metasomal terga 2-6 shining black, without bands of pale pubescence and with only black setae (Figure 51); fore legs of male ordinary but hind tibiae curved (Figure 37), with a flat ventral surface and outer spurs bent near middle; female with relatively elongate inner hind tibial spurs (Figure 22).

Description

Male

Body length 14.0-16.5 mm; head width 4.6-4.9 mm (n 10).

Relative dimensions: HW 100; HL 79-83; UID 48-51; LID 60; MOD 7-8; OOD 11-13; SL 14; F1L 23-24; FRL 95-102; ML 42-43.

Head fairly rounded in anterior view; inner margins of eyes approximately parallel, face between them about 1¼ times as long as broad; vertex gently convex and elevated above summits of eyes; labrum much as in female (Figure 13) but with weak elevation; mandible slender with long acute posterior tooth; attenuated first segment of flagellum as long as next 3 segments together; first recurrent vein distal to first intercubitus by 30-40% posterior length of second cubital cell; propodeal enclosure about large enough to accommodate an ocellus; fore and mid legs unmodified; hind tibiae curved with ventral surface longitudinally concave and transversely flat and spurs bent (Figure 37); hind basitarsi almost as broad as tibiae; hind distitarsus (excluding claws) slightly longer than distance from its insertion to base of segment 2 (Figure 37).

Integument of head and body almost wholly black, most shining on metasomal terga. The following are orange-brown: flagella ventrally, labrum, all legs beyond trochanters, tegulae, proximal portions of wing veins and pygidial plate.

Pubescence of head, mesosoma, first two metasomal terga and legs golden-brown to buff, mostly long and obscuring integument; labrum with a fringe of plumose setae arising under elevation; metasomal terga 3-7 with short, simple to long plumose black setae.

Terminalia: figured by Michener (1965: 84).

Female

This sex has not previously been described.

Body length 17.0-18.5 mm; head width 5.5-5.8 mm (n 10).

Relative dimensions: HW 100; HL 75-78; UID 56-60; LID 67-69; MOD 7; OOD 16-17; SL 14; F1L 22-23; FRL 61-65; ML 48; MBW 14-16; C2L 26-27.

Inner margins of eyes more or less parallel, face between them about as broad as long; vertex strongly elevated above summits of eyes, rather transverse medially; midventral margin of clypeus excavated but mostly transverse; labrum long, truncate apically and with broad basal elevation occupying about one-third of length (Figure 13); mandible strongly broadened subapically with acute, tapering posterior tooth and much smaller anterior tooth; attenuated first segment of flagellum as long as next 3.5-3.7 segments together; wing venation as in male; propodeal enclosure large enough to accommodate only one ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous, translucent or concealing mites); pygidial plate longer than broad and usually narrow at apex, surface even; mid tibial spurs selnder with 13-20 short teeth (n 20); inner hind tibial spurs relatively slender (Figure 22) with 4-6 coarse teeth (n 13).

Integumental coloration and pubescence much as in male but buff pubescence of metasomal terga 1 and 2 sparse and inconspicuous except over foveal areas; basitibial plates dark brown.

Distribution

Southern inland (mulga shrubland) area of Western Australia (Figure 7). Records of the species from the far north of W.A. (including the types) are regarded as probable errors (see Remarks).

Remarks

The sexes are associated on the basis of their distinctive pubescence and coloration and on the basis of coincident collection records.

The name *ordensis* was proposed in manuscript by Rayment but never published by him.

In view of a separation of over 1 300 km between the bulk of collection localities and those in the far north, the reputed collector of the type, A.M. Douglas, was asked if he could verify its provenance. He was unable to do so. The climate and ecology of the far northern localities and the southern range would be very different and yet I cannot detect any differences between specimens recorded from the two areas. Unless new northern records are obtained I would regard the earlier ones as incorrect.

Material Examined

The holotype and the following.

Western Australia

11 km ENE of Anketell HS (28°02′S, 118°51′E), 4-6 Sept. 1981, T.F. Houston, at nests, 9 ♀, WAM; Marchagee Nature Reserve near Coorow, 21 Aug. 1982, M. Powell, 1 ♀, WAM; 4 miles NE of Menzies, 2 Sept. 1971, T.F. Houston, on flowers of *Scaevola spinescens*, 2 ♀, WAM; 'Ord R., Nov. 1951', 2 ♂ [the specimens also bear Rayment paratype labels with his unpublished combination of the specific epithet with *Gastropsis*], ANIC; 25 miles E of Paynes Find, 23 Aug. 1964, W.H. Butler, 23 ♂, WAM; 50 km N of Paynes Find, 16 Aug. 1981, P.G. Kendrick, 1 ♀, WAM; 10 km S of Paynes Find, 10 Sept. 1982, M. Powell, on flowers of

Grevillea sp., 1 ♂, WAM; 6 km ENE of Warriedar HS (29°08′S, 117°11′E), 27 Aug. 1981, T.F. Houston, on flowers of *Scaevola spinescens*, 1 ♀, WAM; 13 km NE of Warriedar HS, 28 Aug. 1981, T.F. Houston, on flowers of *Cassia chatelainiana*, 1 ♂, WAM; same data as for type but dated 9 Oct., 1 ♂ (paratype), WAM; 55 km NE of Wubin, 9 Sept. 1982, M. Powell, on flowers of *Grevillea* sp., 1 ♀, WAM; 28 km W of Yalgoo, 2 Sept. 1981, G.A. Holloway, 2 ♂, 2 ♀, AM.

Ctenocolletes rufescens sp. nov.

Figures 6, 12, 24, 46-48, 52-55

Figure 52 *Ctenocolletes rufescens* male (left) and female.

Holotype

In WAM (81/691), ♂, Balline Station [Homestead at 27°59′S, 114°13′E], Western Australia, 24-25 July 1979, A.M. and M.J. Douglas.

Paratypes

Western Australia

Same data as for holotype, 17 ♂, 1 ♀, ANIC, WAM; Boorabbin Rock (31°12′S, 120°17′E), 4-9 Oct. 1981, T.F. Houston, on flowers of *Melaleuca scabra* and *M. uncinata*, 2 ♀, WAM; Dulyalbin Rock, 30 Sept. 1972, W.M. O'Donnell, 1 ♀, WADA; 13 miles N of Geraldton, 19 Aug. 1971, T.F. Houston, on flowers of *Scholtzia spathulata*, 14 ♂, 1 ♀, WAM; Morawa, 3 Sept. 1978, A.M. and M.J. Douglas, ADAA, on flowers of *Hakea coriacea*, 5 ♂, WAM; 14 km SSW of Mt Jackson (30°15′S, 119°16′E), 24 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 5 ♀, ANIC, WAM; Mullewa, Sept., L.J. Newman, 2 ♀, WADA; 50 km E of Mullewa, 3 Sept. 1981, G.A. Holloway, 1 ♂, AM; 30 km W of Sandstone (27°59′S, 119°18′E), 7 Sept. 1981, T.F. Houston, on flowers of *Eucalyptus oldfieldii*, 2 ♂, WAM; 8 km NE of Tamala HS (26°42′S, 113°43′E), 21-23 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii*, 4 ♂, WAM; 8 km S of Yellowdine, 22 Oct. 1974, C.A. and T.F. Houston, on white flowers of *Grevillea*, 3 ♀, WAM.

Diagnosis

Most like *C. centralis* and *C. nicholsoni* and unlike other species in combining the following features: integument of head and body black; metasomal terga with erect, highly plumose, buff to rufous pubescence forming distinct transverse bands; eyes of male (except the smallest specimens) distinctly converging dorsally; mid tibial spur of female relatively broad with long coarse teeth (much as in Figure 20).

Differs from *centralis* and *nicholsoni* as follows: male with fore basitarsus normal (not attenuated and curved), fore and hind trochanters without ventral projections and facial pubescence rufous rather than buff; female with labrum densely pubescent beneath basal elevation (not bare unless worn), midventral margin of clypeus concave (Figure 12) rather than convex or trilobed, apical plate of hind femur almost wholly covered by dark brown pubescence (Figure 24; not at least half bare with golden setae over remainder), and pubescence of mesosternum wholly white (sooty in *nicholsoni*); both sexes with relatively shorter first segment of flagellum, equal in length to next 3½ or 4 segments combined (5 or 5½ in other species) and relatively smaller propodeal enclosure, large enough to accommodate only one ocellus (not 2 or 3 transversely).

Description

Male (holotype)

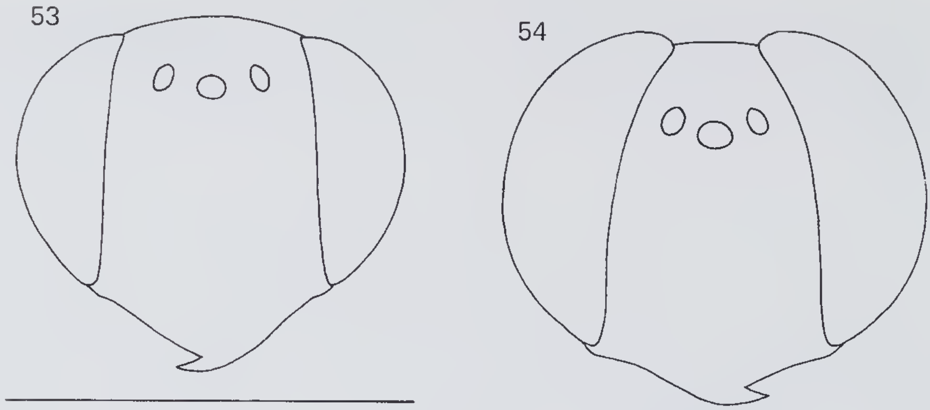
Body length 16 mm; head width 5.0 mm.

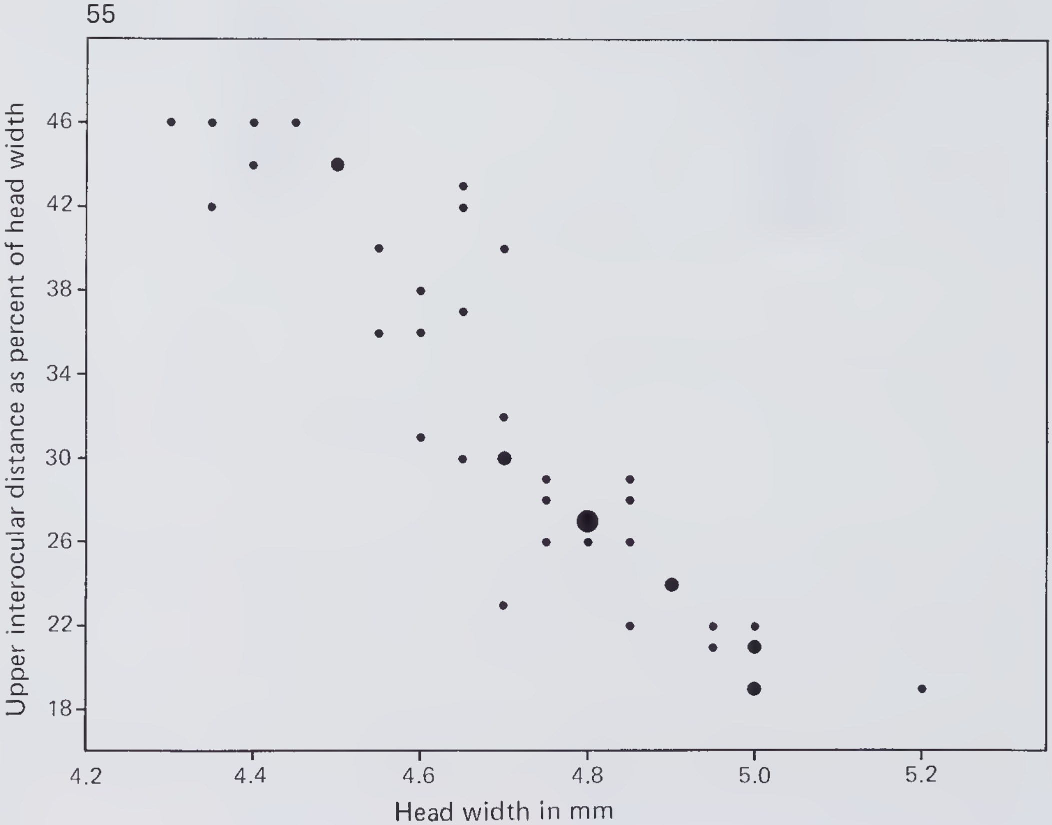
Relative dimensions: HW 100; HL 81, UID 21; LID 62; MOD 7; OOD 6; F1L 25; FRL 80.

Head rounded viewed anteriorly; inner orbits strongly converging above; vertex narrow, level and depressed below level of tops of eyes; face much longer than wide; attenuated first segment of flagellum as long as next 3½ segments combined; first recurrent vein distal to first intercubitus by one-quarter posterior length of second cubital cell; propodeal enclosure obscured in type (in other specimens large enough to accommodate one or two ocelli); legs ordinary, without projections of trochanters, tibiae and basitarsi straight and not attenuated; fore tarsal claws symmetrical; fore calcar with moderate spine bearing several fine teeth; hind distitarsus (excluding claws) about 70% as long as distance from its insertion to base of segment 2; pygidial plate very narrow, projecting posteriorly.

Integument black except as follows: labrum, mandibles partially, legs from apices of femora to distitarsi, wing veins proximally and pygidial plate orange-brown; tegulae and hind margins of metasomal terga transparent pale brown.

Pubescence generally long, erect and fairly dense, more or less obscuring integument; golden-rust-coloured on face (including fringe across labrum), anterior margin of scutum, whole of metasomal tergum 2 except for lateral areas, broad apical bands on terga 3 and 4 and whole of metasomal segments 5 and 6; sterna 5 and 6 fringed with golden hair; labrum with a dense fringe of plumose setae arising under elevation; black on vertex, wide central band on scutum and another across scutellum and axillae, dorsolateral areas of metasomal tergum 2, wide bands right across terga 3 and 4, tegulae anteriorly and large diffuse patches





Figures 53-55 *Ctenocolletes rufescens* males: (53, 54) heads of smallest and largest individuals (anterior views; scale line = 5 mm); (55) scatter diagram showing relationship between sizes of individuals (judged by head width) and the degree of convergence of their compound eyes on the vertex (small spots represent one individual, medium spots two and the large spot four).

on mesepisterna from near tegulae to venter; tibiae with dark brown setae dorsally; remaining pubescence white.

Terminalia: see Figures 46-48.

Variation: males vary conspicuously in size (head widths range 4.3-5.2 mm, n 43). Associated with this variation is some morphological and chromatic variation.

Morphological variation occurs on the head where the degree to which the compound eyes converge on the vertex increases with overall size of the individual. While small males have relatively broad, gently convex vertices which exceed the tops of the eyes (Figure 53), larger males have progressively flatter, relatively narrower vertices which, in the largest individuals, may be depressed below the level of the compound eyes (Figure 54). The correlation between size and eye convergence is apparent from the scatter diagram (Figure 55).

Size-linked chromatic variation is seen in the intensity of the black patches of pubescence and their extent on the lateral and ventral areas of the mesothorax: larger males have more intense and more extensive black patches than smaller ones. The smallest individuals have predominantly white pubescence on mesosterna and mesopleura.

There also appears to be some age variation with the rufous pubescence of young males fading to almost a straw colour in older specimens.

Female

Body length 18-19 mm; head width 5.1-6.1 mm (n 15).

Relative dimensions: HW 100; HL 74-77; UID 51-55 (37 in one); LID 68-70; MOD 7; OOD 15-17 (12 in one); SL 13; F1L 22; FRL *c.* 57; C1L 18-20; C2L 24-26.

Vertex moderately convex viewed anteriorly; compound eyes slightly converging above and face between them a little wider than long; mid ventral margin of clypeus evenly concave (Figure 12); labrum about twice as wide as long with basal elevation occupying about half its length (Figure 12); mandibles long and slender (as in Figure 5; teeth frequently very worn); attenuated first segment of flagellum as long as next 4 to 4¼ segments together; first recurrent vein enters posterior margin of second cubital cell about one-third its length from first intercubitus; propodeal enclosure small, barely able to contain an ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous nor concealing mites); pygidial plate fairly triangular (equilateral) with even, gently convex surface; mid tibial spur relatively broad (much as in Figure 20) with 10-17 long coarse teeth (n 20); inner hind tibial spur broad with 4-6 long coarse teeth (8 in one).

Integument predominantly black and non-metallic; hind margins of metasomal terga broadly translucent brown; mandibles, distitarsi, tibial spurs, tegulae and parts of venation brown.

Pubescence generally long and dense, obscuring most of integument; white on posterior of head, lateral and ventral areas of thorax, propodeum, first metasomal tergum and sterna 1-3, basal portions of legs and outer ventral portion of hind tibial scopa; light buff on face (except vertex and areas lateral to ocelli), dense plumose fringe arising under labral elevation, and dorsum of thorax (except for sooty areas); apical margins of metasomal terga 2-4 with adpressed golden to rich orange pubescence; terga 5 and 6 wholly covered by long dense deep orange hair; sterna 4-6 with long apical fringes grading from faint to rich orange; sooty brown on vertex, areas lateral to ocelli, large patch on mid scutum extending narrowly each side in front of tegulae, smaller patches on axillae, scutellum, dorsolateral corners of propodeum, tegulae, and upper mesepisterna, dorsal surfaces of all tibiae, and basitarsi; metasomal terga 2-4 (except margins) with very short sparse black pubescence.

Distribution

Southern Western Australia (Figure 6).

Remarks

The sexes are associated on the basis of morphological and chromatic similarities and coincident collection records.

The specific epithet is Latin for 'becoming red' in allusion to the rusty-coloured pubescence.

Ctenocolletes smaragdinus (Smith, 1868)

Figures 3, 7, 14, 18, 56

Stenotritus smaragdinus Smith, 1868: 254 (female).
Melitribus smaragdinus (Smith) Rayment, 1930a: 11.
Ctenocolletes smaragdinus (Smith) Michener, 1965: 83, figures 214-216.
Melitribus glauerti Rayment, 1930a: 16-17 (female). Syn. nov.
Stenotritus glauerti (Rayment) Rayment, 1930b: 60.
Stenotritus (Ctenocolletes) glauerti (Rayment) Rayment, 1935: 194-195.
Ctenocolletes glauerti (Rayment) Michener, 1965: 83.
Stenotritus speciosus Rayment, 1935: 683, pl. 26, Figures 25, 26 (male). Syn. nov.
Ctenocolletes speciosus (Rayment) Michener, 1965: 83.

Figure 56 *Ctenocolletes smaragdinus* male (left) and female.

Types

Holotype of *smaragdinus:* ♀, Champion Bay [28°46'S, 114°36'E], Western Australia, in BM. See remarks under Distribution.

Holotype of *glauerti:* ♀, Yorkrakine [31°22'S, 117°35'E], Western Australia, in WAM (1919/224).

Holotype of *speciosus:* ♂, Dowerin [31°12'S, 117°02'E], Western Australia, L.J. Newman, in ANIC.

Diagnosis

Immediately distinguishable from all other species by its brilliantly metallic green integument and sparse pubescence.

Description

Male

Body length 14.0-16.5 mm; head width 4.8-5.3 mm (n 29).

Relative dimensions: HW 100; HL 81-84; MFW 44-46; LID 58-59; MOD 7.0-7.5; OOD 10-11; SL 13-14; F1L 22-24; FRL 80-85; ML 38-40; MBW 13.

Inner margins of eyes bowed medially; face narrowest just below level of antennal sockets where it is about two-thirds as broad as eye length; vertex broad and distinctly elevated above summits of eyes; labrum much as in female (Figure 14) but with basal elevation longer; mandible slender with short posterior tooth; attenuated first segment of flagellum as long as next 3¼ segments together; tegulae unevenly convex; first recurrent vein distal to first intercubitus by one-third to one-half posterior length of second cubital cell; propodeal enclosure just large enough to just too small to accommodate an ocellus; pygidial plate smooth with even surface; legs without conspicuous modifications; hind distitarsus (excluding claws) slightly longer than distance from its insertion to base of segment 2; apical (eighth) metasomal sternum produced posteriorly into a large curved spine.

Integument prodominantly brilliant metallic green, mostly shagreened but fairly shiny on more apical metasomal terga. The following are black or black-brown: eyes, ocelli, mandibles (except bases), labrum, antennae (except scapes), tegulae posteriorly, pygidial plate and distitarsi.

Pubescence relatively sparse and inconspicuous above, longest and densest on underparts and propodeum, predominantly white; black-brown on vertex, scutum (except margins), scutellum and axillae, small patch posterior to pronotal tubercles, tegulae, metasomal terga 3-7 and 2 apically, and legs (partially) beyond femora.

Terminalia: figured by Michener (1965: 84).

Female

Body length 17-19 mm; head width 5.6-6.2 mm (n 10).

Relative dimensions: HW 100; HL 81-83; MFW 54-55; LID 67-70; MOD 6-7; OOD 16; SL 13-14; F1L 22-23; FRL 56-59; ML 45-46; MBW 15-16; C2L 25-26.

Head moderately broad; inner margins of eyes slightly converging above, face narrowest above level of ocelli, about as wide as long between eyes; vertex strongly elevated above summits of eyes, rather level medially; midventral margin of clypeus transverse to gently convex; labrum half as long as wide, ventral margin indented, basal elevation broadly carinate but very short and mainly hidden under clypeus when labrum is protracted (Figure 14); mandible moderately slender, broadened subapically, anterior tooth porrect, posterior tooth moderately short (when unworn); attenuated first segment of flagellum as long as next 4.2 segments together; tegulae with pronounced swellings and narrow flange-like margin anteriorly; wing venation and propodeal enclosure as in male; lateral portions of metasomal terga 3 and 4 ordinary (not swollen nor concealing mites); pygidial plate with even surface; mid tibial spurs long and slender with 12-16 short to very short teeth (n 17; Figure 18); inner hind tibial spurs moderately elongate with 4-8 long coarse teeth (n 17).

Integument much as in male but less shiny on metasoma; a conspicuous black non-metallic foveal patch on each side of face between lateral ocellus and eye margin; a similar but larger foveal patch on each side of second metasomal tergum.

Pubescence much as in male but sparser, especially the blackish setae on thorax; metasomal terga 2-4 with minute black setae, 5 and 6 with long, dense black hair apically; metasomal foveae with buff tomentum visible only in oblique light; hind femoral apices covered by dense black hair; hind tibial scopa mainly white, blackish dorsally; sterna 2-4 with fringes of long, white hair.

Distribution

South-western Australia (Figure 7). The outlying records from Champion Bay (Geraldton) and Busselton are based on single specimens and while not improbable should perhaps be regarded with some reservation.

Remarks

It appeared unnecessary to examine the type of *smaragdinus*. Rayment (1930*a*) differentiated *glauerti* from *smaragdinus* on the grounds that it was larger and lacked dorsal fringes of white hair on the abdomen. However, in Smith's original description of the latter species the only white abdominal fringes mentioned are ventral ones. In describing *speciosus*, Rayment (1935) suggested it might be the male of *glauerti*. That this is so has now been confirmed by capture of mating pairs.

Material Examined

The holotypes of *glauerti* and *speciosus* and the following.

Western Australia

10 km S of Aldersyde, E of Pingelly, Oct. 1977, T. White, 1 ♂, WAM; Boorabbin Rock (31°12'S, 120°17'E), 4-9 Oct. 1981, T.F. Houston, on flowers of *Verticordia chrysantha*, 3 ♂,

WAM: Bruce Rock, Oct. 1952, A. Douglas, 1 ♂, WAM; Busselton, 11 Feb. 1970, S.J. Curry, 1 ♂, WADA; near Emu Rock (32°27'S, 119°25'E), 53 km E of Hyden, 9-14 Oct. 1979, T.F. Houston (on flowers of *Leptospermum erubescens,* 1 ♂; on flowers of *Melaleuca microphylla,* 1 ♀; ex sleeping aggregation on *Casuarina* shrub, 14 ♂; on flowers of *M. scabra,* 1 ♀; *in copula* on heath shrub, 1 ♂, 1 ♀), WAM; Glen Eagle, 21 Nov. 1972, K.T. Richards, 1 ♀, WADA; 16 miles E of Lake Grace, 29 Sept. 1952, Key and Wallace, 1 ♀, ANIC; 'Laverton' [in error according to collector], 12 July 1967, K.T. Richards, 1 ♀, WADA; 5.5-6.6 km SW of McDermid Rock (32°01'S, 120°44'E), 27 Sept.-3 Oct. 1978, T.F. Houston *et al.* (on flowers of *Verticordia chrysantha,* 4 ♂; on flowers of *Grevillea biformis,* 1 ♀; on flowers of *Melaleuca leptospermoides,* 1 ♀), WAM; Merredin, 2 ♂, ANIC, WAM; Mt Walker School turn-off, 8 Sept. 1969, P.N. Forte, 8 ♀, WADA; Narrogin, 37-3862, 1 ♀, ANIC; Northam, Jessup Coll., 1 ♀, AM; 50 miles E of Southern Cross between no. 7 tank and no. 7 pump, 9 Oct. 1978, D. Knowles, 1 ♀, WAM; Tutanning Reserve, 18-25 km E of Pingelly, 30 Oct.-3 Nov. 1980, T.F. Houston, on flowers of *Verticordia picta,* 1 ♂, 1 ♀, WAM; Yellowdine (3.5-5.5 km S of, 27 Oct. 1978, on flowers of *Baeckea leptospermoides,* 1 ♀; 8 km S of, 22 Oct. 1974, on flowers of *Verticordia picta,* 2 ♀), T.F. Houston, WAM.

Ctenocolletes tricolor sp. nov.

Figures 6, 15, 29, 30, 43-45, 57

Ctenocolletes albomarginatus Michener, 1965: 266 (part).

Figure 57 *Ctenocolletes tricolor* male (left) and female.

Holotype

In WAM (82/128), ♂, 8 km S of Yellowdine [31°18'S, 119°39'E], Western Australia, 22 Oct. 1974, C.A. and T.F. Houston, on white flowers of *Grevillea.*

Paratypes

Western Australia

Boorabbin Rock [31°12'S, 120°17'E], 4-9 Oct. 1981, T.F. Houston, on flowers of *Melaleuca scabra,* 1 ♀, WAM; Merredin [but see Michener 1965: 266], A. Douglas, 'Paratype *Ctenocolletes albomarginata* C.D. Michener', 1 ♀ [also bears an unpublished Rayment manuscript name in the genus *Anthoglossa* meaning golden pygidium], WAM; reserve 6 km ENE of Merredin, 29 Oct. 1978, T.F. Houston, on flowers of *Grevillea paradoxa*, 1 ♂, WAM; Moorine Rock, Sept. 1952, D.L. McIntosh, 'Paratype *Ctenocolletes albomarginatus* C.D. Michener', 1 ♂, 1 ♀, ANIC; 14 km SSW of Mt Jackson (30°15'S, 119°16'E), 24 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 1 ♀, WAM; same data as for holotype, 6 ♂, WAM.

Diagnosis

Most like *C. albomarginatus* (see diagnosis for that species).

Description

Male (holotype)

Body length *c.* 18 mm; head width 5.4 mm.

Relative dimensions: HW 100; HL 80; UID 39; LID 58; MOD 8; OOD 9.5; SL 12; F1L 23; FRL *c.* 87; ML 40; MBW 12.5.

Inner margins of eyes more or less parallel, face between them much longer than wide; vertex only slightly convex viewed anteriorly and scarcely exceeding summits of eyes; labrum somewhat like that of female (Figure 15) but basal elevation smaller, occupying only one-third of its length; mandible slender with large acute posterior tooth and small blunt anterior tooth; attenuated first segment of flagellum as long as next three segments together; first recurrent vein distal to first intercubitus by two-fifths posterior length of second cubital cell; propodeal enclosure extremely small, unable to accommodate an ocellus, and narrowing posteroventrally to less than half minimum thickness of first flagellum segment; pygidial plate swollen and wrinkled anteriorly; legs lacking conspicuous modifications except for unequal fore tarsal claws (inner claw longer and modified; Figures 29, 30); hind distitarsus (excluding claws) 85% as long as distance from its insertion to base of segment 2; last visible (eighth) metasomal sternum strongly concave and bidentate apically (Figure 44).

Integument black generally, moderately shiny and non-metallic (metasomal terga are faintly iridescent). Labrum, mandibles distally, fore legs beyond and including femoral apices and pygidial plate orange-brown to red-brown.

Pubescence generally long, dense, erect and obscuring integument (except on metasomal terga). White as follows: on head posteriorly, thorax (except dark patches to be noted), propodeum, first two metasomal terga, narrow apical fringes on terga 2 and 3, sterna 1-4 (and 5 laterally), legs proximally to apices of femora, and ventral margins of hind tibiae. Rich golden hair covers face (except vertex, areas lateral to ocelli and midline of clypeus) and spreads from supraclypeal area; a weak fringe beneath labral elevation. Sooty brown to black pubescence occurs as follows: on vertex, broad band across scutum and another across scutellum and axillae, tegulae, diffuse patches posterior to pronotal tubercles, over metasomal terga 3-7 (longest on distal terga), dorsally on tibiae and over tarsi generally.

Terminalia: see Figures 43-45.

Variation: size variation appears slight, the range of head widths being 5.0-5.4 mm (n 8). Little discernible variation occurs in head form (upper interocular distance varies from 39-45% of head width). In most specimens the pale pubescence across the anterior margin of the scutum is distinctly buff and the labrum in one is almost black.

Female (paratype WAM 82/136)

Body length 19 mm; head width 6.0 mm.

Relative dimensions: HW 100; HL 78; UID 53; LID 68; MOD 8; OOD 17; SL 13; F1L 22; FRL *c.* 60; ML 48; MBW 14; C2L 22.

Head moderately broad; vertex only slightly elevated above summits of eyes and face between eyes about as broad as long; midventral margin of clypeus slightly unevenly concave; labrum (Figure 15) with basal elevation occupying about half its length; mandible slender with moderately long acute posterior tooth; attenuated first segment of flagellum as long as next 3.7 segments together; wing venation and propodeal enclosure as in male; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous, translucent and concealing mites); pygidial plate with smooth gently convex surface; mid tibial spurs relatively short and broad with 13 long coarse teeth; inner hind tibial spurs very broad with 5 and 6 long coarse teeth (plus 1 or 2 smaller ones).

Integument predominantly black and non-metallic with elevation of labrum, tibial spurs and pygidial plate orange-brown.

Pubescence of head, mesosoma and first 4 metasomal terga much as in male; fifth and sixth metasomal terga with long, very dense orange hair; metasomal sterna with long apical fringes becoming increasingly more orange from first to sixth; all tibiae with pubescence white ventrally and dark brown dorsally.

Variation: in two other paratypes mid tibial spurs have 13-15 teeth and inner hind tibial spurs 4-6 coarse teeth (plus 4 or 5 finer ones).

Distribution

Southern Western Australia, confined as far as known to an area (Figure 6) spanning only about 200 km.

Remarks

The sexes are associated on the basis of similar features of pubescence, coincident collection records and correlation of characters with those of the near species *albomarginatus.*

The specific epithet alludes to the three distinct colours of the pubescence.

Discussion

The morphological characters of the species were analysed cladistically. The closeness of *centralis* to *nicholsoni* and *albomarginatus* to *tricolor* is obvious, but the affinities of the remainder are not. A proper understanding of the species' relationships is required to form a framework for discussion of behavioural traits in a forthcoming paper. Additionally, it is useful to identify the ancestral character states of *Ctenocolletes* so that its relationship to *Stenotritus* may become clearer.

Results of the analysis are presented graphically in Figure 58. The cladogram was devised to account for the greatest number of shared, presumed derived character states as was possible. The characters utilized are listed in Table 2 with presumed derived and ancestral states (for 2 and 12 more than one derived state is recognized). One difficulty in constructing the cladogram was that only female characters for a unique type were available for *fulvescens* and discovery of the male may place it differently in the scheme.

There are several character states whose distribution amongst the species does not support the cladogram (see top of Figure 58). These states were presumed to be derived and, if this is so, their presence in unrelated species has to be attributed to parallel evolution. Alternatively, the states may be ancestral ones which have been retained in these species but lost (or modified) in their congeners. The polarity of character states or gradients was deduced initially (and in some cases very tentatively) by comparisons with the states prevailing within the genus, the family and the superfamily.

Character 1 was a difficult case. Convergence of the eyes on the vertex in males is a relatively uncommon feature in bees and was considered derived within the Apoidea. It characterizes most *Stenotritus* and all but two *Ctenocolletes* whose males are known. Consequently, it would be logical to propose that convergent male eyes is an ancestral character state of the Stenotritidae and that reversion to the ancestral apoidean state has occurred in those species with more parallel eyes. Alternatively, convergent eyes may have arisen independently in *Stenotritus* and clade D of *Ctenocolletes*.

Character 4 also posed problems. Compared with most bees, the stenotritids have a small enclosure. In *Stenotritus* and some *Ctenocolletes* the enclosure is of a fairly uniform, moderately small size (which may be an ancestral state) but in several *Ctenocolletes* it is very much smaller. Ought this tiny enclosure be regarded as derived because it culminates a trend to reduction, or should it be viewed as representing an ancestral condition in the genus with the moderate enclosures of some species representing a derived, reversionary state? Given the relationships inferred from cladistic analysis I believe it would be more parsimonious to adopt the latter view. Reversion to a moderate enclosure is suggested for clade B and (probably independently) for *fulvescens*. Otherwise it is necessary to propose that a tiny enclosure has arisen independently in *rufescens* and clades C and E.

