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Volume 5, Part 1, 1977

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Cover: *Amphibolurus parviceps butleri*, drawn by Martin Thompson, Western Australian Museum. This pretty little agamid lizard is only known from the Edel Land peninsula, Shark Bay. It is named after Mr and Mrs W.H. Butler, who generously financed the Western Australian Museum's expedition to Shark Bay in spring 1976.

ISSN 0312-3162

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#### EDITOR'S NOTE:

The purpose of the *Records of the Western Australian Museum (Rec. West. Aust. Mus.)*, is to contain the results of original research, of collecting expeditions, and will also include brief notes on other matters connected with this institution. For the information of contributors the term 'results of original research', where it concerns growth of knowledge in the areas of responsibility of the Museum, will include (in addition to papers comprising complete studies) notes on, descriptions, or analyses, of significant specimens, progressive results of surveys or archaeological excavations, lists of types, partial taxonomic revisions and bibliographic lists of papers published by the staff of the Western Australian Museum in other journals.

Papers submitted to the *Records* by workers other than staff and researchers working in the Museum, or Honorary Associates, will be required to be based upon the collections of the Western Australian Museum or such other functions of the Western Australian Museum which in the view of the Records Committee are relevant to the publication.

New volumes will commence at intervals determined by the number of pages published since the last volume.



# DESCRIPTIONS OF THREE NEW GENERA AND EIGHT NEW SPECIES OF MONACANTHID FISHES FROM AUSTRALIA

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[Received 21 September 1976. Accepted 8 December 1976. Published 17 June 1977.]

## ABSTRACT

Three new genera and eight new species of monacanthid fishes are described from Australian seas. The new genera are *Cantheschenia*, *Bigener* and *Colurodontis*. The first contains *Cantheschenia longipinnis* (Fraser-Brunner) from Lord Howe Island and Western Australia (previously included in *Cantherhines*) and *C. grandisquamis* n.sp. from Queensland. The latter two genera are monotypic, containing *Bigener brownii* (Richardson) from southern Australia and *Colurodontis paxmani* n.sp. from Western Australia and Queensland. The remaining new species with approximate distributions in parentheses are as follows: *Eubalichthys caeruleoguttatus* (Western Australia), *E. fuscusinus* (Western Australia), *E. quadrispinis* (South Australia), *Meuschenia flavolineata* (southern Australia including Tasmania), *M. venusta* (Western Australia and New South Wales), and *Rudarius excelsus* (Queensland). In addition, a key to the genera of Australian monacanthids and a list of the known species from this region are presented.

## INTRODUCTION

Australian seas contain 54 species of monacanthid fishes, which far surpasses the number known from any other area (Indonesian-Malaysian Archipelago : approximately 25 species; Japan : 16 species). Many of these have remained poorly known due mainly to the large number of nominal species and the scattered, sporadic nature of the literature. This paper is the result of an investigation to determine the number of valid Australian species and is part of a revisionary study of the family Monacanthidae currently in progress. In the course of this work several new species were discovered and it was necessary to redefine the limits of some genera which left other species unaccommodated. Thus three genera and eight species are herein described as new. A key to the Australian genera is provided as a

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guide to their relationships and a list of species known to inhabit Australian seas is also included.

## METHODS

Measurements were made with needle-point dial calipers to the nearest mm (to the nearest 0.1 mm for measurements less than 10 mm). Fig. 1 shows the measurements that were taken for this study, in conjunction with the following : standard length (SL), head length, snout length — the anterior point of these measurements was taken as the front margin of the upper lip (where the lip was damaged or missing, the measurement was made from the middle of the anteriormost pair of teeth); body width — taken across the area of greatest width immediately behind gill opening; interorbital width — measurement was taken from the superiormost point on the eye rim; pelvic bony structure length — does not include barbs projecting anteriorly and posteriorly (often lost); measurements involving the first

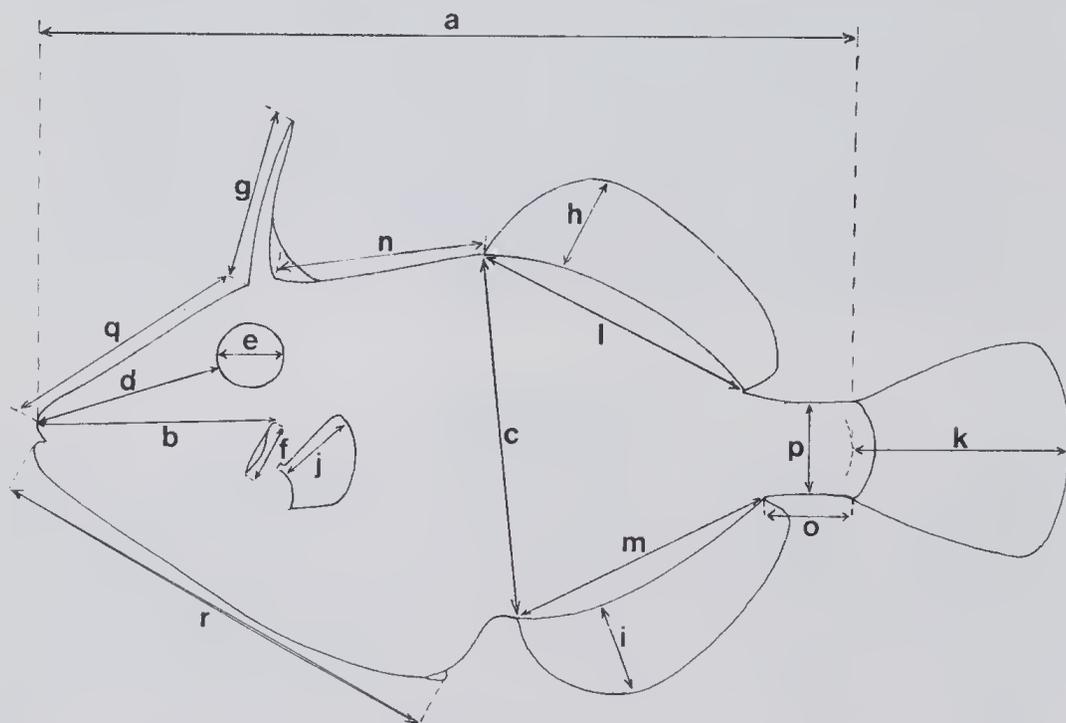


Fig. 1: A guide to the principal measurements used in this paper : a, standard length; b, head length; c, body depth; d, snout length; e, eye diameter; f, gill slit length; g, first dorsal spine length; h, longest soft dorsal ray; i, longest anal ray; j, longest pectoral ray; k, caudal fin length; l, soft dorsal fin base; m, anal fin base; n, interdorsal space; o, caudal peduncle length; p, caudal peduncle depth; q, snout to origin of dorsal spine; r, lower jaw to rear of pelvic bony structure.

dorsal spine were made with the spine in a vertical position; the basal sheath of the soft dorsal and anal fins is not included in fin ray measurements.

The range for proportional measurements which appears in the species accounts is based on specimens in excess of 50 mm SL.

Pectoral fin ray counts were taken from both sides, the left hand side count being listed first in the tables of morphometric data (counts do not include the small rudimentary spine at the origin of the uppermost ray).

The base of the pectoral fin was taken as the uppermost point on the line of flexure which forms when the fin is folded outwards. The centre of the gill slit was taken along the posterior margin of the opercular bones.

Gill raker counts were taken from the outer series on the first gill arch.

Vertebral counts were made with the aid of whole skeletons, radiographs and cleared and stained material.

The peculiar morphology of monacanthids necessitates the following definitions: pelvic bony structure — that structure located in most monacanthids at or near the posterior end of the pelvis, projecting through the skin (Fig. 2) (Randall [1964: 331] calls this the 'pelvic terminus' but as it is not terminal in the genera *Eubalichthys* and *Alutera*, this terminology is not used here); incising scales — the constituents of the pelvic bony structure (see Tyler, 1962), typically two or three pairs (Fig. 3); scale spinules — small to minute spines which arise vertically from the base of the scale, giving the skin its characteristic feel; bristles — elongate scale spinules which develop as a secondary sexual character in the male and may be found either on the caudal peduncle or mid-side of body.

The specimen illustrations have been designed mainly to show colour patterns and obvious structural features. In most cases small structures, such as visible scale outlines, have been omitted or illustrated separately. Apparent minor damage to the skin and fins, usually caused during capture, has also been deleted.

Type specimens have been deposited at the Australian Museum, Sydney (AM); British Museum (Natural History), London (BMNH); CSIRO, Division of Fisheries and Oceanography, Cronulla, New South Wales (CSIRO); Queen Victoria Museum, Launceston, Tasmania (QVM); United States National Museum, Washington, D.C. (USNM); and the Western Australian Museum, Perth (WAM).

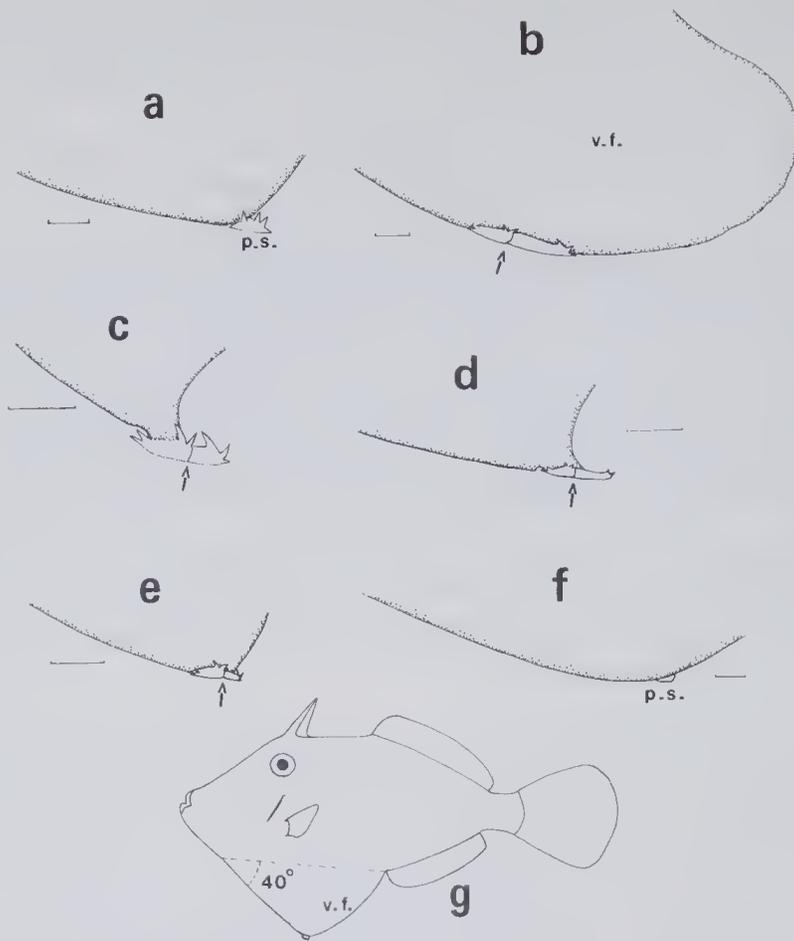


Fig. 2: Semi-diagrammatic illustration showing pelvic bony structures (p.s.) and ventral flaps (v.f.) of certain monacanthids as referred to in the key (dotted line represents the outline of the hidden pelvis, arrow indicates point of articulation, and the horizontal line is equivalent to 5 mm) : a, *Meuschenia*; b, *Monacanthus*; c, *Perpagor*; d, *Paramonacanthus*; e, *Stephanolepis*; f, *Eubalichthys*; g, *Pseudomonacanthus*.

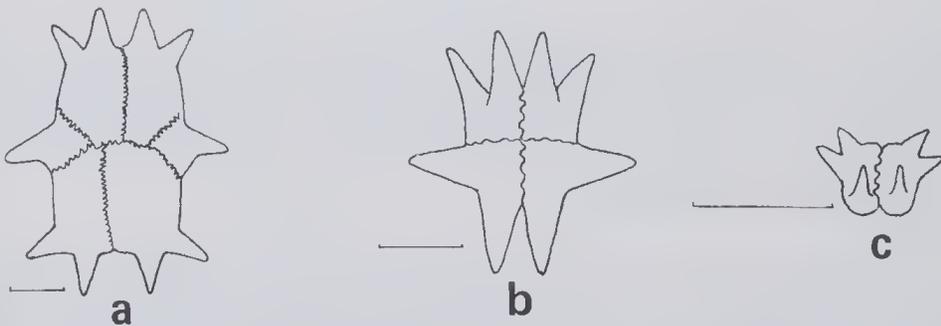


Fig. 3: Semi-diagrammatic illustration of certain pelvic bony structures (ventral view) showing the number of incasing scales as referred to in the key (posterior end faces the top of the page and horizontal line represents 1 mm) : a, 3 pairs (*Cantherhines*); b, 2 pairs (*Penicipelta*); c, 1 pair (*Acanthaluteres*).

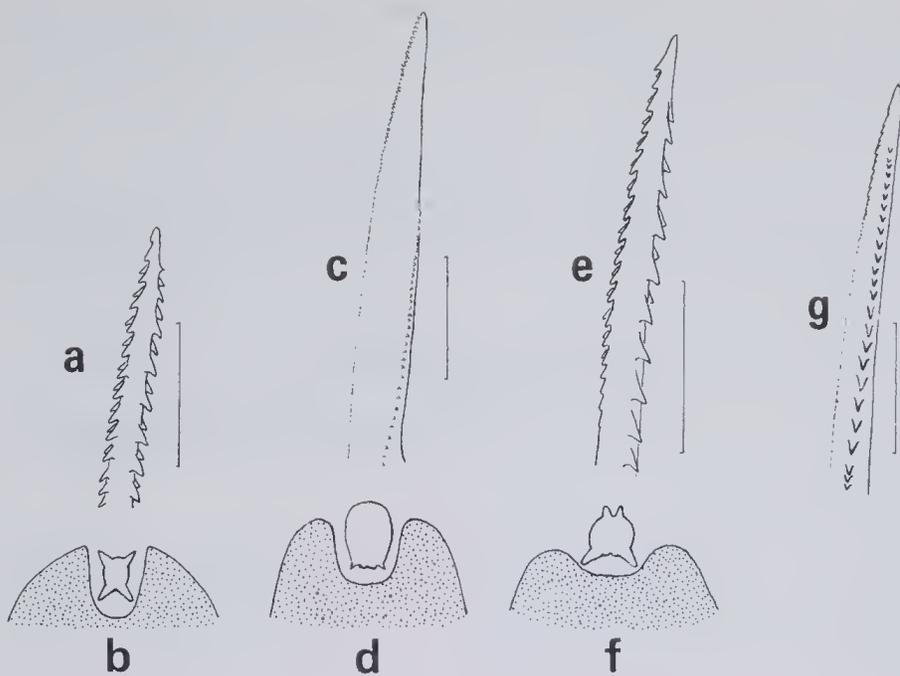


Fig. 4: Semi-diagrammatic illustration showing first dorsal spines (lateral view) and spinal grooves (transverse section) of certain monacanthids as referred to in the key (anterior face towards the left hand side of the page, cross-section made approximately at centre of spine, and vertical line represents 10 mm) : a-b, *Bigener*; c-d, *Cantherhines*; e-f, *Meuschenia*; g, *Thamnaconus*.

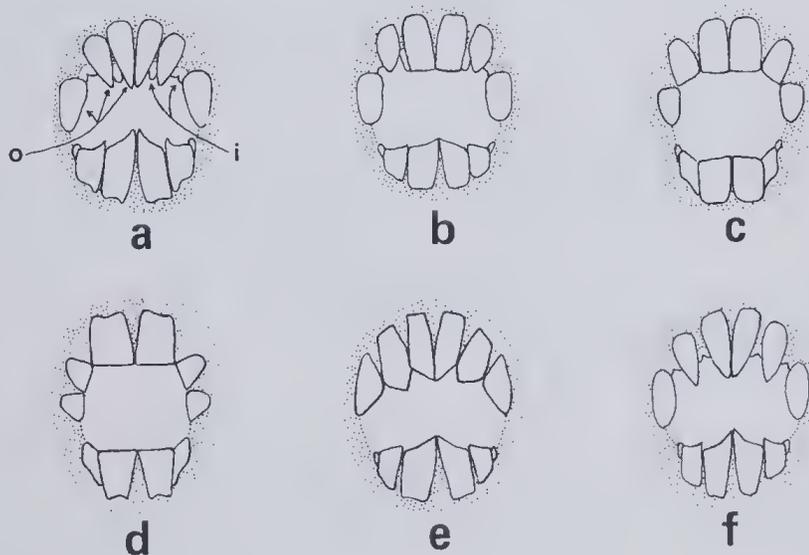


Fig. 5: Semi-diagrammatic illustration showing dentition of certain monacanthids as referred to in the key (i, inner teeth; o, outer teeth) : a, generalised condition; b, *Penicipelta*; c, *Acanthaluteres*; d, *Colurodontis*; e, *Chaetoderma*; f, *Acreichthys*.

## KEY TO THE AUSTRALIAN GENERA OF MONACANTHIDAE

- 1a. Fleshy barbel on lower jaw ... .. *Anacanthus* Gray, 1831
- 1b. No barbel on lower jaw ... .. 2
- 2a. First dorsal spine not fully erectile, enveloped  
in a loose flap of skin attached to back ... *Paraluteres* Bleeker, 1866
- 2b. First dorsal spine fully erectile ... .. 3
- 3a. Snout produced into a tube, turning upwards  
at mouth  
... .. *Oxymonacanthus* Bleeker, 1866
- 3b. Snout not tubular ... .. 4
- 4a. Soft dorsal and anal fins each with 43 or  
more rays ... .. 5
- 4b. Soft dorsal and anal fins each with 39 or  
less rays ... .. 6
- 5a. First dorsal spine originates well in advance  
of eye  
... .. *Pseudalutarius* Bleeker, 1865
- 5b. First dorsal spine originates over eye  
... .. *Alutera* Cloquet, 1816
- 6a. Pelvic bony structure located at posterior  
termination of pelvis (Figs 2a-e) ... .. 8
- 6b. Pelvic bony structure located anterior to rear  
end of pelvis (Fig. 2f) or absent ... .. 7
- 7a. Small to medium pelvic bony structure located  
about ½ to 1 eye diameter anterior to  
posterior end of pelvis; size large (up to 400  
mm SL); belly non-inflatable  
... .. *Eubalichthys* Whitley, 1930
- 7b. No pelvic bony structure; size small (up to  
70 mm SL), body circular in profile; belly  
inflatable  
... .. *Brachaluteres* Bleeker, 1866
- 8a. Pelvic bony structure not movably articulated  
with pelvis (Fig. 2a) ... .. 9

- 8b. Pelvic bony structure movably articulated with pelvis (Figs 2b-e) ... .. 21
- 9a. First dorsal spine generally wholly received into a deep prominent groove in back when depressed (Figs 4b and 4d); pelvic bony structure consists of 1-3 pairs of incising scales (Fig. 3) ... .. 10
- 9b. Depressed first dorsal spine located in a relatively shallow groove (Fig. 4f) or spinal groove absent; pelvic bony structure usually consists of 2 pairs of incising scales ... .. 14
- 10a. First dorsal spine with round anterior face (Figs 4c-d), usually originating over anterior half of eye, armed with very small barbs or barbs obsolete; 3 pairs of incising scales ... .. 11
- 10b. First dorsal spine 4-edged, with a row of strong downward-directed barbs along each side (Figs 4a-b), originating over anterior to posterior halves of eye; 1-2 pairs of incising scales ... .. 12
- 11a. Soft dorsal fin rays 26-29; anal fin rays 22-25; adults with toothbrush-like patch of bristles or several long spines on middle of side  
 ... .. *Amaneses* Gray, 1835
- 11b. Soft dorsal fin rays 32-39; anal fin rays 28-35; no bristles or spines on middle of side although paired spines or a dense patch of fine bristles may be present mid-laterally on caudal peduncle  
 ... .. *Cantherhines* Swainson, 1839
- 12a. Central pair of teeth in upper jaw with pointed extremities (Fig. 5a); 2 pairs of spines on each side of caudal peduncle (small in adult female and juveniles) ... .. *Bigener* n.gen.
- 12b. Central pair of teeth in upper jaw with truncate cutting edges (Figs 5b-c); no caudal peduncle spines ... .. 13

- 13a. Obvious pelvic bony structure, consisting of 2 pairs of incising scales (Fig. 3b); extremities of all outer teeth in upper jaw not truncate, middle one of each side usually pointed (Fig. 5b); adult male with toothbrush-like patch of bristles on middle of side; size medium-large (up to 250 mm SL)  
 ... .. *Penicipelta* Whitley, 1947
- 13b. Weak pelvic bony structure, consisting of 1 pair of incising scales which are difficult to distinguish from adjacent scales (Fig. 3c); extremities of all outer teeth in upper jaw truncate (Fig. 5c); no bristles on side; size small (up to 95 mm SL)  
 ... .. *Acanthaluteres* Bleeker, 1866
- 14a. Size at maturity very small (15-17 mm SL); barbs on anterior face of first dorsal spine directed upwards; elongate bristles on caudal peduncle of adult male; soft dorsal rays 22-28; anal rays 20-24  
 ... .. *Rudarius* Jordan & Fowler, 1902
- 14b. Size at maturity medium to large (about 50 mm SL and above); barbs on anterior face of first dorsal spine directed downwards or obsolete; caudal peduncle armed with strong spines, dense patch of short bristles or naked; soft dorsal rays 28-39; anal rays 26-37 ... .. 15
- 15a. Pelvis very mobile, usually capable (before preservation) of moving vertically through an arc of 40° or more, producing a large ventral flap (Fig. 2g); soft dorsal rays 28-36; anal rays 26-34... .. 16
- 15b. Pelvis not so mobile, capable of moving vertically through an arc of usually much less than 40°, producing a small to medium ventral flap; soft dorsal rays 32-39; anal rays 30-37 (very rarely 30) ... .. 17
- 16a. Each scale on side with 1 strong spinule, surmounted by a flat fleshy papilla; no

- spines on caudal peduncle; soft dorsal rays  
28-31; anal rays 26-29  
... .. *Scobinichthys* Whitley, 1931
- 16b. Each scale on side with 1 to many slender  
spinules; 1-3 spines in a longitudinal row on  
lower portion of caudal peduncle (small in  
adult female and juveniles); soft dorsal rays  
29-36; anal rays 27-34  
... .. *Pseudomonacanthus* Bleeker, 1866
- 17a. Soft dorsal and anal fins usually elevated  
anteriorly, at least in adult male; no spines on  
caudal peduncle; coloration generally dull ... .. 18
- 17b. Soft dorsal and anal fins not elevated anter-  
iorly, outer margin convex; caudal peduncle  
spines often present (small in adult female  
and juveniles, large in adult male); coloration  
generally bright with vivid patterns ... .. 20
- 18a. Head and body elongate, head length much  
greater than body depth; 20 vertebrae  
... .. *Nelusetta* Whitley, 1939
- 18b. Head and body not so elongate, head length  
equal to or less than body depth ... .. 19
- 19a. Soft dorsal and anal fins prominently elevated  
anteriorly in both sexes; barbs in postero-  
lateral series on first dorsal spine usually  
directed laterally (Fig. 4g) or obsolete; 19  
vertebrae  
... .. *Thamnaconus* Smith, 1949
- 19b. Soft dorsal and anal fins usually elevated only  
in adult male; barbs in postero-lateral series  
directed rearwards; 20 vertebrae  
... .. *Parika* Whitley, 1955
- 20a. Upper profile of snout concave in adults;  
first dorsal spine originates over anterior half  
of eye, armed with very small barbs; 19  
vertebrae  
... .. *Cantheschenia* n.gen.

- 20b. Upper profile of snout concave to convex (usually straight to convex in adult male); first dorsal spine originates over anterior to posterior halves of eye, armed usually with medium to large barbs in postero-lateral series. (Fig. 4e), obsolete in large specimens; 20 vertebrae  
 ... .. *Meuschenia* Whitley, 1929
- 21a. Anterior teeth in both jaws with truncate cutting edges (Fig. 5d)  
 ... .. *Colurodontis* n.gen.
- 21b. Anterior teeth in both jaws prominently pointed (Figs 5a, 5e and 5f) ... .. 22
- 22a. Dermal filaments greatly developed; inner teeth not visible (Fig. 5e)  
 ... .. *Chaetoderma* Swainson, 1839
- 22b. Dermal filaments not greatly developed, although small to medium ones may be present, especially in juveniles; extremities of inner teeth usually project between outer teeth (Figs 5a and 5f) ... .. 23
- 23a. Pelvic bony structure relatively large, armed with prominent barbs (Fig. 2c); first dorsal spine strong, originating over anterior half of eye; bristles present on caudal peduncle of adult male ... .. 24
- 23b. Pelvic bony structure elongate or short, armed with small barbs (Figs 2b, 2d and 2e); first dorsal spine slender to medium, originating over anterior to posterior halves of eye; caudal peduncle armed with spines, bristles or naked ... .. 25
- 24a. All 4 internal teeth in upper jaw with anterior extremities notched (Fig. 5f); bristles on caudal peduncle of adult male usually in a well defined patch; 20 vertebrae  
 ... .. *Acreichthys* Fraser-Brunner, 1941

- 24b. Upper 2 internal teeth with anterior extremities pointed (Fig. 5a); adult male generally with all scales on side of caudal peduncle developing short bristles, decreasing in size anteriorly; 19 vertebrae  
 ... .. *Pervagor* Whitley, 1930
- 25a. Ventral flap large, posterior border usually extending well past pelvic bony structure (Fig. 2b); typically 3 pairs of spines on each side of caudal peduncle (small in adult female and juveniles)  
 ... .. *Monacanthus* Oken, 1817
- 25b. Ventral flap small to medium, rear border usually not extending posterior to pelvic bony structure; no paired spines on caudal peduncle ... .. 26
- 26a. Movable segment of pelvic bony structure usually elongate and tapered (Fig. 2d); caudal peduncle unarmed or only a single spine on upper portion; some caudal fin rays of adult male usually produced into filaments  
 ... .. *Paramonacanthus* Bleeker, 1866
- 26b. Movable segment of pelvic bony structure short (Fig. 2e); patch of small bristles may be present on caudal peduncle of adult male, extending along middle of side; no caudal filaments but second soft dorsal ray usually elongate in adult male ... .. 27
- 27a. First dorsal spine with small but prominent downward-directed barbs on anterior face; each scale on sides with 1 to many small spinules arising directly from basal plate  
 ... .. *Laputa* Whitley, 1930
- 27b. First dorsal spine with small but not noticeably downward-directed barbs on anterior face or barbs obsolete; each scale on sides with 1 to many spinules branching out from a single pedicle  
 ... .. *Stephanolepis* Gill, 1861

## BIGENER new genus

Type species: *Aluterius ? brownii* Richardson, 1844-8: 68.

### Diagnosis

A genus of monacanthid fishes with the following combination of characters: central pair of teeth in both jaws with pointed extremities; first dorsal spine square in cross-section, with prominent downward-directed barbs along each corner, the posterior series slightly larger; first dorsal spine received wholly into a deep prominent groove in back when depressed; 2 pairs of spines on each side of caudal peduncle, enlarged, curving forwards and preceded by a dense patch of bristles in adult male, small in adult female and juveniles; 2 pairs of incising scales fused to posterior end of pelvis; vertebrae 7+13.

### Description

The following description is based on 16 specimens of *Bigener brownii*, 53-329 mm SL.

Dorsal rays 31 to 34; anal rays 29 to 31; pectoral rays 10 to 11; caudal rays 12; vertebrae 7+13.

Body compressed and somewhat elongate, width 2.0-2.2 in head length, depth 2.5-2.8 in SL; head 3.3-4.1 in SL; upper profile of snout concave (juveniles) to convex, snout length 4.1-4.5 in SL; eye diameter 2.8-4.4 in head length, 1.0-1.4 in interorbital width; gill slit centred below anterior half of eye, occasionally in front of eye, length 3.2-5.2 in head length; pelvis capable of moving vertically through an arc of usually less than 15°, producing a small ventral flap.

Mouth small, terminal, lower jaw projecting, lips not obviously fleshy; dentition consists of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones; 3 teeth on each side of lower jaw, posterior one small to minute; extremities of all external teeth except posteriormost in each jaw pointed; 2 series of slender acute teeth on each side of upper pharyngeal region, first with 7-9 small teeth, second with 3-4 slightly larger ones; gill rakers 38-39 (2 specimens).

First dorsal spine moderately strong, length 1.6-1.8 in head length, originating over anterior half of eye in adults, over centre or posterior half in juveniles, wholly received into a deep prominent groove in back when depressed; dorsal spine square in cross-section, armed with prominent downward-directed barbs on each corner, posterior ones slightly larger; with increasing size barbs on outer portion of dorsal spine become obsolete; second dorsal spine small, hidden in skin at rear base of first spine; soft

dorsal and anal fins not elevated anteriorly, longest soft dorsal ray (about 8th to 12th) 2.7-2.9 in head length; length of soft dorsal fin base 2.6-2.9 in SL, somewhat longer than base of anal fin; interdorsal space large, 0.8-1.2 in head length; base of pectoral fin below anterior half of eye in adults, posterior half in juveniles; posterior margin of caudal fin round, length 1.0-1.3 in head length; all fin rays except those of caudal generally unbranched; pelvic bony structure non-mobile, small (3.9-4.2 in eye diameter), consisting of 2 pairs of incasing scales fused to posterior end of pelvis.

Scales on body small to minute, armed with 1-3 short spinules, curving posteriorly at extremities, giving the skin a smooth to velvety feel; extremities of spinules in adults multifid (usually 3-4 short projections directed posteriorly), supporting a flat fleshy papilla; typically 2 pairs of spines on caudal peduncle, small in juveniles and adult female, strong and curved forwards in adult male; spinules on scales anterior to caudal peduncle spines of adult male prominently elongate, the extremities curving forwards, forming a dense patch of bristles extending to below 20th to 25th soft dorsal ray.

#### Remarks

The well known species *Bigener brownii* was previously included in *Acanthaluteres*, described by Bleeker (1866: 13) to accommodate *Aleuterius paraguadatus* Richardson (1844-8), which is now regarded as a junior synonym of *Acanthaluteres spilomelanurus* (Quoy & Gaimard, 1824). An additional species, *Penicipelta vittiger* (Castelnau, 1873) has also been previously assigned to this genus, under the name *Acanthaluteres guntheri* (Macleay, 1881), a junior synonym. The main character common to these three species is the shape and armature of the first dorsal spine and deep groove for its reception when depressed. However, *Acanthaluteres* is here considered monotypic on the basis of the unique form of the pelvic bony structure of *A. spilomelanurus*. Whereas *Bigener brownii* and *Penicipelta vittiger* both have 2 pairs of incasing scales fused to the posterior end of the pelvis, *Acanthaluteres spilomelanurus* possesses only one pair (Fig. 3c) (Tyler in his 1962 paper has shown the importance in the reduction of the pelvic bony structure in balistid-monacanthid evolution). In addition, *Bigener* is separable from *Penicipelta* in dentition, the former having the typical monacanthid condition of pointed teeth (Fig. 5a), whereas the latter possesses truncate teeth (Fig. 5b). *Bigener* is apparently an intermediate form between *Penicipelta* and *Meuschenia* (see preceding key for generic characters of *Meuschenia*).

This genus is named *Bigener* (Latin: meaning 'hybrid') with reference to the possession of characters apparently indicative of its relationships with two other genera. It is here used as a singular noun of common gender.

## CANTHESCHENIA new genus

Type species: *Amaneses (Cantherhines) longipinnis* Fraser-Brunner, 1941: 198.

### Diagnosis

A genus of monacanthid fishes with the following combination of characters: body moderately deep, 1.9-2.4 in SL, upper profile of snout slightly to prominently concave; first dorsal spine slender to moderately strong and armed with very small barbs, originating over anterior half of eye, partly received into a shallow groove in back when depressed; 2 pairs of spines of each side of caudal peduncle, very small in juveniles and adult female, large and curving forward in adult male; 2 pairs of incasing scales fused to posterior end of pelvis; vertebrae 7+12.

### Description

The following description is based on 16 specimens of *Cantheschenia longipinnis*, 80-189 mm SL and *C. grandisquamis* n.sp. (see description below).

Dorsal rays 34 to 39; anal rays 32 to 36; pectoral rays 11 to 13; caudal rays 12; vertebrae 7+12.

Body moderately deep, 1.9-2.4 in SL; head rather acute, 3.2-3.7 in SL; upper profile of snout slightly to prominently concave, length 4.0-4.3 in SL; eye diameter 3.2-4.2 in head length; gill slit centred below posterior half of eye, length 2.8-3.6 in head length; pelvis capable of moving vertically through an arc of 20° or less, producing a small to moderate ventral flap.

Mouth small, terminal, lips not obviously fleshy; dentition consists of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones; 2-3 teeth on each side of lower jaw (small posterior tooth lost in *C. longipinnis*); anterior outer teeth in both jaws with pointed extremities; 2 series of slender acute teeth on each side of upper pharyngeal region, 6 small teeth in anterior series, 3 slightly larger ones in posterior row.

First dorsal spine slender to moderately strong, originating over anterior half of eye, partly received into a shallow groove in back when depressed; dorsal spine armed with 4 series of small to minute barbs, 2 adjoining rows on anterior face and 1 series on each postero-lateral edge; soft dorsal and anal fins not elevated anteriorly, about equal in height, outer margin round; base of pectoral fin below posterior half of eye or behind; all fin rays except those of caudal generally unbranched; pelvic bony structure small to moderate, 4.1-5.4 in eye diameter, consisting of 2 pairs of incasing scales fused to rear end of pelvis, armed with small to medium barbs.

Caudal peduncle armed on each side with 2 pairs of spines, very small in juveniles and adult female, strong and curving anteriorly in adult male; spinules on scales anterior to spines of adult male rather elongate and acute, forming a dense patch of bristles extending a short distance anteriorly along middle of side.

### Remarks

This genus contains two species, *Cantheschenia longipinnis* and *C. grandisquamis* n.sp. (see description below), the former having been placed by previous authors in *Cantherhines* (Randall, 1964; Allen *et al.*, 1976). However, while possessing some characters of this genus (for example, a concave upper profile of snout, placement of the first dorsal spine over the anterior half of the eye with armature consisting of small to minute barbs, and 19 vertebrae), the reduction in number of the constituents of the pelvic bony structure of *Cantheschenia longipinnis* from three pairs to two pairs of incising scales and absence of a deep spinal groove in back indicates its relationship to *Meuschenia*.

This genus is named *Cantheschenia* (combination of the first two syllables of *Cantherhines* and last three of *Meuschenia*) with reference to its apparent relationships with *Cantherhines* and *Meuschenia*. It is here used as a feminine singular noun.

### *Cantheschenia grandisquamis* new species

(Fig. 6; Table 1)

### Holotype

AM I.15684-045, 183 mm SL, male, collected at One Tree Island, Capricorn Group, Great Barrier Reef, Queensland (23°30'S, 152°05'E), by explosives at 29 metres, F. Talbot *et al.*, 1 December 1969.

### Diagnosis

A species of *Cantheschenia* with the following combination of characters : relatively large scales on side of body with prominent outlines forming a reticulate pattern (Fig. 6b), each scale with many small spinules arranged in series radiating from a slightly larger central spinule; soft dorsal rays 39, anal rays 36, pectoral rays 13; colour pattern consisting of a dark brown to yellowish brown background with a patch of iridescent blue spots on side of throat and breast, a similarly coloured line along basal sheath of both soft dorsal and anal fins, and upper and lower 4 rays of caudal fin dark blue, with a black bar along posterior margin, the remainder of fin yellow-orange.

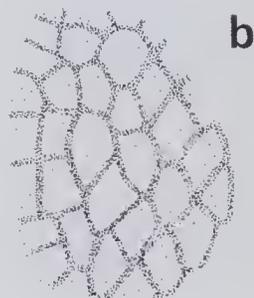
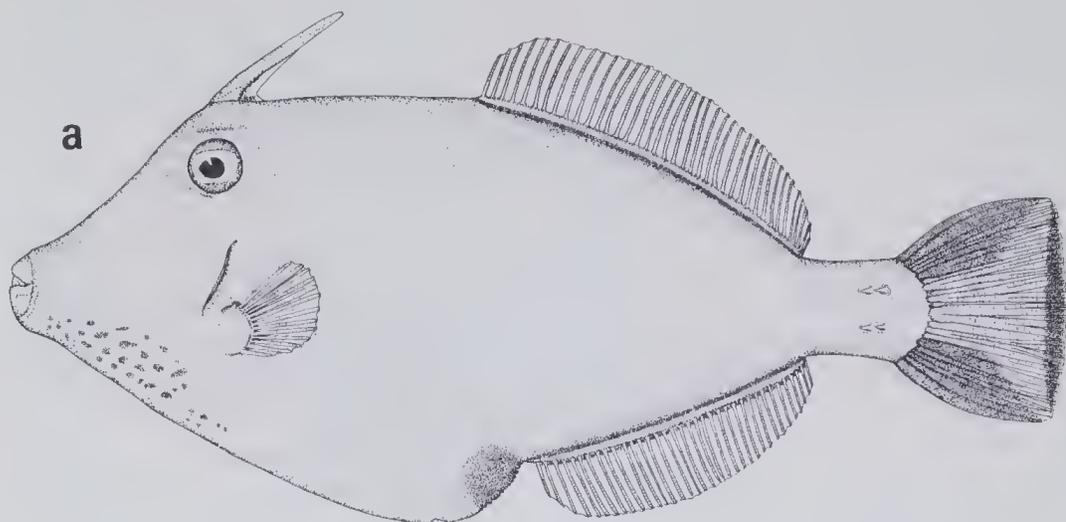


Fig. 6: *Cantheschenia grandisquamis* n.sp. : a, holotype, AM I.15684-045, 183mm SL; b, scale outlines on mid-side of body (largest scale approximately 2.5 x 1.5mm).

### Description

Measurements for the holotype, the only known specimen, are presented in Table 1.

Dorsal rays 39; anal rays 36; pectoral rays 13; caudal rays 12; vertebrae 7+12.

Body compressed and moderately deep, width 2.2 in head length and depth 2.4 in SL; head rather acute, length 3.7 in SL; upper profile of snout prominently concave, lower profile concave to a lesser extent, snout length 4.3 in SL; eye diameter 4.2 in head length, 1.2 in interorbital width; gill slit centred below centre of eye, length 2.8 in head length; pelvis capable of moving vertically through an arc of about 20°, producing a small to moderate ventral flap.

Mouth small, terminal, lips somewhat fleshy; dentition normal, consisting of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones; 3 teeth on each side of lower jaw, posterior one small; all external teeth except posteriormost in each jaw pointed; pharyngeal teeth appear to be normal (based on radiographs), with 2 series of slender acute teeth on each side of upper pharyngeal region.

Table 1: Measurements in mm and fin ray counts of type specimens of *Cantheschenia grandisquamis*, *Eubalichthys quadrispinis* and *Meuschenia venusta*.

	<i>C. grandisquamis</i>		<i>E. quadrispinis</i>		<i>M. venusta</i>	
	Holotype AM I.15684-045		Holotype AM E.987		Holotype WAM P.14881	Paratype CSIRO C.2284
Standard length	183		204		110	125
Head length	50		61		37	40
Body depth	76		117		48	47
Body width	23		23		17	18
Snout length	43		54		29	33
Eye diameter	12		14		11	9.8
Interorbital width	14		19		10	11
Gill slit length	18		16		9.8	11
1st dorsal spine length	37*		29*		20	22
Longest soft dorsal ray	18		22		12*	*
Longest anal ray	18		22		12	14
Longest pectoral ray	18		17		11	12
Caudal fin length	38		91		27*	*
Soft dorsal fin base	77		68		43	47
Anal fin base	62		69		38	41
Interdorsal space	53		62		24	27
Caudal peduncle length	17		23		7.5	11
Caudal peduncle depth	20		32		9.9	12
Pelvic bony structure length	2.9		1.2		2.5	2.5
Snout to origin of dorsal spine	50		68		39	44
Lower jaw to rear of pelvic bony structure	102		118		64	72
Soft dorsal ray count	39		32		34	34
Anal ray count	36		33		32	31
Pectoral ray count	13-13		14-13		12-12	12-12
Sex	Male		Female		Female	Male

\* measurement affected or not taken because of damage.

First dorsal spine moderately strong, length 1.4 in head length, originating over a point just posterior to anterior border of eye, partly received into a shallow groove in back when depressed; armature of dorsal spine consists of 4 rows of minute downward-directed barbs, 2 series on anterior face close together, almost obsolete, and 1 series on each postero-lateral edge, those near base somewhat larger, pointing laterally; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins not elevated anteriorly, about equal in height, longest soft dorsal ray (16th) 2.8 in head length; length of soft dorsal fin base 2.4 in SL, considerably longer than base of anal fin (3.0 in SL) (bases of fin membranes not perforate); interdorsal space relatively long, 0.9 in head length; base of pectoral fin below a point just anterior to posterior border of eye; caudal fin rather truncate, length 1.3 in head length; all fin rays except those of caudal unbranched; pelvic bony structure small, 4.1 in eye diameter, consisting of 2 pairs of incising scales armed with moderate barbs, fused to rear end of pelvis.

Scales on head and body moderate in size with distinct outlines, especially on mid-side of body, forehead and breast; mid-body scales each with many short acute spinules in series radiating from a slightly larger central spinule, all of which curve posteriorly at their extremities, giving the skin an extremely coarse feel; 2 pairs of strong forward-curving spines on each side of caudal peduncle; spinules on scales anterior to these spines rather elongate and acute, forming a patch of small bristles with a velvety touch, extending to below 26th or 27th soft dorsal ray; lateral line scales visible after slight drying.

Colour of holotype in alcohol (see Fig. 6a) : head and body dark brown, with mid-side of body a paler brown; patch of blackish brown spots on side of throat extending to below pectoral fin base; blackish brown line on basal sheath of both soft dorsal and anal fins, latter fin with similarly coloured spots on base of membranes forming an interrupted line; caudal peduncle spines translucent, covered with a dusky membrane, bases yellowish; area of prominent scales on forehead and breast pale yellowish brown; blackish brown blotch surrounding anus; first dorsal spine dark brown, membrane yellowish with brown markings; soft dorsal, anal and pectoral fins hyaline (except line on anal as above); caudal fin with area of upper and lower 4 rays dark brown, each band contracting prominently on posterior half of fin, a semi-lunar black bar along rear margin, remainder of fin yellowish brown.

Colour in life (based on a colour transparency provided by N. Coleman and a colour plate in Deas, 1971 : 31, both of live fish under water) : head, upper and lower profiles of body dark brown; area of prominent scales on

side of body yellowish with a reticulate pattern of dark brown lines (see Fig. 6b); iridescent blue spots on side of throat and breast to below pectoral fin base; iridescent blue line on basal sheath of soft dorsal and anal fins; caudal peduncle spines and surrounding scales yellowish orange; first dorsal spine dark brown, membrane bright yellow with iridescent blue markings near second spine; soft dorsal, anal and pectoral fin rays brown, membranes hyaline, anal with an interrupted iridescent blue line along basal membranes in 1 specimen; yellowish orange of caudal peduncle extends onto mid portion of caudal fin with upper and lower 4 rays iridescent dark blue, and narrow black transverse bar along posterior margin.

### Comparisons

*C. grandisquamis* is easily distinguished from the only other member of the genus, *C. longipinnis*, by its prominently outlined scales, the latter species having a smooth skin consisting of minute scales. Also, *C. grandisquamis* possesses three teeth on each side of the lower jaw, the posteriormost one very small but not absent as in *C. longipinnis*. Colour patterns are also distinctive as *C. longipinnis* does not have the bright coloration and vivid patterns of *C. grandisquamis*. It is usually a dull brown, sometimes with indistinct dark spots on sides. Other related species which possess well defined scales, such as *Meuschenia trachylepis* and *Amaneses scopas*, have spinules arranged in transverse series on the mid-body scales rather than radially as in *C. grandisquamis*.

### Remarks

*C. grandisquamis* is known only from the holotype collected at One Tree Island and two underwater photographs, one by N. Coleman at Middle Island and the other by W. Deas from Heron Island (pers. comm.). All these localities are in the near vicinity of Gladstone, Queensland, which is approximately adjacent to the southernmost limit of the Great Barrier Reef. More intensive collecting in this area should increase the known range of this species.

As with most other monacanthids that inhabit coral reef areas (for example, *Amaneses scopas*, *Cantherhines pardalis*, *Pervagor melanocephalus* and *Oxymonacanthus longirostris*) *C. grandisquamis* possesses a tough skin with strongly armed scales, especially on the forehead and breast.

This species is named *grandisquamis* (Latin: meaning 'large-scale') with reference to the relatively large prominently outlined scales on the mid-side of the body.

## COLURODONTIS new genus

Type species : *Colurodontis paxmani* n.sp. (see below).

### Diagnosis

A genus of monacanthid fishes with the following combination of characters : all external teeth with truncate cutting edges, anteriormost pair in each jaw extending across full width of mouth (Fig. 7c); 2 vertical small tusk-like processes on internal surface of anteriormost pair of teeth in lower jaw; first dorsal spine originates over posterior half of eye, armed with 2 series of prominent downward-directed barbs on anterior face, much smaller and more numerous than those in postero-lateral rows; scales on body with 1 central spinule supported by a transverse ridge, those spinules on caudal peduncle of adult male moderately elongate, curving anteriorly; pelvic bony structure movably articulated with pelvis.

### Description

See following description of *C. paxmani*, the only species presently known in this genus.

### Remarks

*Colurodontis* appears to be closely related to both *Acreichthys* and *Pervagor* but is easily distinguished from them and other monacanthid genera which possess a movable pelvic bony structure by the truncate central pair of teeth in each jaw. *Acanthaluteres*, which has a similar dentition, is not allied to *Colurodontis* as it possesses a weak, non-mobile pelvic bony structure.

This genus is named *Colurodontis* (Greek: meaning 'truncate-tooth') with reference to the unusual dentition, and is used here as singular noun of feminine gender.

### *Colurodontis paxmani* new species

(Fig. 7; Table 2)

### Holotype

WAM P.15454, 120 mm SL, male, collected from Shark Bay (approximately 25° 30'S, 113° 30'E), Western Australia, W. & W. Poole on *Bluefin*, July, 1966.

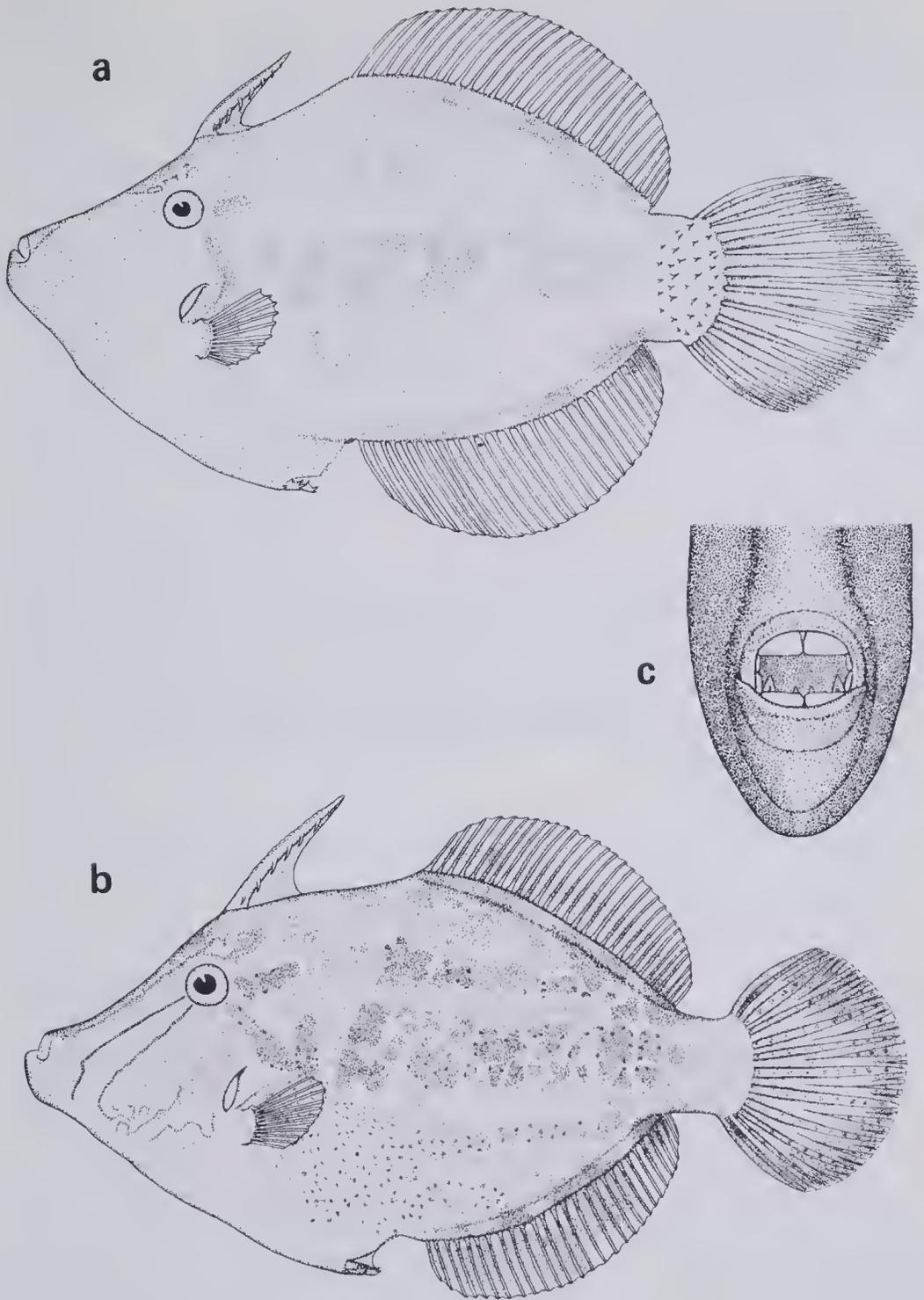


Fig. 7: *Colurodontis paxmani* n.sp.: a, holotype, WAM P.15454, 120 mm SL, male; b, paratype, WAM P.25573-001, 87 mm SL, female; c, anterior view of jaws of above paratype.