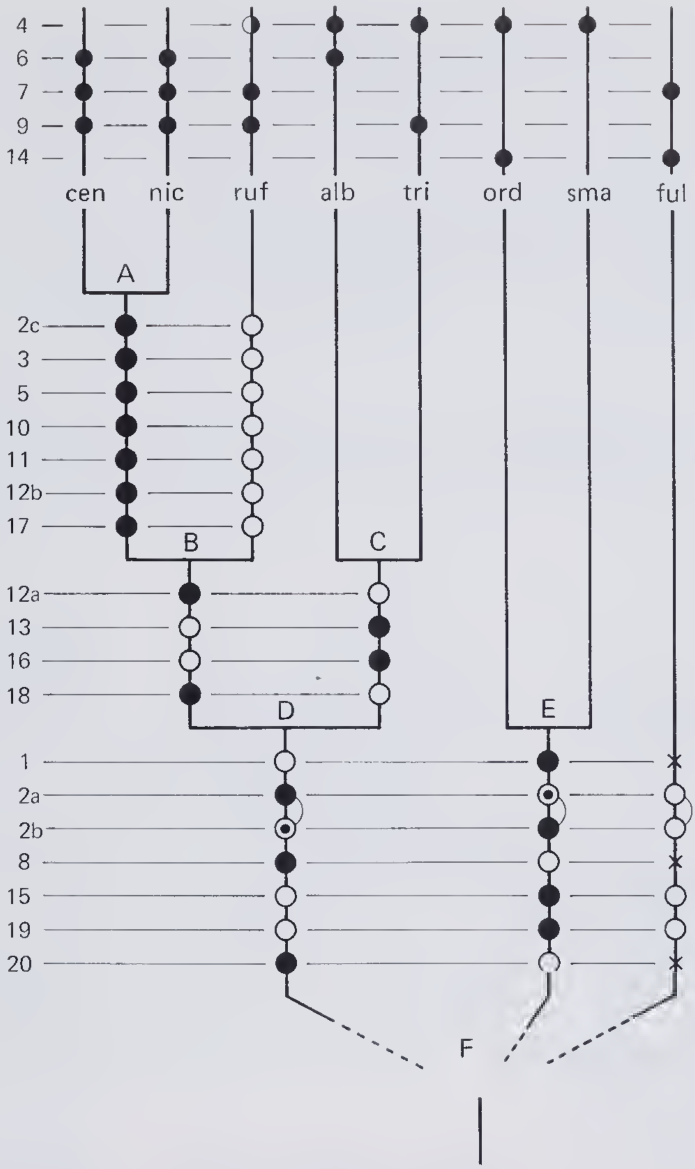


Figure 58 Cladogram showing inferred interrelationships of the species of *Ctenocolletes*. Species names are abbreviated (e.g. 'cen' = *centralis*). Solid circles represent presumed synapomorphies supporting clades above them. Open circles represent presumed ancestral states in sister groups or species. Open circles with solid centres indicate an alternative derived state (represented by solid circle linked by arc). Crosses on *fulvescens* line indicate that male character states are unknown. Solid circles at top of diagram represent presumed derived character states not supporting cladogram (half-solid circle indicates state applies only to one sex). Characters and their states may be identified by numbers on left which correlate with those of Table 2. Letters (A-F) are to facilitate discussion of particular clades.

Similarly, the lateral tergal convexities of females that often contain mites (character 6) were initially viewed as possibly synapomorphous. However, given the inferred species' relationships, I would now have to propose that either the state is ancestral for clade D and the convexities have been lost from *rufescens* and *tricolor* independently, or it was derived independently in clade A and *albomarginatus.* I remain equivocal as to these possibilities.

The ancestor of *Ctenocolletes* would presumably have exhibited most of the ancestral states listed in Table 2 (taking the first alternative where more than one is listed). As explained, doubt exists as to which states are ancestral for characters 1, 4 and 6.

Table 2 Characters for cladistic analysis. Identification of the derived and ancestral states of each character preceded cladistic analysis and the cladogram devised gives cause to review some identifications (see text for further explanation).

Character		Derived state	Ancestral state
1	Compound eyes of male	Not converging on vertex	Converging on vertex (at least in large males)
2	Ventral flange of labrum (especially in female)	(a) Longest medially, semicircular to rather triangular	(a) Short and transverse
		(b) Rather trapezoidal, ventral margin emarginate	(b) As for (a)
		(c) Rather triangular	(c) More semicircular
3	Length of first segment of flagellum of male as percent of head width	More than 30%	22-25%
4	Size of propodeal enclosure relative to an ocellus	Able to accommodate one or less	Able to accommodate more than one
5	Distance between 1st recurrent and 1st intercubital veins as fraction of posterior width of 2nd cubital cell	1/4 or less	1/3 to 1/2
6	Lateral portions of metasomal terga 3 and 4 of female	Convex, translucent to transparent, and hollow beneath (often with mites)	Even, not convex, not hollow beneath (without mites)
7	Posterior and lateral margins of metasomal terga	Transparent	Opaque
8	Apex of 8th metasomal sternum of male	With broad obtuse prominence, indented or excavated medially	With narrow prominence, neither indented nor excavated medially
9	Width of mid tibial spur of female (including teeth) as percent of length	20% or more	Less than 20%

Table 2 (continued)

Character	Derived state	Ancestral state
10 Ventral processes of fore trochanters of male	Present	Absent
11 Fore basitarsi of male	Attenuated, arcuate and expanded distally	Normal (straight and uniformly thick)
12 length of hind distitarsus of male (excluding claws) as percent of distance from its insertion to base of segment 2	(a) Less than 75% (b) Less than 60%	(a) At least 75% (b) At least 60%
13 Fore tarsal claws of male	Unequal and dissimilar	Equal and alike
14 Patches or bands of blackish setae on mesothorax (especially scutum)	Absent	Present
15 Fringes of pale pubescence across posterior margins of metasomal terga 2-5	Absent	Present
16 Colour of marginal hair bands of metasomal terga 1-4 of female	White, contrasting sharply with rufous hair of terga 5 and 6	Buff, not contrasting with but grading into rufous hair of terga 5 and 6
17 Apical plate of hind femur of female	At least half bare	At least 3/4 covered by hair
18 Hair of metasomal terga 3-6 (chiefly in male)	Mostly soft, erect and highly plumose	Mostly stiff, reflexed, simple or only slightly plumose
19 Hair of metasomal terga 5 and 6 of female	Black	Buff or rufous
20 Dorsal processes of penis valves of male compared with apical extensions	Much larger	Much smaller

Acknowledgements

I am grateful to the following people for allowing me access to the collections in their care, for assistance and for the loan of specimens: Dr C. Smithers and Mr G. Holloway (AM), Dr I. Naumann and Ms J. Cardale (ANIC) and Mr K. Richards (WADA).

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An abstract must be given, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and should be suitable for reprinting in reference periodicals. Contrary to Recommendation 23 of the International Code of Zoological Nomenclature it may include names of new taxa.

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The International System of units should be used.

Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

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Contents

RECORDS OF THE WESTERN AUSTRALIAN MUSEUM

Volume 10, Part 4, 1983

Records of the Western Australian Museum

The *Records of the Western Australian Museum (Rec. West. Aust. Mus.)* is published irregularly with up to four parts appearing each year. A series of supplements, usually devoted to recording the basic data and results of specific Museum studies, is also produced. The journal and supplements are available for sale or exchange, the current price per part being $5.00 plus postage. All but a few back issues are available and orders and enquiries should be addressed to the Bookshop, Western Australian Museum, Francis Street, Perth, W.A. 6000, Australia.

Cover The *Egmont* from a contemporary drawing. Illustrated by Jill Ruse.

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A New Species of *Ctenocolletes* (Hymenoptera: Stenotritidae)

Terry F. Houston*

Abstract

Ctenocolletes tigris sp. nov. is described from the Great Victoria Desert of Western Australia.

Introduction

The species described herein was discovered just too late for inclusion in my revision of the genus *Ctenocolletes* Cockerell (Houston 1983) in which eight species were recognized. This ninth species was discovered during a field trip to the Great Victoria Desert in September 1982. Specimens are lodged in the Western Australian Museum, Perth (WAM), and the Australian National Insect Collection, CSIRO, Canberra (ANIC).

Terminology used here is explained in my revision (l.c.).

Systematics

Family Stenotritidae

Genus *Ctenocolletes* Cockerell

Ctenocolletes tigris sp. nov.

Figures 1-10

Holotype

In WAM (82/1877), ♂, 36 km NNE of Neale Junction, Western Australia, 28°03′S, 126°02′E, 18-20 September 1982, B. Hanich and T.F. Houston, on flowers of *Dicrastylis exsuccosa*.

Paratypes

Western Australia (collected by B. Hanich and T.F. Houston, September 1982; in WAM unless stated otherwise): 37 km NE of Laverton, 28°21′S, 122°37′E, 10-12th, on flowers of *Baeckea stowardii* (1 ♂, 1 ♀, *in copula*), *Dicrastylis exsuccosa* (2 ♂), *Wehlia thryptomenoides* (3 ♂, 3 ♀), and sleeping on *Acacia* flower, 6.20 a.m. (1 ♂); same data as for holotype, 4 ♂, 4 ♀, ANIC, WAM; 65 km NNE of Neale Junction, 28°47′S, 126°07′E, 17-18th, sleeping on *Ptilotus obovatus* flower, early morning, 1 ♂; 98 km NNE of Neale Junction (28°18′S,

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Figure 1 *Ctenocolletes tigris* sp. nov.; holotype male (top) and paratype female (W
82/1872). Scale line = 1 cm.

125°49′E), 17th, on flowers of *Solanum*, 1 ♀; 4 km WSW of Tugaila Rockhole, NE of Lake Throssell, 27°10′S, 124°32′E, 13th, on flowers of *Dicrastylis exsuccosa*, 1 ♀.

Diagnosis

Differs from other *Ctenocolletes* in having light yellow, enamel-like integumental bands across metasoma, cream clypeus, finely pectinate fore tibial spur and relatively large, serrate mid tibial spur of female, and distinctive genitalia and apical metasomal sterna of male.

Description

Male (holotype)

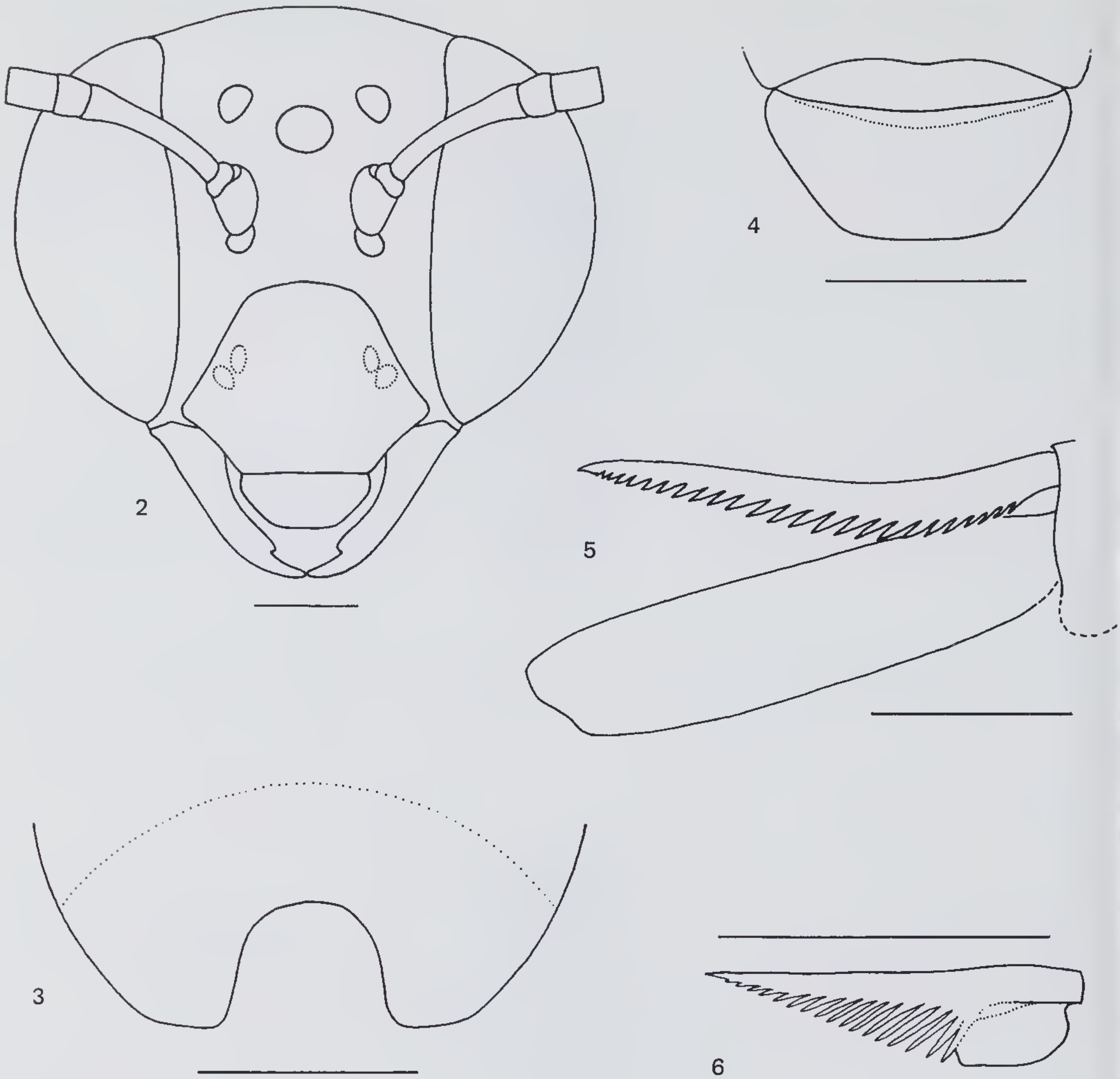
Body length 16.5 mm; head width 5.0 mm.

Relative dimensions: head width (HW) 100; head length (HL) 79; upper interocular distance (UID) 48; lower interocular distance (LID) 57; median ocellus diameter (MOD) 9; ocellocular distance (OOD) 10; scape length (SL) 12; scape width (SW) 8; length first segment of flagellum (F1L) 26; length remainder of flagellum (FRL) 90; mandible length (ML) 37; basal width of mandible (MBW) 13.

Inner margins of eyes sinuate but approximately parallel, eyes not convergent dorsally (Figure 2); vertex elevated above summits of eyes; face narrowest below level of antennal insertions; clypeus strongly convex in upper part; labrum deep as in female (Figure 4) but without a basal elevation; mandibles slender, bidentate; attenuated first segment of flagellum as long as next $3\frac{1}{3}$ segments together; first recurrent vein distal to first intercubitus by 44% of posterior length of second cubital cell; propodeal enclosure large enough to contain only one median ocellus; metasomal sternum 6 smooth, posterior margin broadly rounded except for large U-shaped median emargination (Figure 3); apex of eighth (apical) sternum acute (Figure 8); pygidial plate smooth; legs without conspicuous modifications (Figure 1); arolia well-developed; hind distitarsus (excluding claws) *c.* 90% as long as distance from its insertion to base of segment 2.

Integument black except as follows. Cream to light yellow: clypeus (except pair of brown spots each side), labrum, mandibles proximally, wide apical and lateral bands on metasomal terga 1-6 (Figure 1) and paler scalloped bands on sterna 1-6. Orange-brown: flagella ventrally, translucent tegulae, bases of wing veins, legs (except coxae and trochanters) and pygidial plate. Cream to yellow areas almost impunctate, glossy and enamel-like; remaining areas generally dull to faintly shining.

Pubescence of head (except clypeus and vertex) and mesosoma long, dense, erect, plumose and largely obscuring integument; buff dorsally (without patches of blackish setae), white elsewhere. Clypeus bare except laterally. Vertex, metasomal terga 1 and 2 and sterna 1-6 with sparser, erect plumose setae. Terga 3-6 with only sparse simple setae coloured like underlying integument; seventh with long plumose buff setae laterally.



Figures 2-6 *Ctenocolletes tigris* sp. nov. (2-3) holotype male: (2) head (anterior view); (3) 6th metasomal sternum (ventral view). (4-6) Female (anterior views): (4) labrum and mid-ventral margin of clypeus; (5) mid tibial spur and basitarsus; (6) fore tibial spur. Setation omitted. Scale lines = 1 mm.

Terminalia: see Figures 7-9; eighth metasomal sternum with very dense, plumose buff pubescence lateroapically.

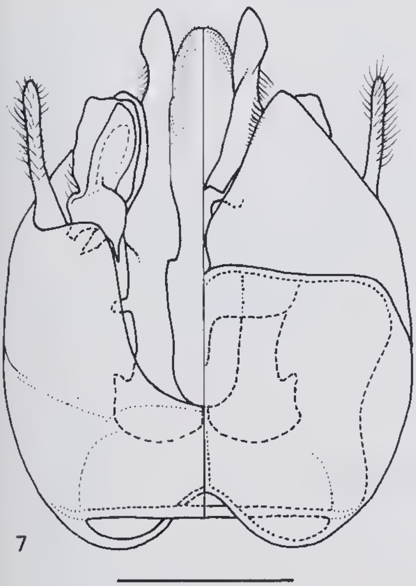
Variation: little evident. Body length 15.5-17.0 mm; head width 4.8-5.2 mm (n 13). Relative dimensions — UID 47-50, F1L 24-26, FRL 85-93, ML 33-39. Posterior margins of metasomal sterna 1 and 6 vary from wholly opaque cream to partially or wholly transparent brown. One paratype (WAM 82/1860) has abnormal metasoma with terga 4 and 5 fused medially and yellow band of former broken.

Female

Body length 16-19 mm; head width 5.5-5.9 mm (n 9).

Relative dimensions: HW 100; HL 75-78; UID 54; LID 65; MOD 8; OOD 14; SL 12; SW 7; F1L 24-25; FRL 58-62; ML 40-45; MBW 15-16; mid tibial spur length 35-40.

Head distinctly wider than long; face as wide as long between compound eyes; inner margins of eyes approximately parallel; mid ventral margin of clypeus concave (in most, weakly biconcave – Figure 4); labrum three-fifths as long as wide, its basal elevation occupying about one-third of length and flange rather trapezoidal (Figure 4); mandibles moderately slender, bidentate; attenuated first segment of flagellum as long as next 4¼ to 4½ segments together; spine of fore-tibial spur with 12-16 long fine teeth (Figure 6); mid tibial spur almost as long as mid basitarsus with 19-28 short stout teeth or serrations (Figure 5); inner hind tibial spurs with 4-6 very long coarse teeth; hind distitarsus (excluding claws) slightly longer than distance from insertion to base of segment 2; arolia absent; venation as in male; propodeal enclosure too small to accommodate a median ocellus; lateral portions of metasomal terga unmodified (not convex and hollow beneath); pygidial plate acutely triangular with an even surface.



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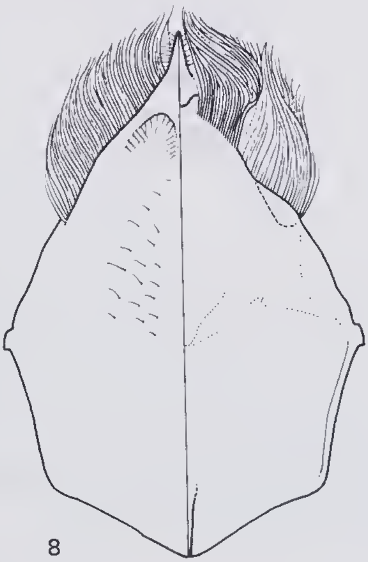

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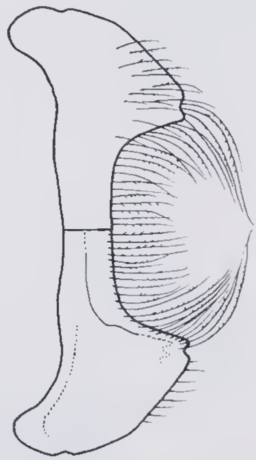

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Figures 7-9 *Ctenocolletes tigris* sp. nov.; terminalia of paratype male (WAM 82/1856) (dorsal aspect on right half of each figure, ventral on left; Figure 9 rotated 90° clockwise): (7) genital capsule; (8-9) 8th and 7th metasomal sterna, respectively. Scale line = 1 mm.

Integument generally like that of male except as follows. Labrum orange-brown; clypeus cream only medially (brown to black laterally); metasomal terga 1-4 only with yellow apical bands (Figure 1); hind margins of metasomal sterna only very narrowly cream or (in some specimens) orange-brown; legs predominantly black, only tibiae and distitarsi orange-brown.

Pubescence much as in male; clypeus bare only medially; labrum sparsely setose without a dense fringe beneath elevation; scopa (on hind tibiae and basitarsi) of long silvery white to buff setae; metasomal tergum 1 with only very sparse erect plumose setae, 2-4 with inconspicuous short simple setae, 5 and 6 with long, dense, plumose, buff setae.

Distribution

Great Victoria Desert of Western Australia (Figure 10).

Figure 10 Map of southern Western Australia showing collection localities of *Ctenocolletes tigris* sp. nov.

Remarks

The specific epithet (Latin for 'tiger' and alluding to the black and yellow banding) is used as a noun in apposition.

In my revision of *Ctenocolletes*, the interrelationships of the 8 species known then were analysed cladistically on the basis of 20 characters and a cladogram devised (Houston 1983, Table 2, Figure 58). The character states of *C. tigris* would place it with *C. ordensis* Michener and *C. smaragdinus* (Smith) in clade E of my cladogram supported by synapomorphies 1, 2b and 15 but not 19. This last is black pubescence on metasomal terga 5 and 6 of the female (not a character I would weight heavily). There is an additional synapomorphy I had earlier overlooked — absence of arolia in females (a character I would weight heavily). Within this group of three, relationships are less certain and very diverse characters are exhibited. Although *C. tigris* shares some features with *C. ordensis* (such as plain buff pubescence over dorsum of thorax, and orange-brown legs), the latter species agrees more with *C. smaragdinus* in the form of the tibial spurs of females and sixth metasomal sternum of males and the presence of black pubescence on metasomal terga 5 and 6 of females.

Reference

Houston, T.F. (1983). A revision of the bee genus *Ctenocolletes* (Hymenoptera: Stenotritidae). *Rec. West. Aust. Mus.* 10 (3): 269-306.

Received 8 December 1982 Accepted 30 December 1982 Published 30 September 1983

Rec. West. Aust. Mus. 1983, 10 (4): 315-317

A New *Ramphotyphlops* (Serpentes: Typhlopidae) from Western Australia

G.M. Storr*

Abstract

A new blind-snake, *Ramphotyphlops howi*, is described from north-west Kimberley.

Introduction

It was observed in a recent revision of *Ramphotyphlops* (Storr 1981) that in the Western Australian Museum there were only eight specimens of blind-snake from north-west Kimberley. Yet these few specimens represented five species (four of them new), which led to the expectation that several more species remained to be discovered in this region.

It was therefore no great surprise when the first specimen of blind-snake collected in the Port Warrender/Mitchell Plateau area proved to be new.

Ramphotyphlops howi sp. nov.

Figures 1 and 2

Holotype

R77226 in Western Australian Museum, collected by P. Griffin on 22 April 1982 at Walsh Point, Western Australia, in 14°34′S, 125°51′E.

Diagnosis

A dark, moderately slender blind-snake with rounded snout, 18 midbody scale rows and nasal cleft proceeding from second labial. Most like *R. guentheri* (Peters) but darker and having fewer ventrals (434 v. 525-580) and a completely divided nasal. Distinguishable from *R. micromma* Storr by its much larger eye and nasal cleft terminating lower on nasal and thus not visible from above.

Description

Total length (mm): 210. Tail length (% total length): 2.9.

Rostral (from above) oval, about one and one-third as long as wide, a little more than half as wide as head and not extending back to level of eyes. Frontal

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much smaller than prefrontal. Snout rounded in profile. Nostril inferior, much nearer to rostral than to preocular. Nasal cleft proceeding from second labial to nostril, thence curving upwards and forwards to rostral.

Midbody scales in 18 rows. Ventrals 434; scales very wide and only narrowly in contact with adjacent scales of same longitudinal row, i.e. approaching condition in *R. braminus* (Storr 1981: 270). Subcaudals 16.

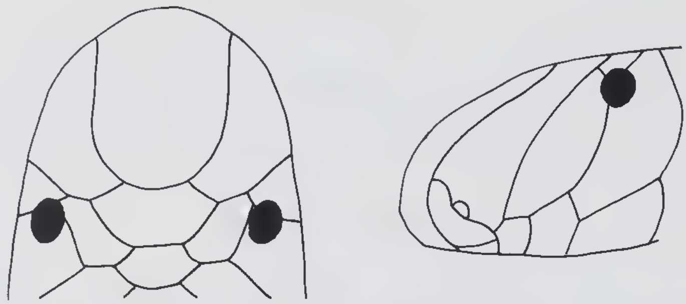

Figure 1 Head of *Ramphotyphlops howi.*

Figure 2 Holotype of *Ramphotyphlops howi*, photographed in life by P. Griffin.

Back dark brown, gradually merging with brown lower surface. Head a little darker than back. Terminal fifth of the tail still darker, i.e. blackish-brown.

Distribution

Known from one place on shore of Admiralty Gulf in subhumid north-west Kimberley. The holotype was found on damp, clayey, stony soil just before dawn.

Derivation of Name

After Dr R.A. How, head of the Museum's Department of Biological Survey.

Reference

Storr, G.M. (1981). The genus *Ramphotyphlops* (Serpentes: Typhlopidae) in Western Australia. *Rec. West. Aust. Mus.* 9: 235-271.

Received 25 May 1982 Accepted 18 February 1983 Published 30 September 1983

Rec. West. Aust. Mus. 1983, 10 (4): 319-334

The Scaddan Implement, A Re-analysis of a Probable Acheulian Handaxe Found in Western Australia

C.E. Dortch* and J.E. Glover†

Introduction

In 1949 N.B. Tindale described a bifacially flaked flint implement found in a rural district of Western Australia and interpreted it as an Aboriginal artefact (Tindale 1949). The specimen (Figures 1 and 2), known as the Scaddan implement, had been the subject of debate among several Australian scholars for a decade prior to Tindale's publication. The late H.V.V. Noone was apparently somewhat puzzled by the Scaddan implement, and in his only published reference to the specimen wrote:

> In the neighbourhood of Scaddon [*sic*], near Esperance, has been found a remarkable biface implement in flint, with unfortunately the point broken. This shows dark stained patination, and is in form and appearance strikingly similar to the Lower Paleolithic implements found in England (Noone 1943: 278).

F.D. McCarthy was not hesitant in questioning the origin of the Scaddan implement. He states:

> There is some doubt as to whether the Scaddan specimen is an Australian implement. It resembles more closely the flint *coup de poing* from Europe, examples of which, brought here by various people or in ships' ballast, have found their way into strange places in Australia. (McCarthy 1958: 178)

Our own doubts about the Scaddan implement being an Aboriginal artefact have led to the following re-analysis.

Provenance

In 1930 Mr Burney Randell donated the bifacially flaked stone implement shown in Figures 1 and 2 to the Western Australian Museum, Perth. The late Mr Randell had found the artefact during road building operations near Scaddan, a small settlement 48 km north of Esperance, Western Australia (Figure 3). The late Mr Ludwig Glauert, then Curator of the Museum, registered the specimen 'E9636'[1]

---

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[1] Specimen registration numbers referred to in the text pertain to the archaeological collection, Western Australian Museum, Perth.

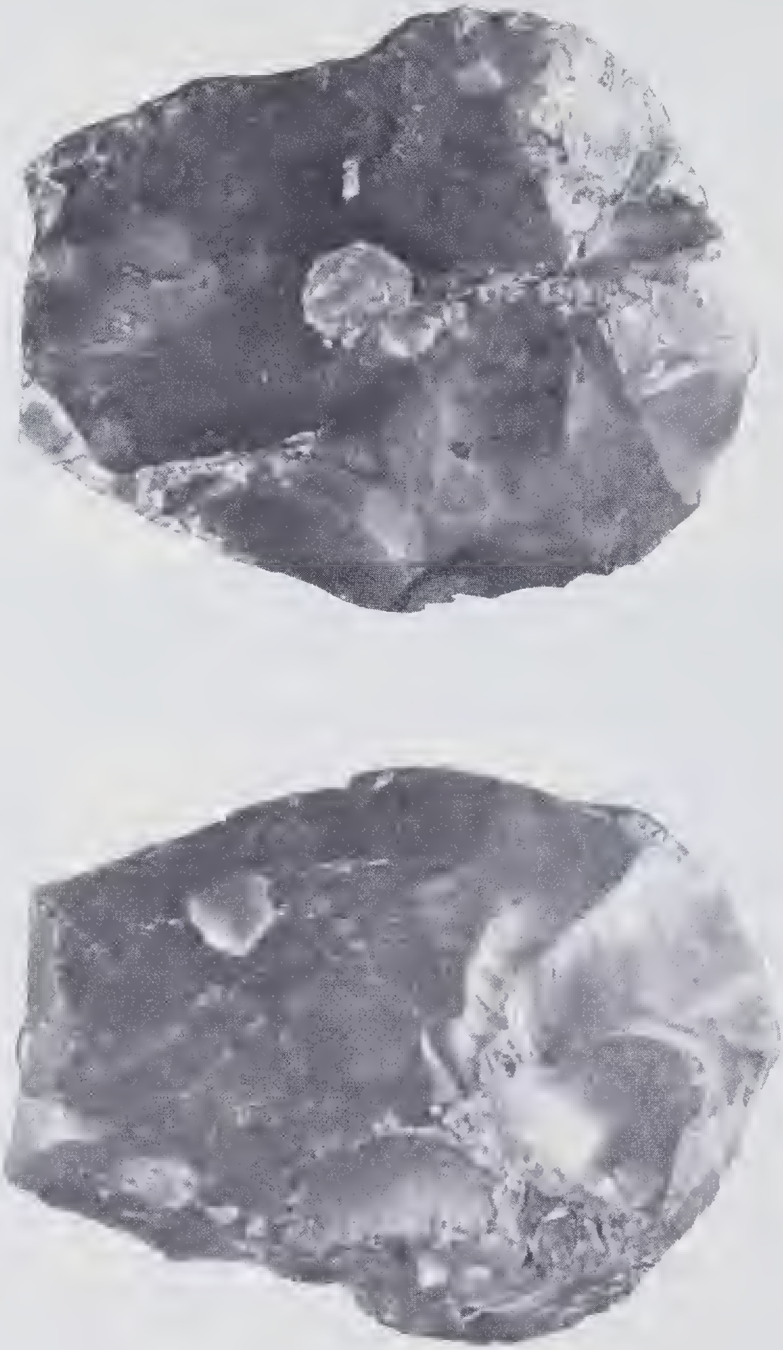

Figure 1 The Scaddan implement.

and described it as 'a chipped and used flint'. The provenance of the piece, as given in the Museum register in Glauert's handwriting, is: '30 miles NE of Esperance, behind Duke of Orleans Bay.' An original label adds the notations 'Palaeolith' and 'Scaddan dist.'. A few years later Glauert referred to the piece as the 'Scaddan Implement' in his official correspondence (W.A. Museum archives).

In April 1939, Glauert showed the specimen to Tindale in Perth, and a few weeks later Tindale visited the Scaddan area but failed to recover any similar artefacts. In his description of the Scaddan implement Tindale provides the only known description of the circumstances of the find and of the neighbourhood of the find site.

> The present biface implement from Scaddan, registered number WAM [E] 9636, was found by Mr Randall [*sic*] about 1930 during the excavation of surface soil and laterite gravel in the making of the main road from Norseman to Esperance. The actual site was on a plain 35 miles inland, north of Esperance.
>
> In 1939, with Dr J.B. Birdsell, an opportunity occurred to visit the area where this implement had been found. It proved to be on a broad, virtually treeless, laterite-gravel covered plain, extending for many miles, with only slight undulations and occasional washed out gutters, several feet in depth. These did not, however, cut through the laterite soil layers. Water was scarce in the area and no definite signs of former native occupation could be detected. One day's searching of such erosion gutters in the vicinity yielded no useful evidence. It seemed likely, however, that the yellow staining of the patinated flint, which is equally well affected on both faces of the implement, might have developed by burial in such a lateritic soil. (Tindale 1949: 164-165)

In a letter dated 16 February 1944, Glauert states:

> I have shown [the Scaddan implement] to persons interested in stone implements as it is so unlike anything previously known to us from Western Australia. To me it always brings to mind the British and French palaeolithic 'Hand-axe' or 'Boucher' and it is my opinion that it is a European object brought to Western Australia and either lost or intentionally thrown away. (Letter to H.M. Hale, Esq., W.A. Museum archives)

In the same letter Glauert concedes that the piece 'may eventually prove to be a Western Australian [specimen] which closely resembles the old European type.'

In 1971 one of us (C.E.D.) examined the Scaddan implement and concluded that it was simply a mis-labelled Acheulian handaxe, probably from south-eastern England, which had been mistakenly registered under an Australian provenance. However, after reading the above comments and descriptions of Glauert, McCarthy, Noone and Tindale, and after making inquiries which established that Mr Randell, the finder, had actually given the piece to Glauert on his return from the Esperance area, it became clear that the piece had been indeed collected at Scaddan.

Archaeological Description (C.E.D.)

The Scaddan implement is a stained, patinated, heavily abraded and invasively flaked flint biface; the extremity of its narrow end has been broken off, as indicated in Figure 2. The surface of the fractured extremity is patinated and stained, and its edges are abraded, thus showing that this is an ancient break. Small patches of cortex remaining on both faces show that the piece is made from a nodule or piece of tabular stone and not from a large flake or flaked fragment. Tindale (1949: 163) gives the tool's dimensions as follows: length 110 mm; width 83 mm; and thickness 43 mm.