Table 2: Measurements in mm and fin ray counts of selected type specimens of *Colurodonitis paxmani*.

	Holotype		Paratypes		WAM		WAM	
	WAM P.15454	WAM P.15455	WAM P.25570-001	BMNH 1976.8.23.4	WAM P.25571-001	WAM P.25572-001	WAM P.25572-001	WAM P.25572-001
Standard length	120	118	74	62	42	31		
Head length	35	35	25	20	15	11		
Body depth	66	69	43	33	23	16		
Body width	18	15	12	8.3	7.0	4.9		
Snout length	26	25	17	15	9.1	6.7		
Eye diameter	8.5	8.9	8.0	6.6	5.3	4.0		
Interorbital width	10	10	7.2	6.1	5.0	3.6		
Gill slit length	8.7	9.5	5.8	3.1	2.4	1.6		
1st dorsal spine length	26	30	21	16	12	6.3		
Longest soft dorsal ray	20	19	9.0	7.3	6.8	3.9		
Longest anal ray	20	19	8.6	7.1	6.8	3.9		
Longest pectoral ray	15	16	10	7.3	6.7	4.0		
Caudal fin length	43	40	26	22	15	10		
Soft dorsal fin base	60	59	31	26	18	12		
Anal fin base	54	54	29	24	17	12		
Interdorsal space	28	32	19	15	10	7.0		
Caudal peduncle length	6.8	7.5	4.8	4.5	2.8	3.4		
Caudal peduncle depth	22	21	12	9.4	6.5	4.0		
Pelvic bony structure length	5.8	6.6	4.2	3.5	3.1	1.2		
Snout to origin of dorsal spine	35	33	23	21	13	10		
Lower jaw to rear of pelvic bony structure	70	70	52	40	29	19		
Soft dorsal ray count	30	30	30	28	32	28		
Anal ray count	30	29	29	27	31	27		
Pectoral ray count	11-11	11-11	11-11	11-11	12-12	11-11		
Sex	Male	Male	Female	Female	Male	Juvenile		

## Paratypes

39 specimens, 11-120 mm SL (unless otherwise designated, all specimens at WAM). Western Australia: P.14871, 78 mm SL, Shark Bay, R.J. McKay, June 1958; P.15455, 118 mm SL, same data as for holotype; P.23242-52, 11 specimens, 12-16 mm SL, between Montebello Islands and Onslow, in *Sargassum* weed, J.B. Hutchins, 11 May 1973; P.24124-5, 2 specimens, 11-12 mm SL, Kendrew Island, Dampier Archipelago, under buoy, J.B. Hutchins, 26 October 1973; P.24126-7, 2 specimens, 13-14 mm SL, Kendrew Island, Dampier Archipelago, in *Sargassum* weed, J.B. Hutchins, 26 October 1973; P.25568-001, 2 specimens, 68-79 mm SL, Shark Bay, R.J. McKay, 5 June 1962; P.25569-001, 8 specimens, 14-17 mm SL, Exmouth Gulf, surface trawl at night, R.J. McKay, 20 June 1964; P.25570-001, 74 mm SL, skeleton, Shark Bay, R.V. Peron, May 1966; P.25571-001, 41 mm SL, Shark Bay, R.J. McKay; P.25572-001, 31 mm SL, Onslow, seine net over reef near caravan park, 25 June 1975; P.25573-001, 87 mm SL, Woodmans Point, near Perth, push-net in weed, M. Thompson, March 1976; AM IB.316, 113 mm SL, Shark Bay, G.P. Whitley, June 1939; BMNH 1976.8.23.4, 62 mm SL, Shark Bay, R.J. McKay, 5 June 1962; USNM 216435, 78 mm SL, Shark Bay, R.J. McKay, 5 June 1962. Queensland: QM I.1935, 5 specimens, 11-18 mm SL, Raine Island (11° 35'S, 144° 05'E), Wanetta Pearlring Company, 27 May 1914.

## Diagnosis

See relevant section pertaining to the genus.

## Description

Measurements and counts of the holotype and selected paratypes are presented in Table 2.

Dorsal rays 27 to 32; anal rays 26 to 31; pectoral rays 10 to 12 (generally 11); caudal rays 12; vertebrae 7+12.

Body prominently compressed and moderately deep, width 1.9-2.4 in head length and depth 1.7-1.9 in SL; head 3.0-3.4 in SL; upper profile of snout slightly to prominently concave, length 4.1-4.7 in SL; eye small, diameter 3.0-4.1 in head length, 0.9-1.2 in interorbital width; gill slit small, 3.7-6.1 in head length, anterior margin prominently curved, centred below posterior half of eye or behind; pelvis capable of only limited vertical movement, producing a small ventral flap.

Mouth small, somewhat superior, lower jaw protruding, lips rather fleshy; dentition consists of 3 external and 2 internal teeth on each side of

upper jaw, 2 teeth on each side of lower jaw, all external teeth with truncate cutting edges (Fig. 7c); anteriormost pair of teeth in each jaw extend across full width of mouth, meeting adjacent teeth at right angles; each anterior tooth of lower jaw possesses a small vertical tusk-like process on internal surface just below cutting edge, the 2 processes tending to form a small groove at teeth junction (Fig. 7c); internal teeth of upper jaw plate-like, with no external cutting edges; 2 series of slender blunt teeth on each side of upper pharyngeal region, first with 5 teeth, second with 3, all of a blackish colour; gill rakers 16-19 (2 specimens).

First dorsal spine moderately strong, length 1.2-1.3 in head length, originating over posterior half of eye, no spinal groove in back; dorsal spine armed with 4 series of prominent downward-directed barbs, anterior face with 2 adjoining rows of relatively small barbs, those in posterolateral rows very large, about half as numerous as anterior barbs (anterior series may be hidden in skin); second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins almost evenly rounded, about equal in height, longest dorsal ray (about 7th to 9th) 1.8-2.8 in head length; length of soft dorsal base 2.0-2.4 in SL, somewhat longer than base of anal fin (bases of fin membranes not perforate); interdorsal space relatively short, about equal to first dorsal spine, profile rising rather steeply to soft dorsal fin in adults; base of pectoral fin below posterior half of eye or behind; caudal fin with rounded posterior margin, middle rays relatively elongate in adult male, length 0.8-1.0 in head length; all fin rays except those of caudal generally unbranched; caudal peduncle deep, length 2.1-3.2 in depth; pelvic bony structure moderate in size with prominent barbs, length 1.3-1.9 in eye diameter, consisting of 3 pairs of incasing scales, anterior 2 pairs fused to rear end of pelvis, posterior pair movably articulated with anterior scales; posterior pair of incasing scales partly fused together posteriorly.

Scales on body small, each with 1 short conical spinule directed posteriorly, giving skin a slightly rough feel; with increasing size, a transverse ridge develops through base of spinule; adult male with a patch of elongate recurved spinules on side of caudal peduncle, extending a short way along mid-side of body, spinules decreasing in size anteriorly, longest about 3-4 in eye diameter; scale outlines prominent on caudal peduncle of adult male.

Colour of holotype in alcohol (Fig. 7a) : head and body pale brown with darker blotches on side forming a wide longitudinal stripe from area behind gill slit to centre of caudal peduncle, width of stripe 1.5-1.8 times eye diameter; 2 dark bars radiate from posterior border of eye, upper extending

about 1 eye diameter towards soft dorsal base, lower almost reaching uppermost pectoral ray; 3 faint blotches on bases of soft dorsal and anal fins, posteriormost one on anal base prominent; upper portion of head with irregular line extending from below first dorsal spine origin, through nostrils, along snout profile to corner of mouth; all fins pale brown to dusky, caudal more blackish posteriorly with narrow irregular pale terminal bar. Paratypes as above with the following exceptions : dark blotches on side of body tend to form 2 additional longitudinal stripes, one from eye to rear base of soft dorsal fin, the other from pectoral to rear base of anal fin; 2 narrow dark lines extend from anterior border of eye towards mouth, bending downwards to throat, the posterior line forming a wavy pattern on side of throat; pelagic juveniles pale with irregular darker blotches.

Colour in life (from colour transparencies and aquarium observations of female specimen WAM P.25573-001 — see Fig. 7b) : ground colour of body pale grey to pale blue with many close-packed green and dark brown blotches, the latter tending to form 3 longitudinal stripes on sides; head greenish brown with 2 thin iridescent blue lines on snout, extending from eye towards mouth, bending downwards to throat, posterior line forming a wavy pattern on side of throat which may extend onto side of breast; small iridescent blue spots may be present near upper profile of head and body; pale orange brown blotch on mid-side of caudal peduncle; first dorsal spine turquoise with dusky membrane; soft dorsal and anal fins hyaline to dusky with 3 irregular dark brown blotches on basal sheath, extending onto fins; caudal fin rays turquoise, membranes orange with a longitudinal row of brown spots between each ray, rays and membranes becoming blackish posteriorly (membrane between upper 2 and lower 2 rays entirely blackish); spinules on scales turquoise. The following are significant variations in live colour pattern : replacement of longitudinal body stripes with irregularly arranged greenish brown blotches; a pale blue stripe on dorsal profile, extending from snout tip to caudal peduncle; dark brown spots may be scattered on body, especially lower half, or absent.

### Comparisons

*C. paxmani* is easily distinguishable by its unusual dentition from all other monacanthid species that possess a movable pelvic bony structure (see also remarks under preceding section on genus).

### Distribution

*C. paxmani* is known from Cockburn Sound, Fremantle, northwards to the Dampier Archipelago, Western Australia, and also from Raine Island, north Queensland.

## Remarks

Pelagic juveniles of *C. paxmani* (11-17 mm SL) have been collected in Western Australian waters from floating *Sargassum* weed in association with juvenile *Paramonacanthus oblongus*, a wide ranging species of the Indo-West Pacific area. However, except for five pelagic juveniles from Queensland, *C. paxmani* is known only from Western Australia. Future collecting activity will probably expand the known range of this species.

Post-pelagic juveniles and adults are apparently inhabitants of sea-grass beds (*Posidonia* spp.).

*C. paxmani* is named in grateful appreciation to Mr B. Paxman who was instrumental in obtaining many monacanthid specimens for the collections of the Western Australian Museum.

### *Eubalichthys caeruleoguttatus* new species

(Fig. 8; Table 3)

#### Holotype

WAM P.5204, 212 mm SL, male, collected near Beagle Island (29°48'S, 114°52'E), Western Australia, W. & W. Poole on *Bluefin*, March 1962.

#### Paratypes

22 specimens from Western Australia, 35-253 mm SL (unless otherwise designated, all specimens at WAM). P.9156, 129 mm SL, Shark Bay, prawn trawl at 36 metres, E. Barker, 21 September 1964; P.9157, 134 mm SL, Shark Bay, R.J. McKay, 1960; P.9159, 115 mm SL, Exmouth Gulf, R.J. McKay, 1960; P.11828-9, 2 specimens, 117-142 mm SL, Shark Bay, prawn trawl at 22 metres, E. Barker, 11 October 1964; P.14845, 190 mm SL, skeleton, Shark Bay, A. McKenzie, August 1965; P.14875, 115 mm SL, Exmouth Gulf, R.J. McKay, October 1958; P.14887, 100 mm SL, Exmouth Gulf, R.J. McKay, 17 July 1958; P.22100, 253 mm SL, 56 kilometres NW of Cape Cuvier, J. Penn, 29 July 1972; P.22310, 241 mm SL, same data as for P.22100; P.25555-001, 35 mm SL, Pelsart Group, Houtman Abrolhos, March-August 1960; P.25556-001, 53 mm SL, Shark Bay, A. McKenzie, August 1965; P.25557-001, 24 kilometres W of Carnarvon, prawn trawl at 28 metres, L. Marsh and M. Sinclair, 3-4 June 1975; P.25558-001, 6 specimens, 76-98 mm SL, 15 kilometres SW of Point Quobba, prawn trawl at 38-42 metres, J.B. Hutchins, 13 April 1976; P.25559-001, 44 mm SL, between Koks Island and Point Quobba, W. & W. Poole on *Bluefin*, 23-30 June 1958; P.25579-001, 245 mm SL, 30 kilometres NW of Koks Island, by fish trawl at 76-82 metres, C. Ostle on board Taiwanese trawler, July

1976; AM I.19168-001, 76 mm SL, BMNH 1976.8.23.2, 78 mm SL, USNM 216434, 88 mm SL, all with same data as P.25558-001.

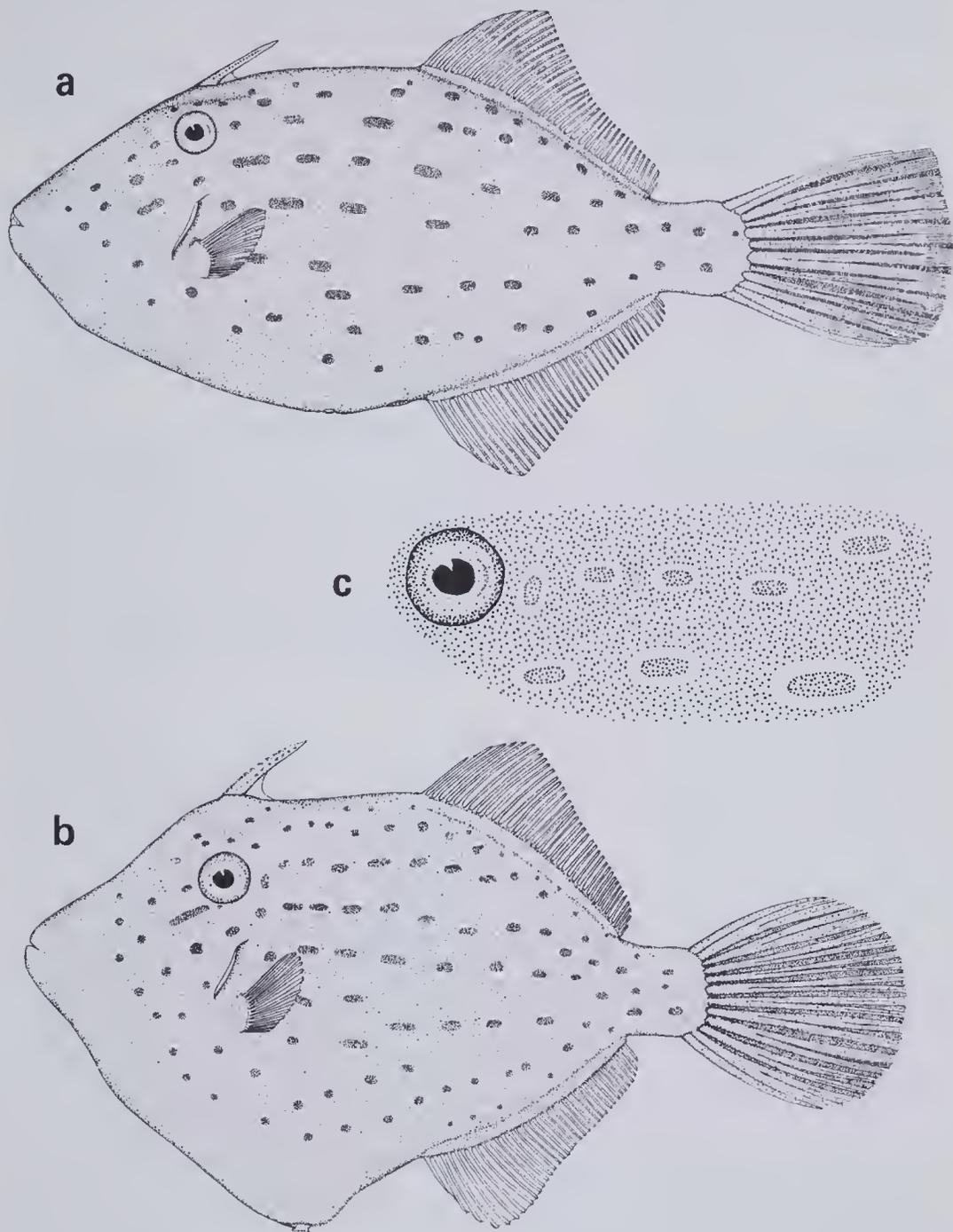


Fig. 8: *Eubalichthys caeruleoguttatus* n.sp. : a, holotype, WAM P.5204, 212 mm SL, male (some upper and lower caudal fin rays damaged); b, paratype, WAM P.14887, 100 mm SL, female; c, variation in colour pattern.

Table 3: Measurements in mm and fin ray counts of selected type specimens of *Eubalichthys caeruleoguttatus*.

	Holotype		Paratypes			
	WAM P.5204	WAM P.22100	WAM P.14845	WAM P.9157	WAM P.25558-001	WAM P.25556-001
Standard length	212	253	190	134	98	53
Head length	64	80	60	44	33	20
Body depth	97	109	90	66	54	31
Body width	27	37	25	18	13	7.6
Snout length	54	65	50	36	26	15
Eye diameter	15	20	14	11	8.7	5.1
Interorbital width	20	24	19	13	10	6.5
Gill slit length	21	24	19	15	11	6.3
1st dorsal spine length	30	*	19*	24	16*	8.5*
Longest soft dorsal ray	38	48	34	22	14	6.2
Longest anal ray	31	43	27*	21	12	6.5
Longest pectoral ray	20	23	16*	14	9.7	5.5
Caudal fin length	68*	70*	64	46	35	15
Soft dorsal base	82	92	75	52	39	21
Anal fin base	77	83	67	48	36	20
Interdorsal space	64	74	55	37	27	15
Caudal peduncle length	18	26	16	12	7.6	4.5
Caudal peduncle depth	28	24	24	17	12	6.7
Pelvic bony structure length	2.6	3.0	2.3	1.8	1.5	1.4
Snout to origin of dorsal spine	62	75	60	43	33	20
Lower jaw to rear of dorsal spine	115	133	106	77	57	34
Soft dorsal ray count	38	37	37	37	37	*
Anal ray count	36	35	35	35	36	34
Pectoral ray count	14-14	14-12	14-14	14-13	14-14	14-14
Sex	Male	Female	Male	?	Female	Juvenile

\* measurement or count affected by damage, distortion or deformation.

## Diagnosis

A species of *Eubalichthys* characterised by the following combination of characters : body moderately deep (1.7-2.4 in SL); first dorsal spine relatively short (1.8-2.4 in head length); caudal fin elongate (0.9-1.3 in head length); colour pattern consisting of brownish grey background with round to elongate blue spots on head and body arranged in longitudinal series.

## Description

Measurements and counts of the holotype and selected paratypes are presented in Table 3.

Dorsal rays 35 to 38; anal rays 34 to 36; pectoral rays 13 to 14 (fin of 1 specimen with 12 rays appears to be deformed); caudal rays 12; vertebrae 7+12.

Body compressed and moderately deep, width 2.2-2.6 in head length and depth 1.7-2.4 in SL; head 2.7-3.3 in SL; upper profile of snout slightly concave to convex (latter condition occurring in large adults), length 3.5-3.9 in SL; eye diameter 3.8-4.3 in head length, 1.1-1.4 in interorbital width; gill slit relatively long, 2.9-3.3 in head length, usually centred below anterior half of eye for specimens greater than 150 mm SL, below posterior half or behind eye for smaller specimens; pelvis usually capable of moving vertically through an arc of 25° or less, producing a small to medium ventral flap.

Mouth small, terminal, lips not fleshy; dentition normal, consisting of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between the outer ones; 3 teeth on each side of lower jaw, posteriormost small to minute; extremities of all external teeth except posteriormost in each jaw pointed; 2 series of slender acute teeth on each side of upper pharyngeal region, first with 7 small teeth, second with 3 slightly larger ones; gill rakers 30-34 (2 specimens).

First dorsal spine short, 1.8-2.4 in head length, slender to moderately strong, compressed antero-posteriorly in large adults; dorsal spine originates over anterior half of eye, received into a shallow groove in back when depressed or spinal groove absent; dorsal spine armed with 4 series of small to medium downward-directed barbs, anterior face with 2 adjoining rows, each lateral edge with 1 row directed sideways; with increasing SL anterior barbs become relatively smaller, approaching obsolescence; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins elevated anteriorly, longest dorsal ray (about 5th-7th) 1.7-3.2 in head length, slightly longer than longest anal ray; length of soft dorsal base 2.5-2.8 in SL, somewhat longer than base of anal fin (bases of fin membranes

not perforate); interdorsal space 1.0-1.3 in head length; base of pectoral fin usually below posterior half of eye, behind eye in juveniles; caudal fin relatively long in adults, with several upper and lower rays slightly produced in male, length 0.9-1.3 in head length; all fin rays except those of caudal generally unbranched; pelvic bony structure non-mobile, small (3.6-6.7 in eye diameter), consisting of 2 pairs of incising scales armed with small barbs (barbs lost with age), located about  $\frac{1}{2}$  to 1 eye diameter anterior to posterior end of pelvis.

Scales on body very small, each with 1-3 transverse rows of minute slender spinules (up to 6 in each row), giving the skin a smooth to velvety feel; scale outlines visible only under magnification; caudal peduncle unarmed.

Colour of holotype in alcohol (Fig. 8a): head and body brown with longitudinal series of round to elongate purplish brown spots, about 7 series on side of body, upper and lower rows tending to follow respective body profiles and meeting on side of head, 2 series extending onto caudal peduncle; soft dorsal, anal and pectoral fins yellowish brown, membranes of outer portions dusky; caudal fin rays pale greenish grey, membranes dusky, becoming darker on posterior half of fin. Paratypes as above with the following exceptions: ground colour varies from greenish grey to brownish grey; spots on head and body may be pale blue to grey, surrounded by a wide paler ring (see Fig. 8c) or almost invisible.

Colour in life (from two freshly caught specimens, 79 and 245 mm SL): large specimen — ground colour brownish grey, paler ventrally; longitudinal series of large blue spots on head and body, more iridescent near upper and lower profiles; all fin rays turquoise, membranes of soft dorsal and anal dusky on outer portions, caudal membranes dusky becoming increasingly darker towards posterior margin; small specimen — ground colour brownish grey with somewhat darker irregular blotches on body, and indistinct yellowish blotches on head; longitudinal series of prominent pale blue to iridescent blue spots on sides of body and head; first dorsal spine brownish grey, membrane more blackish; soft dorsal, anal and pectoral fin rays brownish orange, membranes dusky; caudal fin rays pale brownish grey, membranes dark brownish grey becoming blackish near outer margin; iris yellow; lips pale orange.

### Comparisons

*E. caeruleoguttatus* is readily distinguished from other species of the genus by the characteristic longitudinal series of round and elongate blue spots on a brownish grey ground colour. *E. fuscusinus* has prominent dark

brown stripes on head and body following the curved course of the lateral line; *E. mosaicus* possesses yellow oval blotches arranged longitudinally on head and body, sometimes with blue lines forming a mosaic pattern on side; *E. gunnii* is brown with darker blotches and spots forming a mosaic pattern on side; and *E. bucephalus* may be wholly brown or black, or brownish grey with 3-4 longitudinal black stripes, and eye with a prominent white marginal ring (juveniles pale brown with scattered dark brown spots on head and body). The colour pattern of *E. quadrispinis* is not known; however the presence of spines on the caudal peduncle easily separates this species.

### Distribution

Known only from Western Australia, from Beagle Island, south of Geraldton, north to Exmouth Gulf. It has been taken in depths of 22 to 82 metres.

### Remarks

This species is named *caeruleoguttatus* (Latin: meaning 'blue-spotted') with reference to the blue spots on the head and body.