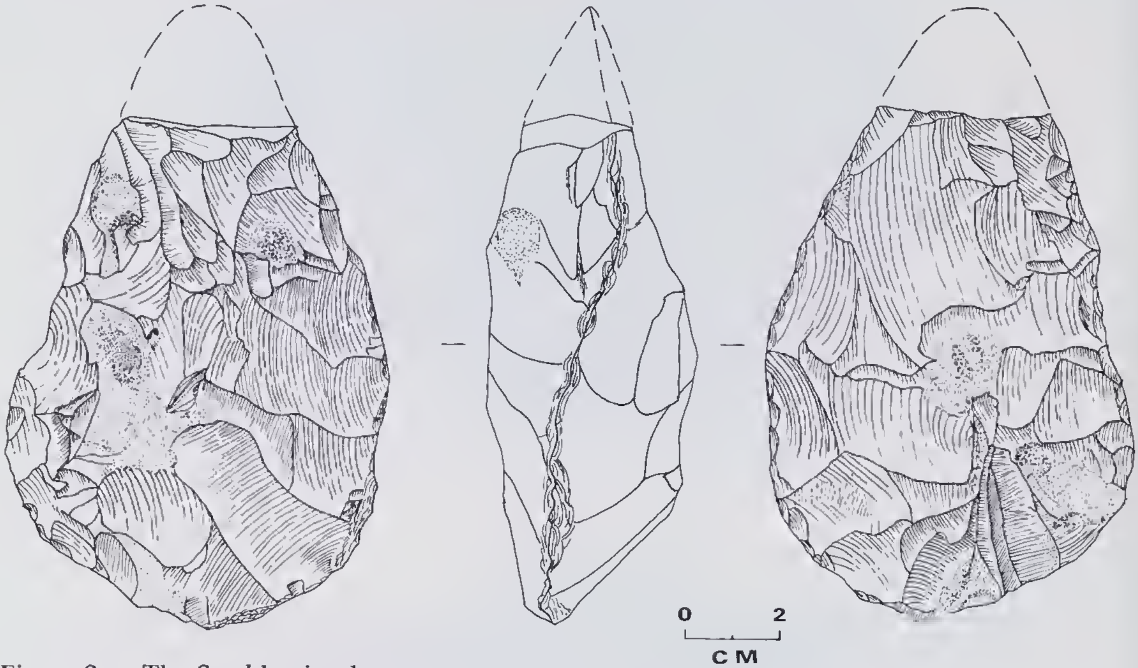

Figure 2 The Scaddan implement.

Both faces of the piece are very largely covered with invasive flake scars. Most of these are shallow, including some which are elongated. Flake scars of this kind are typical of those produced by direct percussion using a 'soft' hammer of bone or antler (Bordes 1961: 8; Newcomer 1971: 88-90). There are some smaller flake scars along the edges which were produced deliberately to shape and straighten the edges. One edge (Figure 2) is very clearly in the form of the 'inverted S' described by Wymer for Thames valley Palaeolithic handaxes (Wymer 1968: 56), and the other edge is slightly curved towards the upper end.

Both edges are largely obliterated by small, relatively deep and overlapping flake scars typical of the natural edge damage resulting from abrasion or battering by transported material in rapidly flowing water. These scars are in part obscured by marked rounding and grinding which again is typical of the damage found on stream abraded stone artefacts (Shackley 1974; Wymer 1968). This damage extends over most of both edges; on parts of the edges of the broken narrow extremity; and on many of the ridges between the flake scars on both faces. In places the abraded surfaces are as much as 3 mm wide, and thus according to

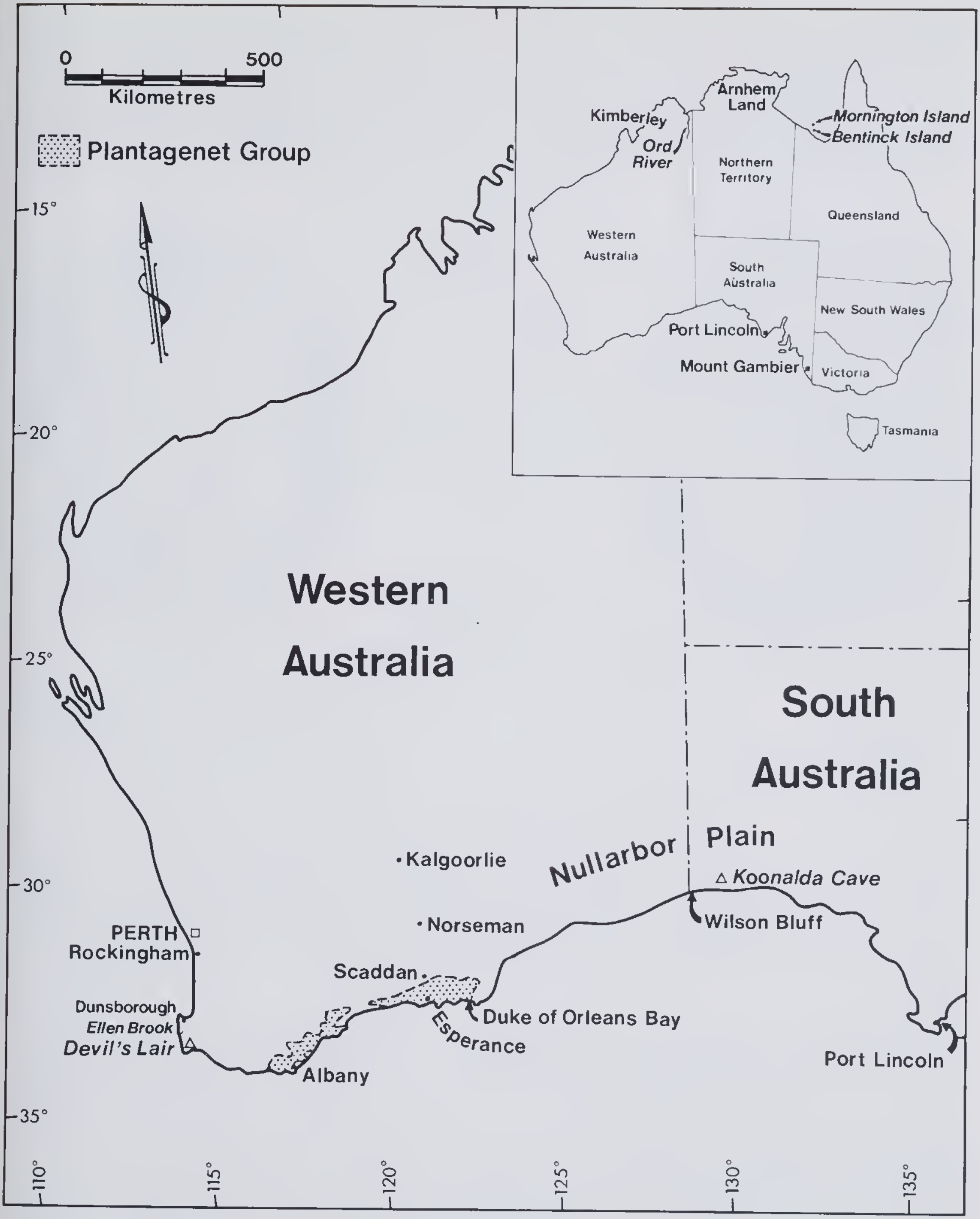

Figure 3 Map showing localities mentioned in the text.

Shackley's classification (1974: Table 1), the piece can be described as heavily abraded.

The heavily abraded condition of this piece is anomalous for the Scaddan district, where there is no water source of sufficient velocity to produce abrasion to the degree noted above. With the exception of wave action on sea beaches there is no source of high velocity water flow along the whole of the south coast of Western Australia, a distance of some 1300 km; and there seem to be no relict Quaternary high velocity stream channels in this region. Therefore, unless it had been abraded on a local beach, the Scaddan implement must be introduced.

There is a hairline crack extending for 30 mm on one face of the Scaddan implement (left end, upper view, Figure 1). Such cracks are commonly found on English Palaeolithic handaxes, and Wymer (1968: 16) attributes them to frost action. If this hairline crack results from frost it would suggest that the piece had been subjected to temperatures very much colder than those at Scaddan, where at present frost is rare and never severe (*Western Australian Year Book* 1973). However past climates in the area may have been sufficiently cold to produce hairline cracks in flint.

Typologically this specimen can be most conveniently described in terms of classifications based largely on the outline shapes of English or French Palaeolithic handaxes (cf. Bordes 1961; Roe 1968; Wymer 1968). A firm classification is not possible as the specimen is incomplete, and because it is an isolated find (cf. Roe 1975: 2). However if the implement had been found in a Thames valley Palaeolithic site it could be classified under Wymer's 1968 scheme as a type 'G' (sub-cordate) or a type 'J' (cordate). In either case the piece would receive the subletter 'f' because of the inverted S-twist on one edge (Wymer 1968: 55-60).

Using Roe's (1968) multi-variate analysis of English Lower and Middle Palaeolithic handaxes, the Scaddan implement can be placed tentatively within the 'ovate tradition' in which some pointed forms occur. Following Bordes' study of European Palaeolithic handaxes (Bordes 1961: Figures 8 and 9) the piece could be described as 'cordiform'. The above provisional classifications help support the view that the Scaddan implement, both stylistically and typologically, is very similar to evolved Acheulian handaxes from southern England (Roe 1968; Wymer 1968).

Although it is distinctive, the Scaddan implement is not the only bifacially flaked large implement from south-western Australia. Recently there have been found two other bifaces, one from Dunsborough (Figure 4; Glover *et al.* 1978), and another from Ellen Brook, 40 km to the south (Figure 5). Both these pieces are unequivocally south-western in origin, since they are made of Eocene bryozoan chert thought to have been quarried by Aborigines from outcrops on the continental shelf which are now submerged by post-glacial sea level rise (see below). These pieces do not resemble Palaeolithic handaxes, but they do show that south-western Aborigines did make bifaces, if only rarely. Both implements are from sites where there are rich chert assemblages thought to be Middle Holocene to late Pleistocene in age (Bindon and Dortch 1982; Ferguson 1980). No other evidence for bifacial flaking is known from other chert or flint assemblages from Devil's Lair, Quininup Brook, Koonalda Cave or a number of other late Pleistocene to early Holocene sites in the South-West, the south coast, or the Nullarbor Plain (cf. Dortch 1979; Ferguson 1981; Wright 1971).

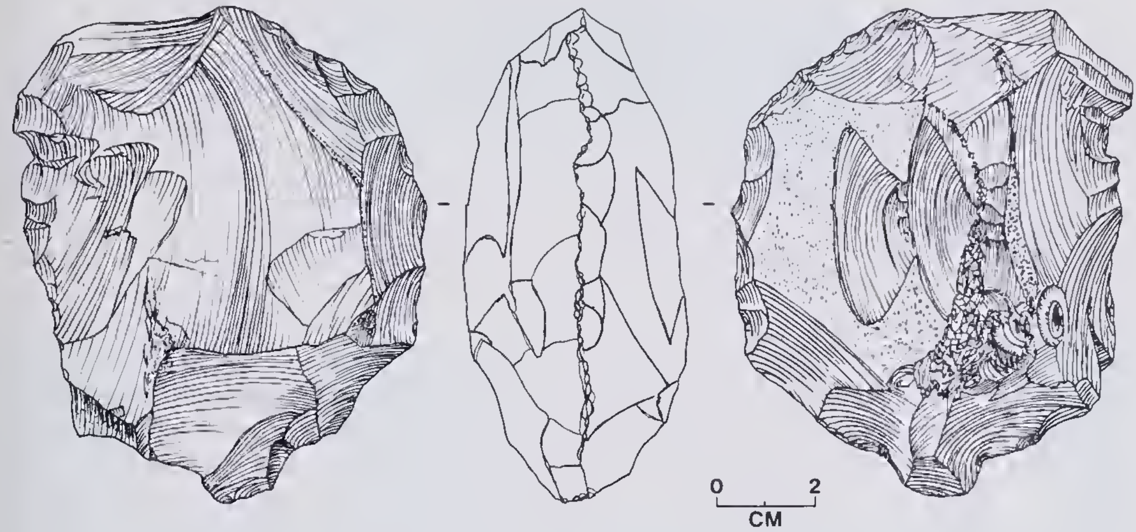

Figure 4 The Dunsborough implement.

Geological Implications (J.E.G.)

Geological Setting of the Scaddan Implement

Western Australian geological units near the south coast which yield flint for artefacts comprise the Late Eocene Plantagenet Group around and west of Esperance (Figure 3) and the Middle and Late Eocene Wilson Bluff Limestone, which extends along coastal cliffs from South Australia about 400 km westward, and is also exposed in caves in the Nullarbor Plain. Playford *et al.* (1975) outline the geology of the area. Some 200 km north of Esperance, near Norseman, the Late Eocene Norseman Limestone is also locally silicified. English flints used for Palaeolithic handaxes, on the other hand, were nodules or tabular pieces from Cretaceous chalk (Wymer 1968: 14). Thus, if the age of the Scaddan implement could be determined from its fossils, the problem of its provenance would be greatly clarified. Unfortunately, as described below, the fossils are too altered for precise determination, and the less definitive factors of surface staining, patination, mineralogy and texture must be used.

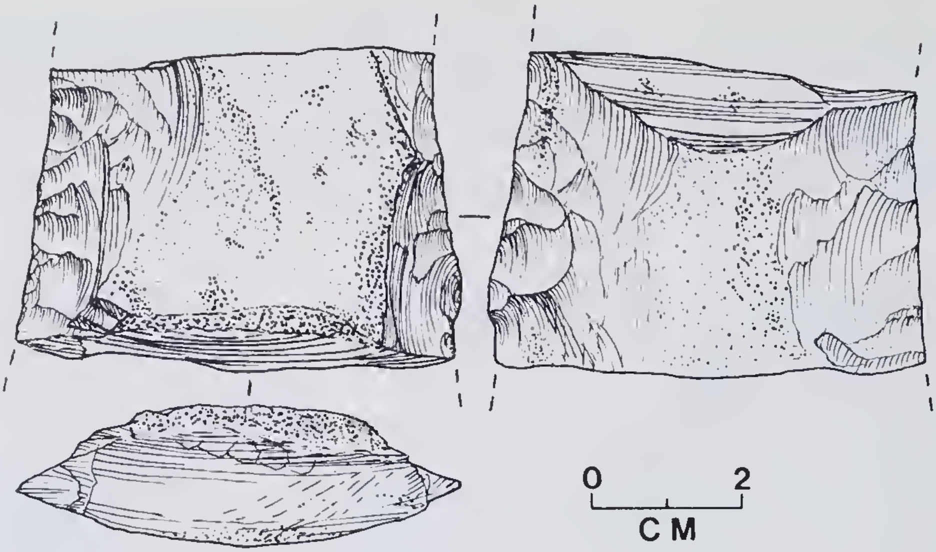

Figure 5 The Ellen Brook biface.

Chert and Flint: A Problem of Terms

There is confusion in the use of the terms chert and flint. Petrologists, who define rocks from their chemistry, mineralogy and texture, use the term chert for dense rocks composed of one or more forms of silica, namely, opal, cryptocrystalline and microcrystalline quartz, and chalcedony (a fibrous form of quartz). Chert commonly forms by silicification of sedimentary rock, frequently limestone, as can be demonstrated by field relationships, and by contained relicts of originally non-siliceous fossils. Chert can also form as a primary rock, by chemical precipitation. The term flint is recognized by most petrologists as a synonym for chert that should be dropped, or at best, reserved for chert used in artefacts (e.g. Pettijohn 1975: 394). To some archaeologists the term chert has a different meaning; for example Bray and Trump (1973: 57) define chert as poor quality flint. The term flint, which is widely used and understood by archaeologists, and is synonymous with chert as defined by the petrologists, will be retained here. All flint described in this paper contains microfossils, and appears to be formed by secondary silicification of sedimentary rocks that were at least partly calcareous.

Patina and Stain

The surface of flint bodies is commonly described in terms of patination and staining (e.g. Wymer 1968: 16). When alkaline water passes over the surface of a flint object it begins to dissolve individual grains of the fine-grained siliceous aggregate, reducing their size and thus leaving minute spaces between them (see Schmalz 1960). The resultant, modified, slightly porous aggregate scatters light more than the dense, unaltered flint within the body, and produces a distinct white or bluish-white envelope or patina around the darker core. Patination may proceed to a depth of over 1 mm, but commonly forms a far thinner skin. It can affect the original surface of a flint nodule, or naturally or artificially flaked surfaces. Stains, on the other hand, are produced by deposition of colouring agents, commonly iron oxide or manganese oxide. Staining solutions easily penetrate patinas because of their porosity, and the stain on patinated flint may therefore extend well below the surface.

Petrology and Palaeontology of the Scaddan Implement

The surface of the Scaddan implement is locally rather polished and shiny, and ranges, because of staining, from light brown (5 YR 5/6) through dark yellowish-brown (10 YR 4/2) and dark yellowish-orange (10 YR 6/6) to yellowish-grey (5 Y 7/2).[2] The surface in places contains crescentic marks up to 1 mm in diameter, which appear to be shell shards that are not especially obvious in thin section of the fresh rock, but which have been accentuated on the stained and patinated surface. There are also several greyish, dull, circular, rather bulbous areas about 1 cm in diameter on the surface. Sectioning shows that the interior of the rock is aphanitic and medium grey (N 5), but that parts of it consist of well-defined irregularly shaped bulbous masses commonly about 1 cm in diameter, of aphanitic, pinkish-grey (5 YR 8/1) material. These may account for the bulbous surface areas. Sectioning also shows that a patina of about 0.1 mm thick has absorbed some of the stains which colour the surface. Staining and patination prevent translucency in hand-specimen, even on the sharp edges of the cuts made for thin section analysis.

Microscopic examination reveals that both the medium grey and pinkish-grey material in the core are cryptocrystalline silica (i.e. with a mean grain-size $<$ 0.01 mm in diameter). The medium grey material is clear in thin section whereas the pinkish-grey material is cloudy, and contains abundant clay-sized impurities. Fossils are found throughout. They consist of spicules, rare globigerinid foraminifera, shell shards, and material of uncertain affinities. There are traces of probable dinoflagellates, but upon extraction they proved too altered for satisfactory determination.

Table 1

	Na	K	Li	Fe	Ca	Mg	Al	P
Scaddan implement	402	199	4.3	375	301	18	251	58
Dunsborough implement	520	380	4.1	1065	99	69	640	24

Analytical data for the Scaddan implement, and for the Dunsborough implement which is described below, are presented in Table 1 (P analysed by inductively coupled plasma spectrometry, Li by flame emission spectrophotometry, other elements by atomic absorption spectrophotometry, figures in ppm).

[2] Colours and symbols refer to the Rock-color Chart (Rock-color Chart Committee 1963).

Comparison of the Scaddan Implement with English Handaxes

The Scaddan implement was compared with an Acheulian handaxe from Taplow, Buckinghamshire, England (A5608) and one from Maidenhead, Berkshire, England (A5603). The three are similar in external and internal colouration, but the patination of the Maidenhead specimen is less pronounced than that of the other two. The Maidenhead handaxe also contains a portion composed of radiating chalcedony, not evident in the others, but no significant distinction can be made between the three, petrologically or palaeontologically. Analytical data were compared with those presented for British and European flint by Sieveking *et al.* 1972, but the results appear to be inconclusive.

Comparison with the Flint from the Esperance Area

Flakes (artefacts) have been collected from sites within 30 km of Esperance and are doubtless derived from the Plantagenet Group. They fall into two main categories:

1. The first category contains flakes ranging in surface colour mainly from greyish-orange (10 YR 7/4) to very light grey (N 8) and white (N 9). These flakes are composed of dull opal and clear, rather translucent chalcedony. Microscopically, the chalcedony shows up as flaring aggregates with opal commonly exhibiting colloform texture. Microfossils are poorly preserved. This flint is mineralogically and texturally quite distinct from the flint of the Scaddan implement.
2. The second category contains flakes that are composed of clear cryptocrystalline silica, and range from greyish-red (10 R 4/2) and moderate yellowish-brown (10 YR 5/4), to light grey (N 7). They thus resemble the surface of the Scaddan implement in colour, but their colouration persists, fairly uniformly, throughout the flakes. There is no patination, and thin portions are moderately translucent. There are in places small patches of a white chalcedonic skin, but these appear to represent portions of the original surfaces of the nodules or beds from which they were struck. Under the microscope, small dusty aggregates of clay-sized impurity, indeterminate fossil remains (probably globigerinid foraminifera), possible pelletal material, and angular grains of quartz sand and silt are present in the cryptocrystalline siliceous base. The differences between the flint of these flakes and that of the Scaddan implement suggest that they come from different flint formations, but it is not possible to make a significant distinction between them.

Comparison with Flint from Artefact Scatters

140 km east of Norseman

These flakes (A22038) are very like the second category just described from Esperance. They are composed essentially of cryptocrystalline silica and contain vaguely defined microfossils, palimpsests of possible calcareous pellets, and angular grains of quartz silt. No patination was observed, and surface colouration persists throughout. It is not certain which formation yielded the material, and it may have been derived either from silicified Norseman Limestone, or from rocks of the Plantagenet Group.

Comparison with Flint from Wilson Bluff Limestone

The flakes which were collected from Wilson Bluff (B998) range from white (N 9) through shades of pale grey to light brownish-grey (5 YR 6/1). Flake scars lack patination, but a few areas which seem to represent natural surfaces of the nodule from which the flakes were struck, have a white (N 9) or pinkish-grey (5 YR 8/1) patina of cryptocrystalline quartz up to 0.5 mm thick. Under the microscope it can be seen that the flint is composed essentially of cryptocrystalline silica, and contains abundant, well-defined, siliceous bryozoa. This flint seems to belong to a different formation to that of the Scaddan implement.

Comparison with the Dunsborough Implement

The Dunsborough implement (Figure 4) which was recovered from the small resort of that name on Geographe Bay about 200 km south of Perth, has been described in detail (Glover *et al.* 1978). The implement ranges from medium bluish-grey (5 GY 6/1) and yellowish-grey (5 Y 7/2), and is rimmed locally by a bluish-white (5 B 9/1). patina. In thin section, it can be seen to consist essentially of silicified bryozoa and foraminifera in a matrix of cryptocrystalline silica. Texturally, the Dunsborough implement seems to fit within the considerable range exhibited by flint artefacts from the Perth basin. It differs from the Scaddan implement in colour and in containing more and better preserved skeletal material.

There is no doubt that the Dunsborough implement originates in the Southern Hemisphere for it contains a microflora probably of Early or Middle Eocene age that includes *Nothofagidites* sp. and *Haloragicidites harrissii.* The surface colouration, texture, size and general morphology of the implement place it within the range of biface variation known from European Palaeolithic assemblages, but stylistically it does not closely resemble any of the classic forms of Acheulian or Mousterian handaxes from north-western Europe.

The geological formation from which the Dunsborough implement is likely to have been derived was probably exposed west of the present west coast before the Flandrian transgression. If so, its provenance will have been far to the west of the provenances of Western Australian flints described above, and its geological history will have been different. There are no chemical analyses of artefacts known to have originated in the Albany-Wilson Bluff area with which the data of the Scaddan and Dunsborough implements can be compared.

Summary

Petrographic comparisons show that the raw material of the Scaddan implement resembles English flint, but petrography does not supply a sufficient basis for

ruling out an origin in south-western Australia. Unlike the Dunsborough implement and some flakes from the Perth Basin (Glover 1975), the Scaddan handaxe has not yielded diagnostic fossils. However, the mineral staining on this specimen is very similar to the distinctive and varied ochreous hues found on the Thames valley handaxes, and its patination resembles that found on many European Palaeolithic implements (cf. Wymer 1968).

Discussion

Typological and technological considerations, and various surface features suggest that the Scaddan implement is English in origin, and the petrology accords with the hypothesis. If it is English, there are two basic ways in which the specimen could have come to Australia, both of which have been suggested by McCarthy (1958: 178). Firstly, the piece could have been brought by an English settler between *c.* 1870 and the 1920s. Secondly, it could have been carried to Australia in flint ballast loaded in the lower Thames valley or another part of southern England during the 19th century.

For the first alternative it is significant that many English emigrants came to Western Australia during the 1920s, some decades after English Palaeolithic implements had become common collectors' items in England (Wymer 1968). Many emigrants settled on farms north of Esperance, and the Scaddan implement may simply be a lost specimen or curio which had belonged to one of these people. The piece may even have been deliberately left in a place where it was likely to be discovered, but we do not think that a hoax is more likely than a purely accidental set of circumstances leading to its discovery.

The idea of ballast origin is attractive. McCarthy (1958: 178) implies that flint implements have more than once been dumped with ballast in Australia; and Tindale (pers. comm., N.B. Tindale) states that flint tools have been recovered from 'Thames gravel' ballast at Port Lincoln, South Australia (Figure 3). Dumps of English ballast are also known from Rockingham, and from Hamelin Bay, near Devil's Lair, but no flint implements have been reported from them. Unfortunately, we know of no flint ballast at Esperance, the nearest port to Scaddan.

There are several ways in which an implement carried in ballast could have been transported inland. Large pebbles and cobbles are uncommon in some south-western coastal areas, and on occasion ballast stones have been used as road and railway filling. Conceivably local quartzite cobbles used in surfacing the Esperance-Kalgoorlie road in the vicinity of Scaddan were supplemented by flint ballast brought from the port. If so, the Scaddan implement could have been brought there in a load of road surfacing material and was subsequently discovered during road improvements.

Another feasible origin may be connected with the use of English flint pebbles in the processing of gold ore in the Kalgoorlie area during the 1890s (pers. comm.,

D. Hutchison). Although the origin of these pebbles is obscure it is likely that they were brought from ballast dumps on the coast. There was a great deal of traffic between Esperance and Kalgoorlie during the 1890s gold rush, and it is plausible that English flint pebbles, intended for the Kalgoorlie mills, were for some reason lost or dumped at Scaddan, and that the Scaddan implement was among them. Or someone, perhaps an Aborigine, may have found the Scaddan implement at an ore mill site or in a ballast dump at one of the ports and then taken it to Scaddan.

No choice can be made at present between the alternatives listed above. It is significant, however, that there are several ways in which a European Palaeolithic implement could have reached Scaddan.

Our evidence corroborates the opinions of earlier workers that the Scaddan implement is likely to be of European origin. Nevertheless, Tindale's interpretation (Tindale 1949) of Aboriginal origin was clearly not unreasonable. Large, bifacially flaked, stone artefacts are distributed all over mainland Australia. Most of these pieces are edge-ground axes, whose working edges have been shaped by bifacial grinding. Many others are unground axe rough-outs or blanks, and often these were important trade items carried over long distances (e.g. Binns and McBryde 1972; Mulvaney 1976). Blanks for edge-ground axes and other large bifaces stylistically reminiscent of Acheulian or Mousterian handaxes are uncommon or rare, though they occasionally do occur in assemblages in widely separated regions. The best documented concentration of large, invasively flaked flint bifaces on the Australian continent is found in south-eastern South Australia and western Victoria. Tindale (1941) designated these assemblages the 'Gambieran' industry, after nearby Mt Gambier, South Australia. Illustrations of selected bifaces from this district (Mitchell 1949: Figures 32, 33; Stapleton 1945: Figures 1, 10, 11) show them to be very similar to Palaeolithic handaxes, as noted by these two authors, and by others (McCarthy 1940: 30-33; Mulvaney 1961: 71-72; Tindale 1941: 145, 165).

The regional stone industries of Kimberley and parts of the Northern Territory also contain a series of bifacially flaked spear points, including occasional rough-outs resembling Palaeolithic handaxes. McCarthy (1976: Figure 8) illustrates several bifaces from the Barkly Tableland, N.T. and north-western Queensland which are similar to small Mousterian handaxes.

A unique example of an ethnographic or modern Australian biface which bears a striking resemblance to an Acheulian handaxe comes from Rosewood Station in the Ord Valley, east Kimberley (Figure 3). This specimen (Figure 6) was made on 10 September 1972 by a craftsman of the Miriwung tribe, and collected by one of us (C.E.D.). The Miriwung man made this artefact in about two minutes using a river pebble weighing approximately 0.7 kg as a hammerstone. The production of this piece was entirely unsolicited, and it is most unlikely that the craftsman had ever seen any illustrations or specimens of Acheulian handaxes. Designated by its maker as a multi-purpose axe or hatchet (and termed *menindhelang* in the Miriwung language), the piece is a most impressive example of the recurrence of a stone tool form through time. Had it been intended for use this implement would have been hafted, and presumably would have had a cutting edge made by grinding on both faces of its broad end. However it is made of ferruginous siltstone, an inferior rock seldom or never used as the material for edge-ground axes, which are typically made of fine-grained igneous rock, or of quartzite. Other rough-outs or blanks for Australian edge-ground axes or for spear points resemble Palaeolithic handaxes, though not generally to the degree seen in this piece from east Kimberley.

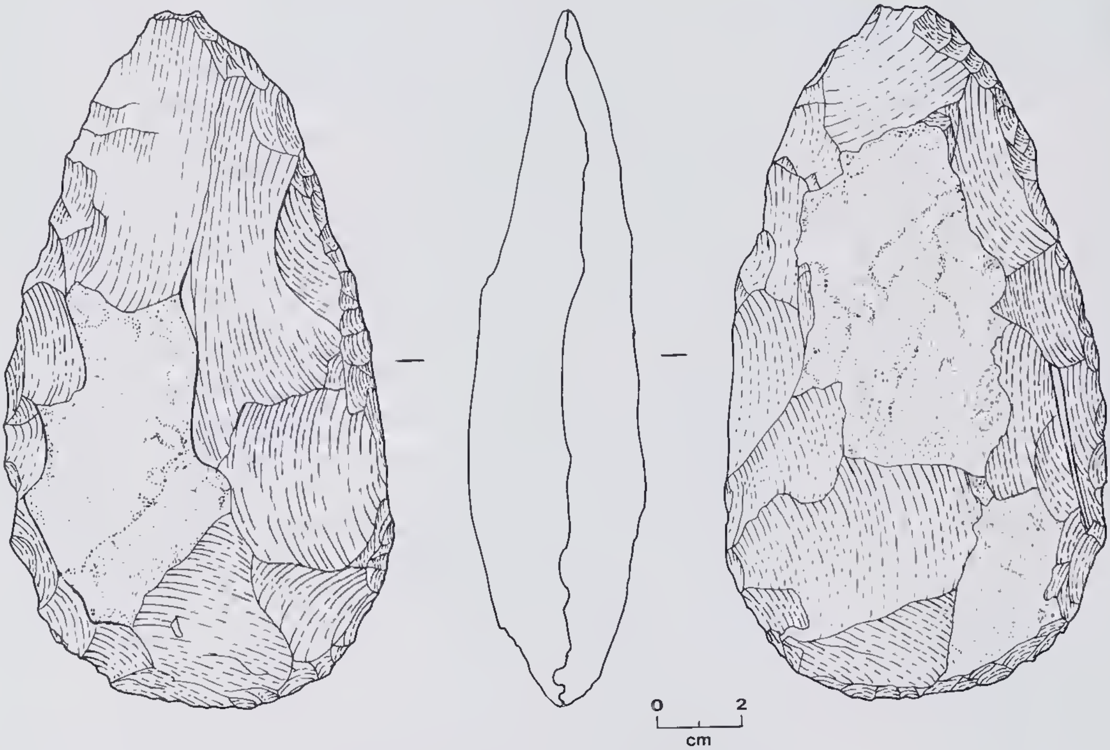

Figure 6 Modern Australian biface, Rosewood Station, Kimberley.

Tindale obtained functional data for a kind of crude tool resembling a Lower Palaeolithic biface which was still being made a few decades ago on Bentinck and Mornington Islands in the Gulf of Carpentaria (Figure 3). This tool, described as being of 'crude biface form' (Tindale 1949: 161), and as a 'bifacial fist axe' (Tindale 1977: 26) is called *tjilangand* by its Kaiadilt makers. Tindale observed that these handaxes were used for heavy woodworking and, in the case of old specimens, 'may serve for hammering oysters off rocks.' (1977: 260). He also notes that in woodworking the *tjilangand* fist axe tends to be used by pushing the cutting edge away from the user, rather than drawing it towards him. Brief though they are, Tindale's observations are probably the most relevant ethnographic data recorded anywhere for suggesting the function of Lower or Middle Palaeolithic handaxes.

It is clear then that large, bifacially flaked tools, sometimes closely resembling Palaeolithic handaxes, are an integral part of Australian material culture, both archaeological and ethnographic. At the same time European Palaeolithic implements have occasionally, in F.D. McCarthy's words, 'found their way into strange places in Australia.'

The evidence for the origin of the Scaddan implement is not conclusive, but its typology and style, technique of manufacture, heavily abraded condition, colouration, patina and petrography accord well with an origin in Europe, and less well with an Australian origin. We have shown, moreover, how the artefact could have been brought to Scaddan, in one of several ways, from England. The Scaddan implement is therefore probably an English Acheulian handaxe.

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Shipwrecks in Jervoise Bay

Mike McCarthy*

Introduction

Jervoise Bay, south of Fremantle, Western Australia (Figure 1) is a well known graveyard of ships and appears to have been used as such from 1890 to 1910.

The bay was not the only graveyard in use at that time. At least four hulks were sunk in Careening Bay, the *Dato, Day Dawn,* the Careening Bay Unidentified and possibly the emigrant ship *Rockingham.* The iron hulk *Conference* was scuttled on a reef 32 km north of Fremantle, and the remains of an iron or part iron framed vessel lie just south of the Marmion Angling Club (possibly the hulk *Lalla*). After 1910, with few exceptions, all redundant hulks and barges were dumped in the deep water graveyard south-west of Rottnest Island. *The Beaches, Fishing Ground and Sea Routes Protection Act,* 1932 formalized that *de facto* arrangement and the post World War II period saw numerous war surplus vessels, submersibles, flying boats, hulks and barges scuttled in the designated area.

Jervoise Bay itself was named after Captain Jervoise of H.M.S. *Success,* and first came into prominence in 1829 with Thomas Peel's unsuccessful attempts to start a township at Clarence just south of Woodman Point.[1]

The *Rockingham,* Peel's third emigrant ship, appears to have been the first casualty in Jervoise Bay and apparently drove ashore in May 1830 at Clarence after breaking her capstan during a heavy storm. Her armament of four guns was apparently thrown overboard and these appear likely to still remain in the bay, having been recorded six months later as being sunk in the sand at Clarence. The *Rockingham* was later refloated and the settlers soon drifted away from what proved to be an ill-founded venture. The proposed township of Clarence was soon forgotten.[2]

In 1912, preliminary work began on the building of the proposed Henderson Naval Base at Jervoise Bay. This base was to include facilities for 26 warships with docks, workshops, refuelling facilities, ammunition and explosive storage, wharfs, breakwaters, anti-aircraft stations and medical facilities. These plans were shelved, however, with the advent of World War I and were later abandoned. Jervoise Bay then went through another relatively quiet period with only two shipwrecks, the *Abemama* in 1927 and *Alacrity* in 1931. The arrival in 1964 of the Underwater Explorers Club (U.E.C.) heralded another era in Jervoise Bay with the club's base on the southern shore of Woodman Point being a focal point for the new

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Figure 1 A map of the Fremantle area showing Jervoise Bay.

breed of diving adventurers and historians. These hardy souls literally crawled over every inch of the bay in the late 1960s and first reported the existence of eight wrecks in the course of their searches and underwater activities.[3] The U.E.C. were followed in 1971 by small ship-building companies who built their facilities almost on the site of old Clarence itself. More recently, in the late 1970s, the oil drilling rig *Ocean Endeavour* was built in a specially dredged basin at the top of the bay. The success of this venture heralded the events which led indirectly to the funding of this study, as it became apparent that the bay with its calm water, vacant shoreline and proximity to both Fremantle and the heavy industry of Kwinana, was an ideal site for further development.

Before these new developments began, however, environmental impact studies were commissioned and a grant of $2,000 was made to the Western Australian Museum to fund a study of the wrecks in the bay and ascertain which, if any, were worthy of preservation. This grant from the Department of Conservation and Environment enabled the Museum to allocate one staff member (the author) to commence on-site and archival work using members of the Maritime Archaeological Association of Western Australia (M.A.A.W.A.) as voluntary field and archival assistants.

The project commenced in November 1978 with six major aims:

1 to locate all the wrecks in the bay;
2 inspect and evaluate each site;
3 identify each site from the research and physical remains;
4 produce reports to be submitted to the relevant authorities;
5 preserve those worthwhile sites by the best means possible;
6 report on the overall project.

The project was completed in August 1979 with preliminary reports presented including a submission to the Environmental Protection Authority in which the Museum outlined its policy on the future treatment and/or preservation of the wrecks in the bay.[4]

The Known Wrecks at the Commencement of the Study

At the commencement of the study in November 1978 the known wrecks in the bay were:

Wreck 1 a submarine believed to be the *K XI*;
Wreck 2 the twin-screw steamer *Alacrity*, blown ashore in 1931;
Wreck 3 the three-masted wooden schooner *Abemama*, blown ashore in 1927;
Wreck 4 a scattered wooden wreck believed to be the *Gemma*, beached in 1893;
Wreck 5 a site believed to be one or both the iron ex-sailing vessels *Conference* and *Herschell*;
Wreck 6 a site thought by many to be rubbish or a modern iron-framed barge or boat launching cradle;

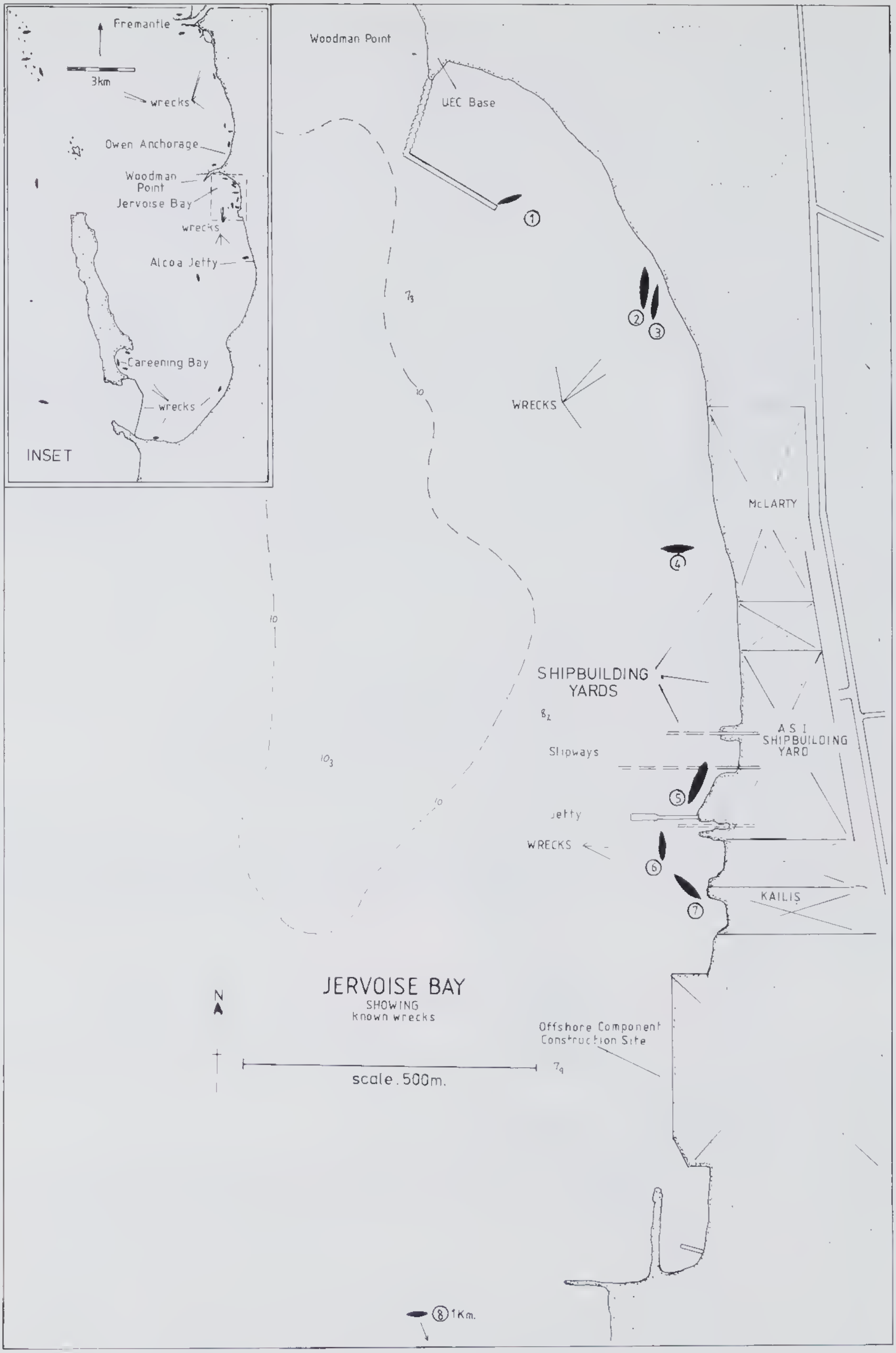

Figure 2 Jervoise Bay showing the endangered sites.

Wreck 7 a wooden wreck under a large ballast mound, possibly the hulk *Redemptora*;

Wreck 8 a small wooden wreck near the Alcoa Jetty.

The Search for Wrecks

An underwater search for known sites was conducted on weekends by volunteers from the M.A.A.W.A.[5] This search was conducted on a 150 m wide strip running along the shores of the bay, there being little likelihood of a vessel being wrecked or scuttled in the deeper water. Aerial photographs were also studied and all but two of the known wrecksites were seen as distinct outlines or as changes in the appearance of the sea floor. Despite an extensive search, the M.A.A.W.A. found only the eight wrecks previously known and all lay within 60 m of the shore on a sand bottom and in depths between 2 and 5 m of water. Seven of the sites lay in the area of proposed development and were therefore seen to be at risk.

Archival Research and Site Analysis

At the conclusion of the archival search, only two of the eight sites (*Abemama* and *Alacrity*) were positively identified with at least 13 vessels remaining as possibilities for the other six sites. Of these 13, one wreck (*Gemma*) was recorded as having been scuttled in the bay itself and two others (*Ellen* and *Camilla*) were recorded as having been abandoned in the area but not specifically in the bay.

In an attempt to match the archival evidence with the physical remains, each individual site was then photographed and measured for length and breadth. Plans were drawn and site conditions assessed, physical features were noted and samples of fastenings and timbers taken for analysis. Identification of each site was then attempted by comparing the physical evidence with information from archival and other sources. Each wrecksite was approached in a manner consistent with its position, characteristics and content. The techniques used in identifying and assessing each site are varied and become evident in the following site analysis. In cases where sites (e.g. Wrecks 4, 6 and 8) could not be conclusively identified, the details of all vessels possibly constituting that site are given with reasons (if any) for considering any one ship the most likely of those considered as possibilities.

Wreck 1: The Submarine *K VIII*

Submarine *K VIII* details:

Launched at Flushing 15 September 1922

Dimensions	:	64.1 m x 5.6 m, draught 4.1 m
Displacement	:	520/715 tons and 583/810 tons full load
Engines	:	Two 2-stroke MAN diesels of 1400 hp
		Two electro-motors total 630 hp twin screw
Speed	:	15 knots surface and 8 knots under water

Armament	:	One 12.7 mm machine gun, four 45 cm torpedo tubes, 6 torpedoes, 1 x 8.8 cm gun
Wrecked	:	1943

According to the records of the Naval Historical Department of the Royal Netherlands Navy, H.M.N.S. *K VIII* sailed for the Netherlands Indies in 1923 with *K II* and *K VII* and in 1926 voyaged with the *K II, K VII* and *K XI* to Manila, the Philippines and back. The vessel was held in reserve in Surabaya at the outbreak of war with Japan in 1941. She was recommissioned in 1942 and after a number of patrols, left Surabaya for Fremantle arriving on 17 March 1942. On arrival, she was not considered of value as an operational unit and was de-commissioned on 8 May 1942 and then sold for scrap in August 1942. She was eventually abandoned in 1943 in Jervoise Bay after being partially stripped. Her 220 V, 2200 amp main electro-motor was rcmoved at that time and until recently was used to supply DC power to ships on the main Fremantle slipway.

Her conning tower was also removed and fitted to the pilot boat *Lady Forrest,* to be removed when that vessel was put on display at the Fremantle Museum. In 1957, a decision was made to remove the wreck and salvage diver T. Sullivan and his crew destroyed the submarine with explosives in that year. According to the diary kept by Mr Sullivan, the remaining sections were dragged ashore or lifted on to a barge and sold for scrap.

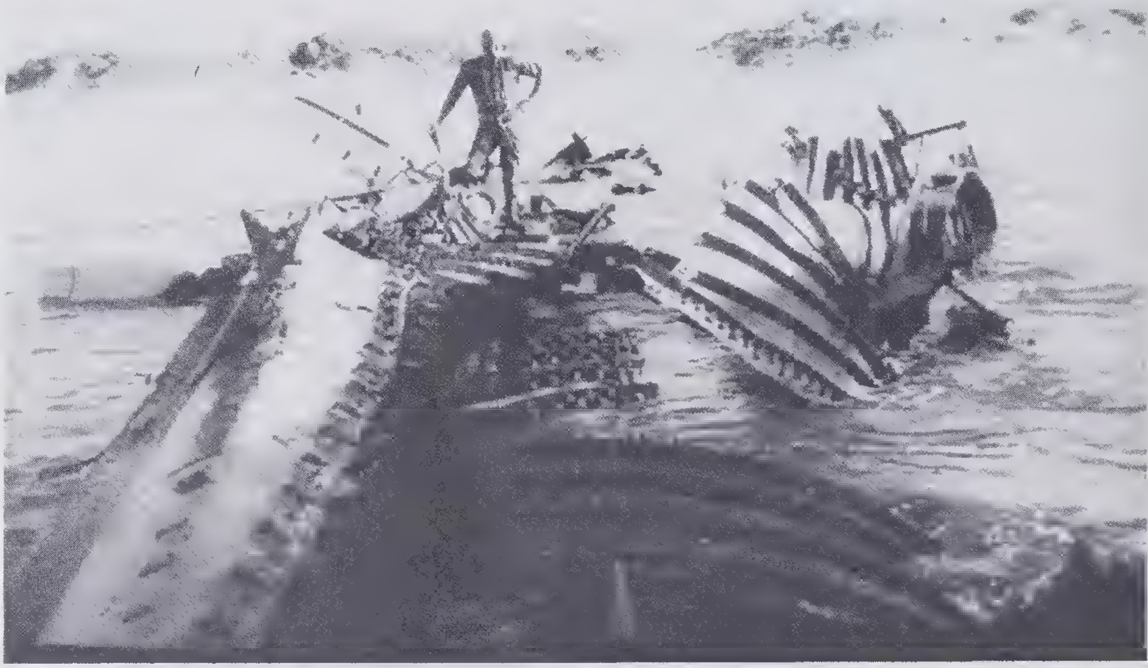

Figure 3 *K VIII* in the early stages of demolition. Sullivan Collection.

Figure 4 The bow of *K 8*. Sullivan Collection.

Figure 5 The *K XI* being salvaged after sinking in Fremantle harbour. Photo: Mrs Sweetman.

There was initially some confusion with the *K VIII* and the *K XI* (another Dutch submarine) as both vessels were dismantled at Fremantle and many local people believed that the Jervoise Bay wreck was the *K XI*. The *K XI* was in fact scuttled in 1946 at the Rottnest Graveyard in latitude 32°04′S, longitude 115°22′E.[6] A comparison of the bow of the Jervoise Bay wreck and that of the *K XI* shows that the two vessels were substantially different. The salvor's diary, contemporary photographs and a comparison of these with naval records, notably *Janes Fighting Ships,* proves the issue beyond doubt.[7]

Figure 6 Silhouettes from *Janes Fighting Ships* showing *K XI* and *K VIII.*

The wrecksite is little more than an unrecognizable spread of twisted metal over an area of 61 m x 10 m. The only relatively intact section is a portion of double hull measuring 10 m x 5 m. The wreck lies on an east-west axis in about 7 m of water and has little to offer archaeologically or visually. The photographic and historical record that has been prepared is considered all that is now left of value to the public in general and to the diving fraternity. Excavation of the site was not considered to be a useful exercise due to the extent of demolition work and the scant remains.

Wreck 2: *Alacrity*

Moving south, the next wreck is that of the *Alacrity.*

Alacrity (ex *Jean Bart*)

Official number	:	07685
Construction	:	Steel, twin-screw, two decks, tug
Dimensions	:	Length 145.6 ft (44.4 m), beam 27.1 ft (8.3 m), depth 13.5 ft (4.1 m)
Tonnage	:	353 tons gross, 349 tons underdeck, 32 tons net
Rig	:	Rigged as a ketch. Top speed 12 knots
Built	:	1893 by the Societe Anonyme des Forges et Chartiers de la Mediterranee, at Havre, France
Engines	:	Two triple expansion engines each with cylinders of 15 in. (32.1 cm), 23 in. (58.4 cm) and 35½ in. (90.17 cm)

		diameter with a stroke of 23½ in. (59.7 cm) developing 122 hp.
Wrecked	:	April/May 1931[8]

Figure 7 The *Alacrity*. Richard McKenna Collection.

Purchased by Howard Smith and Co. of Melbourne, the *Alacrity* first appears in the Fremantle Shipping Register in 1902. The vessel was then acquired by the Department of Naval Works and was used during World War I as an unarmed patrol vessel in the Indian Ocean and as a tug in Fremantle Harbour. She stayed with the Navy and in 1919 was involved in the transport of Admiral Lord Jellico in his inspection of Cockburn Sound as a potential naval base. She was involved in the preparation of the Jervoise Bay area for the Henderson Naval Base and was thus employed when all further work on the base was abandoned.[9]

Responsibility for the disposal of the Henderson Naval Base plant ashore and afloat was vested in the Minister for Works and Railways who referred the question of the disposal of *Alacrity* to Cabinet. They decided that the vessel be submitted for sale by auction on 16 December 1925, together with surplus dredging equipment.

She was bought by A.E. Tilley and Co. and in 1931 was sold to the wrecking firm of J.E. Hall, Machinery and Metal Merchants of Fremantle. A short time later in April or May of that year, the *Alacrity* broke away from her mooring and drifted ashore to where she now lies.

The wrecksite measures 44 m x 10 m and lies in about 3 m of water, 50 m from shore on a north/south axis. In contrast to earlier years only a small portion of the wreck breaks the surface and the majority of the hull beyond the turn of the bilge has collapsed. The site was a favourite haunt of young children and beach-goers till the dredging undertaken for the construction of the oil rig *Ocean Endeavour* undermined the site and caused the shoreline changes that have now left the wreck about 50 m out to sea.

Figure 8 The *Alacrity* during dredging activity. Photo: Jon Carpenter.

In comparison with the earlier years the wreck is no longer a visual or recreational attraction to shorebound visitors. There is little of value on the site due to its accessibility, though it is an interesting and relatively safe wreck for the diver in calm conditions with an offshore breeze.

A series of photographs of the vessel when operational, laid-up and ashore has been prepared along with a selection of underwater slides and photographs.

Detailed measurement of the site appears of little value due to the spread of collapsed material, and the extensive hull corrosion.

A number of items have been earmarked for recovery and possible display.

Wreck 3: *Abemama*

The next wreck south is that of the *Abemama* and though this site lies only about 8 m to the east of the *Alacrity* and slightly south, it was often totally covered with a protective layer of sand (see Figures 8, 12).

Figure 9 The *Abemama* at anchor — the vessel in the background is the *Alacrity*. Photo: Mrs A. McGhie.

Details of the *Abemama* are as follows:

Official number	:	138200
Construction	:	Wood. Iron fastened. Single deck. Poop and deck houses, eliptical stern, carvel plank
Dimensions	:	Length 133.6 ft (40.7 m) x beam 32.6 ft (9.9 m) x depth 12.2 ft (3.7 m)
Tonnage	:	395 tons (gross), 317 tons (under deck), 337 tons (nett)
Rig	:	Three-masted schooner
Built	:	Liverpool, Novia Scotia by the S.B. and Transportation Company in 1918.
Wrecked	:	27 June 1927[10]

History

In 1919 she was registered in Liverpool, Nova Scotia. Her owner was Yu Wing of Sydney, New South Wales. She was then purchased by the Patrick Steamship Company and in 1920 was registered under that company's name in Auckland, New Zealand.

She worked the Eastern States trade and gradually deteriorated, leaving the trade in 1923. She was recorded by the Albany harbour master in that year as arriving in a sorry state:

> Schooner *Abemama* from Newcastle in distress with a loss of sails, sundries on deck and leaking.[11]

Following repairs, she set sail for Fremantle and was registered there in 1924, her owner being G. Atkins of Adelaide. She plied between Point Cloates and Fremantle under a new owner and master and was sold in 1926 to the Abemama Shipping Co. of Perth. She was later involved in the construction of the Beadon Point Jetty. By 1927 she was idle and lay at North Wharf for several months. Later she was moved to an anchorage near the *Alacrity* in Jervoise Bay and the vessel placed in the care of Mr and Mrs A. McGhie.

Mrs McGhie described the loss of the *Abemama* thus:

> We spent some months living on a sailing ship called the *Abemama* which was used in the construction of jetties in the N.W. Australia. Early in the year 1927, the ship was moved to an anchorage in Cockburn Sound where the Kwinana Refinery is now. We were moored to a ten inch link chain, put down by the navy. Everything was fine, we were very happy, Arnold looking after the boat and keeping up repairs.
>
> Suddenly, on the 17 June, a terrible storm came up and we had a terrible day of rain and squalls. I was alarmed, but true to a sailor's tradition, my husband assured me that ships were human and they would not hurt anyone.
>
> As dusk drew near the weather got worse. My husband said, 'Hughie (the wind), if you want to put us on the beach do it before dark.' After scanning the area of the storm he came to me and said he could see a break in the weather and only one more squall to go through — if we could get through that one we would be safe; but if we should go, it would only touch bottom and roll over. I was quite satisfied and thought he knew best. He put an anchor at the ready to let go quickly if the worst should happen. It was nearly 7 p.m. and I looked up to the sky praying as I did, and saw two stars shining so brightly, and said to my husband how lovely they looked, he said, 'yes, they are our lucky stars — one for you and one for me!' Then suddenly the squall broke in an 80 mile an hour gale and with a loud report the anchor chain snapped. Arnold said, 'My God! She has gone.' and rushed up to the front deck to let the anchor go to keep the ship's head into the gale so that it would not turn over.
>
> I went to the side of the ship and just then saw sparks go over the side — I thought it was my husband, with a cigarette, gone overboard. I called to him, but the din and waves lashing us in all their fury prevented him from hearing me. In terror I thought I would jump over to be with him, when, to my relief, he came back from the front deck. Just then the ship thudded on the bottom and a terrible sick feeling came over me; the ship was being terribly pounded. I said I was afraid, and it was terrible. Arnold reassured me that all was well and that every bump we got put us nearer the beach. He was so calm and never once let me see he was worried. One sign from him would have been fatal for me as I knew he understood the ship and sea.
>
> He was trying to let off distress signals, but could not manage it with the ship pounding and seas breaking over us. In the mean-time, I thought of the fire in the galley — so took two pieces of wood out of the stove to prevent fire spreading on ship; and in trying to throw them into the water I was dashed against the side and burnt my fingers. I spent a terrible time being thrown around the deck from side to side (which was about 50 feet). I looked and felt like a half-drowned rat. Then I managed to grasp an iron ring on the deck (used to lash timber down) and I just swung around on this — almost dying of thirst as I seemed to open my mouth as the waves came over and swallowed salt water. Arnold came along and said he thought we would be safe on board until morning. Looking at the sea and the angry waves along the shore, I said I was too frightened to leave and too frightened to stay.

> Then the rigging came off the mast (112 ft high) and my husband realising the danger of it crashing, said we must leave the ship. I was shivering with fright – not cold. He poured 5 gallons of oil on the water over the side, then placed a planking stage and a rope ladder for me to climb over to jump into the 12 ft dinghy as it was lowered. I put my burnt fingers onto the top rung of the ladder then my weight on same and all the skin came off my fingers, but I never felt any pain. I was beyond that and all fear left me then, as I had quite made up my mind that we would die together. I jumped into the boat, my husband sliding down the rope that lowered it, then cut the same. Then we seemed to go right under the ship, but after a desperate struggle with the waves my husband got near the shore and jumped out and pulled me and the boat full of water as near to the sandhills as possible (into about 2 feet of water).
>
> The sandhills were so steep I could not climb up, so I waded a little way and came to a crack in the hills and climbed up to safety. I fell over in the heavy sand, but I knew I had to keep going till I reached the light-house – about a mile away. All the time I was struggling along I was listening to hear the mast crash. I am certain if it had I would have died on the spot, so great was my fear. When I got to the light-house all I could say was 'Water!' – I was desperate for water. They knew what happened and the men went to the boat. I was still shivering with fright and begging for water, but the lady of the house thought only to get me dry and a hot drink. You will never know what that first drink of water meant to me. I stayed the night at the light-house and my husband walked the nine miles to Fremantle. Next morning the police helped us such a lot to get a few clothes as I was in borrowed ones.
>
> All the fresh water in the ship had got salty. My husband had to stay on the shipwreck for some weeks dismantling same. I would not leave him so stayed on board. The pounding of waves and the bumping of the boat kept us from sleeping. So I managed to persuade Arnold to take our beds up into the sandhills for one night, however, it poured with rain and back we went. I was finally forced to leave the ship and live in town.
>
> This deed of calm efficient seamanship was the means of saving two lives as five months later we had a little daughter.[12]

A few weeks later 'vandals' were reported to have set fire to the wreck and she was totally destroyed (Figures 11a and b).

The Site

The site itself is quite extensive, though as one would expect contains little other than constructional items. The wreck had been preserved under a layer of sand until the recent shoreline changes that resulted in the collapse of the *Alacrity* served to completely expose the *Abemama* for study and photography. It now lies in about 2 m of water, 30 m from shore.

An underwater excavation of the site was not necessary in view of the undermining caused by the storms and dredging and though this has been of great assistance for this study, the wreck may gradually disintegrate as it is no longer protected by the sand or the hull of the *Alacrity*.

The site lies on a similar though slightly converging axis to the *Alacrity*. There is about 8 m separating the two wrecks at the closest point. At one time the

Figure 10 The *Abemama* ashore. Sawday Collection.

Figure 11(a), (b) The burnt-out remains of the *Abemama* showing exposed deck supports. Photos: Mrs McGhie wrecks were even closer as evidenced by earlier photographs and one appears to have moved over the years.

A photomosaic and photographic elevation of the wreck has been completed and it is evident that the ship lies on its port side and that this side has been preserved to about the turn of the bilge and beyond by the sand cover. There is little of display value on the wreck excepting rigging and constructional fittings.

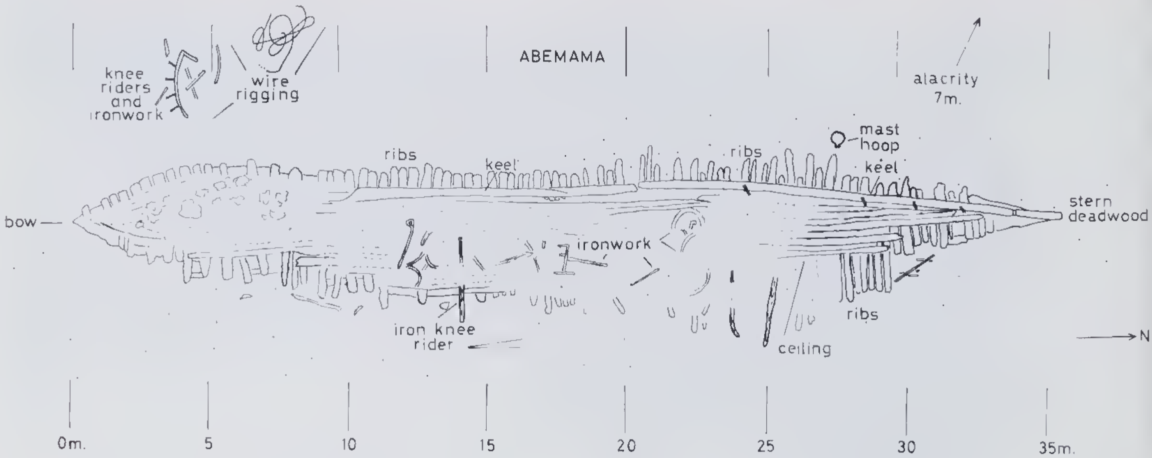

Figure 12 The *Abemama* wrecksite.

Some of the vessel's log books are housed at the Battye Library and the interview with Mrs McGhie was recorded. A collection of photographs has been assembled from Mrs McGhie's and other collections.

The wreck is of value from an educational point of view, as the *Abemama* is the only easily accessible and safe wooden sailing shipwreck available for study in the metropolitan area. She is one of the last sailing ships to be wrecked on this coast and represents a late stage in North American sailing ship construction. Indeed, the whole *Alacrity/Abemama* complex is a valuable recreational and educational asset. The site has been used by students in the Post Graduate Diploma course in Maritime Archaeology at the Western Australian Institute of Technology as a major field practical, and numerous project reports have been filed at the Western Australian Museum.

Wreck 4: *?Ellen*

The next wrecksite south is what was formerly known as the *Redemptora,* and then later the *Gemma* site, and as such was the subject of an extensive survey by an Underwater Explorers Club team under the late Mike Pollard. Mr Pollard produced a model of the site in 1971 and a comparison of this three-dimensional representation and Figure 13 below emphasises the extent of the further disintegration in the eight-year period.

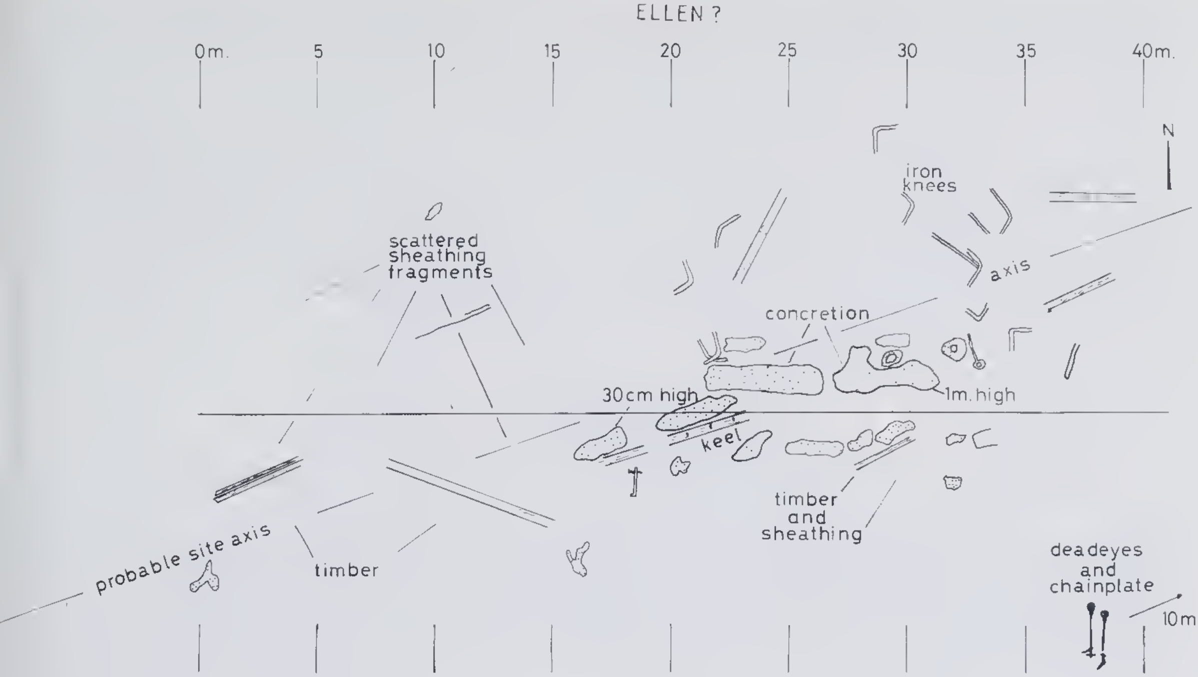

Figure 13 The *?Ellen* site.

The wrecksite is very scattered and as it lies in *c.* 2.5 m of water, within the wave line, is subject to a moderate swell in winter storms. As to be expected of an easily accessible hulk, the site is quite sterile though there are some constructional fittings in the sand over-burden. Random excavation using a small 10 cm diameter airlift, connected to the hookah unit was undertaken in an unsuccessful attempt to find solid hull structure amongst the few scattered timbers remaining. Despite this, enough information on the site was collected to show that the wreck was built of wood, was fastened with iron and yellow metal and had some iron deck knees. The presence of further fittings in the vicinity of the wreck is evidenced by the complete sets of dead-eyes and chain plates found just off the shore. A keel bolt diameter of 1 inch (2.54 cm) and keel size of 12 inches (30 cm) square indicates a vessel of 300-350 tons with an indeterminate length due to the wreckage spread.[13]

Various timber samples were taken and submitted to the Commonwealth Scientific and Industrial Research Organization (CSIRO) for analysis and proved to be:

Treenail	*Pinus ponderosa* (western North America)
Unknown	*Pinus resinosa* – Red or Norway Pine (eastern North America)
Keel	*Pseudotsuga menziesii* – Douglas Fir (western North America)
?Keel	*Betula* sp. – Birch (common to Europe and America)
?Keel	*Betula* sp. – Birch (common to Europe and America)
?Keelson	*Betula* sp. – Birch (common to Europe and America)[14]

Apart from the treenail, an identification of each timber as a specific constructional unit was difficult and they are, therefore, labelled as unknown or with a query. Indications are, however, of an American-built vessel.

The timber sample therefore tends to eliminate the *Gemma* which was known to have been beached in the bay but was German built. There was substantial trade in timber from America to Europe, however, and though this complicates the issue it is unlikely that all the timbers including the treenail would have been imported and the wreck, therefore, is most likely that of an American-built vessel.

The remains of seven American-built vessels lie in close proximity to Fremantle. Four of those wrecks have to date been identified, i.e.

Day Dawn	ex-whaler *Thomas Nye, c.* 1886
Alex T. Brown	American four-masted schooner, 1917
Abemama	American three-masted schooner, 1927
Redemptora	An American-built vessel of 1,235 tons wrecked between 1890-1910

Three others, *Harrison, Annie Lisle* and *Ellen* await identification, with only the *Ellen, Abemama* and *Redemptora* as known losses in the Jervoise Bay area.

It appears likely then that the wrecksite is that of the *Ellen,* being the only medium-sized North American-built vessel apart from the *Abemama* known to have been recorded as lost or abandoned in the area (*Redemptora,* as will be seen, is too large). The timbers used in the *Ellen* match those of the sample with one major exception, the presence of Douglas fir in the sample and tamarack (larch) on the *Ellen.* This anomaly cannot be totally discounted however, as the other two American-built hulks, the *Annie Lisle* and *Harrison* are yet to be identified. Their details are as follows:

Annie Lisle

Official number	:	52359
Construction	:	Wood, part iron bolts, single deck, round stern, felt and yellow metal sheathed.
Dimensions	:	139.9 ft (42.6 m) x 26.3 ft (8.0 m) x 12.72 ft (3.8 m)
Tonnage	:	347.42 tons gross, 297.73 tons net
Rig	:	Three-masted barque
Built	:	1865 by P.G. Labbee of Quebec, Canada
Scuttled	:	Unknown[15]

Her early history is not known though she is recorded as transferred to London in 1865 and sold to Captain W. Hayes for coastal trading in that year. In 1887, she was badly damaged in a collision with S.S. *Australind* and she was sold at auction for £42 with her gear fetching £98. In 1889 she is referred to as a hulk coming up from Rockingham with sand ballast for another vessel. In 1891 she is recorded as unfit to carry perishables and thereby being forced to carry iron and coal only. She is mentioned in 1910 as a local wreck but the date and place of abandonment is not reported.[16] Her figurehead was found on Rottnest Island after her collision in 1887 and is now on display at the Port Adelaide Nautical Museum.