### *Eubalichthys fuscusinus* new species

(Fig. 9; Table 4)

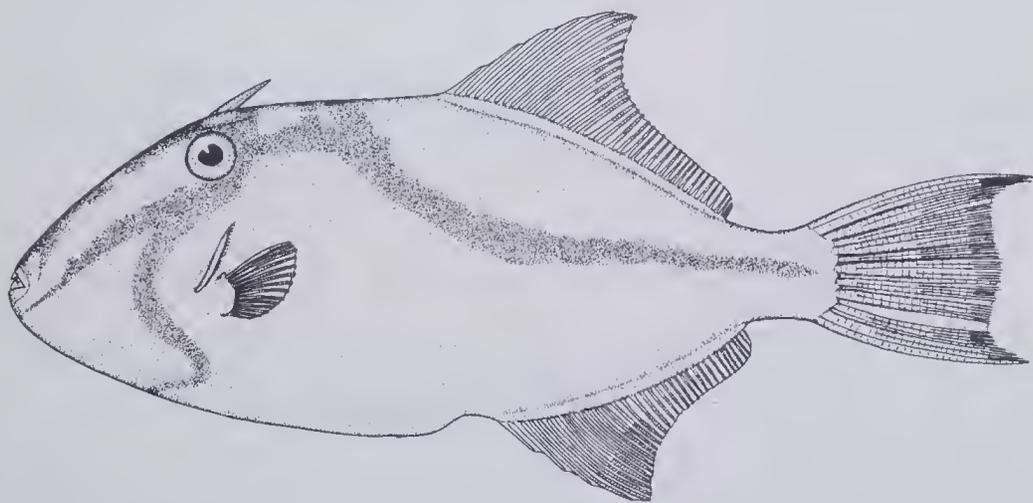


Fig. 9: *Eubalichthys fuscusinus* n.sp., holotype, WAM P.25580-001, 273 mm SL.

## Holotype

WAM P.25580-001, 273 mm SL, male, collected 30 kilometres NW of Koks Island (24° 45'S, 113° 09'E), Western Australia, by fish trawl at 76-82 metres, C. Ostle on board Taiwanese trawler, July 1976.

## Paratypes

4 specimens, 231-253 mm SL. WAM P.25579-002, 2 specimens, 231-253 mm SL, AM I.19167-001, 241 mm SL, BMNH 1976.8.23.3, 244 mm SL, all with the same data as for holotype.

## Diagnosis

A species of *Eubalichthys* with the following combination of characters : body relatively elongate (depth 2.4-2.7 in SL); first dorsal spine short (2.7-3.2 in head length); caudal fin lunate and moderately elongate (0.9-1.1 in head length); colour pattern consisting of brownish grey background with prominent dark brown stripe following the curved paths of the lateral line, singular on body and dividing into 3 stripes on head.

## Description

Measurements and counts of the holotype and paratypes are presented in Table 4.

Dorsal rays 36 to 39; anal rays 34 to 37; pectoral rays 13 to 14; caudal caudal rays 12; vertebrae 7+12.

Body compressed and rather elongate, width 2.0-2.3 in head length and depth 2.4-2.7 in SL; head 3.2-3.3 in SL; upper profile of snout convex, length 3.8-4.1 in SL; eye diameter 4.2-4.7 in head length, 1.2-1.4 in inter-orbital width; gill slit 3.1-3.6 in head length, centred below centre of eye or slightly farther forward; pelvis capable of moving vertically through an arc of not more than 10°, producing a small to inconspicuous ventral flap.

Mouth small, terminal, lips not fleshy; dentition normal, consisting of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones; 3 teeth on each side of lower jaw, posterior one small; all external teeth except posteriormost in each jaw with pointed extremities; pharyngeal teeth appear normal (from radiograph) with 2 series of slender acute teeth on upper portion of pharyngeal region; gill rakers 35 (1 specimen).

Table 4: Measurements in mm and fin ray counts of type specimens of *Eubalichthys fuscusinus*.

	Holotype		Paratypes		
	WAM P.25580-001	WAM P.25579-002	BMNH 1976.8.23.3	AM I.19167-001	WAM P.25579-002
Standard length	273	253	244	241	231
Head length	84	78	75	75	69
Body depth	111	98	92	92	93
Body width	40	39	34	36	30
Snout length	71	66	62	64	56
Eye diameter	18	18	18	17	16
Interorbital width	25	23	22	21	19
Gill slit length	27	24	22	21	22
1st dorsal spine length	26	28	28	23	21
Longest soft dorsal ray	60	53	52	53	47
Longest anal ray	53	47	46	49	43
Longest pectoral ray	26	24	23	24	22
Caudal fin length	90	74	71	80	70
Soft dorsal fin base	108	96	89	90	88
Anal fin base	94	86	79	80	77
Interdorsal space	74	69	71	69	63
Caudal peduncle length	21	23	25	22	25
Caudal peduncle depth	29	26	24	25	24
Pelvic bony structure length	2.8	2.9	2.8	2.8	2.6
Snout to origin of dorsal spine	83	79	72	74	65
Lower jaw to rear of pelvic bony structure	132	125	123	118	116
Soft dorsal ray count	39	37	36	36	38
Anal ray count	37	36	34	34	35
Pectoral ray count	14-14	14-13	13-13	14-14	13-13
Sex	Male	Male	Male	Male	Male

First dorsal spine short (2.7-3.3 in head length), compressed antero-posteriorly with prominent lateral edges, received wholly into a shallow to moderately deep groove in back when depressed; dorsal spine armed with 4 series of small downward-directed barbs, 2 adjoining rows on anterior face, 1 row along each lateral edge consisting of relatively larger laterally-directed barbs (barbs becoming obsolete with increasing SL); second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins prominently elevated anteriorly, longest soft dorsal ray (5th) 1.4-1.5 in head length, somewhat longer than longest anal ray; length of soft dorsal fin base 2.5-2.6 in SL, considerably longer than base of anal fin (bases of fin membranes not perforate); interdorsal space 1.1 in head length; base of pectoral fin below posterior half of eye; caudal fin lunate and relatively long, 0.9-1.1 in head length; all fin rays except those of caudal generally unbranched; pelvic bony structure non-mobile, small (6.2-6.4 in eye diameter), consisting of 2 pairs of incising scales armed with minute barbs, located about  $\frac{1}{2}$  eye diameter anterior to posterior end of pelvis.

Scales on body minute, each with 1-5 transverse rows of minute slender spinules, giving the skin a smooth to slightly velvety feel; scale outlines visible only under magnification; caudal peduncle unarmed.

Colour of holotype in alcohol (Fig. 9) : head and body pale brownish grey with a prominent dark brown stripe (about  $\frac{1}{2}$  eye diameter in width) following the curved paths of the lateral line, singular on body and dividing into three stripes on head; uppermost head stripe joined across dorsal profile to corresponding stripe of opposite side by 3 short bars, first across snout and posterior 2 on either side of dorsal spine, and lowest stripe confluent with corresponding stripe across throat; some irregular blotches extend from upper portion of body stripe to interdorsal space; all fins with turquoise rays, membranes hyaline to dusky. Paratypes are similarly coloured.

Colour when fresh (frozen specimens) : colour is generally the same as in the preserved condition described above except that the ground may be more brownish with bronze reflections.

### Comparisons

*E. fuscusinus* is easily distinguished from the closely related *E. caeruleoguttatus* by its distinctive coloration (see comparisons section for *E. caeruleoguttatus*). In addition, *E. fuscusinus* is relatively more elongate (body depth 2.4-2.7 in SL) than *E. caeruleoguttatus* (1.7-2.4).

## Distribution

*E. fuscusinus* is known only from the type locality off Carnarvon, Western Australia, in relatively deep water (80 metres).<sup>1</sup>

## Remarks

This species is named *fuscusinus* (Latin: meaning 'brown-curve') with reference to the brown stripe which follows the curved paths of the lateral line on the head and body.

### *Eubalichthys quadrispinis* new species

(Fig. 10; Table 1)

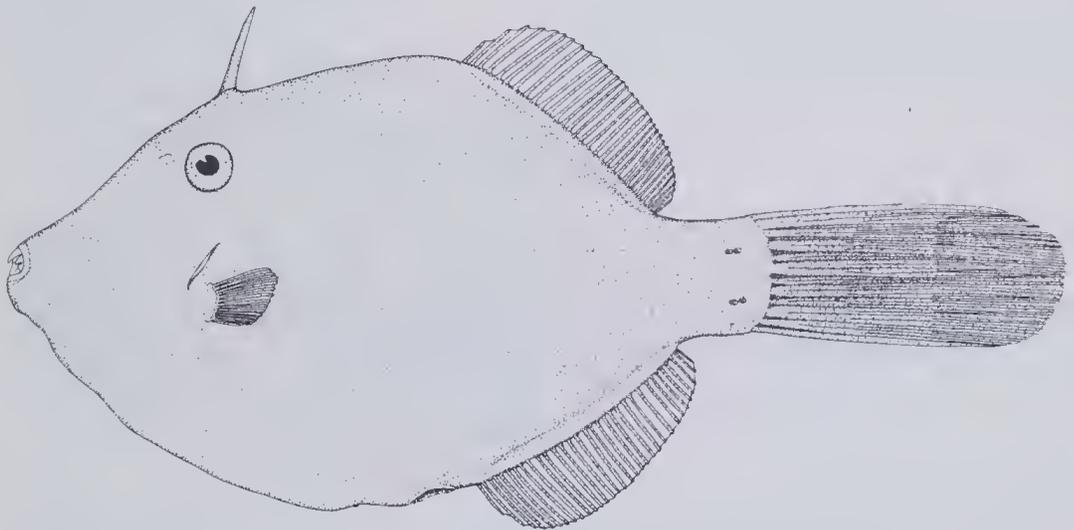


Fig. 10: *Eubalichthys quadrispinis* n.sp., holotype, AM E.987, 204 mm SL.

## Holotype

AM E.987, 204 mm SL, female, 80 kilometres off Cape Wiles (34° 57'S, 135° 41'E), South Australia, 135 metres, FIV *Endeavour*, 28 September 1909.

<sup>1</sup> While this paper was in press, further material sent on loan from the CSIRO, Cronulla produced another specimen of *E. fuscusinus*, CSIRO C.4867, which was collected off the north-west coast of Western Australia by the Japanese research vessel *Umitaka Maru* in 1960. The following measurements and counts pertain to this specimen: standard length — 224 mm; body depth — 95 mm; soft dorsal ray count — 36; anal ray count — 34. This male specimen is here designated as a paratype.

## Diagnosis

A species of *Eubalichthys* with the following combination of characters : low fin ray counts (D.32; A.33); base of anal fin longer than soft dorsal base; caudal fin greatly elongate (0.7 in head length); 2 pairs of spines on each side of caudal peduncle; pelvic bony structure very small, located about 1 eye diameter anterior to rear end of pelvis.

## Description

Measurements of the holotype are presented in Table 1.

Dorsal rays 32; anal rays 33; pectoral rays 14 and 13; caudal rays 12; vertebrae 7+12.

Body compressed and deep, width 2.7 in head length and depth 1.7 in SL; head 3.3 in SL; upper profile of snout slightly concave, length 3.8 in SL; eye diameter 4.4 in head length, 1.4 in interorbital width; gill slit centred below a point just posterior to anterior border of eye, length 3.8 in head length; pelvis capable of moving vertically through an arc of  $10^\circ$ , producing an inconspicuous ventral flap.

Mouth small, terminal, lips not obviously fleshy; dentition normal, consisting of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones; 3 teeth on each side of lower jaw, posterior one small; all external teeth except posteriormost in each jaw with pointed extremities; pharyngeal teeth appear normal (based on radiograph), with 2 series of acute teeth on each side of upper pharyngeal region.

First dorsal spine moderately strong, length 2.1 in head length, originating over a point just posterior to centre of eye, no spinal groove in back; dorsal spine armed with 4 series of small to minute barbs, 2 rows on anterior face only visible near extremity of spine, 1 row of outward-directed barbs on each lateral edge, more prominent than anterior barbs; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins not elevated anteriorly, longest dorsal ray (8th) 2.8 in head length, about equal to longest anal ray; length of soft dorsal fin base 3.0 in SL, slightly shorter than anal fin base (bases of fin membranes not perforate); interdorsal space 1.0 in head length; base of pectoral fin below a point just anterior to centre of eye; caudal fin greatly elongate, 0.7 in head length, posterior border round; all fin rays except those of caudal unbranched; pelvic bony structure small, 11.7 in eye diameter, armed with small vertical barbs, no scale divisions visible; rear end of pelvis extends about 1 eye diameter posterior to pelvic bony structure.

Scales on body small, each with 2-4 transverse rows of minute slender spinules, giving the skin a smooth feel; two pairs of small forward-curving spines on each side of caudal peduncle.

Colour of holotype in alcohol (Fig. 10) : after long preservation, head, body and fins brown, with first dorsal spine and caudal fin rays more reddish, and caudal fin membrane somewhat dusky.

### Comparisons

*E. quadrispinis* is easily distinguished from other members of the genus in the presence of spines on the caudal peduncle. It appears to have affinities with the Atlantic species *Alutera schoepfii* Walbaum and *A. heudelotii* Hollard; however, these species lack the characteristic spines on the caudal peduncle (see below).

### Distribution

Known only from the type locality off South Australia.<sup>2</sup>

### Remarks

*E. quadrispinis* is provisionally placed in the genus *Eubalichthys*. It appears to have some characters of *Alutera* which include an anal fin base which is longer than that of the soft dorsal fin and a very small pelvic bony structure, apparently consisting of only one incasing scale (other species of *Eubalichthys* have the soft dorsal fin base longer and pelvic bony structure with two pairs of incasing scales). However the moderately strong first dorsal spine and 19 vertebrae distinguish it from the four known species of *Alutera* (feeble dorsal spine and 20-23 vertebrae).

This species is named *quadrispinis* (Latin: meaning 'four-spined') with reference to the two pairs of spines on each side of the caudal peduncle.

<sup>2</sup> A second specimen of *E. quadrispinis*, CSIRO C.1447 was received from the CSIRO while this paper was in press. It was collected by the Japanese research vessel *Umitaka Maru* off the north-west coast of Western Australia in 1960. The following measurements and counts pertain to this specimen: standard length — 268 mm; body depth — 134 mm; anal ray count — 34 (soft dorsal fin damaged); pectoral ray count — 13.13. This female specimen is here designated as a paratype.

*Meuschenia flavolineata* new species

(Fig. 11; Table 5)

**Holotype**

WAM P.25489-001, 233 mm SL, male, collected on Middle Bank, 2 kilometres SE of Rottnest Island (32°05'S, 115°33'E), Western Australia, by spear at 15 metres, J.B. Hutchins, 24 August 1975.

**Paratypes**

33 specimens, 26-239 mm SL (unless otherwise designated, all specimens at WAM). Western Australia: P.9155, 144 mm SL, Irwin Point, W of Albany, craypot at 40 metres, R.J. McKay, 13 July 1959; P.24514, 157 mm SL, Canal Rocks, spear at 1 metre, J.B. Hutchins, 30 January 1973; P.25150-008, 137 mm SL, Canal Rocks, spear at 2 metres, J.B. Hutchins, 30 December 1974; P.25173-001, 162 mm SL, skeleton, Bickley Point, Rottnest Island, spear at 3 metres, J.B. Hutchins, 16 February 1975; P.25250-004, 176 mm SL, Salmon Bay, Rottnest Island, spear at 10 metres, J.B. Hutchins, 6 April 1975; P.25251-003, 2 specimens, 178-190 mm SL, Bickley Point, Rottnest Island, spear at 10 metres, G.R. Allen and J.B. Hutchins, 9 April 1975; P.25252-002, 201 mm SL, off Carnac Island, 7-8 metres, G.R. Allen, 6 April 1975; P.25549-001, 81 mm SL, Woodmans Point, L. Smith, hand net at 1 metre, April 1976; P.25550-001, 48 mm SL, Ringbolt Bay, Augusta, hand net at 3 metres, J.B. Hutchins, 27 April 1976; P.25551-001, 67 mm SL, Armstrong Point, Rottnest Island, University of Western Australia Zoology Camp, 11 March 1964; P.25553-001, 239 mm SL, same data as for holotype; BMNH 1976.8.23.1, 134 mm SL, Bunbury, fish trap, M. Walker, 5 November 1975; USNM 216433, 164 mm SL, Bickley Point, Rottnest Island, spear at 10 metres, G.R. Allen and J.B. Hutchins, 9 April 1975. Tasmania: QVM 1975.5.197-9, 3 specimens, 198-212 mm SL, Waterhouse area, R.J. Gillham, 4 April 1971. New South Wales: AM I.17019-027, 66 mm SL, Long Reef, Sydney, rotenone and hand net at 0.3 metres, D. Hoese *et al.*, 27 March 1973; AM I.17033-051, 13 specimens, 48-75 mm SL, North Head, Sydney Harbour, rotenone, J. Paxton *et al.*, 6 April 1973; AM I.18301, 2 specimens, 26-40 mm SL, Thompsons Bay, Sydney, R. Kuiter, February 1975.

**Diagnosis**

A species of *Meuschenia* with the following combination of characters : first dorsal spine originating over centre or anterior half of eye, armed with small barbs; 2 pairs of spines on caudal peduncle; skin moderately coarse; colour of adults blackish brown with a yellow-orange patch on caudal

peduncle, continued along middle of side as a yellow stripe; caudal fin entirely black or yellow coloration of caudal peduncle continued onto anterior half of fin.

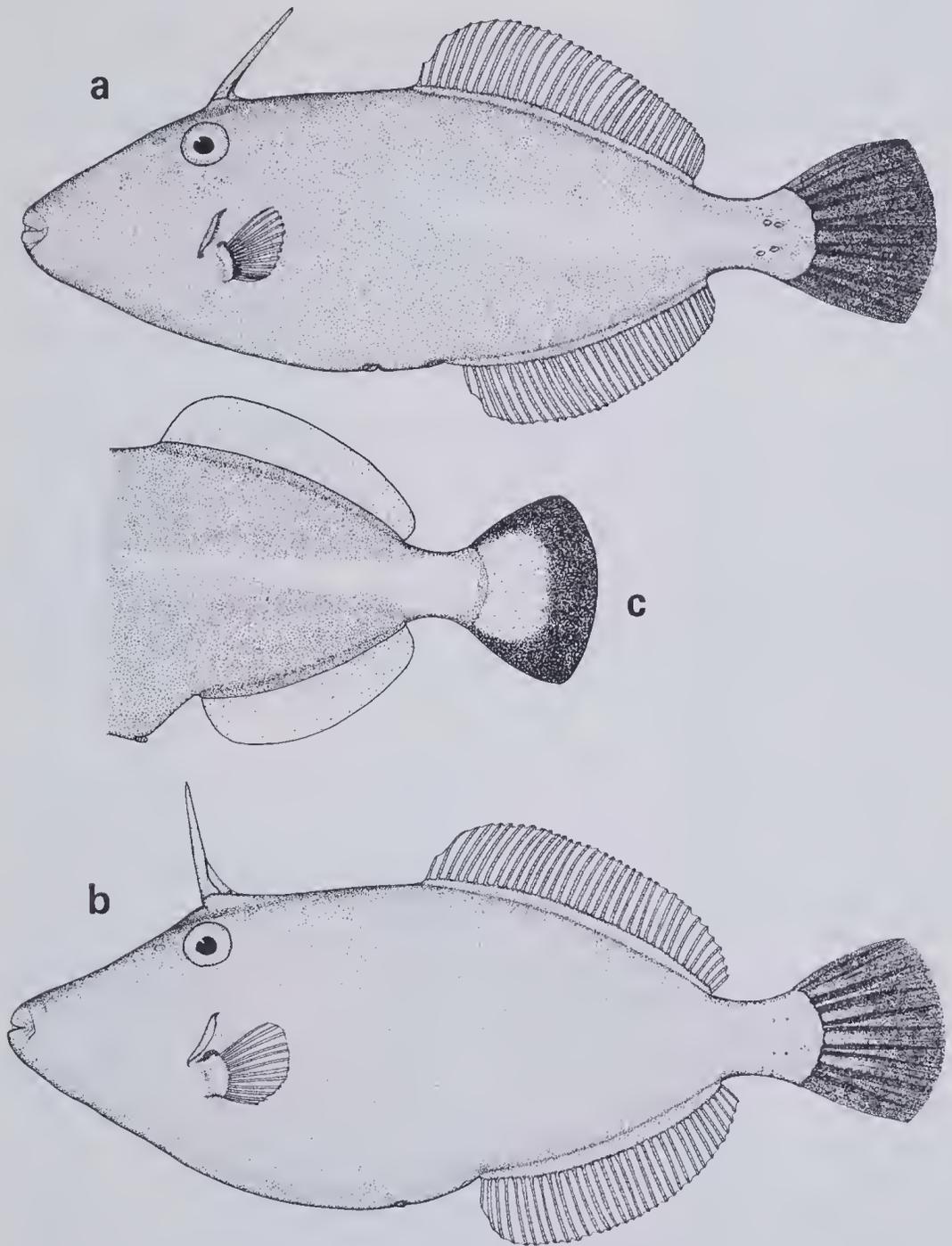


Fig. 11: *Meuschenia flavolineata* n.sp. : a, holotype, WAM P.25489-001, 233 mm SL, male; b, paratype, WAM P.25553-001, 239 mm SL, female; c, variation in life colour pattern.

## Description

Measurements and counts of the holotype and selected paratypes are presented in Table 5.

Dorsal rays 33 to 37; anal rays 31 to 35; pectoral rays 11 to 12; caudal rays 12; vertebrae 7+13.

Body compressed and moderately elongate, somewhat deeper in adult female and juveniles, width 2.0-2.4 in head length and depth 2.0-2.8 in SL; head length 3.0-3.7 in SL; upper profile of snout slightly convex (large male condition) to concave, length 3.9-4.2 in SL; eye diameter 3.3-4.6 in head length, 1.0-1.3 in interorbital width; gill slit centred below anterior half of eye, length 3.4-5.4 in head length; pelvis capable of moving vertically through an arc of generally not more than 15°, producing a small ventral flap.

Mouth small, terminal, lower jaw protruding slightly, lips not obviously fleshy; dentition normal, consisting of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones: 3 teeth on each side of lower jaw, posterior one small; all external teeth except posteriormost in each jaw with pointed extremities; 2 series of slender acute teeth on each side of upper pharyngeal region, first with 7-8 small teeth, second with 3 slightly larger ones (in 1 of 2 specimens examined, teeth in first series on left hand side deformed, somewhat larger than normal, 6 in number); gill rakers 32-33 (2 specimens).

First dorsal spine moderately strong, length 1.3-1.7 in head length, usually originating over centre or anterior half of eye (rarely behind centre), received partly into shallow groove in back when depressed; dorsal spine armed with 4 series of small downward-directed barbs, anterior face with 2 adjoining rows, each postero-lateral edge with 1 row of slightly larger barbs, less in number than those in anterior series; with increasing SL, barbs become more numerous and relatively smaller approaching obsolescence; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fin rays about equal in height, longest soft dorsal ray (about 8th to 10th) 2.4-3.1 in head length; length of soft dorsal fin base 2.5-2.6 in SL, somewhat longer than base of anal fin (base of fin membranes not perforate); interdorsal space 1.0-1.4 in head length; base of pectoral fin usually below posterior half of eye; posterior margin of caudal fin round, length 1.2-1.8 in head length; all fin rays except those of caudal generally unbranched; pelvic bony structure small to moderate, 2.5-5.0 in eye diameter, consisting of 2 pairs of incising scales fused to posterior end of pelvis, armed with small to medium barbs (obsolescent with age).

Table 5: Measurements in mm and fin ray counts of selected type specimens of *Meuschenia flavolineata*.

	Holotype		QVM	Paratypes		AM	
	WAM	P.25489-001		WAM	P.25251-003		WAM
Standard length	233		212	178	137	81	51
Head length	65		60	48	40	26	17
Body depth	85		77	73	61	38	25
Body width	30		25	23	20	11	7.7
Snout length	57		51	41	35	20	13
Eye diameter	14		13	12	11	7.7	5.2
Interorbital width	18		16	15	12	7.8	5.6
Gill slit length	17		14	13	9.6	4.8	3.5
1st dorsal spine length	40		36	32	27	16	11
Longest soft dorsal ray	24		25	16	14	8.7	5.5
Longest anal ray	24		23	15	14	8.5	5.4
Longest pectoral ray	20		20	16	13	8.8	5.5
Caudal fin length	46		38	37	33	21	14
Soft dorsal fin base	92		85	72	53	32	20
Anal fin base	80		72	62	44	29	18
Interdorsal space	58		54	44	35	19	12
Caudal peduncle length	23		23	22	14	7.4	5.5
Caudal peduncle depth	21		19	17	15	8.6	5.2
Pelvic bony structure length	3.7		3.1	3.0	2.2	1.7	2.0
Snout to origin of dorsal spine	67		60	50	43	26	18
Lower jaw to rear of pelvic bony structure	117		114	93	77	49	31
Eye to gill slit	12		11	9.1	7.3	5.0	2.8
Soft dorsal ray count	34		37	36	35	35	34
Anal ray count	33		34	34	34	33	32
Pectoral ray count	12-12		12-12	12-12	12-12	11-11	12-12
Sex	Male		Male	Female	Male	Juvenile	Juvenile

Scales on body small, armed with slender acute spinules curving posteriorly at extremities, giving the skin a rather coarse feel; each mid-body scale with 1-5 spinules in a transverse row, increasing in number with increase in SL, scale outline not visible; 4 spines in 2 longitudinal rows on each side of caudal peduncle (rarely 1 or 3 spines in either row), strong and curving anteriorly in adult male, small and difficult to detect without magnification in juveniles and adult female; elongate spinules on scales anterior to caudal peduncle spines of adult male, forming a dense patch of small bristles, extremities curving forward.