Harrison

Construction	:	Wood
Dimensions	:	Unknown
Tonnage	:	348 tons
Rig	:	Three-masted schooner
Built	:	Probably U.S.A.
Registered	:	U.S.A.
Crew	:	Nine. Master H. Godfrey
Scuttled	:	Unknown[17]

She arrived in Fremantle on 12 January 1877 from Adelaide with a general cargo, left in ballast for Bunbury and arrived back in March of that year with timber and in a leaking condition. After survey in Careening Bay she was condemned and converted into a hulk. She was replaced by the *Egmont* in 1892 and then presumably disposed of by scuttling.

Ellen

Official number	:	35550
Construction	:	Iron and yellow metal fastenings, timbers of birch, tamarack and red pine, wood hull with part iron bolts, square stern.
Dimensions	:	105.0 ft (32 m) x 24.9 ft (7.5 m) x 13.2 ft (4.0 m)
Tonnage	:	242.61 tons gross, 229.29 tons net
Rig	:	Brig
Built	:	1857 at Bathurst, New Brunswick as No. 15 of 1857. Registered at the Port of Miramichi. Owner (64 shares) J. Meahan, a shipbuilder of Bathurst.
Owners	:	1861, Anderson (registered Liverpool); 1870, Marshall and Lilly (registered Melbourne); 1883, Adelaide Steamship Company.
Scuttled	:	18 March 1890[18]

She was built on speculation and her registry was transferred in 1857 to Liverpool, England and then to Newcastle, New South Wales. In 1874 she was involved in the coastal trade and is reported at Rockingham taking on a cargo of jarrah for Melbourne after discharging coal. It appears she continued in the same trade as she is reported arriving in Albany in 1878 with coals from Melbourne. In that same year she left Champion Bay with a cargo of lead for Melbourne but was forced to put into Albany for repairs. In 1882 she is mentioned as a hulk operated by the Adelaide Steamship Company who continued coaling operations at Albany after the closing of the P & O Depot there. The Adelaide Steamship Company minutes of 1883 record thc receipt of a bill of sale for the hulk *Ellen*.

In 1890 she appears in the *West Australian* newspaper as the *Helen:*

> The hulk *Helen* belonging to the Adelaide Steamship Company has been examined by a diver and found to be unfit for further use. She has been condemned and will probably be sold.[19]

The Adelaide Steamship Company did not own an *Helen* in Western Australia and this reference almost certainly refers to the *Ellen* which is recorded in the Harbour Master's Journal in 1890 as:

> Coxswain Stewart engaged in taking hulk *Ellen* to Woodman Point to be abandoned.[20]
> (Woodman Point is the north arm of Jervoise Bay.)

The Underwater Explorers Club, under M. Pollard, conducted an unsuccessful search of the northern shore of Woodman Point for the *Ellen* and found instead, the *James Matthews* (1841).

It is thought unlikely, however, that the harbour master would have allowed a vessel to be deliberately scuttled on the northern shore of Woodman Point as she would be a danger to vessels blown ashore from the Owen Anchorage area immediately to the north (Figure 1). The wreck, therefore, is presumed to lie to the south of Woodman Point, in Jervoise Bay.

?Ellen/?Annie Lisle/?Harrison

Apart from the known scuttling of *Ellen* on or near Woodman Point, there is little to go on in matching the site with any of the three American-built vessels.

Site length is of little use due to the effects of wave action and all three vessels could have been fitted with iron knees. The *Ellen* wrecksite match with birch and red pine is promising but not conclusive.

Another unidentified American-built vessel was found in Careening Bay in 1973 of length in excess of 100 ft (30 m), an indicated tonnage of 300-400 tons and of a mid to late 19th century period. Large quantities of coal from New South Wales were evident throughout, and a timber analysis showed:

Pinus ponderosa : (western North America)
Robinia pseudoacacia : Black Locust (eastern and central North America)

No ironwork was evident on site and no valid conclusions about its identity can be made at present.

There is still a possibility that the Underwater Explorers Club missed the *Ellen* on Woodman Point and if that is so, then the indications would be that the Jervoise Bay wreck is the *Annie Lisle* (a 'local' wreck) and the Careening Bay site the *Harrison* or vice versa.

Till that time Wreck 4 in Jervoise Bay should be known as 'Jervoise Bay unidentified, number one, possibly *Ellen*'.

Wreck 5: *Egmont*

The next site was until the latter part of this study, known simply as the 'iron wreck'.

Local historians believed the site was either or both the hulks *Conference* or *Herschell,* both ex-sailing vessels whose ultimate fate was then unknown. *Conference* however, is now known to have been scuttled north of Fremantle and *Herschell* is recorded as scuttled on Inner Island, Albany on 2 July 1908.[22]

The 'two wreck' idea was eliminated by length and breadth measurement though the site was very confusing and widespread. On inspection, certain anomalies became apparent, with the stern section appearing to fit more a screw-driven vessel than a sailing ship. It was also decided in view of the sterile nature of the site to use a 60 cm diameter propellor wash to excavate instead of the more gentle 15 or 10 cm airlifts used on other sites.

The Museum's workboat *Beagle,* was manoeuvred and anchored fore and aft over the site. The propellor wash was attached and at 1000 rpm in 3 m of water, the blast effectively cleared areas of about 2 m square to a depth of 1 m, sufficient in the four test holes dug to show that apart from being a sterile site, the wreck was an ex-steamer used for the storage of coal and not a sailing vessel as previously thought.

Detailed measurement and drawing of the site were not seen to be a valid exercise and the following drawing from an aerial photo is considered an adequate substitute in view of the financial and temporal constraints imposed on the study.

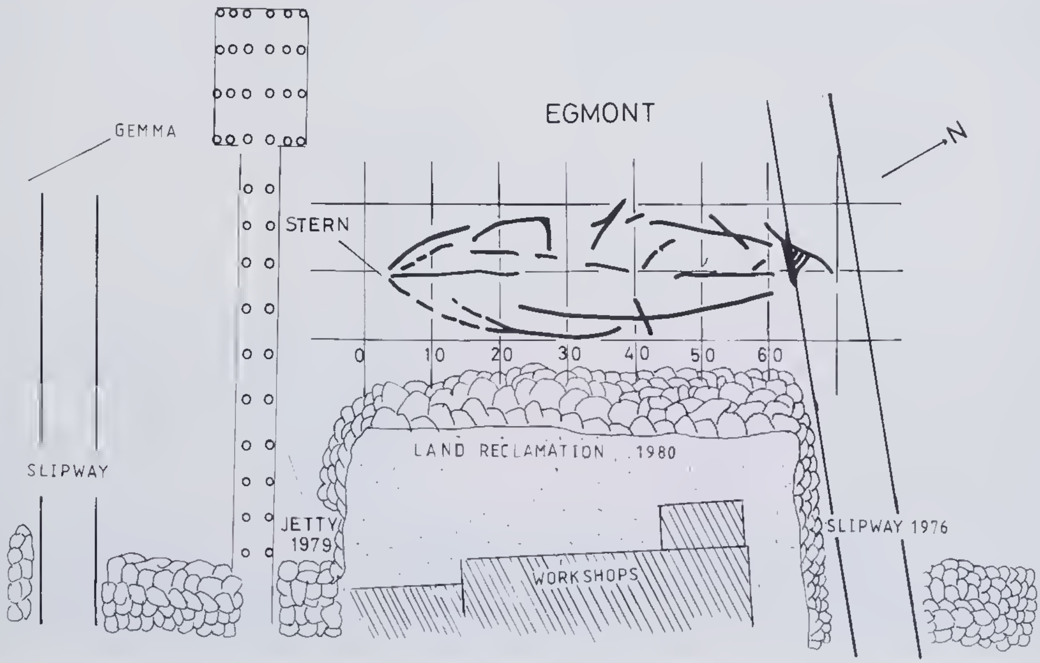

Figure 14 The *Egmont* site. From an original by Don Edwards, M.A.A.W.A.

The drawing shows the difficulty experienced in attempting to quickly illustrate a collapsed iron and steel site when underwater. The spread of the vessel's hull both inward and out makes an accurate assessment very difficult. This type of drawing is an interesting solution and perhaps is all that is necessary in the circumstances prevailing here.

Having established that the vessel was formerly a steamship, a search of available records showed that two hulks of this category, *Gunga* and *Egmont* were possibilities.

The steamer *Gunga* was built for the Australian Steam Navigation Company in 1864 and was a 1257 ton brig-rigged vessel of 257 ft (78 m) in length.[23] After being of no further use as a steamer, she was dismantled and converted into a hulk and towed to Fremantle. Eventually, she was considered redundant and is recorded as having been stranded on a beach near Fremantle around 1920.[24]

Egmont is also recorded as a cargo steamer in the coal trade 'until comparatively recently when she became a hulk in Sydney Harbour'.[25]

The identification of the site, therefore, appeared resolved as *Gunga* until the wrecksite was measured at 65 m (213 ft). It therefore appeared that the site could not have been the *Gunga* and on length measurements and other details the wreck appeared to be the *Egmont* which had previously been reported as the first ship scuttled off Rottnest.

Figure 15 The *Egmont* from a contemporary drawing.

Having deduced that the wreck was most likely the *Egmont* a contact with her former owners, the Adelaide Steamship Company was established, and their historian, after a search of company records, replied giving details of the vessel's fate.

It appears that on 31 March 1910 the company was informed that the *Egmont* had been dismantled and abandoned. When she was slipped in 1909 she was found to be in such a bad condition that she was condemned. After all the gear, winches, boilers, etc. were removed, she was scuttled by dynamiting off Clarence Rocks (Jervoise Bay). From that time on she was virtually forgotten and was evidently further demolished in the retrieval of salvageable metals and decking and the more recent construction of a slipway at Australian Shipbuilding Industries (see Figure 14).

The history of the vessel is as follows:

Official number	:	50039
Construction	:	Iron, single-screw, 1 deck, 4 bulkheads
Dimensions	:	Length 171 ft (52.1 m), beam 25.3 ft (7.7 m), depth 12.2 ft (3.7 m)
Tonnage	:	401 tons gross, 309 tons net
Rig	:	Brig rig
Built	:	1864 at Renfrew by Henderson Coulborn and Co. Port of registry – London. Original owners Panama, New Zealand and Australian Royal Mail Co. Ltd.
Engines	:	Compound steam, 2 cylinder, 80 hp.[26]

She was rebuilt in 1875 and is registered in Lloyds 1888 with the following dimensions:

200 ft (60.9 m) x 24.8 ft (7.5 m) x 18.3 ft (5.5 m)
419 tons net
670 tons gross
670 tons under deck
Schooner rig
Engine 100 hp, 2 cylinder compound

After five years with the Panama New Zealand and Australian Royal Mail Company, she was sold to the Australasian Steam Navigation Company and operated on the Queensland coastal trade. She was lengthened at Pyrmont, Sydney and in 1886 was taken over with her parent company by the Australasian United Steam Navigation Company. She was converted to a hulk in 1892 and then passed through a number of hands till she was acquired in 1900 by the Adelaide Steamship Company. She was used as a coal hulk at Fremantle, being scuttled in 1910 at Clarence in Jervoise Bay.

On the basis of the match of *Egmont's* final length with the Clarence wreck-site and on the additional strength of the Adelaide Steamship Company's records, it is reasonable to conclude that this site is *Egmont* and not *Gunga*.

Wreck 6: *Gemma*

Of all the sites assessed, this particular site which forms the apex of a triangle between the *Egmont* and the Wreck of Stones is perhaps the most perplexing.

Many doubted whether this was a wreck at all. No timber structures were visible in the thick weed growth that almost covered the scattered iron wreckage. M. Pollard maintained a continued interest in the site, despite the early scepticism. He was convinced the site constituted a wreck and his original description of the 'Apex' site (as he called it) was of a small vessel with heavy iron frames, some of which stood off the wood-covcred bottom. He also recorded a pair of four-spoked wheels (possibly a pump crank) connected by a two-bearing crankshaft. These lay amidships and projected about 1 m from the bottom. Both the weed growth and the wheels have now disappeared. A large iron windlass with a wooden barrel and iron whelps was located at the northern end of the site and an anchor chain led 50 m north from this to a small section of the starboard bow of the vessel (measuring 1.75 m x 0.55 m). This section contained a hawse pipe, a bollard and fairlead. Random airlifting of the main site using a hookah-powered rigid 10 cm pipe revealed extensive timber remains throughout the site. This and the spread of the ironwork warranted further investigation and a series of test excavations were planned.

The small aluminium workboats previously used were substituted by the Museum workboat *Henrietta* on which was mounted a 1200L/minute compressor connected to two semi-rigid 12 cm airlifts.

Five shallow trenches were dug across the wreck and a photomosaic and drawing taken of each excavation.

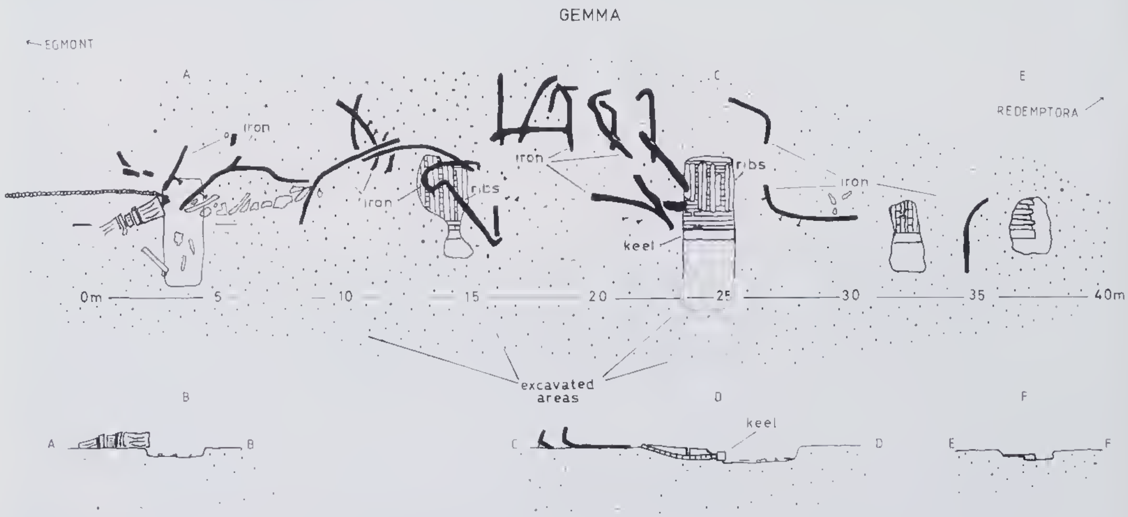

Figure 16 A drawing of the 'Apex' site.

The extent of the wreckage (36 m x 7 m) and the spread of timber can be seen (Figure 16) and it is evident that the vessel lies on its starboard with most of the port side gone. Further hand fanning of the area under the ironwork revealed more timbers and at its maximum spread there appears about 7 m of the port side planking and ribs remaining. The ceiling and keelson have been dispersed in storms or destroyed by worm infestation.

All the ironwork is situated on the starboard side of the keel as one would expect if the vessel went down with a large list to that side. The standing ironwork and the spread of wreckage on one side of the keel was not unusual, but the keel lay almost vertically upright and an attempt to explain this interesting feature of the wreck is shown below:

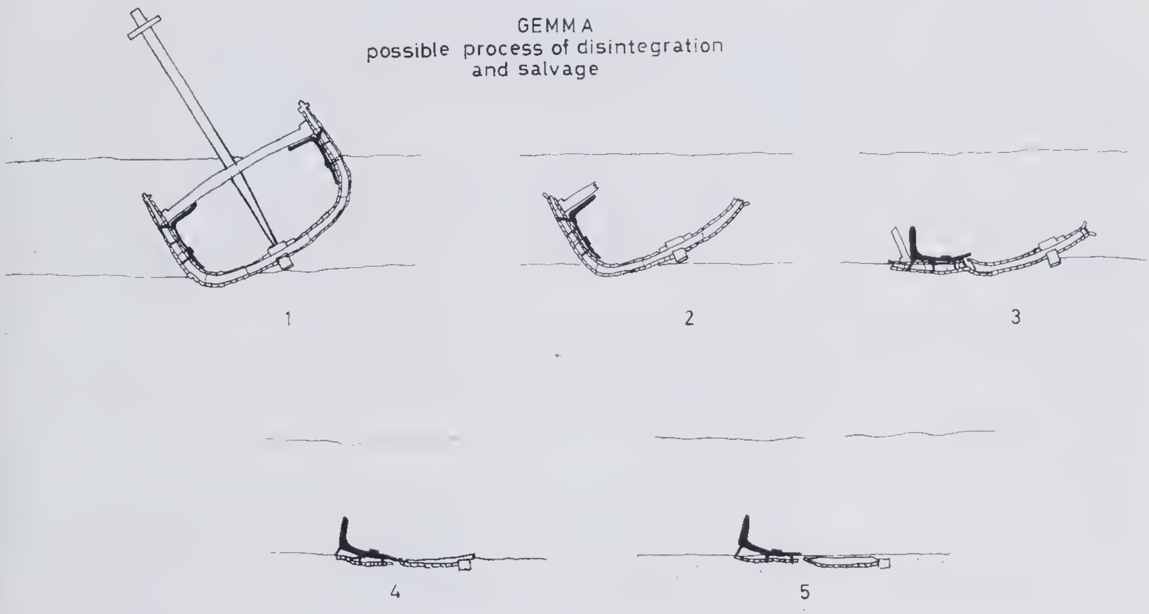

Figure 17 A series of sketches representing the process of disintegration of the wreck.

The series shows a section of the vessel and a gradual process of disintegration (or salvage). The upper ironwork could have been salvaged or fallen towards the centre of the site and is not shown after the first sketch. The process of flattening of the timbers leaving the hanging knee standing and the keel almost vertical is then shown.

A yellow metal bolt 58 cm long, diameter 2.5 cm (1 inch) was recovered from the site and inspection of the clinch ring showed the figures '1 1/8' impressed into the upper surface. Measurement showed that this referred to the inner diameter of the ring but no valid conclusions could be made due to the small difference between the English, German and Amsterdam inch (a difference too small to be detected on the internal diameter of the corroded ring).[27] An analysis of the composition of the bolt was also undertaken and showed a composition most like a medium leaded brass, that is a copper, zinc and lead alloy. This and other fastening sizes, e.g. butt bolts of 11/16 inch (1.8 cm) diameter indicate a vessel in the 300 ton range.[28]

Timber analysis conducted by the Wood Quality Group of CSIRO showed the following:

Ceiling	*Pinus sylvestris* – Scots Pine (central Europe)
Keel	*Ulmus* sp. – possibly European Elm
Plank	*Pinus sylvestris* – Scots Pine (Europe)
Treenail	*Eucalyptus* sp. – eucalypt (Australia)
Rib	*Picea* sp. – Sprucc (Europe and America)
Unknown	*Ulmus* sp. – possibly European Elm

It is evident from the timber analysis, therefore, that the wreck was that of a European-built ship possibly repaired somewhere in Australia (eucalypt treenail). The possibility of the treenails being imported to Europe makes the latter conclusion only tentative however.

There are no European ships apart from the *Gemma* known to have been sunk in the region of Jervoise Bay, but the *Amur* was seen as a distinct possibility in view of its circumstances, timber analysis and large amount of ironwork present on site.

The details of *Amur*, ex *Agnes Holt*, are as follows:

Official number	:	7645 Classed as experimental, subject to biennial survey
Construction	:	1 deck, 3 masts, round stern, carvel-built, woman figure-head. Keel: English and American Elm. Stem and stern-post: English Oak. Knees of iron plates, all the bolts of yellow metal. 'This vessel is fastened entirely with yellow metal outside except the flat of floor which is treenailed. There are 14 pairs of iron straps 4 ft x 8/11 inches (122 x 1.84 cm) placed diagonally outside the frame 5 ft 6 inches (1.67 cm) part-rivetted to each frame.'[29]
Lloyds Register 1865 shows	:	'Frame part iron, with iron beams.'
Dimensions	:	112.9 ft (34.4 m) x 24.3 ft (7.4 m) x 11.9 ft (3.6 m)
Tonnage	:	Old 292 tons, new $235^{67}/_{100}$ tons
Built	:	Sunderland, Durham, 22 Novembcr 1862
Owners	:	Bateman, Pearse and Marmion
Port of registry	:	Fremantle
History	:	The *Amur* was originally purchased by Pearse and Marmion of Western Australia to help cstablish a whaling enterprise. She was afterwards a regular visitor to the port and operated to a variety of areas – interstate, Mauritius, Singapore, etc.

She has more than a local interest, however, being an early 'composite' type vessel.[30] Her builder G.S. Moore was the successful applicant in the case Jordan v. Moore of 1865 concerning the extension of the Jordan patent and of royalties for composite shipbuilding.[31]

The *Amur* it appears, was not a true 'composite ship' however, and fits more closely a transition from the all-wood to composite. The *Annals of Lloyds Register* explains this gradual change more clearly:

> The first composite ship to appear in the Register Book . . . was entered in the edition for 1851 with the notation 'iron frame planked' . . . in 1860 . . . the experience of the committee with this type of ship . . . led them to regard composite vessels as experimental . . . subject to biennial survey . . . various modes of construction were at first proposed. Some of the vessels had wood floors and iron angle frames . . . or some equally novel sectional form; many variations also existed in the modes of fastening.[32]

The *Amur* was built in 1862 but the rules for composite ships were not issued till 1867, and as the *Annals* point out 'nearly every composite ship since built has been constructed in accordance with their provisions'.[33]

The length, wooden floors, treenails, predominantly yellow metal fastenings and timber analysis fit the site as does the 'part iron frame with iron beams' description in *Lloyds Register*.

On the other hand, the fourteen pairs of iron straps 4 ft x 8/11 inches (122 x 1.84 cm) placed diagonally outside the frame 5 ft 6 inches (167.5 cm) are not evident but the majority of the ironwork present is part rivetted to each frame.

Eventual Fate of *Amur*

The *Inquirer* of June 1887 notes:

> The barque 'Amur' stranded at Rockingham has been visited by Captain O'Grady. He reports her on the beach about three quarters of a mile north of Rockingham and is apparently injured.[35]

The *Amur* was subsequently refloated, for a search of the contemporary *Shipping News*[36] shows she is recorded from 6 July 1888-15 February 1888 under the heading 'Vessels in Harbour' as '*Amur* laid up', suggesting that the vessel was afloat but inoperative.

The *West Australian* newspaper of the same period shows that the ship was laid up at Rockingham. The vessel then disappears from the records though her register was closed on 12 December 1890 with the following comment:

> This vessel was stranded on the beach near Rockingham, Fremantle Harbour, about two years ago, and has since been abandoned.[37]

She was fastened entirely with yellow metal, and her abandonment would have likely been followed by subsequent heavy salvage for her valuable fastenings. If she was afloat, her owners would have been required to move her to an area away from shipping, and the nearby graveyard including Jervoise Bay appeared a likely possibility.

Local residents, however, recall seeing the ribs of a vessel called the *Annie* or *Amur* north of Rockingham (just off Weld Street near the new Grain Terminal).[38] Thus, even though all protruding remains were removed by the 1950s, this lead must be considered a very promising one, especially in view of the proximity of the area to the stranding of the *Amur.* Until that site is located, however, the issue is still in doubt.

The details and history of the *Gemma* are outlined below.

Gemma (ex *H. Beenke*)

Construction	:	Wood
Dimensions	:	Length 120.4 ft (36.6 m) x beam 26.7 ft (8.1 m) x depth 13.5 ft (4.1 m)
Tonnage	:	318 tons gross, 306 tons net
Rig	:	Brig
Built	:	Elsfleth (on the river Aller between Bremen and Bremerhaven, Germany) in 1868 by J. Ahlers
Owners	:	C. Bethell of London[39]

The vessel entered Fremantle under the command of E. Bolt on 10 January 1886 with a cargo of coal from Fleetwood, England. She was retained here for use as a hulk. In September 1886 she is recorded as 'grounded 150 yards from the new South Jetty', after having just loaded a cargo of grain and other perishables from the *Mary Blair.* On 29 September she was still aground and full of water, with the crew assisting the harbour master to heave her upright. From 1-6 October there was a team of divers working on her patching up her hull and on 21 October she was pumped afloat and towed to deep water and anchored. She appears to have operated without major incident till 15 August 1893 when she was scuttled in the bay:

> Mr Butcher, to Careening Bay in *Flinders* and after discharge of the coals into the hulk from the *Gemma* towed the latter into Jervoise Bay where she was beached.[40]

Small but significant quantities of coal have been found on site and the timber analysis fits a European-built ship such as the *Gemma.* We know the *Gemma* was repaired at Fremantle and that she was beached in Jervoise Bay. As the only other wooden sites in the bay have American timber, the *Gemma*/Apex link must be considered a strong one. The *Amur* is still a possibility but like the *Ellen*/*Annie Lisle* question, the former in each case is recorded as lost in the area and must be considered the more likely at present.

Wreck 7: *Redemptora*

The next wreck south is the Wreck of Stones being a large stone (ballast) covered site discovered by local divers in the early 1960s. In January 1978, members of the Maritime Archaeological Association of Western Australia began diving in an effort to survey and possibly identify the wreck. They reported that the wrecksite was the remains of a wooden vessel at least 47 m in length carrying an estimated 200-400 tonnes of granite ballast.[41] Several small pieces of coal were found amongst the stones but these and the few small glass sherds visible on the site were insufficient to enable any positive conclusion to be drawn. The drawing below shows the trench along the keelson caused by the vessel collapsing outwards as the hull weakened.

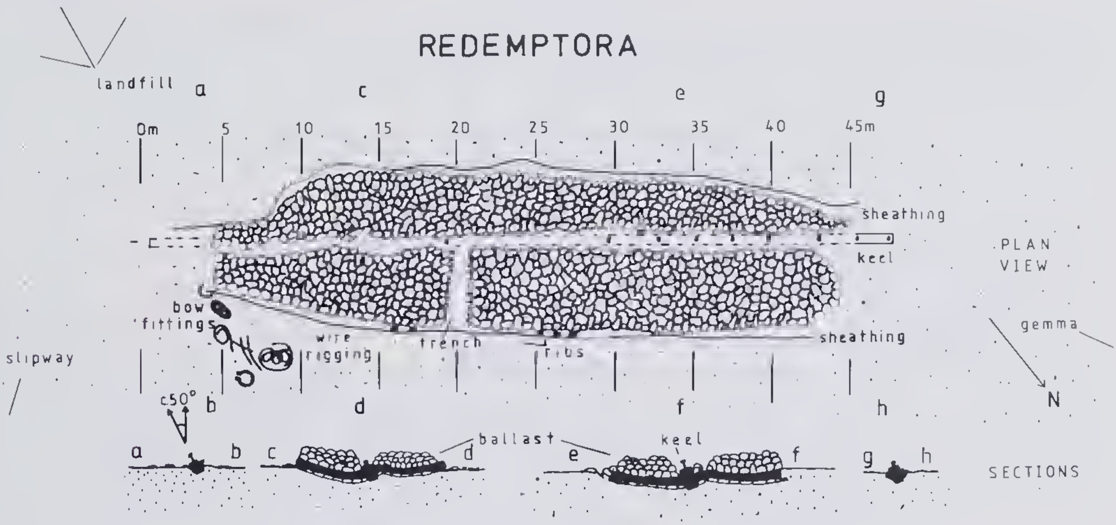

Figure 18 The Wreck of Stones from an original by R. Miners, M.A.A.W.A.

Although this survey also failed to positively identify the ship, the M.A.A.W.A. believed that it was the wreck of the American-built 1235 ton Brazilian ship *Redemptora* on the basis of an early personal communication to H. Roberts of the Underwater Explorers Club, which referred to the *Redemptora* being run ashore and burnt at Clarence in Jervoise Bay.

The ballast mount length at 47 m was larger than the overall length of all the known wooden vessels lost in the area except perhaps the *Redemptora* itself and the Association's tentative match thus appeared reasonable.

In view of their identification of the site as the *Redemptora,* the Maritime Archaeological Association of Western Australia attempted no further excavation apart from a trench dug through the ballast to ascertain the extent of the timber remains. Apart from delineating the site, no other excavation was deemed desirable in view of the danger of interfering with the stable nature of the wreck, which should lie in its present undisturbed state for decades.

For the purposes of this study, however, a more positive identification was required, and to this end a timber sample was sent to CSIRO and appeared as follows:

Keel	*Acer nigra* – Hard Maple (eastern North America)
Treenail	*Quercus* sp. – possibly Red Oak (America or Europe)

Sacrificial wood	*Pinus strobus* – (eastern North America)
Frame	*Quercus* sp. – Red Oak (European or American)

Various fastenings and fittings were also measured and these, with the timber sample, indicated a large mid to late 19th century vessel probably built on the eastern seaboard of North America.

A comparison of these sizes with Lloyds minima of 1864 further indicated a vessel of the 12-1300 ton range, e.g.

Plank size 5 inches (13 cm)
Keel bolt diameter $1^9/_{16}$ inches (4 cm)
Butt bolt diameter 1 inch (2.5 cm)[42]

The twin hawses, 6 inch (15.24 cm) circumference rigging wire and 8 inch (20.3 cm) plank spikes add more weight to that analysis.

Apart from the *Redemptora* of 1235 tons but of as yct an unknown length, the only other known hulks of similar tonnage were the ex Blackwall Frigatc *St. Lawrence* of 1131 tons gross and 179 ft (54.5 m) length and the *Zephyr* of 189 ft (57.5 m) and 1336 tons gross. Both of these vessels were scuttled at Albany on the south coast and therefore could not be considered as possibilities here.

The only conflicting factors then in a match with the American-built 1235 ton *Redemptora* were the large amount of ballast apparently left in a coal hulk to the detriment of her carrying capacity and an apparent keel length of only about 47 m (156 ft) which cven with allowance made for fore and aft rake was too short for a vessel of *Redemptora's* tonnage.

Baker's *Maritime History of Bath Maine* records 11 vessels between 1000 and 1300 tons built in 1853 with lengths ranging from 176-198 ft (53-60 m).[43] In view of this discrepancy a further dive on site was completed in January 1982 and an excavation completed beyond the obvious kcel remains.

The keel was seen to extend 8 m beyond that reported by the Maritime Archaeological Association of Western Australia giving a minimum keel length of 55 m (180 ft), with an overall length of vessel between perpendiculars of at least 60 m (*c.* 190-200 ft), i.e. well within the expected range.

As *Redemptora* is recorded as sunk in 1892 with 2300 tons of coal one can only assume the relatively large amount of ballast remaining (200-400 tons) did not materially affect her economic carrying capacity and was, therefore, left in place. Further research needs to be done in this area however.

The Wreck of Stones is then beyond reasonable doubt, the *Redemptora.* The wreck itself is almost totally covered with the ballast layer and as such, should remain thus protected for many years. When required, it would then be available for study by future generations.

History

The *Redemptora* left Rio de Janeiro in August 1888 bound for Adelaide with a cargo of sugar and coffee. She was a fully rigged ship of 1235 tons and a crew of 23. Her last voyage is recorded thus:

> **Arrival of a Brazilian Ship in Distress**
>
> About 4 o'clock on Sunday afternoon a large vessel was sighted from Rottnest, heading for Fremantle. She was boarded at 8 o'clock that evening by Pilot Butcher, when she was found to be the ship *Redemptora*, Captain Francisco Casavecchia, bound from Rio de Janeiro, Brazil to Adelaide. The Pilot brought the ship to an anchor during the night off the North Beach, and yesterday morning the tug *Dolphin* proceeded to the vessel and towed her to Gage Road, where she came to an anchor at 10.30 a.m. There is no one aboard who was able to speak English, but fortunately, Captain Casavecchia understands French, whereby he was able to carry on a conversation with Captain Russel, Chief Harbour Master. The *Redemptora* is a ship of 1,235 tons (Brazilian) register, and hails from Rio de Janeiro from which port she sailed on August 10, with a cargo consisting of 233 tons of sugar, and 200 tons of coffee, being consigned to Messrs. Charles Hart and Co., Adelaide. After rounding the Cape of Good Hope, when in latitude 42°S and 45°W., the *Redemptora* encountered a heavy gale which lasted four days, during which time the ship rolled very heavily and it was considered desirable to lower some of the spars, where-upon the main top gallant mast, main top mast, and fore top gallant mast, were struck. The ship, however, continued to roll and was making from five to six inches of water an hour. Having a donkey engine on board, this was kept going, whereby she was able to keep pretty free. Captain Casavecchia states that he put into Fremantle to ascertain whether his ship could be repaired here. She does not make much water when in smooth sea, but it is evident that the ship has been severely strained. The *Redemptora* is a wooden vessel, and was built 35 years ago in America. Lloyds surveyor, Captain Owston, will make a survey of the ship to ascertain the condition of her hull, and if found necessary, she will probably be condemned. As the ship stands at present, she draws 17 ft of water aft, and 16 ft forward. She is owned by Messrs. Granalli and Co. of Rio de Janeiro.[44]

The hull was sold to J. Lilly apparently on behalf of the Adelaide Steamship Company for £315 with the gear and stores, etc. being sold to a variety of buyers notably J. and L. Bateman, Wood and Ericson, Hammonds and Hubble and Captain Siddell.[45]

The hull was then used as a coal hulk in Careening Bay from 1 December 1888 and is reported in 1892 to have sunk in Careening Bay carrying 2300 tons of coal.[46] She was raised three months later and then disappears from the records.

The *West Australian* of 19 October 1910 refers to the *Redemptora* as a local wreck and she was obviously run ashore and abandoned some time between 1892 and 1910.[47] The *West Australian* newspaper of 13 September 1957 contains a reference however, to a Captain Jacobs (then 88 years old) who recalls salvaging in 1898 the cargo of a wrecked barque *Redemptoara* [sic] for the Adelaide Steamship Company in the area of Cape Leschenault.[48] The Adelaide Steamship Company, however, has no apparent records of the salvage of the vessel and there is no record of the unlikely possibility of the refloated hulk *Redemptora* being re-registered for sea-going purposes after being initially condemned as unseaworthy. There is a possiblity then that the wreck referred to by Captain Jacobs is not the vessel under consideration and is more likely the barque *Villalta,* wrecked on Leschenault Reef in 1897 with a cargo of timber.

Wreck 8: *Camilla*

The last of the known sites in the Jervoise Bay area is a small wooden copper fastened wreck in 2 m of water, 60 m from shore. It lies on an east/west axis about 1 km south of the Wreck of Stones, and just north of the Alcoa Jetty.

The wreck lies on its starboard side with most of the port side gone and measures 20.25 m x 4 m beam. The site has iron knees, and is lightly built.

A timber analysis undertaken by CSIRO shows that the vessel was most likely built in Europe and later re-planked or repaired in Australia or New Zealand.

The results of the analysis are:

Keel	*Ulmus* sp. – possibly European Elm
Keelson	*Ulmus* sp. – possibly European Elm
Treenail	*Quercus* sp. – Red Oak (Europe or America)
Plank	*Araucaria* sp. – possibly Australian or New Zealand Pine
Unknown	*Ulmus* sp. – possibly European Elm

Of all the sites in the area, the wreck most fits the description of the lighter *Camilla* which was owned by J. Ball who operated small wooden vessels in that capacity after 1897.

The records of the Fremantle Harbour Trust which commenced in January 1903 show the following:

> J. Ball owner of condemned lighter *Camilla* was served with notice to remove the vessel from the Harbour without delay as she is an obstruction.
>
> I have to report the *Camilla* has this day been removed in the harbour and beached beyond Woodman Point as directed.[49]

A search of *Lloyds Register* showed two vessels of that name fitting the wreck in terms of size and ownership.

The likely *Camilla* was one built at Leith, England in 1834. Her details and history are as follows:

Official number	:	32403, QWBF
Construction	:	Wood barquentine, 1 deck, 190 ton
Built	:	1894 at Leith, England by Beilbun and Co.
Dimensions	:	85.9 ft (26 m) x 23.6 ft (7.1 m) x 14.5 ft (4.21 m)

In 1853, she is recorded as leaving Leith for Adelaide and does not appear in *Lloyds Register* again. She is seen in *Lloyds Universal Register* (a different series) in 1885 and in 1891 is recorded as owned by the Bank of van Diemans Land, Hobart. She is recorded in 1892 as owned by the Orient Steam Navigation Co. and Lloyds records her 'now a hulk'.[50] The Register of British Ships at Hobart shows the vessel was sold on 26 March 1891 to the Orient Steam Navigation Co. of Adelaidc, a firm which also operated out of Albany, Western Australia and there is a possibility that the vessel found its way to this coast.

There are obvious problems, however, especially with the discrepancy in length,[51] and more research is required. Being outside the area of development, however, and not at risk, work on site was postponed till a later date.

Site Identification

It can be seen then, that the *K VIII, Abemama, Alacrity, Egmont* and *Redemptora* are positively identified sites. The *?Ellen* and *?Gemma* sites are much less positive connections. The position of *Camilla* is reasonably sure though the question as to which *Camilla* is obviously not answered satisfactorily and needs more research.

Submission to the Environmental Protection Authority

Of the seven endangered sites, the *Abemama, ?Gemma* and *Redemptora* were recommended in a submission to the Environmental Protection Authority in 1979 as worthy of retention in their present state. Only the *?Ellen, ?Gemma* and possibly the *Redemptora* can be protected undcr the relevant Acts of Parliament however. and a logical give-and-take approach, without taking recoursc to legal sanctions was seen to be of more value, especially as the Museum is keen to see all the wrecks preserved if possible.

The *Maritime Archaeology Act,* 1973 is operative in State waters, for example Jervoise Bay, and does not cover wrecks lost after 1900, such as the *Abemama* 1927. The *Commonwealth Historic Shipwrecks Act,* 1976 which allows for such vessels as *Abemama* being declared 'historic' cannot be invoked as Jervoise Bay lies in State and not Federal waters. The *Ellen* site (if it is so), though automatically protected by the State *Act* (i.e. pre-1900) would not normally warrant such protection under the Commonwealth *Act,* being almost totally destroyed by wave action and a direct comparison to the more worthwhile sites *Abemama, ?Gemma* and *Redemptora.*

In September 1979 the Environmental Protection Authority produced its report and recommendations in which paragraph 4.9, with reference to historic wrccks, read:

> The Western Australian Museum has recently carried out a survey of Historic Wrecks in Jervoise Bay and concluded that three of the seven wrecks located are significant and should be preserved. The four remaining wrecks contain some material of interest and this should be removed if development will affect them.
>
> The authority is of the opinion, therefore, that the wrecks of the *Abemama, (Gemma)* and Wreck of Stones should be left undisturbed. If development work is proposed which would affect (the other) wrecks then the Museum should be given adequate notification and funding to enable salvage operations to be undertaken.[52]

Here was the solution to the problem mentioned abovc.

The first stage of development has already occurred in the area of the *Egmont, Redemptora, Gemma* and *K VIII*, and the success of early informal personal contact can already be seen. The study shows there are no solid legal, historical or other grounds to prevent the destruction of the *Egmont* site for example, but the building contractors did their utmost to avoid causing any damage when constructing the 1979 jetty near the wreck. The informal contacts made with the contracting firm, site engineer, foreman and chief diver had positive results and similar approaches have been made in regard to the other wrecks in the area. All the government and private bodies involved in developing the area have been informed of the Museum's interest in the wrecks and of our desire to co-operate and assist in planning so that conflict can be avoided.

Recent indications are that development proposals with the bay are referred ultimately to the Department of Conservation and Environment who then contact the Museum for advice on whether the proposal affects any of the important historic wrecks in the bay. Should a site be actually required for further development, however, and there is failure to reach a compromise on avoiding the wreck, the following lines of action have been planned, on the basis of the surveys done:

K VIII (1943)

The site will be abandoned if necessary, to the developers. Documentation and recording is now complete and nothing further can be done apart from removing that section of the hull remaining and positioning it in a safe location.

Alacrity (1931)

Informal meetings will be arranged to have the development relocated to miss the site, but should these fail, the rudder, propellor shaft, propellors and a section of hull plating with frames will be removed. These items will then be stored adjacent to a protected site elsewhere until required for study and for a projected Maritime Museum display on ships' fittings. Storage will be designed so as not to unduly affect the electrolytic balance of the site(s) nearby.

Abemama (1927)

The total preservation of this site is sought. The wreck is seen to be of value as an educational tool and as a well preserved example of this last stage of wooden ship-building techniques. She has also proved of value in training of future maritime archaeologists, to schools and the average diver, being the only wooden wreck of easy and safe access on the coast. The Federal Government have also seen fit to support the protection of wrecksites based on their educational and recreational value, and have added this new criteria for assessment to those originally used.[53]

?Ellen (1890)

This site is so badly broken up that little remains and it could be abandoned after the removal of all worthwhile fittings. An extensive magnetometer or metal detector search will be necessary as some fittings, e.g. dead-eyes with attached chainplates were found 10 m off the starboard bow. Fittings ready for retrieval, display and study, are keel scarph joint sections, false keel section and iron knees. The site is, however, automatically protected under the provisions of the *Maritime Archaeology Act*, 1973 by virtue of being in State waters and wrecked before 1900.

Egmont (1910)

The site is so badly broken up as to be of little value historically or visually and may not warrant any more than salvage of those parts of value for study and/or display. The site could then be abandoned to the developers. The problems of inexpensive and quick measurement on a collapsed or heavily corroded iron site are obvious and the photographic and historical records prepared are considered all that is necessary at present. The rudder, steering gear and hawsepipes will be retained and stored for eventual display.

?Gemma (1893)

The total protection of this site is sought. Like the *Abemama* there is a substantial section of the vessel remaining including what may be a complete collection of the ironwork associated with the vessel's hull. The wreck lies close to existing slipways and jetties, but is in a safe and relatively deep position.

Redemptora (*c.* 1900)

The total protection of this site is also sought. The wreck itself is almost totally covered with the ballast layer and as such should remain thus protected for many years. When required, it would then be available for study by future generations. Of all the worthwhile sites in the bay, this appears to have the most stable environment and potential for continued safe existence under its protective layer of ballast. It lies very near an existing slipway, however, and requires a close liaison with the future developers of the area to avoid any damage.

Conclusions

1 Many of the sites in the bay are abandoned 19th century hulks, and it is this almost forgotten class of shipwreck that has present, and more importantly, future value to maritime archaeologists and marine historians.

The hulk is often abandoned in out of the way calm, shallow water and these old vessels often exist today in relatively good condition. Some are intact only up to those areas encased in sand or other sediment. Others, such as the wooden *Vicar of Bray* in the Falkland Islands, the *Edwin Fox* in New Zealand and the iron *Santiago* in South Australia, are almost intact hulls.

Many former hulks have been refloated and restored, e.g. *James Craig, Polly Woodside* and *Great Britain* and a great deal has been learnt about the construction of these vessels in the process.

Most of the hulks throughout the world, however, would appear like those in Jervoise Bay as much less imposing or even interesting structures to the present day; but that does not lessen their potential value for future generations.

There is already a wealth of information on ship-building techniques of the 19th century but even more can be learned from an examination of the physical remains themselves especially when the wreck is identified and its details known.

The ship's graveyard and the abandoned hulk can be a rich source of such information. Even if the wrecks there cannot, or need not be excavated and examined now, their future worth should be realized and steps taken to record their position and condition and preserve them for the future.

2 The study has, apart from its primary purpose and intrinsic value, a number of important ramifications. One such outcome has been to highlight the mutual support and benefit that the amateur and professional groups in maritime archaeology and history can gain from such a study.

3 Had the Museum taken a contentious approach and used the *Maritime Archaeology Act,* 1973 and/or the *Historic Shipwrecks Act,* 1976 when construction actually started, the results might not have been as encouraging. Informal contact at the early planning stage has helped avoid any potentially damaging clash of interest. The realization by both sides that compromise is necessary and pre-planning essential has led to a situation that will hopefully allow the proper study of those worthwhile sites and more importantly, their retention for the future.

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A New Genus and Species of Boarfish (Perciformes: Pentacerotidae) from Western Australia

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Abstract

Parazanclistius hutchinsi gen. nov., sp. nov. is described from five examples taken from south-west Western Australia. The genus differs from the superficially similar *Zanclistius* Jordan, 1907, in the more anterior placement of the pelvic fin, possession of scales on the opercle and subopercle, more deeply concave dorsal snout profile, larger number of lateral line pores, and relatively longer pectoral fins.

Introduction

In the course of a revision of the Pentacerotidae (Hardy 1983), onc example of a boarfish from Rottnest Island, Western Australia, was found to be quite different from other known species. Four further examples have since been examined, enabling a detailed description of the species to be made. Because of several significant differences between the species here described and the superficially similar Australasian species *Zanclistius elevatus* (Ramsay and Ogilby, 1888), the former is placed in a new genus, bringing to eight the number of genera for the family, and to five the number of pentacerotid species recorded from Western Australia.

Methods and Abbreviations

Measurements were taken following Hardy (1983). All specimens were X-rayed for vertebral and caudal ray counts.

The following abbreviations are used in the text: SL, standard length; HL, head length; N, number of specimens examined; NMNZ, National Museum of New Zealand, Wellington; WAM, Western Australian Museum, Perth.

Systematies

Parazanclistius gen. nov.

Type species: *Parazanclistius hutchinsi* sp. nov.

Diagnosis

A genus of pentacerotid fishes superficially resembling *Zanclistius*, but having the pelvic fin base anterior to the pectoral fin base, and well-developed scales on

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the opercle and subopercle. The pectoral fin of *Parazanclistius* is relatively longer than in *Zanclistius,* and the dorsal snout profile considerably more concave. In addition, *Parazanclistius* has a greater number of lateral line pores (66-72) than *Zanclistius* (55-65).

Description

See following description of *P. hutchinsi.*

Remarks

The description of *Parazanclistius* brings to 4 the number of genera, all monotypic, in the subfamily Histiopterinae (the other genera are *Evistias* Jordan, 1907, *Histiopterus* Temminck and Schlegel, 1844, and *Zanclistius* Jordan, 1907). This contrasts with the 4 remaining pentacerotid genera, which comprise 9 species. Recognition of such a degree of monotypicity in the histiopterine genera, reflects in my opinion their considerable morphological divergence. Table 1 demonstrates the discordant nature of shared characters in these genera. That these character states simply represent interspecific differences cannot be reasonably entertained if consistency in generic criteria is to be maintained within the family. On the basis of shared characters, it might be argued that *Zanclistius* and *Parazanclistius* are sister groups; the overall body proportions, falcate dorsal fins, fin formulae, and number of vertebrae apparently support this. However, *Parazanclistius* exhibits a number of uniquely derived features, including the depressed nature of the snout and more anteriorly positioned pelvic fins, which must be significant at the generic level, when viewing the family overall. The presence of scales on the opercular and subopercular bones, appears to represent an evolutionary reversal, since no other pentacerotids show this feature. Even *Paristiopterus gallipavo,* which has considerable epithelial covering of the skull bones, unlike the remainder of the family, lacks scales on the opercular bones. On the other hand, the heavier and more rugose development of the occipit with age, and broad rounding of the interorbit seen in *Parazanclistius, Histiopterus* and *Evistias* contrasts with *Zanclistius,* in which the occipit becomes hooked and the interorbit deeply medially depressed.

Several other features add support to the considerable divergence that has apparently taken place between *Zanclistius* and *Parazanclistius.* The posterior margin of the anal fin differs in the 2 genera. In *Zanclistius* the anteriormost anal fin rays are longest, the posterior margin being straight (see Hardy 1983: Figure 3A), whereas the posterior margin in *Parazanclistius* is rounded. The two genera differ also in number of lateral line pores (55-65 in *Zanclistius,* 66-72 in *Parazanclistius*), and in length of pectoral fin (2.6-2.9 times in SL in *Zanclistius* specimens ⩾ 174 mm SL, 2.1-2.5 times in SL in *Parazanclistius* specimens ⩾ 188 mm SL).

In all, such character divergence is comparable with that seen between other pentacerotid sister groups —*Paristiopterus* (2 species) and *Pentaceropsis* (1 species); *Pentaceros* (3 species) and *Pseudopentaceros* (3 species) (see Hardy 1983).

Parazanclistius hutchinsi sp. nov.

Figure 1; Table 1

Zanclistius elevatus (non Ramsay and Ogilby). McCulloch, 1911, p. 67 (part), figs 16, 18; Maxwell 1980, p. 114 (part), pl. 33.

Holotype

WAM P.25718-001, 188 mm SL, Transit Reefs, Rottnest I. (32°00'S, 115°30'E), speared, R. Bullock, 7-9 m, 6 February 1977.

Figure 1 Holotype of *Parazanclistius hutchinsi*, WAM P.25718-001, 188 mm SL.

Paratypes

Four specimens, all from Western Australia. WAM P.725, 204 mm SL, off Bald I., E of Albany (34°56'S, 118°28'E), Chief Inspector of Fisheries, 25 August 1920; WAM P.16411, 278 mm SL, Bunbury (33°20'S, 115°38'E), speared, J. Lamera, 28 December 1968; NMNZ P.12195 (2 specimens), 196-197 mm SL, Western Great Australian Bight (33°15'S, 124°06'E), 79 m, Engel high lift ground net, *Soela* (S05/81/7), 29 November 1981.

Diagnosis

As for genus.

Description

The following counts and proportions are for the holotype and, in parenthesis, the range for the 4 paratypes. (Measurements and counts of the type specimens are presented in Table 2.)

Table 1 Selected characteristics of histiopterine genera.

	Evistias Jordan, 1907	*Histiopterus* Temminck and Schlegel, 1844	*Zanclistius* Jordan, 1907	*Parazanclistius* gen. nov.
Number of vertebrae	27	24-25	24-25	25
Build of dorsal spines	similar	penultimate spine heaviest	similar	similar
Posterior margin of dorsal fin	rounded	rounded	falcate	falcate
Position of pelvic spine base	immediately posterior to pectoral fin base	below posterior of pectoral fin base	below posterior of pectoral fin base	in advance of pectoral fin base
Condition of opercle and subopercle	exposed	exposed	exposed	scaled
Position of mouth relative to orbit	well in advance	well in advance	well in advance	underneath or just in advance
Development of occipit with increasing age	more rugose, rounded	more rugose, rounded	more rugose, hooked	more rugose, rounded
Development of interorbit with age	broadly rounded	broadly rounded	deeply medially depressed	broadly rounded
Dorsal fin formula	IV-V, 26-28	IV, 23-29	V-VII, 25-29	VI, 25-27
Anal fin formula	III-IV, 11-14	III, 8-10	III, 12-17	III, 13-14

Table 2 Measurements and counts of type specimens of *Parazanclistius hutchinsi.*

	Holotype WAM P.25718-001	Paratypes WAM P.16411	WAM P.725	NMNZ P.12195	NMNZ P.12195
Standard length	188	278	204	197	196
Head length	67	97	71	72	69
Snout-vent length	110	168	119	115	118
Snout length	32	44	31	34	30
Upper jaw length	24	33	26	25	25
Width of orbit	23	29	27	26	26
Least bony interorbital width	17	30	18	21	19
Posterior of bony orbit to posterior of operculum	22	33	24	21	22
Snout to base of pectoral fin	70	107	77	76	75

Table 2 (continued)

	Holotype	Paratypes			
	WAM P.25718-001	WAM P.16411	WAM P.725	NMNZ P.12195	NMNZ P.12195
Snout to base of pelvic fin	62	96	69	65	65
Posterior of dorsal fin base to posterior of anal fin base	36	53	39	36	37
Length of caudal peduncle	26	39	30	27	29
Body width at base of pelvic spine	24	37	28	30	27
Body width at base of pectoral fins	29	45	33	36	37
Body depth at base of pelvic spines	117	172	123	128	124
Body depth at base of first anal spine	118	164	112	125	124
Snout to origin of dorsal fin	102	135	109	107	101
Length of dorsal fin base	135	180	142	132	134
Length of dorsal fin spinous base	44	61	49	49	42
Length of dorsal fin soft base	105	140	106	100	106
Origin of pelvic spine to origin of first anal spine	63	102	73	70	73
Snout to origin of first anal spine	121	195	136	135	133
Length of anal fin base	57	78	59	59	59
Length of anal fin spinous base	20	26	16	19	23
Length of anal fin soft base	41	60	48	45	41
Length of pectoral fin	85	110	86	91	94
Dorsal ray count	VI, 27	VI, 25	VI, 26	VI, 25	VI, 25
Anal ray count	III, 14	III, 14	IV, 13	IV, 13	III, 13
Pectoral ray count	17/17	16/17	18/18	17/17	17/17
Caudal ray count: principal (procurrent)	17(3+2)	17(3+2)	17(3+2)	17(3+2)	17(3+2)
Pelvic ray count	I,5	I,5	I,5	I,5	I,5
Vertebrae	13+12	13+12	13+12	13+12	13+12
Gill rakers	5+17	5+15	5+17	6+16	6+16
Lateral line pores	66	72	66	71	67

Dorsal rays VI, 27(VI, 25-26); anal rays III, 14(III-IV, 13-14); principal caudal rays 17(17); procurrent caudal rays 3+2(3+2); pectoral rays 17(16-18); pelvic rays I, 5(I,5); lateral line pores 66(66-72); vertebrae 13+12(13+12); gill rakers 5+17(5-6+15-17, range 20-22).

Body strongly laterally compressed, dorsal profile broadly rounded before dropping steeply under dorsal fin rays to caudal peduncle; ventral profile flattened, strongly rounded at anal fin base to caudal peduncle; belly keeled; snout-vent 1.7(1.7) in SL; depth at pelvic spine origin 1.6(1.5-1.7) in SL, at first anal spine 1.6(1.6-1.8) in SL; width at base of pelvic spine 7.8(6.6-7.5) in SL, at base of pectoral fin 6.4(5.3-6.2) in SL.

Head broadly covered with rugose, striated bones anteriorly, 2.8(2.7-2.9) in SL; preorbital, circumorbitals, preopercular, and ventral surface of mandible with large sensory pits roofed by membrane; snout very deeply concave, lightly built and somewhat elongate, 2.1(2.1-2.3) in HL; anterodorsal surface of snout and nasal region scaleless; mouth slightly oblique; lips and chin highly villose; chin with 6 large pores, lower jaw ventral margin with several smaller pores; jaws even anteriorly, teeth of both jaws short, conical and slightly curved, set in broad bands anteriorly, bands narrowing along sides; vomer toothless; nostrils close together and equally sized, anterior one with a prominently raised posterior margin, equidistant between eye and snout; interorbit moderately broad, flattened or rounded, 3.9(3.2-3.9) in HL; eyes large, bony orbit 2.9(2.6-3.3) in HL; posterior of bony orbit to posterior angle of opercular 3.1(3.0-3.4) in HL; occipital crest rounded; nape carinate; dorsal fin continuous, base extensive and scaled, 1.3(1.4-1.5) in SL; snout to dorsal origin 1.8(1.8-2.1) in SL; dorsal spines heteracanth, slender, received in a weak dorsal groove, increase progressively in length; base of dorsal spines 4.3(4.0-4.7) in SL; anteriormost dorsal rays long, concave posterior margin; base of dorsal rays 1.8(1.8-2.0) in SL.

Anal fin continuous, base moderately short and scaled, 3.3(3.3-3.6) in SL; snout to anal origin 1.5(1.4-1.5) in SL; pelvic spine to first anal spine 3.0(2.7-2.8); anal spines increase progressively in size, third rather more slender than second; base of anal spines 9.4(8.5-12.8) in SL; posterior margin of anal rays rounded; base of anal rays 4.6(4.3-4.8) in SL.

Caudal peduncle short, moderately deep, 7.2(6.8-7.4) in SL; posterior of dorsal fin base to posterior of anal fin base 5.2(5.2-5.5) in SL; caudal fin scaled basally, slightly emarginate.

Pectoral fin elongate, pointed, 2.2(2.1-2.5) in SL; snout to pectoral fin base 2.7(2.6) in SL.

Pelvic spine fails to reach first anal spine, base in advance of pectoral fin base, fin long and rounded; snout to pelvic fin base 3.0(2.9-3.1) in SL. Lateral line strongly arched from shoulder, peaking under the posteriormost dorsal spine, before dropping more shallowly to caudal peduncle, thence straightening to caudal fin base. Scales small, ctenoid, extensive patches on cheek, above and behind eye, and over opercle and subopercle.

Colour of holotype (in isopropyl alcohol): body generally pale brown, darkening slightly on belly and adjacent to dorsal and anal fin bases; dorsal region of snout, upper lips, sides of lower jaw, and base of chin dark brown; cheeks behind posterior corner of mouth with yellowish sheen; dorsal, anal and caudal fins with indistinctly edged, narrow, darkish bands crossing rays; a prominent, white-edged, black spot on dorsal fin, centred above bases of posteriormost dorsal fin rays; pectoral fins colourless; pelvic fins with greyish-black membrane especially dark distally.

Distribution

Known from south-west Western Australia, from Rottnest Island, to the western extreme of the Great Australian Bight, and apparently also from South Australia (see McCulloch 1911).

Remarks

The only published records of *P. hutchinsi* are those of McCulloch (1911) and Maxwell (1980), who both included the species in their accounts of *Zanclistius elevatus*. McCulloch's figures 16 and 18, of specimens *c*. 140 and 150 mm SL, are both of *P. hutchinsi* and demonstrate the larger pectoral fin (crossing the lateral line), rounded anal fin, advanced pelvic fin, snout profile and mouth position relative to eye in that species. Not all these differences were documented by McCulloch however. In addition, it is not possible to determine which of the several localities listed by McCulloch, yielded examples of *P. hutchinsi*, though it is likely that they were taken from stations in South Australian waters.

Maxwell's (1980) account included a lateral line pore count of 66-68 for *Z. elevatus*. This is likely to have been taken from *P. hutchinsi* specimens, and his colour reproduction (Plate 33) is also of the latter species.

Parazanclistius hutchinsi is named after J. Barry Hutchins of the Western Australian Museum, Perth, in recognition of his contributions to knowledge of the Western Australian marine fish fauna, and his helpfulness in making available to me considerable amounts of study material from time to time.

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Taxonomic Notes on Some Mangrove-inhabiting Birds in Australasia

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Abstract

Geographic variation is described and the taxonomy revised in the following species that occur in mangroves in Australasia: *Eulabeornis castaneoventris, Halcyon chloris, Alcedo pusilla, Microeca tormenti, Eopsaltria pulverulenta, Pachycephala melanura, P. simplex, P. lanioides, Myiagra ruficollis, M. alecto, Rhipidura rufifrons, Gerygone tenebrosa, G. magnirostris, Conopophila albogularis, Myzomela erythrocephala, Zosterops lutea* and *Cracticus quoyi.* The relationships of some of these species are discussed.

Introduction

Australia has a fairly large number of birds confined more or less to mangrove vegetation. While researching the origin, evolution and speciation of this assemblage (Ford 1982), I assessed current views on geographical variation and taxonomy of each species. For several species it was necessary to carry out taxonomic revisions. This report contains the results of revisions on taxonomy and some conclusions on evolution of these species.

The following species were excluded because their variation has recently been discussed elsewhere: Mangrove Heron *Butorides striatus* (Schodde *et al.* 1980), Little Bronze-cuckoo *Chrysococcyx minutillus* (Ford 1981*a*), Mangrove Fantail *Rhipidura phasiana* (Ford 1981*b*), Mangrove Warbler *Gerygone levigaster* (Ford 1981*c*) and Mangrove Honeyeater *Lichenostromus versicolor* (Ford 1978*a*).

Specimens were examined at the American Museum of Natural History (AMNH) and British Museum (Natural History) (BMNH) in 1976 during tenure of a Frank M. Chapman Fellowship. Specimens were borrowed from the Queensland Museum (QM), Australian Museum (AM), National Museum of Victoria (NMV), South Australian Museum (SAM), National Wildlife Collection, Canberra (CSIRO) and Northern Territory Museum, Arid Zone Research Institute (NTM) and studied at the Western Australian Museum (WAM).

The length of the bill was measured from the tip to the base of the skull to the nearest 0.1 mm, the width of the bill across the middle of the nares to 0.1 mm, the length of the wing as the flattened chord to 0.5 mm, the length of the tail from the outside base of an innermost rectrix to the tail tip to 0.5 mm, and the

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length of the tarsus from the back of the heel to the lowest edge of the last full scale on the front of the tarsus to 0.1 mm. Only measurcments of adults are given in tables. Gazetteers that includc the localities mentioned in the text are given in Mayr (1941*b*) and Storr (1967, 1973, 1977, 1980).

Species List

Eulabeornis castaneoventris Chestnut Rail

The Chestnut Rail inhabits dense forest of estuarine mangroves between Derby (King Sound) and the Smithburne River (eastern side of Gulf of Carpentaria), and on the Aru Islands. Thcre are no records between the McArthur and Albert Rivers (Storr 1973, 1977, 1980). Hartert (1927) recognized the subspecies *sharpei* for the Aru Islands and placed all Australian populations in nominate *castaneoventris.* However the type (AMNH) of *sharpei,* which is reddish-brown on the back wings and tail, matches exactly some adult specimcns from Melville Island and south-western Cape York Peninsula. Individuals in any population apparently vary in coloration of the dorsum from chestnut to olive: all specimens from the Kimberley (Table 1) have an olive dorsum except one in which a few chestnut feathers are replacing old, olive feathers; specimcns from Melville Island vary; and the only specimen from near the head of the Gulf of Carpentaria is chestnut. Specimens with a chestnut dorsum are usually long-winged and so might be old adults. Measurements of *sharpei* fall within the range of variation of Australian birds (Table 1). Until variation in coloration is understood, no subspecies should be accepted.

Halcyon chloris Collared Kingfisher

This kingfisher occurs in coastal mangroves and offshore islands between Shark Bay and north-eastern Ncw South Wales (Serventy and Whittell 1976; Storr 1973). Elsewhere it ranges from the region of the Red Sea, through southern Asia, to northern Polynesia and has becn divided into about fifty subspecies (Mayr 1931, 1941*a*, 1949). Australian populations are currently considered to compose one subspecies *sordida,* which extends into southern New Guinea (bctween China Straits and the Mimika River) and the Aru Islands (Keast 1957; Mayr 1941*b*). It is replaced by nominatc *chloris* in western New Guinea and *colona* on the eastern satellite islands of New Guinca. The eastern and western Australian populations of *sordida* migrate northward in winter to southern New Guinea (Keast 1957) but, as judged on specimen records, it may be resident in Kimberley and Northern Territory and some birds winter on Cape York Peninsula.

Though similar to nominatc *chloris* in size (Table 2), *sordida* is distinguished by its dusky olive-green crown and back. Mature *sordida* are less dusky, more greenish on the crown and more blue-green on the back and rump than juveniles. Immatures of *chloris* are also dusky above but those of *sordida* are duskier. Males are brighter than females on the primaries and tail in both subspecies. The type locality of *sordida* is accepted as Cape York (Condon 1975) and only dusky specimens have been collected from Shark Bay to Cape York. However, most specimens from central Queensland, south-eastern Queensland and north-castern New South Wales are less dusky above, darker and brighter blue on the wings and tail, and more bluish, less greenish, on the rump than *sordida.* They could represent a dimorphism or a separate subspecies *colcloughi.* The form *colona* on the eastcrn Papuan islands is smaller than *sordida* (Ogilvie-Grant 1915; Rand and Gilliard 1975). The population on thc Pilbara coast is also characterized by short wings (Table 2). Until the basis for the variation in colour of southcrnmost eastern Australian birds is understood, only two subspecies secm acceptable for Australia: *sordida* and an unnamed population in the Pilbara.

Alcedo pusilla Little Kingfisher

This species ranges from the Moluccas through New Guinea and northern Australia to the Solomon Islands. It has three isolates in Australia: Northern Territory between Anson Bay and the Roper River, including Melville Island and Groote Eylandt; Cape York Peninsula south on the Gulf coast to the Archer River and on the east coast to the Chester River; and north-eastern Queensalnd betwecn Cairns and Townsville, including the Atherton region and Hinchinbrook Island (Keast 1957; Storr 1973, 1977; Anon. 1976). Keast (1957) divided Australian populations into two subspecies: *ramsayi* for the Northern Territory and *halli* for north-eastern Queensland; populations on Groote Eylandt and Cape York Peninsula were considered to have hybrid characteristics.

Size differences between the Australian isolates and nominate *pusilla* of southern New Guinea are slight (Table 3) but there are distinct differences in coloration: *ramsayi* is a pale royal blue, *halli* deep royal blue and *pusilla,* deep purplish-blue (darker than *halli*). Most specimens (AMNH) from Cape York Peninsula available to Keast were in various stages of plumage between the juvenile and adult phases. Juveniles have the upperparts and sides of breast more greenish and dusky, the breast with some blackish barring, the forehead scalloped and the supraloral and neck spots tinged orange (Ogilvie-Grant 1915; Anon. 1976; pers. obs.). Juveniles of *ramsayi* are more greenish or turquoise than those of *halli.* Adult specimens from Cape York Peninsula are more like *halli* in coloration though those from the western sidc are somewhat pale, possibly because of gene flow from *pusilla.* Accordingly, I accept the subspecies proposed by Keast but include the population on Groote Eylandt in *ramsayi* and that on Cape York Peninsula in *halli.*

Two subspecies are recognized for New Guinea (Mayr 1941*b*; Rand and Gilliard 1967): *laetior* in northcrn New Guinca between Geelvink Bay and Astrolabe Bay, and *pusilla* in thc rcst of New Guinea, including its western and eastern satellite islands and Torres Strait islands. The subspecies *laetior* is similar to nominate *pusilla* but paler and brighter. Mayr and Rand (1937) remarked on the variation in *pusilla* but their specimens (AMNH) were in various stages of plumage between the first-year and adult phases (pers. obs.).

Microeca tormenti Kimberley Flycatcher

This species occurs between Napier Broome Bay (Pago) and Barred Creek and on islands in the Bonaparte Archipelago. It is confined to dense mangroves whereas *M. flavigaster* favours open forest and only occasionally occurs in mangroves (and monsoon forests). Any lingering doubts that *tormenti* occurred outside the Kimberley (Seyfort 1973) were dispelled by Mason (1977) who showed that records of it in the Northern Territory were based on misidentifications of *Pachycephala simplex*. Formerly known as *M. brunneicauda*, Parker (1973) discovered that Campbell's type was a specimen of *P. simplex*. Vaurie (1953) considered it to be a geographical representative of *M. flavigaster* that had lost carotenoid pigments, a view accepted by Ford (1978*b*) and Schodde (1981). Table 4 shows that *tormenti* is fairly similar to the geographically nearest population of *flavigaster* (the nominate form in the Northern Territory) in dimensions including bill width. *M. tormenti* is drab like *M. leucophaea* but has no white on the tail and has yellowish rather than buffy under-wing coverts.

Eopsaltria pulverulenta Mangrove Robin

In Australia the Mangrove Robin ranges between Exmouth Gulf and Cardwell. It occurs on some inshore continental islands (Dampier Archipelago, Bonaparte Archipelago) Melville Island, Bickerton Island, Sir Edward Pellew Group, Clerke Island and Hinchinbrook Island, and has gaps along the Eighty Mile Beach, Joseph Bonaparte Gulf, parts of the Gulf of Carpentaria (Galbraith 1974) but not round Cairns (*pace* Storr 1973). On mainland New Guinea it occurs from Killerton Island west along the south coast to the Utanata River, and at Geelvink Bay, Humboldt Bay and the Sepik River upstream to Kanganaman (Gilliard and LeCroy 1966). It is fairly common in many parts of Australia (Pilbara, Kimberley, Melville Island, Karumba, Cape York and Cardwell) but appears to be generally uncommon in New Guinea and Aru Islands except perhaps the southern coast of Irian Jaya.