Colour of holotype in alcohol (Fig. 11a) : head and body blackish brown to greenish grey with an indistinct pale longitudinal band extending along middle of side from caudal peduncle to below origin of soft dorsal fin; area anterior to spines on caudal peduncle pale yellowish grey, spines translucent with yellow bases; first dorsal spine and membrane blackish brown; soft dorsal and anal fin rays yellowish brown, those of pectoral dark brown, membranes hyaline; caudal fin blackish brown to black with several irregular greenish grey blotches anteriorly; lips blackish brown. Paratypes with similar coloration to above with the following exceptions: head and body entirely blackish brown or (after long preservation) uniform brown; anterior half of caudal fin greenish to brownish grey; juveniles overall greenish grey with lips, spinous dorsal fin membrane and caudal fin (or only posterior half) dusky.

Colour in life (based on underwater observations and a colour transparency provided by N. Coleman — see Fig. 11c) : head and body blackish brown to greenish brown with greenish yellow to orange area on caudal peduncle, extending as an irregular band along middle of side to below origin of soft dorsal fin; patch of bristles on caudal peduncle of adult male bright orange; dorsal and anal fin rays yellowish brown, those of pectoral blackish brown, membranes hyaline; caudal fin of adult male entirely black (fin rays may be somewhat brownish), while that of adult female black with yellow blotch on anterior half (Fig. 11c); when captured, adults generally acquire a pattern of small white to green irregular blotches on head and body, with other coloration more intensified. The following description refers to juveniles 50 to 80 mm SL : pale brownish green with small irregular pale blotches and spots on sides of body and head, tending to form irregular cross bars on dorsal surface of snout and forehead; 2-3 dark bars may be present on throat; all fin rays green, membranes hyaline except for those of caudal which are dusky posteriorly; lips brownish orange.

## Comparisons

*M. flavolineata* is distinguished from other species of the genus by the black or black and yellow caudal fin and the greenish yellow to yellow mid-body band of the adult (Fig. 11c). In addition, all other members possess iridescent blue spots or lines on the head and body, a feature lacking in *M. flavolineata*. It appears to be closely related to *M. trachylepis* but this species possesses well defined scales whereas *M. flavolineata* has no obvious scale outlines.

## Distribution

*M. flavolineata* occurs across the southern portion of Australia, from Newcastle, New South Wales to Fremantle, Western Australia, including northern Tasmania. It inhabits shallow offshore rocky reefs.

## Remarks

This species is named *flavolineata* (Latin: meaning 'yellow-striped') with reference to the yellow band present on side in adult.

### *Meuschenia venusta* new species

(Fig. 12; Table 1)

## Holotype

WAM P.14881, 110 mm SL, female, collected from Shark Bay (approximately 25°30'S, 113°30'E), Western Australia, by trawl net, W. & W. Poole, June 1963.

## Paratype

CSIRO C.2284, 125 mm SL, male, collected W of Garden Island (32°13'S, 115°39'E), Western Australia, by prawn trawl at 72 metres, M.V. *Lancelin*, May 1956.

## Diagnosis

A species of *Meuschenia* with the following combination of characters : head relatively acute, upper profile of snout concave; first dorsal spine armed with small barbs, originating over posterior half of eye; scales on body small, each armed with 1 strong central spinule capped with a fleshy papilla, giving the skin a coarse feel; caudal peduncle unarmed; colour pattern consisting of 4-5 brown longitudinal body stripes on a white background, 2 of which continue anteriorly on head and posteriorly on upper and lower rays of caudal fin.

## Description

Measurements and counts of the holotype and paratype are presented in Table 1.

Dorsal rays 34; anal rays 31 to 32; pectoral rays 12; caudal rays 12; vertebrae 7+13.

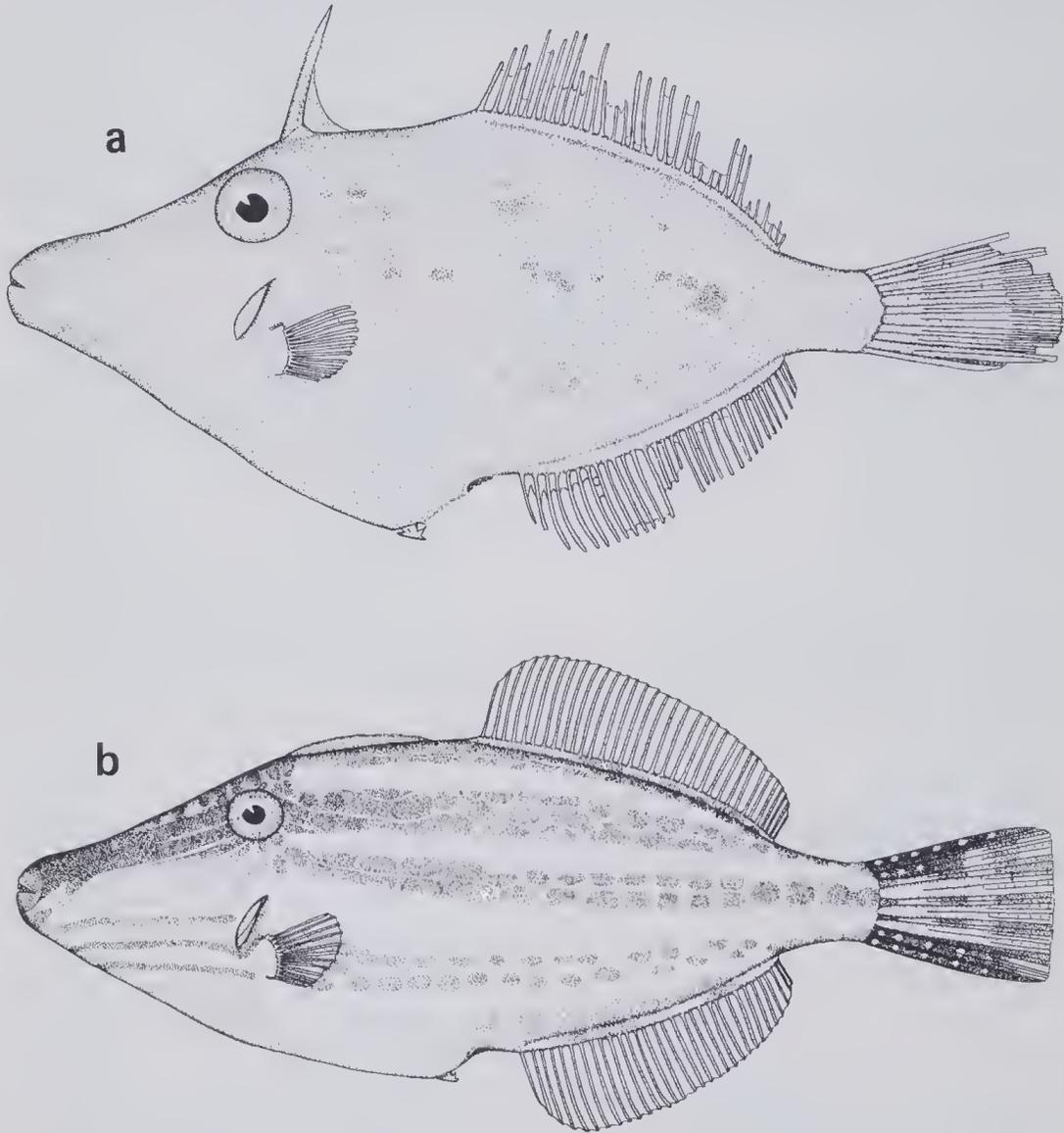


Fig. 12: *Meuschenia venusta* n.sp. : a, holotype, WAM P.14881, 110 mm SL, female (all fins except spinous dorsal damaged); b, male with life colour pattern (based on male paratype, CSIRO C.2284, 125 mm SL and two colour transparencies of live fish underwater).

Body compressed and rather elongate, somewhat deeper in female, width 2.2 in head length and depth 2.3-2.7 in SL; head acute, length 3.0-3.1 in SL; upper profile of snout concave, length 3.8 in SL; eye considerably large in holotype, diameter 3.4 in head length and 0.9 in interorbital width, smaller in paratype (4.1 and 1.1 respectively); gill slit centred below anterior half of eye, length 3.6-3.8 in head length; pelvis capable of moving vertically through an arc of 15° or less, producing a small ventral flap.

Mouth small, terminal, lips not obviously fleshy; dentition consists of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between outer ones (extremity of uppermost inner tooth relatively prominent); 3 teeth on each side of lower jaw, posterior one small; all external teeth except posteriormost in each jaw with pointed extremities; pharyngeal teeth appear normal (based on radiographs), with 2 series of slender acute teeth on each side of upper pharyngeal region.

First dorsal spine moderately strong, length 1.8-1.9 in head length, originating over a point just anterior to posterior border of eye, received partly into a shallow groove in back when depressed (spinal groove of paratype somewhat deeper than that of holotype); dorsal spine armed with 4 series of small downward-directed barbs, 2 adjoining rows on anterior face only prominent on outer 1/3 of spine, lower barbs truncate and angled inwards, and 1 row on each postero-lateral edge directed rearwards (postero-lateral barbs rather obsolete on paratype); second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins damaged on both type specimens but appear to have a round outer margin, longest intact anal ray (5th-6th) 2.9-3.1 in head length; length of soft dorsal fin base 2.6-2.7 in SL, somewhat longer than base of anal fin (fin membrane not perforate at base); interdorsal space 1.5 in head length; base of pectoral fin below a point just anterior to posterior margin of eye; caudal fin short, 1.4 in head length, posterior margin damaged in both type specimens but apparently truncate (based on photographs of live fish — see below); all fin rays except those of caudal unbranched; pelvic bony structure moderate in size, 3.9-4.4 in eye diameter consisting of 2 pairs of incasing scales fused to rear end of pelvis, each scale with prominent barbs.

Scales on body small, each with 1 strong central spinule capped with a fleshy papilla; extremities of spinules acute, curving abruptly rearwards, giving the skin a very coarse feel; caudal peduncle not armed with spines or bristles.

Colour of holotype in alcohol (Fig. 12a): ground colour brown with irregular darker blotches on side of body tending to form 3 longitudinal

stripes; head with 2 faint cross bars on throat, upper profile of snout dark brown, greenish between eyes; first dorsal spine pale turquoise, membrane brown with several paler spots; soft dorsal, anal and pectoral fins hyaline; caudal fin rays pale greenish grey, membranes enclosed within upper and lower 3 rays dark brown, remainder pale brownish grey. The paratype is similarly coloured except that thin pale lines are evident on head and body, with 3 rather more prominent ones originating between cross bars on throat, extending through and below pectoral fin base and tending to form a reticulate pattern surrounding dark brown blotches posterior to pectoral fin.

Colour in life (based on two colour transparencies by N. Coleman of live fish underwater — see Fig. 12b): ground colour white with 4-5 brown longitudinal bands on body consisting of close-packed spots of pupil size and larger, those in upper 3 bands in a somewhat reticulate pattern; 2 bands continue anteriorly on head, one through eye as a dark brown stripe to mouth, the other through pectoral fin as 3 parallel dark brown lines to upper portion of throat, lower 2 confluent with corresponding lines of opposite side; both bands also continue posteriorly on caudal fin; blue lines radiate from margin of eye (except antero-superior portion), those contained within head and body bands iridescent, generally fading on posterior half of body; greyish green area with dark brown spots (slightly smaller than pupil) on dorsal profile of head, from base of first dorsal spine to middle of snout; first dorsal spine brown, soft dorsal, anal and pectoral fins hyaline; several upper and lower rays of caudal fin blackish (continuations of body stripes), each with a row of white spots, remaining rays white, some with darker markings which tend to form 3 cross bars.

### Comparisons

*M. venusta* is readily distinguished from other species of the genus by its colour pattern and scalation. It is the only species which has body stripes consisting of spots arranged in a somewhat reticulate pattern. Each body scale is armed with one strong central spinule capped by a fleshy papilla, whereas the typical adult condition in other *Meuschenia* is one to several transverse rows of small spines (small adults of *M. galii* may also have monospination, but the scales and spinules are minute). *Scobinichthys granulatus* and *Penicipelta vittiger* have a similar scalation to *M. venusta* but *S. granulatus* possesses an extremely mobile pelvis, capable of moving vertically through an arc of nearly 70° (see Fig. 2g) and the central pair of teeth in the upper jaw of *P. vittiger* are truncate (Fig. 5b), whereas the pelvis of *M. venusta* is capable of only limited vertical movement (15°) and its anterior teeth have pointed extremities.

## Distribution

*M. venusta* is known only from the holotype and paratype collected in Western Australia from Shark Bay and off Perth respectively. In addition, it has been reported from Jervis Bay, New South Wales (N. Coleman, pers. comm.) where it was photographed underwater at 18-20 metres (two colour transparencies by N. Coleman, 10th-11th August 1974).

## Remarks

This species is named *venusta* (Latin: meaning 'beautiful') with reference to its vivid coloration.

## *Rudarius excelsus* new species

(Fig. 13; Table 6)

## Holotype

AM IA.6764, 17 mm SL, male, trawled near Lindeman Island (20°27'S, 149°02'E), Queensland, G.P. Whitley, 1936.

## Paratypes

WAM P.25603-001, 15 mm SL (stained and cleared), AM I.19169-002, 15-16 mm SL, both with same data as for holotype.

## Diagnosis

A species of *Rudarius* with the following combination of characters : extremely small size at maturity (15 mm SL); prominently elevated dorsal and ventral profiles; extremely long bristles on caudal peduncle of male, projecting posteriorly to behind middle of caudal fin; low fin ray counts (D.22 to 24; A.20 to 22; P.10).

## Description

Measurements and counts of the holotype and paratypes are presented in Table 6.

Dorsal rays 22 to 24; anal rays 20 to 22; pectoral rays 10; caudal rays 11 to 12 (holotype has 11 which is most likely due to malformation); vertebrae 7+13.

Body short and very deep, producing a postero-anterior compressed appearance, depth 1.1-1.2 in SL; body width 1.8-2.0 in head length; head

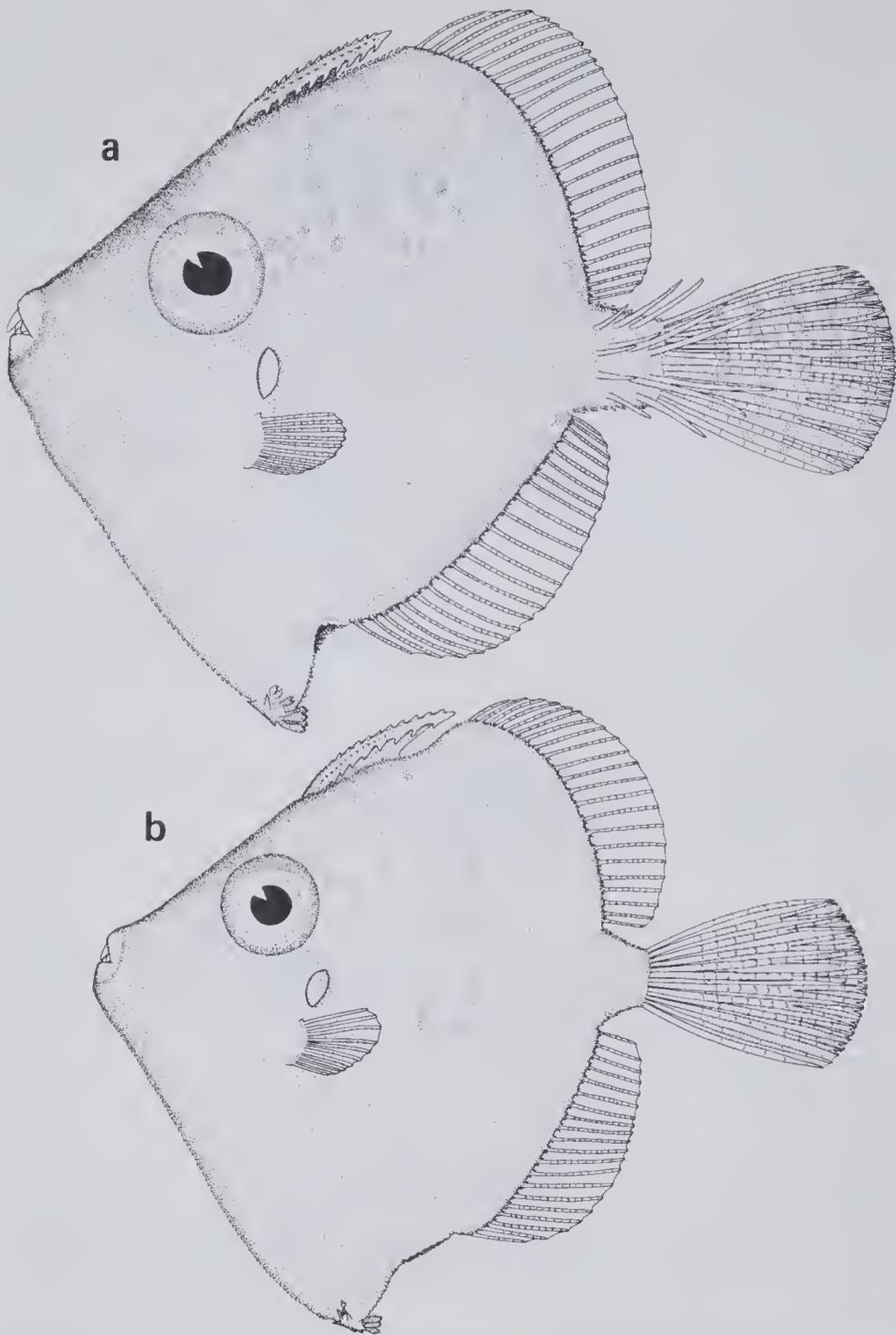


Fig. 13: *Rudarius excelsus* n.sp. : a, holotype, AM IA.6764, 17 mm SL, male; b, paratype, AM I.19169-002, 15 mm SL, female.

Table 6: Measurements in mm and fin ray counts of type specimens of *Rudarius excelsus*.

	Holotype AM IA.6764	AM I.19169-002	Paratypes AM I.19169-002	WAM P.25603-001
Standard length	17	16	15	15
Head length	7.0	6.4	6.6	6.3
Body depth	16	13	14	13
Body width	3.8	3.3	3.3	3.2
Snout length	3.8	3.3	3.7	3.6
Eye diameter	3.4	3.0	2.8	2.7
Interorbital width	3.0	2.6	2.6	2.6
Gill slit length	1.2	0.8	1.0	1.0
1st dorsal spine length	5.4	4.4*	5.1	5.0
Longest soft dorsal ray	3.0	2.6	2.8	2.6
Longest anal ray	3.0	2.6	2.8	2.6
Longest pectoral ray	3.1	2.6	2.3	2.6
Caudal fin length	7.1	6.8	6.7	6.2
Soft dorsal fin base	8.8	6.9	7.1	7.5
Anal fin base	8.4	6.4	6.6	6.9
Interdorsal space	4.9	4.6	4.4	4.9
Caudal peduncle length	1.7	1.5	1.3	1.4
Caudal peduncle depth	2.3	1.7	1.6	1.6
Pelvic bony structure length	1.2	0.8	0.8	0.9
Snout to origin of dorsal spine	7.3	6.9	6.4	6.3
Lower jaw to rear of pelvic bony structure	12	13	12	11
Soft dorsal ray count	24	23	22	24
Anal ray count	22	21	20	22
Pectoral ray count	10-10	10-10	10-10	10-10
Sex	Male	Female	Female	Female

\* measurement affected by damage

prominently elevated dorsally and ventrally, length 2.3-2.5 in SL; upper profile of snout straight to somewhat concave, length 4.1-4.8 in SL; eye relatively large, diameter 2.1-2.4 in head length, 0.9-1.0 in interorbital width; gill slit small, positioned above pectoral fin base and centred below posterior border of eye or behind, length 5.8-8.0 in head length; pelvis capable of moving vertically through an arc of 25° or less, producing a small but prominent ventral flap.

Mouth small, terminal, lips relatively fleshy; dentition consists of 3 outer and 2 inner teeth on each side of upper jaw, extremities of inner teeth projecting between the outer ones; 2 teeth on each side of lower jaw; extremities of all external teeth except posteriormost in upper jaw pointed; pharyngeal teeth not discernible on stained and cleared specimen.

First dorsal spine slender to moderately strong, slightly bent posteriorly, length 1.3-1.5 in head length, originating over posterior half of eye, no spinal groove in back for its reception when depressed; dorsal spine armed with 4 series of barbs, 2 rows of small but prominent upward-directed barbs on anterior face, numbering about 12-13 in each row, and 1 row of considerably larger downward-directed barbs on each postero-lateral edge, about 9-10 in number; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins with somewhat round outer margins, longest soft dorsal ray (7th to 9th) 2.3-2.5 in head length, about equal to longest anal ray; bases of soft dorsal and anal fins curve prominently downwards and upwards respectively to caudal peduncle, length of soft dorsal base 1.9-2.3 in SL (bases of fin membranes not perforate); interdorsal space short, 1.3-1.5 in head length, profile rising prominently from spinous dorsal to soft dorsal origin; base of pectoral fin below or behind rear border of eye; caudal fin relatively long, 0.9-1.0 in head length; all fin rays except those of caudal generally unbranched; pelvic bony structure relatively prominent, length 2.8-3.7 in eye diameter, consisting of 2 pairs of incising scales fused to rear end of pelvis, armed with prominent barbs, and surrounded by several small dermal flaps.

Scales on body moderate in size, each with 1 small central acute spinule, curving posteriorly at extremity, giving the skin a velvety feel; male with about 12 greatly elongate bristles on caudal peduncle, projecting posteriorly to behind middle of caudal fin, extremities curving outwards (all bristles on right hand side broken off near bases); spinules on caudal peduncle of female small, slightly larger and spaced further apart than those on middle of side.

Colour of holotype in alcohol (Fig. 13a): head and body pale brown, lower half of head more whitish; scattered brown spots on upper portion of

body, about  $\frac{1}{4}$  pupil in size; 2 white longitudinal lines on posterior portion of body, extending posteriorly a short way onto caudal peduncle; upper body line continued anteriorly, curving sharply downwards from about centre of side to gill slit and then rising to lower margin of eye; several white horizontal dashes below rear portion of soft dorsal fin base; dark brown ring surrounding posterior margin of lips; soft dorsal, anal and pectoral fins hyaline, caudal pale brown with darker indistinct cross bars, curving anteriorly. Paratypes similar to holotype except the white body lines are not prominent and no cross bars on caudal fin.

### Comparisons

*R. excelsus* is apparently closely related to *R. ercodes* Jordan & Fowler from Japan. It differs mainly in the possession of greatly elongate bristles which project posteriorly from the caudal peduncle of the adult male, whereas *R. ercodes* has a patch of short bristles projecting more laterally than posteriorly. In addition, the dorsal and ventral profiles of *R. excelsus* are more elevated, and it possesses less soft dorsal and anal rays (D.22-24, A.20-22) than *R. ercodes* (D.25-27, A.24-27). *R. excelsus* is similar to *R. minutus* Tyler from Queensland and Borneo in several features including a small size at maturity and the possession of elongate bristles on the caudal peduncle. However, *R. minutus* has a relatively longer body, its pelvic bony structure does not appear to have scale divisions (2 pairs of incising scales in *R. excelsus*) and it possesses relatively large dermal flaps on the body (absent in *R. excelsus* although small ones surround pelvic bony structure).

### Remarks

*R. excelsus* is known only from Lindeman Island, Queensland, the type locality. Its very small size has probably contributed to its rarity.

One female paratype, WAM P.25603-001, was found to be ripe when being prepared for staining and clearing. The eggs are relatively large, about 0.5 mm in diameter, and number approximately 120.

This species is named *excelsus* (Latin: meaning 'elevated') with reference to its prominently elevated dorsal and ventral profiles.

LIST OF THE KNOWN SPECIES OF MONACANTHID FISHES FROM  
AUSTRALIAN SEAS WITH THEIR PRINCIPAL SYNONYMS AND  
DISTRIBUTIONS

(Abbreviations: NSW, New South Wales; NT, Northern Territory; n.WA, northern Western Australia; Qld, Queensland; SA, South Australia; s.WA, southern Western Australia; Tas, Tasmania; Vic, Victoria.)

\* New record for Australia

*Acanthaluteres spilomelanurus* (Quoy & Gaimard, 1824). NSW, Vic, Tas, SA, s.WA.

synonyms: *Aleuterus maculosus* Richardson, 1840

*Aluterius paragaudatus* Richardson, 1844-8

*Monacanthus forsteri* Castelnau, 1872

\**Acreichthys radiatus* (Popta, 1900). Qld (AM IB.6156-7, 5 specimens, Swain Reefs, October 1962).