Though Mayr (1914*b*), Keast (1958) and Rand and Gilliard (1967) collectively recognized four subspecies, geographic variation is slight (Tables 5 and 6). Northern and north-eastern Australian and New Guinea birds have longer wings and tails and shorter bills on average than Pilbara and western Kimberley birds. Table 5 indicates that the change in size is stepped on the western side of the Joseph Bonaparte Gulf. Specimens from the Northern Territory and Melville Island are more blackish on the crown and auriculars than those from elsewhere (Table 6). Newly-plumaged specimens from all populations are fairly alike in coloration of the back and wings; however, faded and worn-plumaged specimens from the Pilbara are paler and browner than those from other populations. Subspecific divisions in *E. pulverulenta* differ if size and head coloration are used independently as criteria; so current divisions are not accepted.

Keast (1958) considered *pulverulenta* to have no close relatives and placed it in a monotypic genus *Peneoenanthe* rather than in *Peocilodryas* as Mayr (1941*c*) tentatively suggested or in *Eopsaltria* as Storr (1973) and Parker (1979) proposed. It is characterized by a strong large bill, prominent rictal bristles, rounded tail, absence of wing-bar, and large patches of white on the tail. Similarities to *Eopsaltria* not admitted by Keast are: streaked and speckled juvenile plumage (*pace* Galbraith 1974); coloration of eggs as in *australis* and *georgiana* (*pace* Keast 1958), dorsal grey as specially in *georgiana*, ventral pattern including diffuse grey gorget as in *georgiana*, and perhaps *griseogularis*, stoutness of bill as in *E. australis 'magnirostris'*, behavioural mannerisms, feeding niche and general coloration like *georgiana*. Thus differences between *pulverulenta* and other species in *Eopsaltria* are best viewed as strongly specific. Schodde (1981) has expressed similar views. *E. pulverulenta* is not a member of *Poecilodryas* which is characterized by prominent superciliary, prominent wing patch and uniformly chocolate to rufous brown plumage in the juvenile. *Poecilodryas* species also have a strong stout bill and prominent rictal bristles.

Pachycephala melanura Mangrove Golden Whistler

P. melanura occurs between Exmouth Gulf and Mackay including many offshore islands (Storr 1973, 1977, 1980) in northern Australia, on many islands in Torres Strait, between Merauke and Milne Bay, on some islands (Teste and Fergusson) in the d'Entrecasteaux Archipelago and on a string of small islands from the Vitiaz and Dampier Straits through the Bismarcks east to Nissan Island and possibly to the Solomon Islands (Galbraith 1956, 1967; Rand and Gilliard 1967; Storr 1973, 1977, 1980; Diamond 1975, 1976). On mainlands it inhabits mangroves whereas on islands it also frequents subhumid scrubs, second-growth scrub-formations and depauperate rainforest. It has gaps in range along the Eighty Mile Beach (between Cape Keraudren and Frazier Downs) and apparently along the north-eastern coast of Queensland (no record between Cape Grenville and Bowen) and has rarely been recorded in central coastal Queensland (Edgecumbe Bay, Bowen; Daydream Island, Whitsunday Group; Seaforth (= Springcliff); Mackay (two specimens in AM) but not the Percy Isles (*pace* Galbraith 1974; QM specimen is *pectoralis*). Three subspecies are currently recognized; *melanura* (Exmouth Gulf to Port Warrender), *spinicauda* (synonyms *hilli* and *violetae;* Napier Broome Bay to Mackay, Torres Strait, Merauke to Hall Sound), and *dahli* (Hall Sound to Nissan Island).

Mayr (1954), Galbraith (1956, 1967) and Ford (1971) have described geographic variation in *P. melanura.* This is slight in males and striking in females. Adult females of *spinicauda* and *dahli* differ from those of *melanura* in being richly yellow rather than whitish on the lower breast, abdomen and flanks; olive rather than grey on the mantle; and more blackish, less olive, on the tail. Adult males of *spinicauda* and *dahli* differ from those of *melanura* in being more intensely yellow ventrally and having a wider yellow collar and a wider pectoral black band. The forms *melanura* and *spinicauda* intergrade between Port Warrender and Napier Broome Bay; here females are varying shades of pale yellow on the belly (Table 7). On proceeding from Napier Broome Bay to Nissan Island, ventral yellow in females becomes more intense, the dorsum becomes more olive and the amount of black on the tail increases but these trends are clinal (Galbraith 1956). There are also some clinal trends in males; for, on proceeding from Exmouth Gulf to Nissan Island, ventral yellow becomes richer, the yellow collar widens, the dorsum becomes more yellowish, and the olive on the tail decreases. In nominate *melanura* there are slight differences in coloration between the populations on opposite sides of the Eighty Mile Beach but these may be associated with clinal trends perhaps accentuated by the gap in range. Size of wing, tail and bill apparently increase in both sexes on proceeding from the Kimberley to Nissan Island (Galbraith 1956; Table 8), and the Pilbara population is apparently longer in wing and tail than the southern Kimberley population of *melanura*. Differences between *spinicauda* and *dahli* are slight and apparently they intergrade gradually (Galbraith 1956; pers. obs.): the adult female of *dahli* is more olive above, more streaked and barred on the throat, darker on the crown and more intensely yellow below; adult males of *dahli* have narrower grey edging, and hence more black, on the remiges. There seems little point in retaining *dahli*. Therefore only two subspecies, *melanura* and *spinicauda* are accepted.

Pachycephala melanura is a member of the *P. pectoralis* superspecies (Galbraith 1956, 1967). Indeed Galbraith (1956), Mayr (1954), Ford (1971) and Storr (1973, 1977, 1980) treated these as conspecific. Mayr believed the presence of buff and reduced yellow on the belly of female specimens (AMNH) of *P. m. spinicauda* round Torres Strait (Cape York, islands in Torres Strait and Daru region) indicated that they had been affected by intrusion of genes from *P. p. queenslandica* which is ochraceous on the belly of females. However, ventral buff in *spinicauda* is a characteristic of first-years and subadults only (Galbraith 1967, pers. obs.) and the specimens with ventral buff seen by Mayr were not adults (pers. obs.). Galbraith (1956) claimed that *P. p. whitneyi* was a variable hybrid population between *P. m. dahli* and *P. p. bougainvillei* and that in the Louisiades *P. p. collaris* was affected by *dahli* genes. Nevertheless, he later (1967) considered *P. m. spinicauda* and *P. p. queenslandica* had abutting ranges and were ecologically (and hence intrinsically) isolated in mid-eastern Queensland but overlooked that *queenslandica* breeds in highland rainforests and subhumid scrubs (500-1500 m) and is only an altitudinal migrant to lowlands in winter (Storr 1973). The significance of *P. pectoralis* in rainforest in the Iron Range area (Forshaw and Muller 1978) is not known but clearly the buffiness in populations of *spinicauda* round Torres Strait is not caused by *queenslandica* genes. The best evidence for *P. melanura* and *P. pectoralis* being separate species is that of Diamond (1975, 1976) who found a chequer-board pattern of distribution, yet no hybridization, in *P. p. citreogaster* and *P. m. dahli* on islands between New Guinea and the Bismarcks.

On the assumption that *P. melanura* evolved somewhere in its present area of distribution, it must have arisen in either north-western Australia, north-eastern Australia, south-eastern New Guinea, or the Bismarcks. In all these areas except north-western Australia it is sympatric or parapatric with some form of *P. pectoralis.* Consequently north-western Australia seems to have been its area of origin. Galbraith (1956) also believed it reached the Bismarcks rather recently.

Pachycephala simplex Grey Whistler

New Guinean populations fall into two groups: the yellow-bellied, olive-backed subspecies of the *griseiceps* group and the white-bellied, brownish-backed subspecies of the *dubia* group (Mayr 1941*b*; Rand and Gilliard 1967; Schodde and Hitchcock 1968). The yellow-bellied group occupies the Aru Islands, western Papuan islands and New Guinea east to about Galley Reach (near Port Moresby) and Astrolabe Bay where it hybridizes (Mayr and Rand 1937; Rand and Gilliard 1967) with the white-bellied group of extreme eastern and north-eastern New Guinea (bordering the Solomon Sea), d'Entrecasteaux Archipelago and Tagula Island of the Louisiade Archipelago. The species also occurs on the Moluccan Islands. It inhabits the substage and lower trees of forest (mainly edges) and dense second-growth forest and undergrowth from sea level up to 1500 m.

The two Australian subspecies are peripheral populations that parallel precisely the geographical variation in New Guinea (Mayr 1954) but may represent a twin invasion by yellow-bellied stock. The subspecies *peninsulae* of the humid zones of north-eastern Cape York Peninsula and north-eastern Queensland is yellow-bellied and has a more conspicuous gorget and brighter dorsum than *perneglecta,* the geographically closest subspecies in New Guinea; it is a weak differentiate and occupies the same habitats as New Guinean forms. The subspecies *simplex* of northern coastal Northern Territory (including Melville Island and Groote Eylandt) is white-bellied and brownish on the dorsum but, on geographical grounds, was probably derived from the yellow-bellied group of New Guinea. If this was so, the independent evolution of two white-bellied forms (*dubia/sudestensis* and *simplex*) would support Galbraith's (1974) conclusion that *simplex* and *griseiceps* are conspecific. *P. s. simplex* lives in mangroves, monsoon forests and swamp-paperbarks; its presence in mangroves had led to its confusion with *Microeca tormenti* (Parker 1973; Mason 1977). The species is absent from most of the coastline of the Gulf of Carpentaria; there are no records between Port Bradshaw and Weipa.

Pachycephala lanioides White-breasted Whistler

The White-breasted Whistler is distributed in mangroves between Shark Bay (Peg's Beach) and the head of the Gulf of Carpentaria (lower Norman River). A recent record from Yandaran, Queensland (Tucker 1977; pers. comm.), requires confirmation. It occurs on Legendre, Enderby and West Lewis Islands in the

Dampier Archipelago, Melville Island and Sir Edward Pellew group, and has gaps in range between Carnarvon and North West Cape, between Pardoo (Cape Keraudren) and Frazier Downs (Whistle Creek) and between the Prince Regent River and Cambridge Gulf.

Mayr (1954), Mees (1964) and Galbraith (1974) accepted three subspecies: *carnarvoni* in mid-Western Australia and Pilbara, *lanioides* in west Kimberley; and *fretorum* between Wyndham and Karumba (Norman River). Though it is uncertain whether the type locality of *fretorum* is Wyndham or Karumba (Mees 1964), the northern population is properly designated as *fretorum.* Table 10 shows that there is a distinct difference in size between *lanioides* and *fretorum.* Adult females of *carnarvoni* are generally brownish or tawny above, not greyish, and perhaps buffier below than females of other subspecies and closely resemble their juveniles. Males of each subspecies are similar in coloration except possibly for more grey, less black, on the upper-tail coverts of *carnarvoni.* I agree with the splitting of this species into three subspecies though they are only weakly differentiated.

Myiagra ruficollis Broad-billed Flycatcher

In Australia, *M. ruficollis* ranges more or less continuously in mangroves between Whistle Creek (Frazier Downs) and Cape Grenville (eastern Cape York Peninsula), and in southern New Guinea between the Mimika and Laloki Rivers (Storr 1973, 1977, 1980; Rand and Gilliard 1967). A record from Noah Creek, near Cape Tribulation, north-eastern Queensland (Cowan 1977) requires confirmation.

All Australian and New Guinean populations are usually placed in the same subspecies (*mimikae*) because they are considered to be alike in size and coloration (Mayr 1941*b*; Keast 1958; Diegnan 1964; Storr 1973, 1977, 1980). However, birds fom the Aru Islands may be larger (Table 11) and a paler shade of rufous on the breast and throat. Unfortunately, the significance of the difference in coloration between birds from the Aru Islands and other populations of *mimikae* cannot be properly assessed because some adults from Melville Island and subadults in all populations are pale on the breast and throat. Some adults have no white edging on the outer vane of the outermost rectrices (*contra* Slater 1974).

Populations of *M. ruficollis* from the Celebes through to the Lesser Sunda Islands compose the nominate subspecies which is characterized by a rich rufous, almost chestnut, breast and throat and a slightly darker dorsum and face than *mimikae.* The subspecies *fluviventris* of Tanimbar Island is like nominate *ruficollis* on the throat and breast but is rufous rather than white on the abdomen, flanks, under-tail coverts and under-wing coverts, and has a greyish-blue rather than a glossy blackish-blue crown and a smaller patch of white below the eye.

Myiagra alecto Shining Flycatcher

The Shining Flycatcher is distributed along the northern fringe of Australia between Karratha and Noosa where it inhabits coastal mangroves and, less commonly, sub-inland thickets and forests along freshwater streams. There are gaps in its range along the Eighty Mile Beach (between Port Hedland and Cygnet Bay, Dampier Land) and the Gulf of Carpentaria (between the Nicholson and Archer Rivers). It is widely distributed to the north of Australia, ranging between the Moluccas and Bismarcks.

Mayr (1941*a*) tentatively grouped all Australian populations under one subspecific name (*nitida*) but, as Keast (1958) and Galbraith (1974) showed, there is some differentiation between populations. In size of bill, Kimberley birds are narrowest and longest, Queensland birds widest and shortest, and Northern Territory birds are shorter than those in Queensland. In size of wing and bill, Queensland birds grade into those in New Guinea (Rand 1942; Storr 1973: Table 12). Mainly on these differences in size and some in coloration, Keast (1958) recognized three subspecies in Australia: *tormenti* in Kimberley, *nitida* in Northern Territory and *wardelli* in Queensland. Unfortunately all female specimens (AMNH) of *tormenti* examined by Keast were immatures (pers. obs.): adult females of *tormenti* have a glossy blue-black crown as in other forms, not a greyish one which is characteristic of juveniles in north-western Australia. There is also little geographic variation in belly colour of males (Galbraith 1974; *pace* Keast 1958). However, there are some clear-cut differences in coloration between females of north-western Australia (Kimberley and Northern Territory) and those of Queensland (Galbraith 1974; pers. obs.); for, the former are white or faintly buff on the under-tail coverts and white on the flanks whereas the latter are rufous to buff on the coverts and buff on the flanks. Additionally, first-years from north-western Australia are less glossy and more greyish, less blackish, on the crown. Apparently, therefore, some isolation exists between the two groups across the Gulf of Carpentaria. Storr (1973) used *rufolateralis* for north-western birds because *nitida* was preoccupied in *Myiagra* by *M. nitida* Gould, a synonym of *M. cyanoleuca.* However, *rufolateralis* (type locality Aru Islands) has a short bill (Table 12) and, in females, pale rufous under-tail coverts and ochraceous flanks. Females of the subspecies on Tanimbar Island, *longirostris,* have rufous under-tail coverts and flanks. Consequently, the next available subspecific name *melvillensis* Mathews must be used for the north-western group if it is to be treated as distinct from other populations. Therefore, two subspecies are accepted for Australia: *melvillensis* (Kimberley and Northern Territory) and *wardelli* (Queensland).

The subspecies *wardelli* of Queensland extends through the islands in Torres Strait to the Fly River lowlands of New Guinea where it intergrades with New Guinean populations in which females are dark chestnut (instead of very dark chestnut) on the dorsum and have the glossy black of the crown demarcated fairly sharply from (instead of merging gradually with) the rufous of the back (Mayr 1941*a*; Rand 1942; Rand and Gilliard 1967; pers. obs.). Populations characterized by a dark or very dark rufous back occur on the western Papuan islands, Geelvink Bay islands, Admiralty Islands and most of lowland New Guinea (up to 300 m) except round Astrolabe Bay where they are apparently affected by gene flow from the pale-backed populations of the Bismarcks (cf. Mayr 1941*a*). The widespread New Guinean form and the populations of the Bismarcks are usually combined under *chalybeocephala* but if Bismarck birds are separated subspecifically they would be known as *chalybeocephala* (type locality New Ireland) and the New Guinea birds would be known as *novaeguineensis* (type locality Mimika River). Another subspecies, *lucida*, characterized by a large bill and very pale chestnut dorsum in females, occurs on the d'Entrecasteaux and Louisiade Archipelagoes.

The differences between juveniles and adult females are more pronounced in nominate *alecto* of the northern Moluccas and *melvillensis* than in *wardelli*, *novaeguineensis* and *chalybeocephala*. In the juvenile, *alecto* has a dull grey head sharply separated from the rufous back, *melvillensis* has a slightly glossy bluish head grading into the back and other forms have a fairly glossy blackish head. Interestingly, *alecto* has a dark rufous back and rufous under-tail coverts in females. Also noteworthy is that in female adults of *melvillensis* the dark crown is more sharply separated from the rufous back than in immatures; this may also be the case in other subspecies.

Rhipidura rufifrons Rufous Fantail

Two distinct subspecies occur in Australia: *dryas* in the northern coastal fringe between Yampi Peninsula (Wojulum) and the Watson River, western side of Cape York Peninsula, and *rufifrons* in coastal eastern Australia (Mayr and Moynihan 1946; Keast 1958; Galbraith 1974). Nominate *rufifrons* has a tail with the basal half rufous (Table 13) and narrow greyish to grey-white tips on the rectrices, slightly more prominent black-and-white scales on the breast, slightly more extensive rufous on the dorsum, flanks and under-tail coverts and slightly greyer sides of the breast; *dryas*, a tail with prominent white tips and little rufous (mostly concealed by the coverts) on the tail, reduced scaling on the breast, a greater tail to wing ratio and a longer bill (Keast 1958). Though essentially an inhabitant of mangroves, *dryas* sometimes frequents monsoon forest, gallery forest and dense riverside thickets. The chief habitats of *rufifrons* are rainforest and wet sclerophyll forest but it also commonly occurs in gallery forest, subhumid scrubs and waterside thickets particularly on migration.

Storr (1973) accepted a subspecies *intermedia* for populations in the north-eastern highlands of Queensland between Mt Amos and the Seaview Range; he stated that it was white-tipped on the tail and generally intermediate in coloration between *dryas* and *rufifrons* which he considered to have a breeding range south from the Bunya Mountains. Keast (1958) also considered birds from the Gulf of Carpentaria (e.g. Watson River) to be intermediate. As shown in Table 13, the pattern of coloration on the tail in breeding birds from north-eastern Queensland is like that of southern *rufifrons* whereas in birds from the Gulf country (including Watson River) the pattern is as in *dryas*. Hence, there is no evidence for intergradation between *dryas* and *rufifrons*; indeed there is a wide gap between their breeding ranges and some of the inland records that have been attributed to *dryas* (e.g. Georgetown) by Storr (1973) were probably migrant *rufifrons*. However, there does appear to be a trend of increasing whiteness on the tip of the tail from south to north in breeding populations of *rufifrons* (including *intermedia*): northernmost birds have pale whitish-grey tips and southernmost, grey to buffy grey tips. Specimens from the Atherton Tableland can be matched with some from Mackay, Blackall Range, Bunya Mountains and Warwick but the trend is apparently clinal. Another character varying clinally in *rufifrons* is the colour of the face between the lores and auriculars and below the eyes: this is brown in southern birds and blackish (as in *dryas*) in northern breeding birds. There may also be some south-north clinal reduction of the degree of rufous on the flanks. Because *rufifrons* and *dryas* do not intergrade, the superficial resemblance of northern-breeding populations of *rufifrons* to *dryas* is a case of convergence. The form *intermedia* should not be recognized; only nominate *rufifrons* and *dryas* are accepted.

In New Guinea, *R. rufifrons* is only represented by four insular subspecies: *louisiadensis* in the Louisiade Archipelago (see Mayr 1941*a*), *squamata* in the western Papuan islands, *henrici* in the Aru Islands (plus Kai and South-east Islands of the Moluccas) and *streptophora* (in mangroves) in the Mimika River area of southern New Guinea (Mayr 1941*b*). The form *streptophora* is fairly similar to *dryas* in coloration (Ogilvie-Grant 1915; Table 13) but is longer tailed.

Gerygone tenebrosa Dusky Gerygone

This is the only species restricted to mangroves between Shark Bay (Bush Bay) and the southern Kimberley (Point Torment or possibly Kimbolton). It has gaps in range between Carnarvon and Yardie Creek and between Cape Keraudren and Whistle Creek (Frazier Downs). The mid-western and Pilbara populations appear to be similar in dimensions whereas the Kimberley population may be a trifle smaller in wing and tail length (*pace* Johnstone 1975; Table 14). The back is olive-grey in specimens from Bush Bay north to Dampier Land but at Point Torment it is dark greyish-brown, a trend towards the closely related *G. magnirostris*. This darkening on the dorsum may be caused by either local adaptation (ecotypy) or some hybridization with *magnirostris*. Interestingly, *tenebrosa* has black legs whereas *magnirostris* has slate grey legs but one dark specimen of *tenebrosa* (as judged on its cream irides and width of bill) has slate grey legs. The male specimen from Kunmunya (WAM) in the wet north-western Kimberley, identified by Johnstone (1975) as *tenebrosa* is peculiar; it supposedly had cream irides and black legs as in *tenebrosa*, but its bill width of 3.5 mm, dark olive-brown back and buffy breast and flanks identify it as *magnirostris*; its other measurements are wing 50, tail 40 and bill length 13.2 (cf. Tables 14 and 15). Hence, there is no absolute evidence for an overlap in the ranges of these species (*pace* Johnstone

1975): specimens of *tenebrosa* have been collected north to Point Torment and those of *magnirostris* south to Kimbolton (Trent River) but Johnstone (pers. comm.) has observed white-eyed gerygones, presumably *tenebrosa*, at Kimbolton.

Johnstone (1975) recognized three subspecies: nominate *tenebrosa* in southern Kimberley, *whitlocki* in the Pilbara and *christophori* in the mid-west. There is little difference between the latter two but *tenebrosa* appears to be smaller (Table 14) and perhaps darker than other populations. Hence, only two subspecies ought to be accepted: nominate *tenebrosa* for Kimberley populations and *christophori* for southern populations.

In classifying *tenebrosa* as a subspecies of *magnirostris*, Meise (1931) clearly believed these two taxa to be closely related. They have a generally dull coloration, faint superciliaries, white arcs above and below the eyes, darkish loral streaks and a weak, repetitive song, and replace each other geographically. They differ mainly in width of bill, ventral coloration (*magnirostris* is slightly buff rather than grey on the breast and flanks), coloration of irides (*magnirostris* is brick-red and *tenebrosa*, white) and nest construction (Johnstone 1975). McGill (1970) hinted that *tenebrosa* may be closer to *G. levigaster*, but this species is more strongly marked on the face and has a sweet, varied and sustained song more reminiscent of *G. fusca* (Ford 1981*c*). The peculiar specimen from Kunmunya also points to *tenebrosa* being closest to *magnirostris*.

Gerygone magnirostris Large-billed Gerygone

Three populations of *G. magnirostris* occur in Australia: north-western Kimberley between Kimbolton (Trent River) and Pago (Napier Broome Bay) including islands of the Bonaparte Archipelago; Northern Territory (including Melville Island, Groote Eylandt and Sir Edward Pellew Group) between the Daly and McArthur Rivers; and northern Queensland from Cape York south on the west coast to the Edward River and on the east coast to Mackay (and Shoalwater Bay?), including islands in Torres Strait and Hinchinbook Island. In the Kimberley, it has been seen only in mangroves; in the Northern Territory, mostly in mangroves, sometimes in adjacent monsoon and riverside forests; and in Queensland, in many sorts of dense vegetation overhanging water, where it penetrates inland along large rivers on Cape York Peninsula (e.g. middle Mitchell) and to lowland rainforest in north-eastern Queensland (Storr 1973, 1977, 1980). A record based on a clutch of eggs from the lower Nicholson River, Gulf of Carpentaria, reported by S.W. Jackson (Storr 1973), requires confirmation.

Meise (1931) placed the populations of the Northern Territory and Queensland in the same subspecies (nominate *magnirostris*); he did not have any material from the isolated population in north-western Kimberley. Table 15 indicates that all three populations are fairly similar in dimensions, though perhaps the Queensland population is slightly smaller in the wing and tail and more like those from southern New Guinea. Queensland birds appear to be the most strongly buff below, and the Kimberley birds, particularly those from near the range of *G. tenebrosa,* the most whitish below. However, there is much individual variation and differentiation between the three populations is weak, so they are treated as one subspecies.

G. magnirostris is well distributed on lowlands up to about 1500 m in New Guinea and its satellite islands where it dwells in the same kinds of habitat as in Queensland (Rand and Gilliard 1967). Meise (1931) recognized eight subspecies (but omitted *hypoxantha* of Biak Island [see Mayr and de Schauensee 1939]), Mayr (1941*b*) ten, and Rand and Gilliard (1967) eleven; each had three subspecies on the mainland. The most distinctive forms occur on the remotest islands and those islands never connected to the mainland during the last glaciation: Biak (*hypoxantha*), Rossel (*rosseliana*) and Tagula (*tagulana*). As remarked by Rand and Gilliard (1967), the various subspecies have been described on the basis of slight differences in tone of the back (varying shades of olive-brown) and in the amount, depth and tone of wash on the undersurface (yellowish-buff to rusty-buff). They are all fairly similar in dimensions (Table 15). Populations on the mainland, Aru Islands and western Papuan Islands differ only slightly (Meise 1931; Rand 1942; pers. obs.); those in the Aru Islands and southern New Guinea, usually placed in *brunneipectus* and *mimikae* (which ought to be combined), are most like the Queensland population in coloration and size (Table 15) but Australian birds apparently have more white on the tips of the tail feathers.

Conopophila albogularis Rufous-banded Honeyeater

Salomonsen (1967) recognized two subspecies in this species, *albogularis* in the Northern Territory (between Port Keats and Roper River estuary, including Melville Island and Groote Eylandt) and Cape York Peninsula (between Cape York and the Staaten River), and *mimikae* in southern New Guinea (between Triton Bay and Port Moresby) and at the Sepik River and the Aru Island but stated that they were doubtfully distinct. Storr (1973) accepted Queensland birds as *yorki.* However, all populations are indistinguishable in coloration. Queensland and New Guinean birds are similar in size, and Northern Territory birds appear to have on average shorter bills than others (Table 16). Subspeciation, at the most, is slight. I accept no subspecies.

Conopophila contains two species, *albogularis* and *rufogularis,* which differ as follows: the throat is white in *albogularis,* rufous in *rufogularis*; the breast is rufous-brown in *albogularis,* grey in *rufogularis*; and the crown and frons are dark grey (unlike the back) in *albogularis,* grey-brown (like the back) in *rufogularis.* As *albogularis* is fairly widespread in New Guinea and has not colonized the Kimberley, it is presumably of New Guinean origin whereas *rufogularis* is confined to Australia where is probably evolved. Thus, these species may represent a case of speciation on opposite sides of Torres Strait-Arafura Sea.

Myzomela erythrocephala Red-headed Honeyeater

The Red-headed Honeyeater occurs in northern Australia continuously between Whistle Creek (Frazier Downs), Kimberley, and the Stewart River, eastern Cape York Peninsula, including continental islands, on islands in Torres Strait, in southern New Guinea between Hall Sound and Triton Bay, and on the Aru Islands. It inhabits mangroves and occasionally nearby thickets and gallery forest.

Specimens from Australia, southern islands of Torres Strait and Hall Sound region of New Guinea average shorter in wing, tail and bill than those from the Aru Islands, most of southern New Guinea and northern islands in Torres Strait (Table 17). However, the pattern of geographic variation in coloration is different: males from the Aru Islands, New Guinea excluding the Hall Sound area, Torres Strait islands and northern Cape York Peninsula are blackish on the dorsum and breast and brown on the abdomen; males from Hall Sound, Gulf of Carpentaria, and most of the Northern Territory and Kimberley are brownish on the dorsum and grey on the abdomen; and from the wet north-western Kimberley and Melville Island, intermediate. This explains why Mayr (1941*b*) and Salomonsen (1967) divided *M. erythrocephala* differently. Mayr (1941*b*) placed the populations in Australia, Torres Strait and south-eastern New Guinea in nominate *erythrocephala* and all others in *infuscata,* whereas Salomonsen also included the population on Cape York Peninsula in *infuscata.* The irregular distribution of dark birds and the discordance of size and coloration indicates that coloration might have partly been affected by climate and, therefore, should be given little weight in any subspecific divisions. Nevertheless, the darkening of birds on Cape York Peninsula might have been partly caused by gene flow from *infuscata* because Torres Strait birds are intermediate in size between *infuscata* and *erythrocephala.* Incidentally, *infuscata* Forbes is not a *nomen nudum* as suggested by Storr (1973) because Forbes (1879) clearly described how it differed from *erythrocephala.*

M. erythrocephala is not particularly close phylogenetically to *M. sanguinolenta* of coastal eastern Australia; for, each belongs to a different species-group within the *M. cardinalis* assemblage (Koopman 1957). The *erythrocephala*-group has no red on the back and abdomen whereas the *cardinalis*-group, which includes *sanguinolenta,* has red on the back. Within the *erythrocephala*-group, *M. adolphinae* of the central mountain-chain of New Guinea is most similar to *M. erythrocephala* in pattern of coloration and sexual dimorphism, though generally smaller and its female having a slight greenish tint dorsally; they presumably represent a Pleistocene speciation. Interestingly, some specimens of *adolphinae* have a trace of red extending from the rump on to the back, a characteristic of the *cardinalis*-group. Koopman (1957) suggested the *erythrocephala*-group probably arose somewhere in the Banda Sea (because this is where there are the most primitive species) and colonized New Guinea quite early in its history. The early New

Guinean form (proto-*adolphinae-erythrocephala*), presumably a rainforest-dweller, later invaded northern Australia where it gave rise to *M. erythrocephala* which colonized New Guinea, either by flying across the Arafura Sea-Torres Strait or by utilizing one of the Pleistocene land bridges over Torres Strait. The occurrence of an isolated population of nominate *erythrocephala* in south-eastern New Guinea and the apparent secondary contact between *erythrocephala* and *infuscata* on islands in Torres Strait underline a complex history of expansions and contractions in the range of *M. erythrocephala* stock. *M. erythrocephala* has also crossed the Timor-Arafura sea and colonized Sumba, where it has produced the distinctive *M. [e.] dammermani*, a slightly melanistic and smaller form. Presumably Salomonsen (1967) treated *M. kuehni* of Wetar Island as specifically distinct from *M. erythrocephala* because it is monochromatic, it has ventral red on the throat and upper breast (rather than confined to the throat as in *erythrocephala*) and its general coloration is drab like the female of *erythrocephala*.

Zosterops lutea Yellow Silvereye

This species occurs plentifully between Shark Bay and the Edward River, western Cape York Peninsula (Mees 1961, 1969; Storr 1973, 1977, 1980), and less commonly between Cairns and Ayr, north-eastern Queensland (Galbraith 1967; Lavery and Grimes 1974) and possibly around Quintell Beach, eastern side of Cape York Peninsula (Johnson and Hooper 1973). Mees (1961, 1969) divided populations in north-western Australia into two subspecies: *balstoni* between Shark Bay and the western Kimberley and *lutea* between the northern Kimberley and the Edward River. He distinguished *lutea* from *balstoni* by its supposedly larger size and slightly brighter, more yellowish coloration. However, variation in size of wing and bill appears to be clinal (Table 18) and many specimens from within the range of *balstoni* in western Kimberley are just as bright and yellow as those from northern Australia. Moreover, individual variation is such that the dullest (or brightest) birds in any population can be matched with those in other populations, and specimens in old plumage are duller and more greenish than those in new plumage. Specimens of the eastern coastal population collected by Lavery and Grimes (1974) were assessed as similar in size and coloration to specimens from the Gulf of Carpentaria. Consequently, there appears to be no subspeciation in *Z. lutea*.

The relationships of *Z. lutea* are unclear. *Z. flava, Z. griseotincta, Z. natalis* and *Z. chloris* (including *citrinella* and *albiventris*) are considered to be phylogenetically closest to *Z. lutea* (Stresemann 1931; Mayr 1944*a*, 1965; Mees 1957, 1961). *Z. flava* is smaller and more yellowish than *Z. lutea*, does not have a black loral spot and has a continuous white eye-rim (not one with a slight gap caused by a black loral spot as in *lutea*); it, therefore, does not appear to be particularly close to *Z. lutea. Zosterops natalis* is light greyish-white below, pale buff on the flanks, dull green above, larger and heavier-billed and has more black on the lore and below the eye than *Z. lutea*; consequently, it also appears not to be specially close but is probably closer than *Z. flava. Zosterops griseotincta* is larger, more greenish below, greyish and green on the loral area, larger billed, brown rather than black in bill coloration and without yellow on the frons. The last species, *Z. chloris*, is quite like *Z. lutea* in pattern and coloration round the eye, fairly similar in size and pale yellow on the frons; undoubtedly it is the most closely related to *Z. lutea.* Indeed, Mayr (1944*a*, 1965) considered them conspecific but the parapatric occurrence of *Z. c. albiventris* on small wooded islands off the east coast of Cape York Peninsula and *Z. lutea* in patches of mangroves on the adjacent mainland suggests they are allospecifically related. Within *Z. chloris,* there are two very distinct groups: the yellow-bellied or *chloris*-group of the Moluccas, Celebes, Flores to Bali and Java Sea islands, and the white-bellied or *citrinella-albiventris*-group of Sumba, Lesser Sunda Islands, and islands of south-eastern Banda Sea, Torres Strait and Great Barrier Reef (off coast of eastern Cape York Peninsula). Mees (1957, 1961) initially treated these groups as conspecific but later (1969) as specifically distinct. Strangely, the white-bellied group lies geographically between the yellow-bellied group and *lutea* which, of course, is yellow below. Both *chloris-citrinella* and *lutea* are inhabitants of mangroves, small well-wooded islands and thickets on lowlands of mainlands or large islands but *chloris* ascends to higher altitudes (Mayr 1944). The ancestral home of the form that produced the trichotomy *chloris-citrinella-lutea* is obscure and hence whether north-western Australia was invaded from the Lesser Sundas-southern Moluccan region or vice versa cannot be stated with confidence. However, the extensive distribution of *Z. chloris-citrinella* possibly indicates that it is a fairly old species that has expanded its range since the last glacio-eustatic rise in sea level (Mees 1961). Probably, therefore, *Z. lutea* is the younger form.