*Acreichthys tomentosus* (Linnaeus, 1758). Qld

*Alutera monoceros* (Linnaeus, 1758). Qld, NSW, Vic, WA, NT

synonym: *Aluterus anginosus* Hollard, 1855

*Alutera scripta* (Osbeck, 1765). Qld, NSW, WA, NT

synonyms: *Monacanthus macrurus* Macleay, 1881 (preoccupied)

*Monacanthus maculicauda* Ogilby, 1886 (new name for  
*M. macrurus* Macleay, 1881)

*Amanses scopas* (Cuvier, 1829). Qld, WA

*Anacanthus barbatus* Gray, 1831. Qld, WA

*Bigener brownii* (Richardson, 1844-8). ?NSW, Vic, SA, s.WA.

synonyms: *Monacanthus lineoguttatus* Hollard, 1854

*Monacanthus yagoi* Castelnau, 1878

*Monacanthus guttulatus* Macleay, 1878

? *Monacanthus castelnaui* Macleay, 1881

*Brachaluteres baueri* (Richardson, 1844-8). Qld, NSW

*Brachaluteres jacksonianus* (Quoy & Gaimard, 1824). NSW, Vic, Tas, SA, s.WA

synonyms: *Aleuterius trossulus* Richardson, 1844-8

*Monacanthus oculatus* Günther, 1870

*Monacanthus distortus* Castelnau, 1873

*Brachaluteres fidens* Whitley, 1931

*Brachaluteres wolfei* Scott, 1969

*Cantherhines dumerili* (Hollard, 1854). Qld, NSW, n.WA

synonym: *Monacanthus howensis* Ogilby, 1889

- \**Cantherhines fronticinctus* (Günther, 1866). n.WA (WAM P25541-001, 2 specimens, 101-187 mm SL, North West Cape, 19 May 1976)
- Cantherhines pardalis* (Rüppell, 1835). Qld, NSW, n.WA  
synonyms: ?*Monacanthus homopterus* Cope, 1870  
*Monacanthus brunneus* Castelnau, 1873  
*Pseudomonacanthus melanoides* Ogilby, 1908
- Cantheschenia grandisquamis* n.sp. Qld
- Cantheschenia longipinnis* (Fraser-Brunner, 1941). NSW, WA
- Chaetoderma penicilligera* (Cuvier, 1817). Qld, NSW, WA, NT  
synonyms: *Monacanthus spinosissimus* Quoy & Gaimard, 1824  
*Chaetodermis maccullochi* Waite, 1905
- Colurodontis paxmani* n.sp. Qld, WA
- Eubalichthys bucephalus* (Whitley, 1931). NSW, Vic, s.WA  
synonym: *Cantherines brunneri* Norman, 1937
- Eubalichthys caeruleoguttatus* n.sp. n.WA
- Eubalichthys fuscusinus* n.sp. n.WA
- Eubalichthys gunnii* (Günther, 1870). Vic, Tas, SA, s.WA  
synonyms: ?*Monacanthus baudini* Castelnau, 1873  
? *Monacanthus edelensis* Castelnau, 1875  
*Monacanthus melas* Günther, 1876
- Eubalichthys mosaicus* (Ramsay & Ogilby, 1886). Qld, NSW, Vic, Tas, SA, WA  
synonym: *Weerutta ovalis* Scott, 1962
- Eubalichthys quadrispinis* n.sp. SA, n.WA
- \**Laputa cingalensis* Fraser-Brunner, 1941. Qld (AM E.1963-4, 2 specimens, 134-148 mm SL, trawled off Bustard Head, 10 July 1910; AM I.11127, 151 mm SL, same data as above)
- Meuschenia australis* (Donovan, 1824). Vic, Tas  
synonyms: *Monacanthus rudis* Richardson, 1844  
*Monacanthus convexirostris* Günther, 1870
- Meuschenia flavolineata* n.sp. NSW, Vic, Tas, SA, s.WA
- Meuschenia freycineti* (Quoy & Gaimard, 1824). NSW, Vic, Tas, SA, s.WA  
synonyms: *Monacanthus multiradiatus* Günther, 1870  
*Monacanthus prasinus* Castelnau, 1872  
? *Monacanthus lesueurii* Castelnau, 1873  
*Meuschenia skottowei* Whitley, 1934
- Meuschenia galii* (Waite, 1905). Vic, SA, s.WA
- Meuschenia hippocrepis* (Quoy & Gaimard, 1824). Vic, Tas, SA, s.WA  
synonym: *Aleuterius variabilis* Richardson, 1844-8

- Meuschenia trachylepis* (Günther, 1870). Qld, NSW  
 synonym: ?*Balistes lemniscatus* Lacépède, 1804
- Meuschenia venusta* n.sp. NSW, WA
- Monacanthus chinensis* (Osbeck, 1765). Qld, NSW, WA, NT  
 synonyms: *Balistes geographicus* Cuvier, 1817  
*Balistes mylii* Bory de Saint Vincent, 1822  
*Monacanthus megalouris* Richardson, 1843  
*Monacanthus macrolepis* Fraser-Brunner, 1941
- Nelusetta ayraudi* (Quoy & Gaimard, 1824). Qld, NSW, Vic, SA, WA  
 synonyms: *Aleuterus velutinus* Jenyns, 1842  
*Monacanthus vittatus* Richardson, 1844-8  
*Monacanthus platifrons* Hollard, 1854  
*Monacanthus frauenfeldii* Kner, 1867
- Oxymonacanthus longirostris* (Bloch & Schneider, 1801). Qld, n.WA, NT
- Paraluteres prionurus* (Bleeker, 1851). Qld, NSW
- Paramonacanthus filicauda* (Günther, 1880). Qld, NSW, Tas, WA, NT  
 synonym: *Monacanthus filicauda notonectianus* Whitley, 1931
- Paramonacanthus oblongus* (Temminck & Schlegel, 1850). Qld, NSW, n.WA, NT  
 synonyms: *Paramonacanthus oblongus otisensis* Whitley, 1931  
*Paramonacanthus whitleyi* Fraser-Brunner, 1941
- Paramonacanthus sulcatus* (Hollard, 1854). Qld  
 synonym: *Arotrolepis barbarae* Fraser-Brunner, 1941
- Parika scaber* (Forster, 1801). NSW, Vic, SA, s.WA  
 synonym: *Monocanthus setosus* Waite, 1899
- Penicipelta vittiger* (Castelnau, 1873). NSW, Vic, Tas, SA, s.WA  
 synonym: *Monacanthus guntheri* Macleay, 1881
- Pervagor melanocephalus* (Bleeker, 1853). Qld, NSW, n.WA
- Pervagor nitens* (Hollard, 1854). Qld, NSW  
 synonym: *Monacanthus alternans* Ogilby, 1899
- Pseudalutarius nasicornis* (Temminck & Schlegel, 1850). Qld
- Pseudomonacanthus elongatus* Fraser-Brunner, 1940. Qld, NT
- Pseudomonacanthus macrurus* (Bleeker, 1857). ?Qld
- Pseudomonacanthus peroni* (Hollard, 1854). Qld, n.WA  
 synonym: *Cantherines maynardi* Ogilby, 1916
- Rudarius excelsus* n.sp. Qld
- Rudarius minutus* Tyler, 1970. Qld

- Scobinichthys granulatus* (Shaw, 1790). NSW, Vic, Tas, SA, WA  
 synonyms: *Monacanthus perulifer* Castelnau, 1872  
*Monacanthus margaritifer* Castelnau, 1873  
*Monacanthus brunneus* Castelnau, 1873 (preoccupied)  
*Monacanthus obscurus* Castelnau, 1875 (new name for  
*M. brunneus* Castelnau, 1873)  
*Monacanthus damelii* Günther, 1876  
*Monacanthus saintjoanni* Castelnau, 1878  
*Tantalisor pauciradiatus* Whitley, 1947
- \**Stephanolepis auratus* (Castelnau, 1861). n.WA (WAM P.25579-006, 6 specimens, 115-210 mm SL, off Koks Island, July 1976)
- Thamnaconus analis* (Waite, 1904). NSW
- Thamnaconus degeni* (Regan, 1903). NSW, Vic, Tas
- Thamnaconus hypargyreus* (Cope, 1873). Qld
- \**Thamnaconus modestoides* (Barnard, 1927). n.WA (WAM P.22099, 241 mm SL, off Cape Cuvier, 29 July 1972; WAM P.22101-2, 2 specimens, 133-189 mm SL, same data as above)

#### ACKNOWLEDGEMENTS

I wish to thank the following persons who kindly provided specimens, photographs, radiographs or information: T. Abe, Tokaiku Fisheries Research, Japan; M.L. Bauchot, Muséum National d'Histoire Naturelle, Paris; J.E. Böhlke, Academy of Natural Sciences, Philadelphia; A.J. Dartnall, Museums and Art Galleries of the Northern Territory, Darwin; P.M. Dixon, National Museum of Victoria, Melbourne; J. Glover, South Australian Museum, Adelaide; R.H. Green and E.O.G. Scott, Queen Victoria Museum and Art Gallery, Launceston; P.A. Hulley, South African Museum, Capetown; K. Matsuura, Hokkaido University, Japan; R.J. McKay, Queensland Museum, Brisbane; J. Moreland, National Museum of New Zealand, Wellington; I.S.R. Munro and P. Heemstra, CSIRO, Cronulla; J.R. Paxton and D.F. Hoese, The Australian Museum, Sydney; J.E. Randall, Bernice P. Bishop Museum, Honolulu; B.R. Smith, Kanudi Fisheries Research Station, Papua New Guinea; E. Turner, Tasmanian Museum and Art Gallery, Hobart; A.C. Wheeler, British Museum (Natural History), London; and R. Winterbottom, Rhodes University, Grahamstown. The collections at The Australian Museum, CSIRO and National Museum of Victoria were examined, travelling funds being jointly provided by the Trustees of The Australian Museum and the Food and Agriculture Organization of the

United Nations, Rome. I am grateful to P. Last of the University of Tasmania, Hobart, who made available his unpublished manuscript on the monacanthids of Tasmania. A. Rawlings of the Victorian Underwater Federation sent me notes and photographs of several species from Victoria and New South Wales. N. Coleman of the Australasian Marine Photographic Index, Caringbah, New South Wales, kindly made his colour transparencies available for live colour notes. G.R. Allen of the Western Australian Museum examined several type specimens for me while in Europe and North America, and critically reviewed the manuscript. J. Gaunt of the Western Australian State X-ray Laboratories prepared excellent radiographs of the type material. My wife, Anne, was invaluable for her ability to translate several foreign languages. Finally, I would like to express my thanks to the many friends and fishermen who kindly presented me with their catches.

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# A REVISION OF THE PLESIOPID FISH GENUS *TRACHINOPS*, WITH THE DESCRIPTION OF A NEW SPECIES FROM WESTERN AUSTRALIA

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[Received 17 June 1976. Accepted 8 December 1976. Published 17 June 1977.]

## ABSTRACT

The Australian marine fish genus *Trachinops*, which contains four species is reviewed. *T. taeniatus* occurs along the central and southern coast of New South Wales. In Victoria and Tasmania it is replaced by *T. caudimaculatus*. *T. noarlungae* is known from the Adelaide region of South Australia to the Houtman Abrolhos Group off southwestern Western Australia. *T. brauni* is described as a new species from 27 specimens collected at Rottne Island, Western Australia and at the Houtman Abrolhos. It is distinguished from the other members of the genus on the basis of fin ray and gill raker counts and the presence of greatly elongate pelvic fins. The differences in these characters are of sufficient magnitude to justify the placement of *T. brauni* in a separate subgenus, *Paratrachinops* which is described herein.

## INTRODUCTION

The genus *Trachinops* Günther contains four species which are confined to southern Australia. They are members of the family Plesiopidae, a group of serranoid fishes containing perhaps less than two dozen species. As Weber and de Beaufort (1929) have pointed out, there are greatly different opinions regarding their systematic position. However, I choose to follow Greenwood, *et al.* (1966) who regard them as a distinct family unit. In Australia the Plesiopidae is represented by *Assessor* Whitley (2 species), *Calloplesiops* Fowler and Bean (1 species), *Paraplesiops* Whitley (3 species), *Plesiops* Cuvier (2-3 species), and *Trachinops* (4 species). All are tropical coral reef forms except *Paraplesiops* and *Trachinops*, which normally dwell on shallow rocky reefs of temperate Australia. They range in size from the diminutive *Assessor* (about 50 mm SL) to the relatively large *Paraplesiops*

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which reaches a maximum of about 40 cm SL. Most of the species are cryptic dwellers of dark caverns and ledges. Indeed, the species of *Plesiops* are seldom encountered unless collected with commercial ichthyocides.

The species of *Trachinops* are somewhat aberrant in this respect, occurring in open water aggregations which may include over 100 individuals. They swim up to several metres off the bottom in search of zooplankton which is the main component of the diet. Their peculiar undulating swimming behaviour is responsible for the common appellation of 'hula fish' among marine aquarists. The depth range is relatively wide encompassing rocky pools along the coast and deeper offshore reefs to at least 35 metres. The two species which occur around the rocky islands off the Perth metropolitan district are most commonly encountered between 10-30 metres.

*T. taeniatus* Günther is known from central and southern New South Wales. It is apparently replaced in Victoria and Tasmania by *T. caudimaculatus* McCoy, a species whose geographic limits are poorly known. *T. noarlungae* Glover is distributed from the vicinity of Adelaide, South Australia to the Houtman Abrolhos Group off Geraldton, Western Australia. The range of this species overlaps with that of *T. brauni* n.sp. which is known from the vicinity of Perth to the Houtman Abrolhos. At the latter locality the two species have been taken from rich areas of *Acropora* coral which certainly represents an atypical habitat.

The genus *Trachinops* has not been reviewed previously and there are few records of the various species in the literature.

A summary of counts for the dorsal, anal, and pectoral fin rays, gill rakers on the first branchial arch, and tubed lateral-line scales are presented in Tables 1 and 2.

Type specimens of *T. brauni* have been deposited at the Australian Museum, Sydney (AM); British Museum (Natural History), London (BMNH); Muséum National d'Histoire Naturelle, Paris (MNHN); National Museum of Natural History, Washington, D.C. (USNM); Western Australian Museum, Perth (WAM).

## TAXONOMY

### GENUS *TRACHINOPS* GÜNTHER

*Trachinops* Günther 1861. Cat. Fish Brit. Mus., vol. 3, p. 366 (type species *Trachinops taeniatus* by monotypy).

## Diagnosis

Dorsal rays X to XV (usually XI or XIV), 16 to 21; anal rays III, 17 to 23; pectoral rays 14 to 18; pelvic rays I, 4; branched caudal rays 7 + 8 = 15; anterior lateral-line scales 38 to 90; posterior lateral-line scales 0 to 18; branchiostegal rays 6; gill rakers on first branchial arch 7 to 10 + 16 to 21, total rakers 23 to 31.

Body greatly elongate, the depth 5.3 to 7.1 in standard length; head 3.7 to 4.8 in standard length. Snout 4.7 to 6.7, eye 2.8 to 3.8, bony interorbital 4.1 to 6.1, least depth of caudal peduncle 1.7 to 2.5, length of pectoral fin 1.1 to 1.7, of pelvic fin 0.7 to 2.0, all in the head length; middle caudal rays usually forming elongate filament, 1.7 to 3.4 in standard length.

Colour in alcohol generally tan or light brown, with or without prominent black stripe or band on side or large spot at base of caudal peduncle.

### *PARATRACHINOPS*, new subgenus

The subgenus *Paratrachinops* contains a single species *T. brauni* which is described below. The diagnostic features of this subgenus are presented in the following key.

### KEY TO THE SPECIES OF *TRACHINOPS*

- 1a. Dorsal spines 11 (rarely 10), extremely weak and difficult to distinguish from soft rays; pectoral rays usually 15; gill rakers on first arch 23 to 24; pelvic fins relatively elongate, 0.7 to 1.2 in head length (Western Australia)  
... .. *T. (Paratrachinops) brauni* n.sp.
- 1b. Dorsal spines 14 (rarely 15), relatively pungent and easily distinguished from soft rays; pectoral rays usually 16 to 18; gill rakers on first arch 26 to 31; pelvic fins relatively short, 1.4 to 2.0 in head length (subgenus *Trachinops*)  
... .. 2
- 2a. Black stripe extending along upper side, continuing to tip of middle caudal rays; gill rakers on first arch usually 26 to 28; posterior lateral-line scales usually 0 to 7 (New South Wales)  
... .. *T. taeniatus*

- 2b. Black stripe on upper sides absent; gill rakers on first arch usually 29 to 31; posterior lateral-line scales usually 12 to 18  
 ... .. 3
- 3a. Black spot covering most of caudal fin base; soft dorsal rays usually 16 to 17; soft anal rays usually 17 to 19; anterior lateral-line scales usually 45 to 55; eye diameter usually 2.8 to 3.1 in head length (Victoria; Tasmania)  
 ... .. *T. caudimaculatus*
- 3b. Black spot on caudal base absent; soft dorsal rays usually 20 to 21; soft anal rays 22 or 23; anterior lateral-line scales usually 70 to 90; eye diameter usually 3.2 to 3.5 in head length (South Australia; Western Australia)  
 ... .. *T. noarlungae*

*Trachinops brauni*, new species  
 (Figs 1a and 2; Tables 1, 2 and 3)

*Trachinops taeniatus* (non Günther) Mees, 1962. West. Aust. Fisher. Bull. no. 9 (pt. 3), p. 25.

Holotype

WAM P25545-001, 42.0 mm SL, collected with rotenone off Rottnest Island, Western Australia (approximately 32° 01'S, 115° 26'E) in 3-10 m by G. Allen on 6 March 1975.

Paratypes

AM I.18843-001, 3 specimens, 31.3-43.7 mm SL, collected with rotenone off Armstrong Point, Rottnest Island, Western Australia in rocky pool by zoology students of University of W. Australia on 20 March 1958; BMNH 1976.5.27.1-2, 2 specimens, 40.6 and 48.2 mm SL, same data as preceding types; MNHN 1976.39, 2 specimens, 37.0 and 42.9 mm SL, same data as preceding types; USNM 215917, 3 specimens, 42.5-50.2 mm SL, same data as preceding types; WAM P4894, 4 specimens, 32.0-39.8 mm SL, same data as preceding types; WAM P25164-005, 40.7 mm SL, collected with spear off south side of Rottnest Island, in 3 m by B. Hutchins on 16 February 1975; WAM P25197-004, 2 specimens, 32.3 and 36.0 mm SL, collected with the holotype; WAM P25251-010, 2 specimens, 42.7 and 55.1

mm SL, collected with rotenone off south coast of Rottnest Island in 2-10 m by G. Allen and B. Hutchins on 9 April 1975; WAM P25308-004, 4 specimens, 22.6-26.8 mm SL, collected with rotenone off Seal Island, Wallabi Group, Houtman Abrolhos, Western Australia (approximately 28°31'S, 113°47'E) in 12-16 m by G. Allen on 17 May 1975; WAM P25315-005, 3 specimens, 23.0-30.4 mm SL, collected with rotenone between Seal and Beacon Islands, Wallabi Group, Houtman Abrolhos in 10 m by G. Allen on 20 May 1975.

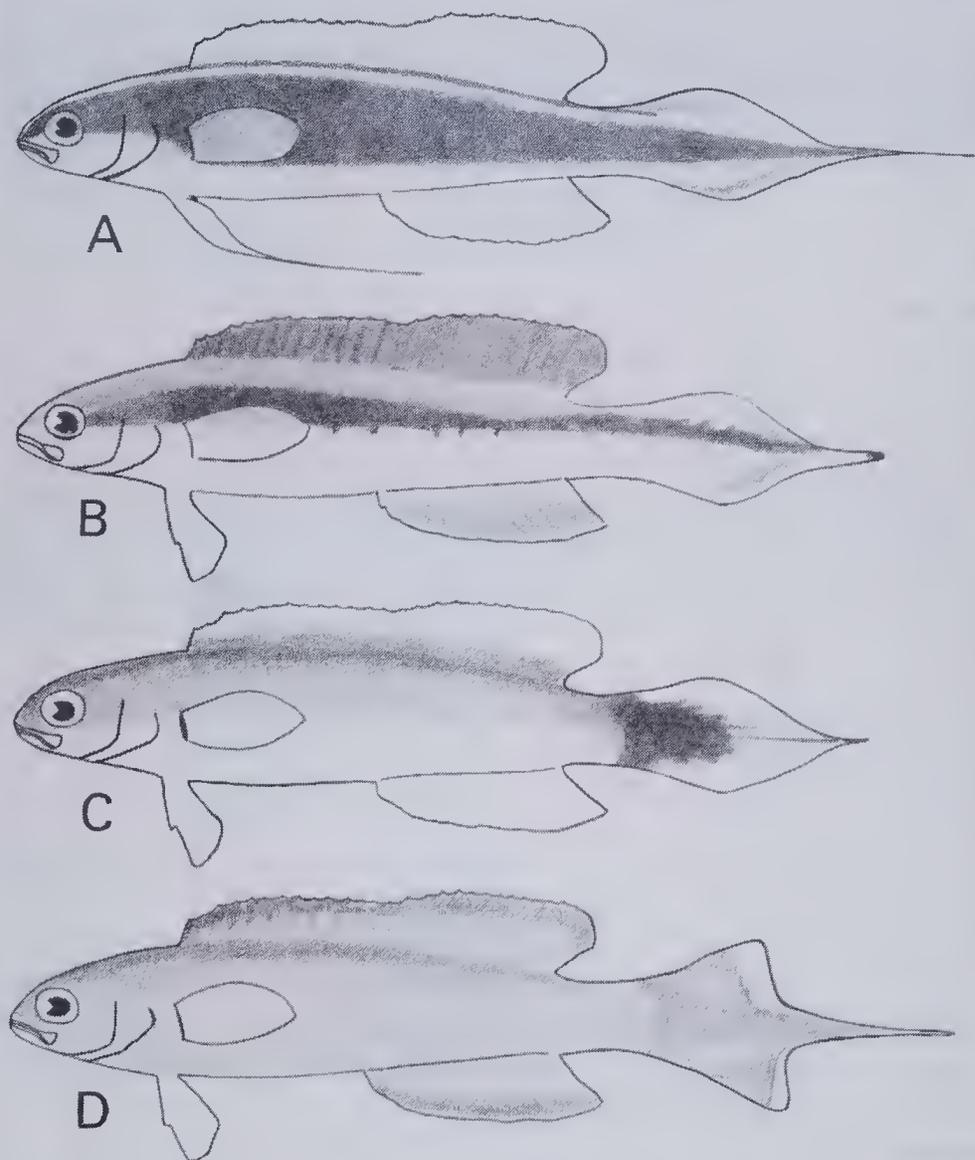


Fig. 1: Comparison of colour patterns for species of *Trachinops*: (a) *brauni*; (b) *taeniatus*; (c) *caudimaculatus*; (d) *noarlungae*.



Fig. 2: *Trachinops brauni*, paratype, 42.7 mm SL, Rottneest Island, Western Australia.

### Description

Measurements in thousandths of the standard length of the holotype and selected paratypes are presented in Table 3. The range of counts and proportional measurements for the paratypes when differing from the holotype appear in parentheses in the following description.

Dorsal rays XI,20 (X or XI,19 to 21); anal rays III,19 (III,19 to 21); pectoral rays 15 (14 to 15); branched caudal rays 8 + 7 = 15; anterior lateral-line scales 38 to 43; posterior lateral-line scales 3 to 5; branchiostegal rays 6; gill rakers on first branchial arch 7 or 8 + 16 or 17, total rakers 23 or 24.

Body elongate, the depth 6.3 (5.6 to 7.1) in standard length, and compressed, the width 1.8 (1.8 to 1.9) in depth (this measurement taken at level of gill opening); head 4.5 (4.1 to 4.6) in standard length; snout 5.5 (5.5 to 6.3) in head; eye 3.0 (3.0 to 3.5) in head; interorbital space slightly convex, the fleshy width about equal to eye diameter, the bony width 5.2 (5.2 to 5.5) in head; caudal peduncle relatively elongate, the least depth 1.6 (1.5 to 1.8) in its length or 2.2 (2.3 to 2.4) in head.

Maxillary reaching a vertical through posterior edge of pupil; mouth oblique, opening dorsally, the anterior end approximately at level of middle of pupil; upper and lower lips about equal in width which is about equal to half eye diameter, at least anteriorly.

Upper jaw with several enlarged canines anteriorly, grading posteriorly to smaller close-set conical teeth, and an inner band composed of low conical teeth; large triangular patch of retorse teeth on either side of median

symphysis at front of upper jaw, apex of triangle formed by an enlarged retorse canine; lower jaw with 2-3 enlarged canines on each side anteriorly with patch of low conical teeth behind on either side of median symphysis; side of lower jaw, vomer, and palatines with 1-2 rows of low conical teeth.

Opercle and preopercle free of spines, but fleshy rounded projection at angle of opercle; upper end of gill opening about level with imaginary line half way between upper pectoral rays and origin of dorsal fin; anterior and posterior nostrils separated by a distance about equal to  $\frac{2}{3}$  pupil diameter; anterior nostrils small, about  $\frac{1}{3}$ - $\frac{1}{2}$  size of posterior nostrils; anterior nostrils with low fleshy rim.

Lateral-line system of body in two sections, the anterior portion originating at upper corner of gill opening, rising obliquely to base of spinous dorsal fin and continuing to below middle portion of soft dorsal fin; posterior section composed of several tubed scales at base of caudal fin; cephalic lateral-line system consisting of pores arranged as follows: dentary-preopercular series with 14 pores, circumorbital-snout series with 14 pores, a single mid-interorbital pore, and temporal-occipital series with about 10 pores.

Scales small, cycloid on head and anterior dorsal portion of body, finely ctenoid elsewhere; predorsal scales extending about to imaginary line connecting preopercle margin of both sides; scales of preopercle and opercle frequently embedded; lower edge of preopercle broadly naked; no scales on interorbital, snout, lips, suborbitals, dentary, and isthmus; no scales on fins except basal portion of caudal.

Origin of dorsal fin slightly behind level of pectoral and pelvic fin bases; dorsal spines slender, flexible, and curved; dorsal spines gradually increasing in height to fifth spine, remaining spines about equal; tallest dorsal spine about 4.2 to 4.5 in head; soft dorsal rays gradually increasing in height to eighth or ninth ray, remaining rays gradually decreasing; tallest soft ray 2.7 to 3.0 in head; origin of anal fin level with first soft dorsal ray; anal spines very weak, scarcely distinguishable from soft rays; first anal spine about  $\frac{1}{2}$  length of second spine; second spine about  $\frac{2}{3}$  length of third spine; soft anal rays gradually increasing in height to fifth ray, remaining rays about equal; soft dorsal and anal rays unbranched except last 7-8 rays.

Caudal fin lanceolate with middle rays forming elongate filaments in adults; length of middle rays 2.7 (2.4 to 3.4) in head. Caudal with 17 principal rays, the median 15 branched, the upper and lowermost unbranched; principal caudal rays preceded by 4-5 progressively shorter assessoray rays.

Pectoral fins rounded, the longest ray 1.3 (1.5 to 1.7) in head, its tip reaching a vertical at base of fifth dorsal spine; pectoral rays branched except two upper and lowermost rays; origin of pelvic fins slightly ahead of pectoral fins; pelvic fins relatively long and attenuate, their length 0.5 (0.7 to 1.2) in head; the tips in the holotype approaching a vertical at base of seventh or eighth soft anal ray.

Colour in life (from 35 mm Ektachrome slide taken in an aquarium): prominent black band originating at tip of snout, gradually widening and covering most of sides, then continuing through middle of caudal fin; area below this band white; narrow stripe of neon blue running from snout, above eye and along body, just below dorsal fin to base of upper caudal rays; a thin strip of black separating neon blue stripe and dorsal fin; dorsal fin largely pale yellow, dusky on basal 1/4 and pale blue on outer 1/4; anal fin mostly translucent, but slightly dusky on basal 1/2 with yellowish submarginal band and light blue border of equal width on outer 1/2; middle rays of caudal fin black, remainder of fin pale blue except submarginal yellow band on upper lobe and brownish submarginal band grading to yellow anteriorly on lower lobe, edge of caudal fin with fine border of neon blue; pelvic and pectoral fins transparent.

Colour of holotype in alcohol: prominent black band extending from snout to caudal fin; area below band pale tan; brown stripe above band from snout to base of upper caudal rays; fins generally pale except black stripe covering middle caudal rays.

The paratypes which were collected at Rottnest Island in 1958 are much paler than the holotype. The prominent band which is black in the holotype and recently collected paratypes is reddish-brown in the older specimens probably because of their longer exposure to alcohol.

#### Remarks

Mees (1962) compared 14 specimens of *T. brauni* with the original description of *T. taeniatus* and a single specimen received on loan from the Australian Museum. He erroneously concluded they were identical. He obviously did not have sufficient comparative material and overlooked the discrepancy in dorsal spine counts. However, Mees did comment on the exaggerated pelvic fins of the Western Australian specimens, which have been designated as paratypes in the present study; these are now deposited at AM, BMNH, MNHN, USNM and WAM (P4894).

The species is named *brauni* in honour of Mr John Braun of Perth for his much appreciated assistance in the field.

*Trachinops taeniatus*

(Fig. 1b; Tables 1 and 2)

*Trachinops taeniatus* Günther, 1861. Cat. Fish Brit. Mus., vol. 3, p. 366  
(type locality, New South Wales).

**Diagnosis**

Dorsal rays XIV, 16 to 17 (rarely 18); anal rays III, 19 or 20; pectoral rays 16 to 17; anterior lateral-line scales 51 to 57; posterior lateral-line scales 0 to 7; approximate vertical scale rows from upper corner of gill opening to caudal fin base 60 to 68; gill rakers on first branchial arch 8 to 10 + 17 to 19, total rakers 26 to 28.

Greatest body depth 5.5 to 6.5, head 4.1 to 4.6, middle caudal rays 2.4 to 3.4, all in the standard length. Snout 4.7 to 5.7, eye 3.1 to 3.8, bony interorbital 5.4 to 6.1, least depth of caudal peduncle 2.1 to 2.3, length of pectoral fin 1.3 to 1.6, of pelvic fin 1.6 to 2.0, all in the head length.

Colour when fresh (from 35 mm Kodachrome transparency taken at Sydney Harbour by R.H. Kuitert): colour of head and body reddish-brown on dorsalmost portion, white on ventral half, these two colours separated by broad blackish stripe extending from eye to distal tip of middle caudal rays; dorsal fin charcoal coloured with narrow blue margin; anal fin dusky grading to yellow-white near base; caudal fin bluish-white with prominent black stripe through middle portion (lower border of black stripe yellow); upper and lower lobes of caudal with pair of faint brown submarginal bands; pelvic fins white; pectoral fins translucent.

Colour in alcohol: head and body generally yellowish or pale tan with prominent black stripe on upper side extending from rear part of head to distal tip of middle caudal rays; dorsal fin black with narrow white margin; anal fin dusky with narrow white margin; caudal fin pale with prominent black stripe through middle portion; pelvic and pectoral fins pale.

**Material examined**

New South Wales — WAM P25530-001, 14 specimens, 26.2-59.7 mm SL, Port Hacking (near Sydney).

The counts and morphometric description given by Günther (1861) are clearly diagnostic and agree well with those of the WAM specimens examined during the present study. The type and two juvenile paratypes are deposited at BMNH (not examined).

*Trachinops caudimaculatus*

(Fig. 1c; Tables 1 and 2)

*Trachinops caudimaculatus* McCoy, 1890. *Prodromus Zool. Victoria*, p.341 (type locality, Williamstown, Hobson's Bay, Victoria).

Diagnosis

Dorsal rays XIV,16 to 17 (rarely XV spines); anal rays III,17 to 19; pectoral rays 18; anterior lateral-line scales 45 to 51; posterior lateral-line scales 13 to 18; approximate vertical scale rows from upper corner of gill opening to caudal fin base 46 to 50; gill rakers on first branchial arch 9 to 10 + 19 to 21, total rakers 29 to 31.

Greatest body depth 5.3 to 6.2, head 3.7 to 4.3, middle caudal rays 2.8 to 3.3, all in the standard length. Snout 4.7 to 5.7, eye 2.8 to 3.2, bony interorbital 4.1 to 4.8, least depth of caudal peduncle 2.1 to 2.5, length of pectoral fin 1.1 to 1.3, of pelvic fin 1.4 to 1.6, all in the head length.

Colour when fresh (from 35 mm Kodachrome transparency taken at Tasmania by D.F. Hoese): upper half of head and body charcoal coloured, lower half tan with slight suffusion of purple; tip of lower jaw dusky; median fins yellowish or pale orange; caudal fin with large black spot at base and middle rays blackish; pelvic and pectoral fins translucent.

Colour in alcohol: similar to fresh coloration except pale portions light tan.

Material examined

Tasmania — AM I.17549-006, 8 specimens, 36.0-57.1 mm SL, Oyster Cove.

The original description by McCoy (1890) is remarkably detailed and accompanied by a superb illustration. The specimens from Tasmania which were examined during the present study are essentially identical to McCoy's Victorian fish. Although the type was not examined it is deposited at the National Museum of Victoria, Melbourne.

*Trachinops noarlungae*

(Fig. 1d; Tables 1 and 2)

*Trachinops noarlungae* Glover, 1974. *Marine and Freshwater Fishes South Aust.* (second ed.), p. 225 (type locality, Port Noarlunga, South Australia).

## Diagnosis

Dorsal rays XIV,20 to 21; anal rays III,22 to 23; pectoral rays usually 17 to 18 (rarely 15); anterior lateral-line scales 73 to 90; posterior lateral-line scales 9 to 14; approximate vertical scale rows from upper corner of gill opening to caudal fin base 80 to 85; gill rakers on first branchial arch 9 to 10 + 18 to 21, total rakers 28 to 31.

Greatest body depth 5.0 to 6.1, head 4.4 to 4.8, middle caudal rays 2.2 to 3.1, all in the standard length. Snout 5.7 to 6.7, eye 3.1 to 3.5, bony interorbital 4.4 to 5.2, least depth of caudal peduncle 1.7 to 2.0, length of pectoral fin 1.4 to 1.7, of pelvic fin 1.5 to 1.7, all in the head length.

Colour in life (from 35 mm Ektachrome transparency taken in 8 m off Rottneest Island, Western Australia): head and body generally light grey, paler on ventral half; dorsal portion of head suffused with yellow; median fins generally dusky except caudal suffused with yellow and distal tips of caudal fin rays abruptly blue; pelvic and pectoral fins translucent.

Colour in alcohol: head and body generally tan to median brown grading to dark brown dorsally; dorsal fin light brown with darker sub-marginal band and narrow whitish border; anal fin slightly dusky with darkish margin; caudal fin generally dusky except tips of upper and lowermost rays abruptly pale; pelvic and pectoral fins pale yellow or tan.

## Material examined

Western Australia — WAM P25197-003, 6 specimens, 46.0-59.0 mm SL, Rottneest Island, WAM P25251-015, 65.4 mm SL, Rottneest Island; WAM P.25308-003, 36.4 mm SL, Seal Island, Wallabi Group, Houtman Abrolhos.

The Western Australian specimens which were examined during the present study agree well with Glover's (1974) description, which although brief, is clearly diagnostic and accompanied by an adequate illustration. The holotype and 8 paratypes are deposited at the South Australian Museum, Adelaide (not examined).

Table 1: Fin ray and gill raker counts for species of *Trachinops*

	<i>brauni</i>				<i>caudimaculatus</i>				<i>noarlungae</i>				<i>taeniatus</i>					
Dorsal spines	X	2																
	XI	9																
	XII																	
	XIII																	
	XIV																	
Soft dorsal rays	XV																	
	16																	
	17																	
	18																	
	19	3																
Soft anal rays	20	5																
	21	3																
	17																	
	18																	
	19																	
Pectoral rays	20	4																
	21	4																
	22																	
	23																	
	14	1																
Total gill rakers on 1st arch	15	10																
	16																	
	17																	
	18																	
	23	5																
24	7																	
25																		
26																		
28																		
29																		
30																		
31																		

Table 2: Lateral-line scale counts for species of *Trachinops*

	<i>brauni</i>				<i>caudimaculatus</i>				<i>noarlungae</i>				<i>taeniatus</i>					
Anterior lateral-line scales	35-39																	
	40-44																	
	45-49																	
	50-54																	
	55-59																	
	60-64																	
	65-69																	
	70-74																	
	75-79																	
	80-84																	
Posterior lateral-line scales	90-94																	
	0																	
	1																	
	2																	
	3																	
	4																	
	5																	
	6																	
	7																	
	8																	
	9																	
	10																	
	11																	
	12																	
	13																	
	14																	
	15																	
	16																	
	17																	
	18																	

Table 3: Morphometric proportions of selected type specimens of *Trachinops brauni* n.sp.

Character	Holotype WAM P 25545-001	Paratype WAM P25251-010	Paratype USNM 215917	Paratype BMNH 1976.5.27.1-2	Paratype WAM P25197-004	Paratype WAM P4894
Standard length	42.0	55.1	50.2	48.2	36.1	37.5
Greatest body depth	159	158	139	145	180	168
Greatest body width	88	87	80	83	94	91
Head length	224	218	219	220	244	245
Snout length	40	34	38	37	39	40
Eye diameter	74	64	62	62	78	80
Interorbital width	43	40	40	41	47	45
Depth of caudal peduncle	100	91	96	95	102	99
Predorsal length	252	245	243	239	274	259
Preanal length	483	450	490	498	521	552
Dorsal fin base length	595	635	598	602	568	568
Anal fin base length	381	387	382	386	327	365
Pectoral fin length	166	145	143	139	144	147
Pelvic fin length	460	245	299	336	207	333
Length of middle caudal rays	505	421	584	519	416	389

## ACKNOWLEDGEMENTS

Thanks are due to Dr D.F. Hoese and Mr R.H. Kuitert for providing valuable specimens and photographs of the eastern Australian species. Mr J. Braun and Mr J.B. Hutchins assisted in collecting type specimens at Rottnest Island. Finally, I thank my wife Connie for carefully preparing the typescript.

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# THE *AMPHIBOLURUS ADELAIDENSIS* SPECIES GROUP (LACERTILIA, AGAMIDAE) IN WESTERN AUSTRALIA

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[Received 16 January 1977. Accepted 4 March 1977. Published 17 June 1977.]

## ABSTRACT

This essentially southwestern group of small agamids consists of four taxa in Western Australia: *Amphibolurus p. parviceps* (Storr), *A. p. butleri* nov., *A. a. adelaidensis* (Gray), and *A. a. chapmani* nov.

## INTRODUCTION

As I suspected when describing it, '*Tympanocryptis parviceps*' is closely related to *Amphibolurus adelaidensis*. Moreover, the small morphologic gap between them is partly bridged by the newly described *A. p. butleri*. However, *A. parviceps* and *A. adelaidensis* coexist near the mouth of the Murchison and must be treated as separate species.

All the material used in this revision is lodged in the Western Australian Museum.

### *Amphibolurus adelaidensis* species-group

#### Diagnosis

Small, short-limbed, somewhat spiny agamid lizards; chin 'terraced' (Storr, 1964:46, Fig 2); nasal large and located wholly below canthus rostralis; dorsal pattern consisting of a wide vertebral stripe of ground colour, flanked by a series of short dark transverse bars or small subangular blotches.

#### Description

Canthus rostralis and supraciliary ridge acute. Tympanum not, partly or entirely covered with small scales. Dorsolateral fold weak or absent. Gular fold strong. Preanal pores continuous with femoral pores but widely

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separated at midline from those of other side; pores located at centre of clusters of 3-5 smaller scales.

Head scales rugose with high median keel. Ordinary dorsals and laterals varying in size and strength of keel, intermixed with large isolated spinose scales (which on back are confined to dark bars). Gulars smooth or weakly keeled. Ventrals and subcaudals moderately to strongly keeled and mucronate.

### Distribution

Southwestern and southern Australia, east to Spencer Gulf.

### KEY

1. Tympanum covered with small scales; 1-3 scales between nasal and labials; no white dorsolateral line; no midlateral series of spines on base of tail ... .. 2  
 Tympanum not or only partly covered with scales; 3-6 scales between nasal and labials; white dorsolateral line present; 3-7 white midlateral spines on base of tail ... .. 3
2. Dorsal pattern inconspicuous or absent; no white midlateral stripe; femoral pores 9-12 and preanal pores 4-5 on each side ... .. *A. parviceps parviceps*  
 Dorsal pattern bold; white midlateral stripe present; femoral pores 5-8 and preanal pores 2-3 on each side ... .. *A. parviceps butleri*
3. Ventral pattern consisting of dark stripes (Fig. 3); pores not extending more than three-quarters way down thigh; tympanum shallow and usually invaded by small scales ... .. *A. adelaidensis adelaidensis*  
 Ventral pattern consisting of a dark reticulum or of white spots on a dark ground; pores extending full length of thigh; tympanum deep-set and bare of small scales ... .. *A. adelaidensis chapmani*

### *Amphibolurus parviceps parviceps*

*Tympanocryptis parviceps* Storr, 1964, J. Proc. R. Soc. West. Aust. 47:46.  
 18 km SE of Ningaloo, W.A. (Storr & Clay).

## Diagnosis

The species *A. parviceps* is distinguishable from *A. adelaidensis* by tympanum covered with small scales; deep and angular loreal trough; fewer scales between nasal and labials; and no midlateral series of spines at base of tail (the scales may be enlarged and slightly raised). The subspecies *A. p. parviceps* is distinguishable from *A. p. butleri* by its reduced colour pattern and more numerous femoral and preanal pores.

## Distribution

Upper west coast of Western Australia from Ningaloo south to Quobba; also Bernier I. and Dirk Hartog I.

## Description

Snout-vent length (mm): 23-46 (N 17, mean 34.0); largest male 42. Length of appendages (%SVL): foreleg 36-48 (N 16, mean 41.1); hindleg 68-83 (N 16, mean 74.3; tail 118-160 (N 17, mean 139.3).

Scale rows between nasal and upper labials 1-3 (N 16, mean 1.9). Upper labials 9-11 (N 15, mean 9.9). Lamellae under fourth toe 18-23 (N 18, mean 20.7). Pores in males only: 9-12 (N 6, mean 10.2) femoral and 4 or 5 (N 6, mean 4.5) preanal on each side.

Dorsal ground colour pale bluish or brownish grey. On each side of back usually a series of small, dark brown hourglass-shaped bars; occasionally patternless. Upper lateral zone brown. Under surface whitish except for grey or black marbling on throat

## Remarks

Four specimens of *A. parviceps* (33683-6) from much further south (18 km S of Kalbarri) are tentatively included with the nominate race on the map, Fig. 2.). They comprise three juveniles and an adult female and are devoid of pattern.

## Material

North-west Division: 3 km N of Ningaloo (19095-6); Point Cloates (8833, 13221, 13483, 19094); Quobba (19097-8, 32631, 53328); Bernier I. (10654, 13164, 20494-5); Dirk Hartog I. (45860-4).

*Amphibolurus parviceps butleri* subsp. nov.

## Holotype

R54728 in Western Australian Museum, an adult male collected by Messrs G. Harold and M. Peterson on 19 August 1976 on white sand covered with

low heath and *Plectrachne* near east shore of Useless Inlet, 29 km NW of Carrarang, Western Australia, in 26°18' S, 113°21' E.

### Diagnosis

Distinguishable from *A. p. parviceps* by stronger and more complex dorsal and lateral colour pattern and fewer pores.

### Distribution

Edel Land, mid-west coast of Western Australia.



Fig. 1. Holotype of *Amphibolurus parviceps butleri*, photographed in life by G. Harold.

### Description

Snout-vent length (mm): 29-43 (N 16, mean 37.0); largest male 43. Length of appendages (%SVL): foreleg 38-43 (N 16, mean 40.9); hindleg 67-82 (N 16, mean 74.3); tail 117-150 (N 16, mean 139.0).

Scale rows between nasal and upper labials 1-3 (N 16, mean 1.7). Upper labials 8-11 (N 16, mean 9.7). Lamellae under fourth toe 20-24 (N 16, mean 22.2). Pores in males only: 5-8 (N 10, mean 6.3) femoral and 2 or 3 (N 10, mean 2.7) preanal on each side.

Dorsal ground colour pale grey to moderately dark grey. Back and base of tail with 8-10 black transverse bars, broken by broad vertebral stripe of ground colour, widest where contacting vertebral stripe and upper lateral zone (each half-bar thus tending to be hourglass-shaped); bars edged with creamy white. Interspace between dorsal bars blotched with pale reddish brown. Vertebral stripe sometimes bisected by a broken, dark brown,

median line. Upper lateral zone dark grey, dotted with white and blotched with black; blotches squarish in shape and continuous with dorsal bars. Creamy white midlateral stripe from base of tail forward nearly to level of foreleg, reappearing anteriorly as short longitudinal bars on side of neck and below temple and as streaks through upper and lower lips. Lower lateral zone and legs grey, dotted white and vaguely banded with dark grey. White under except occasionally for grey marks on throat and less commonly and more faintly on breast. Chin and lips bright yellow in life (*vide* G. Harold).

#### Remarks

This subspecies is named after Mr and Mrs W.H. Butler, whose generous grant to the Western Australian Museum enabled us to carry out a herpetofaunal survey of Edel Land and other parts of the Shark Bay region (a full report of this survey is being prepared).

#### Paratypes

North-west Division: Heirison Prong, 10 km NW of Useless Loop (54726-7, 54872) and 7 km NW (54822); south end of Bellefin Prong (39032-5); Crayfish Bay Well (55031); False Entrance Well (39019, 54839) and 3 km SW (54890); 10 km SW of Carrarang (26683); 1 km E of Editarra Well (54735-6).

#### *Amphibolurus adelaidensis adelaidensis*

*Grammatophora muricata* var. *adelaidensis* Gray, 1841, in G. Grey's Journals of two expeditions . . . western Australia . . . 2:439. Swan River (*vide* Boulenger).

*Amphibolurus adelaidensis* var. *tasmaniensis* Boulenger, 1885, Catalogue of lizards in the British Museum (Natural History), 1:388. 'Tasmania'.

*Amphibolurus pulcherrimus* Boulenger, 1885, *ibid.* Western Australia (Du Boulay).

*Amphibolurus pallidus* Boulenger, 1885, *ibid.* Western Australia, including Perth (Du Boulay).

#### Diagnosis

The species *A. adelaidensis* is distinguishable from *A. parviceps* by tympanum completely or mostly exposed; shallow and rounded loreal trough; more scales between nasal and labials; a series of white spinose midlateral scales at base of tail; and venter strongly patterned. The subspecies *A. a. adelaidensis* is distinguishable from *A. a. chapmani* by ventral pattern striped rather than reticulate or spotted (Fig. 3).

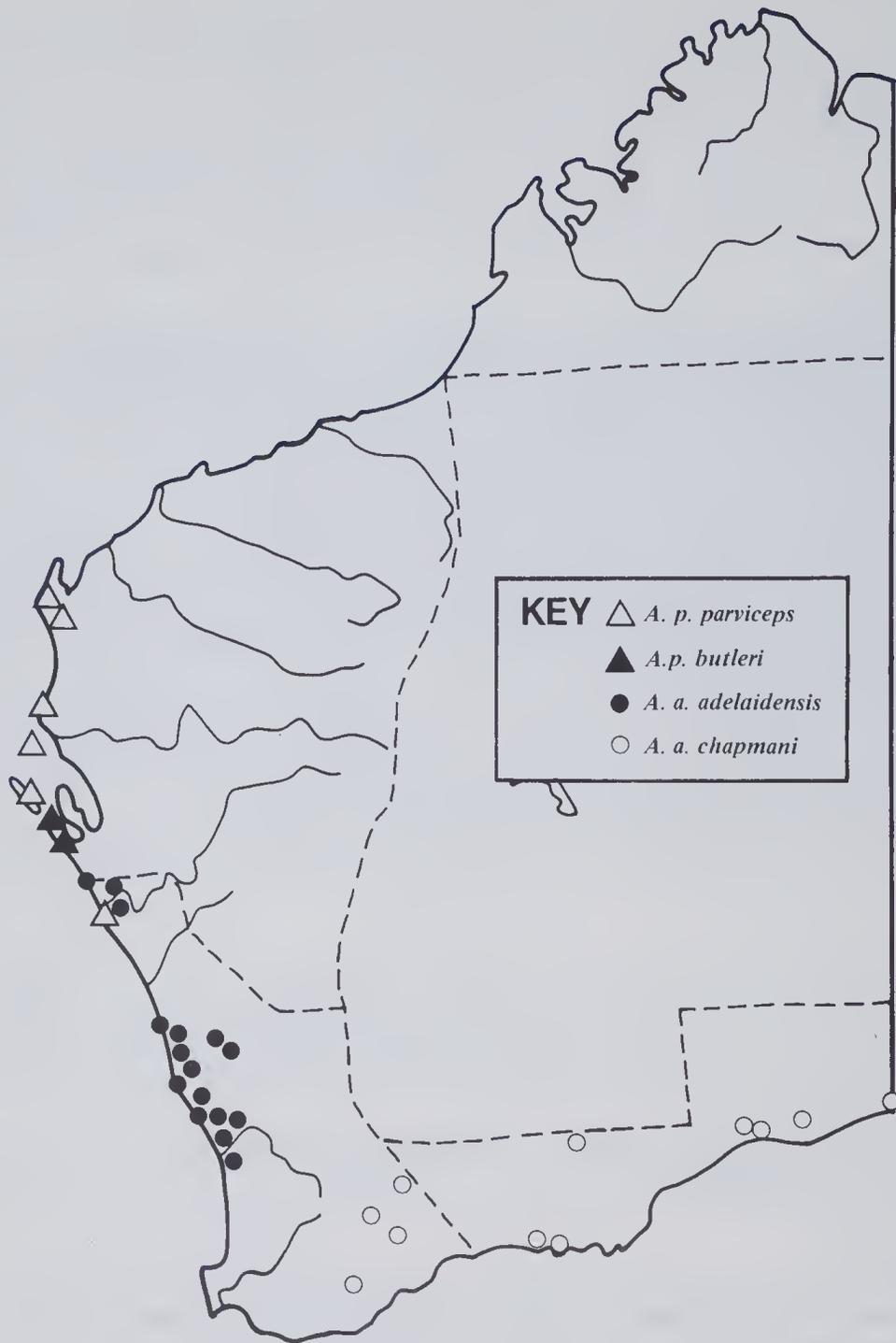


Fig. 2. Map of Western Australia showing location of specimens of *Amphibolurus adelaidensis* species-group.