Cracticus quoyi Black Butcherbird

Widespread in lowland forests in New Guinea, including several western islands (Misol, Salawati, Waigeu and Japen) and the Aru Islands, this species has four isolated populations in Australia (Melville Island plus coastal Northern Territory between Port Keats and the Goyder River, northern Cape York Peninsula south to the Archer and Stewart River, humid north-eastern Queensland between the Endeavour and Herbert Rivers and inland to the eastern Atherton Tableland, and northern central-coastal Queensland between Proserpine (Thompsons Creek) and Port Clinton. Amadon (1951), the last reviser, recognized a long and slender-billed, long-winged subspecies *spaldingi* in the Northern Territory, northern Cape York Peninsula and Aru Islands, a bulbous-billed subspecies *quoyi* in New Guinea and its western satellite islands, and a short-winged, dimorphic (a rufous as well as a black juvenile phase) subspecies *rufescens* in eastern Queensland. Storr (1973) considered the northern Cape York Peninsula population to belong to *quoyi* and the central Queensland population (apart from being monophasic) to be unknown taxonomically. Mees (1964) gave data indicating the population between Merauke and Daru, southern New Guinea, to be part of *spaldingi.*

Apart from the rufous morph in north-eastern Queensland, birds of all populations are similarly black. Table 19 summarizes measurements of all populations. It confirms that Northern Territory birds average the longest in bill, wing and tail but are narrow-billed and that Daru-Merauke birds average longer in wing than other New Guinean birds. However, the table also shows that Aru Island birds are approximately intermediate in dimensions between Northern Territory and New Guinea birds and that birds of the three Queensland populations are fairly similar in dimensions yet smaller than those from elsewhere. When size and coloration are simultaneously considered it is apparent that most populations have differentiated from one another. Nothing is achieved by expressing this subspecifically.

Table 1 Measurements (mm) of *Eulabeornis castaneoventris.*

Population	Males	Females
Wing Length		
Aru Islands		210
Melville I. and N.T.	214, 219(2)	207, 216, 218
Kimberley	209(2), 210(2), 211, 212, 214, 217, 219, 243	194, 200, 205, 206, 218, 220, 223
Cape York Peninsula	223	
Entire Bill Length		
Aru Islands		57
Melville I. and N.T.	59, 63.5, 64, 65	56.5, 57, 58.5
Kimberley	56, 60(5), 61, 62.5, 63, 63.5, 64.5	56, 56.5, 57.5, 59, 61, 62.5, 63
Cape York Peninsula	60	
Tail Length		
Aru Islands		121
Melville I. and N.T.	126, 127, 135	120(2), 130
Kimberley	122, 126, 127, 129, 132, 133	114, 121, 124, 127, 130(2)
Cape York Peninsula	128	
Tarsus Length		
Aru Islands		67.5
Melville I. and N.T.	67(2), 68.5, 76	67, 70.5, 73
Kimberley	61.5, 67, 69, 70, 70.5, 71.5	66, 68, 68.5, 69, 70(2), 71.5
Cape York Peninsula	74	

Table 2 Measurements (mm) of *Halcyon chloris sordida*

Population	Males	Females	Unsexed
Bill Length			
Aru Islands	51, 54.5, 55.5, 56(2), 56.5, 58.5	57, 59, 60.5	
New Guinea	54, 54.5, 57(2)	53, 55	
Pilbara	55.5	54	
Kimberley	60, 61.5	53.5	
Northern Territory	55, 55.5, 56(2), 57.5, 58(2), 59	55.5, 57*, 58.5, 59, 60	56, 58
Eastern Queensland	52, 54, 55(2), 56.5, 57.5, 58(3), 59(2), 59.4	55(2), 56, 57, 59	52, 52.5(3), 53(2), 56, 58, 59.5
Wing Length			
Aru Islands	100, 106, 115	103, 104, 107	
New Guinea	103, 107, 108, 110, 112	101, 104, 105	
Pilbara	95	91	
Kimberley	106(2)	104	
Northern Territory	97, 100(2), 100.5, 102(2), 104.5	94*, 98, 99, 101, 103	97, 99
Eastern Queensland	101.5, 102.5, 103(2), 104(2), 106, 107(2), 107.5, 108, 112, 114	99, 103(2), 106, 110, 115	103, 104(3), 105(2), 108.5(2)
Tail Length			
Aru Islands	71.5, 72, 72.5	71, 76	
New Guinea	67, 68, 71	68, 70	
Pilbara	67.5	67.5	
Kimberley	72, 76	73.5	
Northern Territory	70, 71(3)	66*, 68.5, 69(2), 70, 72(2)	66.5, 70(2), 72
Eastern Queensland	66, 67, 68, 69(2), 70(2), 70.5, 71, 72(2)	67, 69(2), 70, 75	64.5, 65, 66(2), 67, 68, 69, 69.5, 70.5

*Subadult

Table 3 Measurements (mm) of *Alcedo pusilla*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Bill Length								
Northern Territory	10	32.1	29.9-34.2	1.28	5	32.4	31.3-33.3	0.80
Cape York Peninsula	12	32.8	29.2-35.0	1.73	4	32.0	31.5-32.2	0.31
North-east Queensland	16	33.7	30.7-35.8	1.13	11	32.3	29.2-34.7	1.99
South New Guinea	8	32.9	32.0-34.0	0.73	7	31.1	30.0-32.0	0.71
Wing Length								
Northern Territory	10	50.8	49.0-52.5	1.16	5	51.6	50.5-52.0	0.65
Cape York Peninsula	12	51.3	50.5-52.0	0.69	4	52.1	51.0-53.0	0.85
North-east Queensland	16	53.8	52.0-57.0	1.30	11	52.5	50.0-53.5	1.04
South New Guinea	8	50.3	49.0-51.0	0.70	7	51.5	50.0-54.0	1.32
Tail Length								
Northern Territory	7	22.1	20.0-24.0	1.62	5	22.3	21.5-23.5	0.76
Cape York Peninsula	8	21.2	20.0-24.0	1.62	2	22.0	21.0-23.0	
North-east Queensland	16	23.0	22.0-24.0	0.64	11	22.6	21.5-23.5	0.55
South New Guinea	5	20.6	20.0-21.0	0.42	5	21.9	21.0-22.5	0.55

Table 4 Measurements (mm) of *Microeca tormenti* and *M. f. flavigaster*.

Character	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
tormenti	13	74.3	73.5-76.5	1.05	12	71.9	70.0-74.0	1.37
flavigaster	14	72.1	69.5-77.5	1.95	9	69.2	68.0-72.0	1.30
Tail Length								
tormenti	13	57.9	56.0-61.5	1.62	12	56.7	53.5-59.0	1.50
flavigaster	14	54.0	51.0-56.0	1.35	9	53.3	51.5-55.0	1.18
Bill Length								
tormenti	13	14.3	14.0-14.9	0.29	10	14.1	13.6-14.3	0.37
flavigaster	12	13.1	12.8-13.9	0.29	9	12.7	12.3-13.5	0.40
Bill Width								
tormenti	12	5.1	5.0-5.4	0.15	12	5.1	4.9-5.3	0.13
flavigaster	13	5.3	5.0-5.7	0.21	8	5.2	4.8-5.5	0.23
Tarsus Length								
tormenti	12	15.5	14.9-16.2	0.45	12	15.0	14.7-15.4	0.27
flavigaster	14	14.1	13.6-14.5	0.22	9	14.0	13.5-14.5	0.37

Table 5 Measurements (mm) of *Eopsaltria pulverulenta.*

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Pilbara	5	83.6	82.5-85.0	1.08	6	78.8	76.5-81.0	1.69
Kimberley*	24	82.0	77.0-85.5	2.20	22	77.2	74.0-81.0	1.77
Northern Territory	8	85.9	84.5-90.5	2.23	15	80.1	76.0-86.0	2.58
Karumba	12	84.9	82.0-88.0	1.78	8	79.8	77.0-81.0	1.31
Cape York Peninsula	3	86.5	86.0-87.5	0.87	4	79.5	79.0-81.0	1.00
North-east Queensland	1	89.5			5	79.2	77.5-80.5	1.48
New Guinea	1	89.5			2	79.0	79.0-79.0	
Tail Length								
Pilbara	5	63.4	62.0-65.5	1.39	6	59.6	58.0-61.0	1.20
Kimberley*	23	63.6	58.5-67.5	2.26	21	59.4	57.0-63.5	1.87
Northern Territory	8	66.3	64.0-70.0	1.85	15	62.8	58.5-67.0	2.67
Karumba	12	67.9	65.0-70.0	1.76	8	62.6	59.0-68.5	3.03
Cape York Peninsula	3	67.7	66.0-68.5	1.44	4	62.8	60.5-64.0	1.85
North-east Queensland	1	68.5			5	60.6	58.0-63.5	2.53
New Guinea	1	68.5			2	63.0	63.0-63.0	
Bill Length								
Pilbara	5	21.4	20.2-22.4	0.80	6	19.2	18.7-19.9	0.56
Kimberley*	23	20.5	19.9-21.2	0.41	18	18.3	17.7-19.1	0.46
Northern Territory	7	19.8	18.7-21.2	0.95	14	18.3	17.4-20.2	0.90
Karumba	13	19.6	19.1-20.7	0.53	7	17.6	17.2-18.7	0.53
Cape York Peninsula	3	19.5	19.2-20.1	0.52	4	17.3	17.0-17.4	0.20
North-east Queensland	2	19.5	19.3-19.6		4	17.5	17.0-18.0	0.53
New Guinea	1	18.8			3	17.1	17.0-17.2	0.10

* Excludes Cambridge Gulf.

Table 6 Variation in coloration of *Eopsaltria pulverulenta*.

Population	Crown			Auriculars		
	Grey	Intermediate	Blackish	Grey	Intermediate	Black
Pilbara	11	0	0	6	5	0
Kimberley	49	0	0	27	22	0
Northern Territory	4	15	4	0	6	16
Kurumba	12	3	0	6	15	0
Cape York	3	4	0	1	5	1
North-east Queensland	5	2	0	4	4	0
New Guinea	4	0	0	4	0	0

Table 7 Hybridization between *melanura* and *spinicauda* in Kimberley.

Locality	No. of Females Hybrid Score				
	Melanura 0	1	2	3	*spinicauda* 4
St George Inlet	3				
Port Warrender	3	1	2		
Napier Broome Bay		1		1	1
Cambridge Gulf					6

Table 8 Measurements (mm) of *Pachycephala melanura*.

Locality	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Pilbara	7	83.6	81.0-86.0	1.72	7	80.4	79.0-82.0	0.98
South Kimberley	30	80.4	79.0-83.0	1.15	28	79.0	77.0-83.0	1.56
North Kimberley	10	81.4	79.0-84.5	1.84	9	79.3	77.0-82.0	2.19
Northern Territory	12	83.8	81.0-86.5	1.59	8	82.3	78.5-85.5	2.10
Gulf-Cape York	12	87.3	83.0-92.0	2.86	10	83.4	82.0-85.0	1.13
New Guinea	6	91.7	87.0-96.0	2.99	4	89.0	87.0-91.0	1.83
Bismarcks	2	89.5	88.0-91.0		1	92.0		
Tail Length								
Pilbara	7	68.9	69.0-70.0	0.75	7	67.7	66.5-70.0	1.22
South Kimberley	29	65.0	62.0-69.0	1.46	28	64.5	62.0-67.5	1.33
North Kimberley	11	64.9	61.0-70.0	2.54	8	65.1	62.5-68.0	2.70
Northern Territory	12	67.4	65.0-72.0	2.12	10	67.4	65.0-73.0	2.53
Gulf-Cape York	13	69.7	67.5-71.5	1.53	9	66.6	65.5-68.5	1.08
New Guinea	6	70.3	69.0-72.5	1.47	5	69.0	66.5-70.0	1.54
Bismarcks	2	68.5	66.0-71.0		1	69.0		
Bill Length								
Pilbara	7	18.6	17.5-19.4	0.60	5	18.0	17.9-18.1	0.10
South Kimberley	29	18.6	18.1-19.4	0.39	30	18.1	17.1-19.8	0.70
North Kimberley	10	18.5	17.8-19.1	0.36	9	18.5	17.9-19.2	0.52
Northern Territory	14	18.4	17.8-20.0	0.59	9	18.1	17.6-19.0	0.47
Gulf-Cape York	17	19.2	18.6-20.6	0.74	10	18.7	18.3-19.4	0.37
New Guinea	4	20.6	19.5-20.4	1.27	2	20.7	19.1-22.2	
Bismarcks	2	19.8	18.8-20.7		1	20.0		

Table 9 Measurements (mm) specimens of *Pachycephala simplex*.

Subspecies	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
peninsulae	14	77.2	73.5-81.0	1.86	17	74.8	72.5-77.5	1.49
simplex	12	75.3	73.0-76.0	0.96	12	72.5	68.0-74.5	1.66
Tail Length								
peninsulae	15	60.6	57.5-62.0	1.80	19	60.0	57.0-63.0	1.72
simplex	12	59.1	57.0-60.5	1.09	10	57.2	56.0-58.5	0.82
Bill Length								
peninsulae	14	15.5	15.1-16.2	0.35	18	15.3	14.8-15.7	0.37
simplex	12	16.3	15.6-17.4	0.53	12	16.3	15.8-16.9	0.33

Table 10 Measurements (mm) of *Pachycephala lanioides*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Mid-Western Australia	1	99.0			7	97.3	95.0-102	2.50
Pilbara	24	99.6	96.0-104.5	2.00	10	99.4	97.0-101	1.22
Kimberley	30	99.4	95.5-103	2.04	25	97.2	94.0-99.0	1.61
Wyndham	4	94.9	94.0-96.5	1.18	3	92.5	92.0-93.0	0.50
Northern Territory	14	95.1	91.0-99.0	2.32	10	92.7	90.0-94.0	1.60
North-west Queensland	3	96.0	94.0-99.0	2.65	8	92.4	90.5-94.0	1.55
Tail Length								
Mid-Western Australia	1	79.5			7	79.0	77.0-83.0	2.29
Pilbara	24	80.4	77.0-85.0	2.34	13	81.5	75.0-84.0	3.07
Kimberley	29	80.4	77.0-87.0	2.05	26	79.7	75.0-85.0	2.18
Wyndham	4	75.5	73.0-78.0	2.26	3	76.5	75.5-76.5	1.00
Northern Territory	13	75.5	71.5-80.5	2.85	9	75.5	73.0-77.5	1.90
North-west Queensland	2	76.5	74.0-79.0	3.54	8	76.5	74.0-81.0	2.63
Bill Length								
Mid-Western Australia	1	26.3			6	24.8	24.3-25.6	0.46
Pilbara	23	25.2	23.5-27.4	0.87	13	25.4	24.5-26.9	0.73
Kimberley	29	25.0	23.9-26.2	0.65	27	24.6	22.0-26.6	1.06
Wyndham	4	23.4	22.6-24.4	0.79	3	23.1	22.7-23.7	0.51
Northern Territory	14	23.3	22.0-25.1	0.93	9	23.2	22.2-24.0	0.54
North-west Queensland	3	23.9	22.8-25.2	1.21	8	22.7	22.0-23.6	0.67

Table 11 Measurements (mm) of *Myiagra ruficollis mimikae*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Kimberley	19	69.6	68.0-72.0	1.35	10	66.6	65.0-68.0	1.29
Northern Territory	5	71.2	70.0-73.5	1.80	4	70.0	69.0-72.5	1.68
Cape York Peninsula	7	72.0	70.5-74.0	1.63	6	70.3	68.0-71.0	1.13
Aru Islands	2	76.8	76.5-77.0					
New Guinea	2	75.3	72.5-75.0		1	70.0		
Bill Length								
Kimberley	19	17.4	16.8-18.3	0.56	10	16.9	15.4-17.9	0.70
Northern Territory	5	18.2	17.8-18.8	0.40	7	17.9	17.4-18.7	0.48
Cape York Peninsula	7	17.9	17.0-18.5	0.52	9	18.2	17.3-18.8	0.47
Aru Islands	2	17.8	17.5-18.1					
New Guinea	1	17.8			1	18.0		
Bill Width								
Kimberley	19	7.1	6.8-7.4	0.19	10	7.2	6.8-7.5	0.21
Northern Territory	4	7.2	7.0-7.5	0.24	7	7.2	6.9-7.6	0.22
Cape York Peninsula	8	7.1	6.8-7.4	0.22	8	7.0	6.7-7.6	0.29
Aru Islands	2	7.4	7.3-7.5					
New Guinea	1	7.2			1	7.4		
Tail Length								
Kimberley	19	69.2	67.0-73.0	1.69	10	67.7	66.0-70.5	1.40
Northern Territory	5	71.0	68.5-75.5	2.76	7	70.5	69.0-75.5	1.04
Cape York Peninsula	8	72.1	69.0-77.0	2.72	9	70.5	67.0-73.0	1.97
Aru Islands	2	75.3	74.0-76.5					
New Guinea	1	73.0			1	73.0		

Table 12 Measurements (mm) of *Myiagra alecto*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Bill Length								
Kimberley	12	22.4	21.0-23.2	0.66	24	22.4	20.6-24.1	0.90
Northern Territory	12	21.7	20.6-22.4	0.57	16	21.2	20.5-22.1	0.47
Queensland	15	20.2	19.2-21.4	0.73	15	20.0	18.3-21.2	0.84
Daru	8	20.6	19.6-21.6	0.66	7	20.1	19.5-20.9	0.46
Upper Fly	14	20.7	19.5-21.8	0.62	7	20.1	18.8-20.8	0.46
Aru Islands	5	19.6	19.3-20.4	0.47	2	19.1	18.5-19.6	0.78
Tanimbar	5	21.7	21.2-22.2	0.38	4	21.4	21.0-21.8	0.37
Bill Width								
Kimberley	12	5.0	4.7-5.3	0.19	23	5.0	4.7-5.2	0.16
Northern Territory	14	5.2	4.6-5.8	0.29	16	5.1	4.4-5.6	0.27
Queensland	13	5.5	5.1-5.8	0.24	14	5.6	5.1-5.8	0.22
Daru	6	6.0	5.6-6.3	0.29	11	5.8	5.3-6.2	0.30
Upper Fly	15	5.9	5.7-6.4	0.25	9	5.7	5.3-6.2	0.24
Aru Islands	4	5.3	4.9-5.5	0.28	3	5.6	5.1-5.9	0.44
Tanimbar	5	5.3	5.2-5.6	0.17	4	5.7	5.5-5.8	0.17
Wing Length								
Kimberley	12	85.4	83.5-88.0	1.54	18	80.4	76.5-84.0	2.32
Northern Territory	15	85.5	83.5-88.0	1.41	14	80.9	79.0-84.5	2.60
Queensland	16	86.8	83.5-91.0	1.99	14	82.3	79.5-85.5	1.81
Daru	8	89.3	87.0-91.5	1.83	8	84.4	82.0-89.0	2.37
Upper Fly	15	86.9	84.0-92.0	2.33	8	83.6	82.0-86.5	1.64
Aru Islands	4	88.6	86.0-92.0	2.69	3	83.0	82.0-83.5	0.87
Tanimbar	5	85.3	94.5-87.0	0.97	4	81.5	80.0-83.0	1.29
Tail Length								
Kimberley	12	78.4	75.5-83.5	2.27	19	75.7	73.5-79.0	2.19
Northern Territory	15	78.5	76.0-81.5	1.56	14	76.0	73.0-79.0	2.00
Queensland	16	77.5	73.5-82.0	2.24	14	75.2	71.0-80.0	2.89
Daru	8	81.4	79.0-85.0	2.99	8	76.9	72.5-80.5	2.60
Upper Fly	15	77.3	73.0-81.5	2.67	8	75.4	73.0-80.0	2.18
Aru Islands	5	82.3	80.0-85.0	1.99	4	79.5	78.5-82.0	1.68
Tanimbar	4	78.8	76.0-83.5	3.28	3	76.3	73.5-80.0	3.33

Table 13 Measurements (mm) of adult specimens of *Rhipidura rufifrons*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Victoria	13	72.9	68-77	2.6	3	70.3	69-71	1.2
New South Wales	5	72.6	71-55	1.6	2	72.8	72-74	
South Queensland	5	75.8	73-78	2.2				
North-east Queensland	5	73.5	71-76	2.0	1	72.0		
Gulf of Carpentaria	9	69.0	67-71	1.3	4	68.3	67-71	1.6
Northern Territory	9	69.7	66-73	3.2	6	68.8	67-72	2.0
Kimberley	3	69.0	66-71	2.7	1	67.0		
Mimika River	3	75.8	75-77	0.8	1	74.0		
Tail length								
Victoria	13	84.6	79-90	3.3	3	82.3	79-85	3.4
New South Wales	5	85.4	82-89	3.4	2	83.5	81-86	
South Queensland	5	90.0	88-93	2.3				
North-east Queensland	5	87.9	83-93	4.6	1	90.5		
Gulf of Carpentaria	9	90.3	87-95	2.6	4	90.0	86-92	2.8
Northern Territory	9	92.1	87-97	3.6	5	90.8	86-93	3.7
Kimberley	2	91.8	91-93		1	87.5		
Mimika River	3	89.0	84-96	6.2	1	91.0		

Table 13 (continued)

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Rufous Base*								
Victoria	13	45.2	42-52	3.4	3	43.3	43-44	0.6
New South Wales	5	45.6	43-50	2.5	2	43.0	43-43	
South Queensland	5	47.8	43-52	3.5				
North-east Queensland	5	45.8	42-48	2.4	1	47.0		
Gulf of Carpentaria	9	20.7	18-26	2.7	4	21.0	20-23	1.4
Northern Territory	9	22.9	20-25	1.9	1	17.0		
Kimberley	2	22.5	21-24		1	19.5		
Mimika River	2	19.0	18-20		1	21.5		
Pale Tip**								
Victoria	13	8.5	8-10	1.1	3	8.7	8-10	1.2
New South Wales	5	9.2	7-11	1.8	2	8.0	8-8	
South Queensland	5	10.2	9-11	0.8				
North-east Queensland	5	10.2	10-11	0.5	1	10.0		
Gulf of Carpentaria	8	18.9	17-23	2.4	3	19.0	18-20	1.0
Northern Territory	9	20.6	13-23	3.3	1	23.5		
Kimberley	3	20.7	20-21	0.6	1	23.0		
Mimika River	2	17.0	15-19		1	16.0		

* Measured along rachis on outer vane of central rectrix

** Grey in *rufifrons*, white in *dryas* and *streptophora*.
Length of tip measured on inner vane of second outmost rectrix.

Tahle 14 Measurements (mm) of *Gerygone tenebrosa*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Bill Length								
Mid-Western Australia	10	14.2	13.6-14.8	0.37	5	13.8	13.4-14.1	0.31
Pilbara	21	14.1	13.2-15.0	0.43	21	13.9	13.2-14.6	0.43
Kimberley	20	14.0	13.0-14.8	0.45	14	13.6	13.2-14.1	0.27
Bill Width								
Mid-Western Australia	10	3.1	2.8-3.3	0.16	6	2.9	2.8-2.9	0.05
Pilbara	21	2.9	2.7-3.2	0.12	19	2.9	2.7-3.3	0.16
Kimberley	21	3.0	2.7-3.2	0.16	15	3.0	2.8-3.2	0.14
Wing Length								
Mid-Western Australia	10	56.8	54.0-59.5	1.86	7	55.9	55.0-56.5	0.45
Pilbara	22	57.8	54.5-61.0	2.05	20	55.9	54.0-59.0	1.53
Kimberley	21	55.1	53.0-57.0	1.26	15	52.7	50.0-55.0	1.33
Tail length								
Mid-Western Australia	10	45.7	42.5-48.0	2.08	7	45.1	44.0-46.0	0.63
Pilbara	23	47.1	42.5-50.0	2.01	20	45.9	42.0-48.5	1.55
Kimberley	21	44.3	42.0-48.0	1.67	15	42.4	40.0-45.0	1.54

Table 15 Measurements (mm) of *Gerygone magnirostris*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Bill Length								
Kimberley	15	13.4	12.9-14.2	0.43	6	13.1	12.3-13.8	0.53
Northern Territory	15	13.5	13.0-14.2	0.42	10	12.9	12.3-13.4	0.40
North Queensland	12	13.2	12.7-13.8	0.32	17	12.8	12.2-13.3	0.33
South New Guinea	21	13.0	12.2-14.2	0.36	12	12.9	12.0-14.0	0.51
North New Guinea	30	13.3	12.4-14.2	0.47	22	13.3	12.6-14.0	0.39
Bill Width								
Kimberley	17	3.6	2.4-3.8	0.15	7	3.7	3.4-3.9	0.16
Northern Territory	16	3.7	3.5-4.0	0.14	10	3.6	3.5-3.9	0.16
North Queensland	13	3.5	3.3-3.9	0.17	17	3.6	3.3-3.8	0.16
South New Guinea	23	3.7	3.4-3.9	0.17	14	3.7	3.5-4.1	0.17
North New Guinea	30	3.7	3.3-4.0	0.17	21	3.7	3.2-4.0	0.18
Wing Length								
Kimberley	17	55.2	52.0-57.5	1.68	7	52.7	52.0-56.0	1.47
Northern Territory	16	56.6	55.0-58.0	0.93	10	53.5	51.0-55.0	1.27
North Queensland	13	54.6	51.5-57.0	1.89	17	53.7	51.0-56.5	1.73
South New Guinea	24	54.3	51.0-57.0	1.49	14	52.3	50.0-54.0	1.20
North New Guinea	31	55.8	52.0-58.0	1.73	22	52.8	50.5-54.5	1.12
Tail Length								
Kimberley	17	44.9	43.0-47.0	1.09	7	42.5	40.0-46.0	2.29
Northern Territory	15	44.9	41.0-46.5	1.45	10	42.2	40.0-45.5	1.69
North Queensland	13	42.5	38.0-45.5	2.30	17	41.4	38.0-44.5	1.52
South New Guinea	24	41.7	39.5-45.5	1.44	13	40.2	39.0-42.0	1.18
North New Guinea	30	42.8	40.5-46.0	1.37	19	41.0	39.5-43.0	1.21

Table 16 Measurements (mm) of *Conopophila albogularis*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
New Guinea	11	66.5	63.0-68.5	1.59	11	63.5	61.0-65.5	1.52
Northern Territory	18	66.4	65.0-69.0	0.97	8	64.1	62.0-66.5	1.53
Cape York Peninsula	2	68.5	66.0-71.0		2	65.0	64.0-66.0	
Tail Length								
New Guinea	10	46.7	44.0-50.0	1.72	11	44.6	43.0-46.5	1.45
Northern Territory	18	46.9	44.0-49.0	1.38	8	45.6	43.0-47.0	1.38
Cape York Peninsula	2	47.0	45.0-49.0		3	44.0	43.0-45.0	1.00
Bill Length								
New Guinea	10	16.2	15.4-16.8	0.51	11	15.6	15.0-16.2	0.33
Northern Territory	17	15.4	14.6-16.3	0.46	7	14.7	14.1-15.7	0.53
Cape York Peninsula	2	16.5	16.2-16.7		3	15.2	15.0-15.4	0.21

Table 17 Measurements (mm) of *Myzomela erythrocephala*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Kimberley	32	58.7	57.0-61.0	1.24	17	55.3	53.5-57.0	1.02
N.T.-Gulf of Carpentaria	22	58.9	57.5-60.0	0.86	16	55.5	53.0-59.0	1.61
Cape York Peninsula	16	59.3	57.0-62.0	1.36	7	55.2	54.0-56.5	1.11
New Guinea	12	61.6	60.5-63.5	0.85	4	57.4	55.5-59.0	1.44
Hall Sound	2	59.0	59.0-59.0					
Tail Length								
Kimberley	18	41.6	40.0-43.5	0.95	14	39.2	36.5-41.0	1.33
N.T.-Gulf of Carpentaria	22	42.4	41.0-44.5	1.01	15	38.9	36.5-42.5	1.62
Cape York Peninsula	17	42.0	39.5-44.5	1.32	6	38.9	38.0-40.0	0.74
New Guinea	12	45.0	43.0-48.5	1.48	4	41.6	40.0-44.5	2.02
Hall Sound	2	41.5	41.0-42.0					
Bill Length								
Kimberley	30	16.6	16.0-17.7	0.49	14	15.9	15.2-16.5	0.41
N.T.-Gulf of Carpentaria	21	16.9	16.2-17.3	0.35	13	15.9	15.4-16.7	0.37
Cape York Peninsula	12	16.9	16.2-17.3	0.36	7	16.2	15.7-16.7	0.34
New Guinea	12	18.7	18.1-19.0	0.49	4	16.9	16.3-17.4	0.47
Hall Sound	2	17.0	16.2-17.8					

Table 18 Measurements (mm) of *Zosterops lutea*.

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Wing Length								
Mid-Western Australia	13	54.1	52.0-55.0	0.87	15	53.3	52.0-55.0	0.77
Pilbara	39	54.8	52.5-57.5	1.23	20	54.7	52.0-57.0	1.29
Kimberley	18	54.7	52.5-59.5	1.73	14	55.0	50.5-58.0	2.07
Wyndham	5	55.9	53.5-57.0	1.43	2	55.0	54.0-57.0	2.12
Melville I.	11	54.6	52.0-58.0	1.78	8	55.1	54.0-56.0	0.86
Northern Territory	10	56.1	55.0-58.0	1.05	8	55.3	54.0-56.0	1.00
Gulf of Carpentaria	20	56.5	53.5-59.5	1.45	15	56.6	55.0-58.0	1.27
North-east Queensland					3	53.7	52.0-56.0	2.08
Tail Length								
Mid-Western Australia	13	40.9	39.0-42.5	1.13	14	40.8	39.0-42.0	0.87
Pilbara	38	41.9	39.0-45.0	1.62	19	41.7	38.5-44.0	1.51
Kimberley	18	41.2	39.0-44.5	1.34	13	40.2	38.5-43.5	2.03
Wyndham	5	41.1	39.5-43.0	1.55	2	40.3	40.0-40.5	0.35
Melville I.	10	40.7	39.0-43.0	1.34	8	41.8	39.0-44.0	1.60
Northern Territory	10	42.7	40.0-44.5	1.36	8	41.9	39.5-44.5	1.55
Gulf of Carpentaria	18	42.6	40.0-45.0	1.52	15	42.3	40.5-45.0	1.23
Bill Length								
Mid-Western Australia	12	12.8	12.2-13.4	0.44	15	12.4	10.7-13.3	0.66
Pilbara	36	12.9	12.1-13.6	0.36	21	13.1	12.2-13.6	0.34
Kimberley	15	13.5	12.8-14.5	0.51	14	13.3	12.6-14.0	0.44
Wyndham	5	13.9	13.5-14.6	0.43	2	13.6	13.2-14.0	0.57
Melville I.	9	13.9	13.2-14.5	0.54	7	13.8	12.8-14.3	0.61
Northern Territory	9	14.4	14.0-14.8	0.30	8	14.2	13.2-15.2	0.60
Gulf of Carpentaria	19	14.2	13.3-14.9	0.42	14	14.3	14.0-14.9	0.29

Table 19 Measurements (mm) of *Cracticus quoyi.*

Population	Males				Females			
	No.	Mean	Range	S.D.	No.	Mean	Range	S.D.
Bill Length								
Northern Territory	11	60.7	58.0-65.5	2.40	8	53.9	52.0-56.0	1.30
Aru Islands	3	58.2	56.0-60.5	2.25	4	50.9	48.0-54.0	2.46
New Guinea*	29	57.7	54.0-63.0	2.29	29	52.7	47.0-60.0	3.12
Daru-Merauke	8	56.4	53.0-59.0	2.11	2	54.8	53.5-56.0	1.76
Cape York Peninsula	5	52.3	51.0-54.5	1.35	7	49.7	46.5-55.5	2.91
North-east Queensland	40	54.1	48.5-59.0	1.99	21	49.1	45.0-53.5	2.13
Central Queensland	1	53.5						
Bill Width								
Northern Territory	10	13.4	12.5-14.4	0.49	9	13.1	12.4-13.9	0.45
Aru Islands	3	14.1	13.6-14.6	0.50	3	12.9	12.1-13.4	0.72
New Guinea*	20	15.4	14.2-16.5	0.68	23	14.8	13.4-16.2	0.71
Daru-Merauke	8	13.6	13.3-14.9	0.60	2	14.6	13.7-15.4	1.20
Cape York Peninsula	5	13.1	12.8-13.5	0.34	7	12.7	11.9-13.7	0.68
North-east Queensland	40	13.0	11.4-14.6	0.73	22	12.7	11.4-13.6	0.62
Central Queensland	1	12.4						
Wing Length								
Northern Territory	11	201	196-205	3.75	8	187	181-195	4.82
Aru Islands	3	193	188-197	4.51	4	180	176-188	5.56
New Guinea*	33	180	169-192	6.51	32	176	160-185	6.68
Daru-Merauke	8	189	175-196	7.99	2	183	173-192	13.4
Cape York Peninsula	6	177	171-183	5.15	7	172	166-178	4.95
North-east Queensland	40	174	166-185	4.42	22	166	156-170	3.46
Central Queensland	1	174						
Tail Length								
Northern Territory	11	155	145-163	5.34	8	145	139-151	4.43
Aru Islands	3	150	146-153	3.79	4	142	138-145	2.94
New Guinea*	19	138	131-150	5.05	23	136	124-148	6.36
Daru-Merauke	8	147	136-157	7.59	2	138	134-142	5.66
Cape York Peninsula	6	147	142-154	4.59	7	139	130-145	6.24
North-east Queensland	40	142	134-148	4.98	22	135	124-139	3.62
Central Queensland	1	144						

*Exeludes region between Daru and Merauke

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