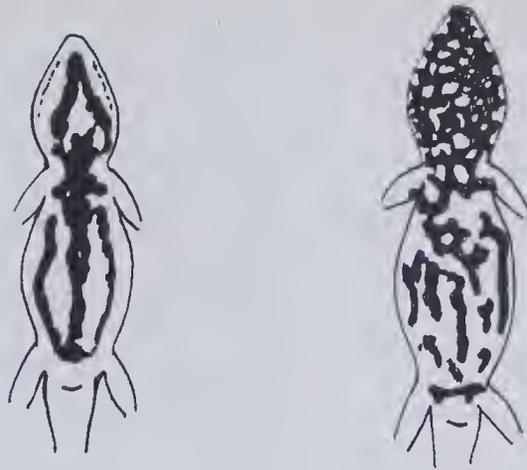


Fig. 3. Sketches of *Amphibolurus a. adelaidensis* (left) and *A. a. chapmani* (right) showing differences in ventral pattern.

### Distribution

Mid-west and lower west coasts of Western Australia, from a little north of the Murchison southwards to a little south of the Swan, inland to Coorow and Muchea.

### Description

Snout-vent length (mm): 21-52 (N 90, mean 38.2); largest male 45. Length of appendages (%SVL): foreleg 34-53 (N 84, mean 43.0); hindleg 54-76 (N 85, mean 67.5); tail 118-189 (N 87, mean 145.0).

Scale rows between nasal and upper labials 3-6 (N 79, mean 4.8). Upper labials 10-16 (N 80, mean 12.6). Lamellae under fourth toe 15-23 (N 73, mean 19.4). Femoral pores confined to proximal two-thirds of thigh, 6-10 (N 31, mean 8.0) in males; very small or absent in females. Preanal pores 2-5 (N 31, mean 3.6) in males. Spinose scales at base of tail 3-6 (N 59, mean 4.2).

Dorsal and upper lateral ground colour pale grey or greyish brown, darkest on head, palest on tail. Wide vertebral stripe and upper surface of tail not or only faintly marked. Head, laterodorsal and upper lateral surfaces of body and side of tail barred with black, brown or grey; bars short and mostly transverse, but oblique on crown and posterior (and sometimes anterior) part of head; bars on back broadest at contact with vertebral stripe, usually edged with creamy white. Under surface white, males marked with black (and females usually with grey) as follows: reticulation on lips; chevron on throat; blotch on breast, extending back from which are a median stripe and

often on each side a curving lateroventral stripe, all three stripes covering on pelvis.

#### Material

South-west Division: 7 km E of Zuitdorp wreck (33924); Mt Curious (33444); 26 km NE of Kalbarri (33489, 33509); Hawks Head Lookout, Kalbarri National Park (33873-4); Four Ways, Kalbarri N.P. (37631); 8 and 3 km E of Murchison House (26639, 27722); 11 km ENE of Kalbarri (27721); Wittecarra Gully, 8 km SE of Kalbarri (33883, 33890-1); Cliff Head, 32 km S of Dongara (13321, 22264); 32 km N of Enneabba (51008); Stockyard Gully (13412); 13 km W of Coorow (13125); 10 km S of Coorow (29769, 29990-1, 54469); Green Head (48497); Mt Peron (48415, 48417-9, 48425-6, 48517, 48539-40, 48546-7, 49126, 49213, 51752); Mt Lesueur (48518); Cockleshell Gully (48521, 52146); 5 km W of Padbury (48441, 48447); near Jurien Bay (16482, 30479, 30502, 46577-80, 49895); near Tombstone Rocks (39054, 39792); Lancelin (11341); Ledge Point (33432) and 29 km E (39684); 24 km SE of Gingin (39685); Lake Pinjar (26055); Melaleuca Park (53321); Mussel Pool (51529-33); Sorrento (41814-8); Wembley Downs (26229-30); Perth (4155-6); Leederville (771); West Leederville (5377); City Beach (26482, 28377, 31083, 41813); Cottesloe (534, 5401); Bentley (46204); Myaree (21886); Jandakot (47364-5).

#### *Amphibolurus adelaidensis chapmani* subsp. nov.

#### Holotype

R24657, adult male in Western Australian Museum collected by G.M. Storr and A.M. Douglas on 8 October 1965 in mallee-teatree scrub at 11 km SSE of Cocklebiddy, Western Australia, in 32°08' S, 126°08' E.

#### Diagnosis

Distinguishable from *A. a. adelaidensis* by ventral pattern consisting of a coarse dark reticulum, tympanum deep-set and completely bare of scales, and pores extending full length of thigh.

#### Distribution

Far southern semiarid zone of Western Australia, west to the Stirling Range and north to the Lake Grace district, Holt Rock, Fraser Range and southern edge of Nullarbor Plain.

#### Description

Snout-vent length (mm): 25-53 (N 17, mean 42.2); largest male 46. Length of appendages (%SVL): foreleg 37-46 (N 17, mean 41.4); hindleg 51-70 (N 17, mean 63.1); tail 113-160 (N 17, mean 134.8).

Scale rows between nasal and labials 4-6 (N 17, mean 5.1). Upper labials 10-14 (N 16, mean 12.0). Lamellae under fourth toe 13-20 (N 16, mean 16.8). Femoral pores in both sexes, 5-10 (N 14, mean 7.8). Preanal pores in both sexes, 2-4 (N 14, mean 2.8). Spinose scales at base of tail 5-7 (N 16, mean 5.5).

Dorsal and lateral ground colour pale grey or pale brown, darkest on head and sides. Wide vertebral stripe usually a little darker than ground colour of rest of back. Head, back, tail and flanks with short black or dark brown bars or lines, transverse except for a few obliquely curving lines on crown of head and occiput. Dorsal bars widest at contact with vertebral stripe and usually edged with creamy white. White dorsolateral line coinciding with dorsolateral fold. Ventral and ventrolateral surfaces and upper lips white, heavily reticulated on chin, throat, breast, belly and ventrolateral surface of body with black, dark grey and dark brown; markings paler in females and sometimes barely discernible; reticulum so dense in some males that throat could be described as black or dark brown, dotted white. Under tail usually cross-banded with black, grey or brown.

#### Remarks

Named after Mr Andrew Chapman of the Western Australian Museum in appreciation of his contributions to Western Australian herpetology.

#### Paratypes

South-west Division: 7 km W of Holt Rock (29592, 34505); North Tarin Rock Reserve (44435-6); Lake Magenta Reserve (40752); Red Gum Pass, Stirling Range (47363).

Eucla Division: Esperance (11368); Cape LeGrand (30801, 41944); Fraser Range (44526); 11 km SSE of Cocklebiddy (24656) and 14 km SSE (53399) and 21 SSE (53401); Madura (31172); 16 km NE of Eucla (24590).

#### REFERENCE

STORR, G.M. (1964)—The agamid lizards of the genus *Tympanocryptis* in Western Australia. *J. Proc. R. Soc. West. Aust.* 47:43-50.



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### Manuscripts

Manuscripts must be submitted in duplicate, typewritten, double spaced with wide margins. Positions of text figures and tables must be indicated. Authors may include an abstract for publication as part of a paper. The Committee may require an author to submit an abstract if no abstract is submitted and it considers that an abstract would be useful.

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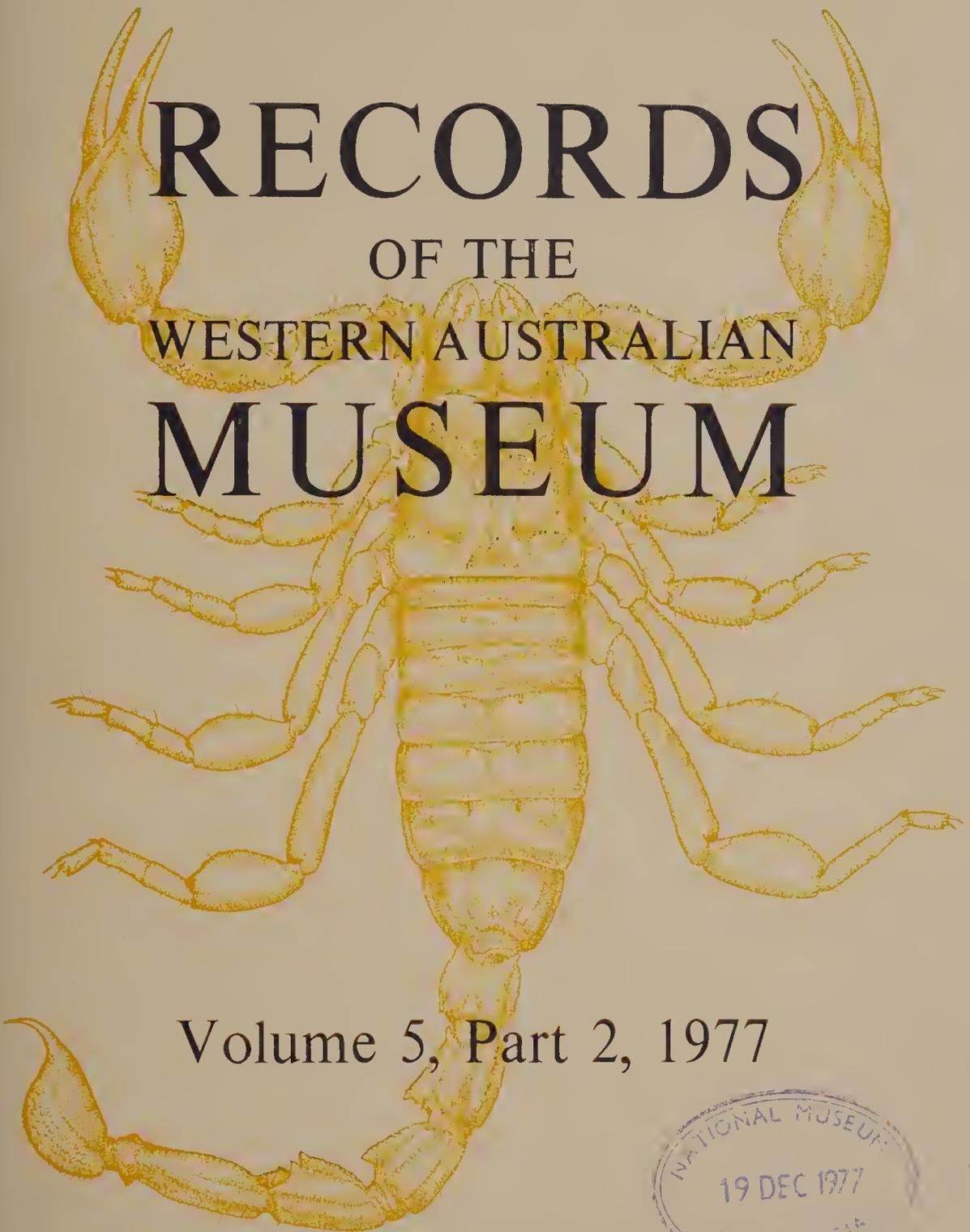
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Cover: Burrowing scorpion (*Urodacus yaschenkoi*) drawn by Mrs Jeanne-Marie Johnson, Western Australian Museum. This is one of the largest species of scorpions in Australia, and is widespread in the central arid parts of the continent. It constructs deep spiral burrows, mainly in sandy soil.

ISSN 0312-3162





# THE TAXONOMY, GEOGRAPHIC DISTRIBUTION AND EVOLUTIONARY RADIATION OF AUSTRALO-PAPUAN SCORPIONS

L.E. KOCH\*

[Received 19 July 1976. Accepted 8 December 1976. Published 30 November 1977.]

## ABSTRACT

The following scorpion taxa are recognized for the Australo-Papuan region: in the Bothriuridae (Bothriurinae) one species of *Cercophonius*; in the Buthidae (Buthinae) three species of *Lychas*, one species of *Isometroides*, two species of *Isometrus*; in the Scorpionidae (Ischnurinae) three species of *Liocheles*; in the Scorpionidae (Urodacinae) nineteen species of *Urodacus* (seven of which are new). *Urodacus* is divided into five species-groups. The characters employed in scorpion taxonomy and particularly in this study are discussed. A detailed system of nomenclature is proposed for the structures of the paraxial capsule. The sexual dimorphism, geographic variation, individual variation and ecological trends are analysed. Distribution maps of all species of Australo-Papuan scorpions are presented. The geographic distribution and evolutionary radiation of Australo-Papuan scorpions are discussed in terms of history of the environment, ecological requirements of species, patterns of distribution, and affinities and derivation of the taxa.

## INTRODUCTION

This publication records part of an enquiry into the relationships and evolutionary history of components of the order Scorpionida, especially its species in the Australo-Papuan region. Of the seven recognized extant families of scorpions, representatives of three, the Bothriuridae, Buthidae and Scorpionidae, occur in this region.

Earlier work on the taxonomy of Australian species had little accompanying biological information and was based on a few specimens which had been received sporadically by workers at various museums. Principal workers were

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Keyserling (1885), Pocock (1888 to 1902), Kraepelin (1894 to 1916) and Glauert (1925 to 1963). Glauert (1925b) mentioned all the important papers on Australian scorpions and dealt with the taxonomy of the Australian Buthidae. Comparatively recently, some biological observations on a few species have been published, e.g. Southcott (1954), Main (1956), Smith (1966) and Koch (1970).

The present publication includes a taxonomic revision of all the scorpion species in Australo-Papua, and is based on the large numbers of specimens that had accumulated in museums and institutions throughout Australia. Six genera are involved. The genus with the most species is the scorpionid *Urodacus* which is confined to mainland Australia and is widespread there. Included are analyses of intraspecific variation and observations on natural history. The origin and evolution of the Australian scorpion fauna are discussed in terms of current ideas on zoogeography. Views are expressed on the manner in which the extant scorpion families reached Australia. Scorpions within the region are discussed in view of the probable features of past environmental history that have been responsible for speciation and the present conditions that limit the distributions of species.

## COLLECTIONS STUDIED AND ACKNOWLEDGEMENTS

Specimens examined were those in the British Museum of Natural History (BMNH), the types in museums in Europe (stated in lists of material examined), the extensive collection in the Western Australian Museum (WAM), and all specimens forwarded to me at the WAM before November 1973 from museums and other institutions in Australia known to have scorpions. Material examined from the South Australian Museum (SAM) had been borrowed for the WAM by the late Mr L. Glauert.

For the loans of specimens I thank:

- Dr C.N. Smithers, Australian Museum, Sydney (AM)
- Dr B.Y. Main, Zoology Department, University of Western Australia (B.Y. Main Collection) (BYM)
- Dr B. Gray, Entomology Section, Department of Forests, Bulolo, Territory of Papua and New Guinea (DFNG)
- Dr P. Stanbury, Macleay Museum, University of Sydney (MM)
- Dr. A. Neboiss, National Museum of Victoria (NM)
- Mr S. Parker, Northern Territory Museum, c/- Arid Zone Research Institute, Alice Springs (NT)
- Mr R.D. Mackay, Papua and New Guinea Public Museum and Art Gallery, Port Moresby (PNGM)
- Mr A.J. Dartnall, Tasmanian Museum and Art Gallery, Hobart (TM)
- Mr E.C. Dahms, Queensland Museum (QM)

Mr W.F. Ellis, Queen Victoria Museum and Art Gallery, Launceston, Tasmania (QVML)

Mr G.B. Monteith, Department of Entomology, University of Queensland (UQ)

The present publication is based on part of a Ph.D. thesis (University of Reading, England). I offer sincere thanks to Dr W.D.L. Ride for supervision; I also thank Professors A. Graham and G. Williams, University of Reading. Professor O.W. Richards, University of London, gave me initial encouragement. I thank Dr G.M. Storr for many useful discussions on taxonomy and geography.

I am indebted to the Trustees of the BMNH for permission to study their collections. For friendship and assistance while I was at the BMNH as an exchange worker in 1966-67, I thank in particular Dr J.G. Sheals, also Dr G.O. Evans and Messrs C.G. Ogden, J. Coles and the late D.J. Clark; and Mr D. Macfarlane of the Commonwealth Institute of Entomology.

I thank Professor M.J.D. White, Department of Genetics, University of Melbourne, for comments on chromosomes, and Dr H.E. Patterson, Department of Zoology, University of Western Australia, who on request prepared for me the slides and photographs of chromosomes.

The drawings of the five complete specimens and of the brachium and humerus of *Urodacus novaehollandiae* were executed by Mrs Jeanne-Marie Johnson. The final versions of the maps were completed by Miss Kim Cannon and Mrs Susan Postmus. I am grateful to Mrs A. Neumann for translations.

## List of Abbreviations

### Collections

AM	Australian Museum, Sydney
BMNH	British Museum (Natural History)
BYM	B.Y. Main's collection stored at Zoology Department, University of Western Australia
DFNG	Entomology Section, Department of Forests, Bulolo, Territory of Papua and New Guinea
MM	Macleay Museum, University of Sydney
NM	National Museum of Victoria
NT	Northern Territory Museum, c/- Arid Zone Research Institute, Alice Springs
PNGM	Papua and New Guinea Public Museum and Art Gallery, Port Moresby
QM	Queensland Museum

QVML	Queen Victoria Museum and Art Gallery, Launceston, Tasmania
SAM	South Australian Museum
TM	Tasmanian Museum and Art Gallery, Hobart
UQ	Department of Entomology, University of Queensland
WAM	Western Australian Museum

#### Measurements

CL	Carapace length
CW	Carapace width
LH	Length of hand
WHS	Width of hand surface
HH	Height of hand
HFF	Length of hand and fixed finger
MF	Length of movable finger
FTL	Fourth tail segment length
FTH	Fourth tail segment height

#### Meristics

##### Trichobothrial groups:

<i>Eb</i>	basal, posterior surface of hand
<i>Et</i>	subdistal, posterior surface of hand
<i>M</i>	median, posterior surface of hand
<i>p</i>	posterior surface of brachium
<i>v</i>	ventral surface of brachium
<i>V</i>	ventral surface of hand

## METHODS

### GENERAL METHODS

All the species of scorpions occurring in Australo-Papua are treated; also included are individuals of Australo-Papuan species that had been collected at localities elsewhere and were present among the material received for study. In the zoogeographic discussions, in accordance with general current views (Schmidt 1954, Walker 1972, Horton 1973), the Australian and New Guinean areas are treated together as a region, its limits being defined by the surrounding 200 metre bathymetric contour.

In the lists of synonymy of the individual species are included references to papers having important statements on taxonomy and about the distribution of the species in the study region. Such a synthesis of available information is considered necessary owing to the lack of recent taxonomic revisions of most of the species. Distribution of the species and their allies

outside the studied region is largely covered by Pocock (1894), Kraepelin (1901), Birula (1917a), Kopstein (1921, 1923) and Giltay (1931).

The types examined included all those whose descriptions in the literature were ambiguous. Where a type has been examined, a statement to this effect is made in the detailed taxonomic treatment of the species to which I allocate it. I agree with the recommendations of Wilson and Brown (1953) and do not use formal subspecific names; following Mayr (1969) species-group names are used instead of formal subgenera.

All specimens were measured and described after preservation; and unless otherwise stated, all specimens examined, including types, are preserved in 70-80% alcohol. A total of 4430 specimens was studied. The drawings were made using a camera lucida. All specimens were sexed except for those in the first instar, which are referred to as young and are excluded from the counts of examined specimens.

Habitat details and other comments given for a particular specimen or species include those obtained from label data, from my field observations, or by my enquiring from the original collectors. Determination labels have been placed with the examined specimens.

In the distribution maps, a single point is plotted to represent one or more locality records within each square having side lengths of 30' latitude and 30' longitude. The summarized statements of geographic ranges include records from the literature. The following categories of specimens in the lists of material examined have not been plotted. (1) Specimens with locality records preceded by a question mark. These doubtful records are discussed in the remarks under each species. (2) Specimens with locality names followed by a question mark. These locality names could not be clarified from any further label data and were not in the gazetteer (Anon 1957) or any of the maps at my disposal. (3) Specimens with no locality data, or of very general regional data such as the name of the State (e.g. North West Australia, South East Queensland, Central Australia) which are given within inverted commas.

During the course of the research, the chromosomes (male karyotypes) of two closely related species of *Urodacus* were examined, and relevant photographs are presented and the findings discussed.

The Australian species shelter mainly under bark or close under objects, such as rocks, on the ground, except for most species of *Urodacus* which construct deep spiral burrows in the ground. Brief information on the burrows is included. A comparative study of the burrows has been prepared as a separate paper (Koch 1978).

In order to record intraspecific variation in the present study it has been necessary to clarify and separate individual variation, sexual dimorphism,

and age variation (i.e. instars and maturity) and details of these aspects are discussed. Attention had also to be given during the delineation of taxa to detecting and excluding features which had resulted from the long preservation. It was found that the dark coloration in variegated species of the Buthidae and Bothriuridae had markedly faded in most specimens that had been preserved for more than 40 years.

The raw data pertaining to this study are lodged in the Western Australian Museum.

## MEASUREMENTS AND MERISTICS

### Taxonomic Use

Vachon (1952) established a detailed system of obtaining measurements for scorpion taxonomy. The set of dimensions usually presented with the description of scorpions has varied from the essential lists, e.g. of Vachon (1952), San Martin (1966), Gertsch & Soleglad (1966), Pohl (1967), Cekalovic (1969) and Newlands (1972), to somewhat more extensive lists (Mitchell, e.g. 1971). Stahnke (1970) extensively discussed mensuration of scorpions. Williams (1972) and Hjelle (1972) both employed the same set of 29 dimensions; and Levy *et al.* (1973) also employ about the same number of measurements.

In the present study in order to supplement the description of each species, two sets of measurements are included: (A) an extensive list of 30 selected dimensions of a type specimen or a representative specimen, and (B) a set of nine standard measurement characters of male and female adults. Where large numbers of specimens were available, samples from all parts of the distribution were used. Precautions were taken to avoid bias (e.g. those due to specimen size or geography) in these samples. The nine measurement characters (i.e. the data given in the present publication) have been used in multivariate analyses of shape in these scorpions (Campbell & Koch, in preparation).

Of the meristic features of scorpions, pectinal tooth count has always been employed by scorpion taxonomists, and has even been the subject of special analyses (Sreenivasa-Reddy 1959). Hjelle (1972) graphed pectinal tooth counts of males and females of the vaejovid *Uroctonus mordax* Thorell and found different modal tendencies in various populations in California. During the present study, an attempt was made to evaluate this character. The count is given for each complete pectinal side.

Other meristic features of scorpions have not been subjected to a detailed analysis of individual variation by other workers, comparable, say with that of the work on some centipedes by Lewis (1968). In the present study,

because of the extent of the variation, eight meristic features have been recorded in species of the genus *Urodacus*.

### Measurements

All measurements in the present study, unless otherwise stated, are in mm.

For measuring the types at the BMNH a pair of wooden calipers graduated to 0.1 mm was used. The measurements of all other specimens were taken using a metal 'Helios' dial calipers graduated to 0.05 mm; measurements of specimens taken with these were read to the nearest 0.1 mm.

Bilaterally symmetrical structures were measured on the right-hand side except in a few instances where the structures on this side were damaged or missing, in which case the left-hand side measurements are given.

Details of the two sets of presented measurements, A and B, are given below.

A. In the set of 30 dimensions presented with the description of each species, the selected individual, where possible, is a type specimen, usually the holotype, or a specimen from the type locality and of the same sex as the type.

As discussed by Stahnke (1970) there are two methods of obtaining body length and tail length: many workers (e.g. Gertsch and Soleglad 1966) measure the components (excluding intersegmental portions) and add them up, while others (e.g. Pocock, Glauert) give an overall measurement. In this study, total length and tail length are given as only general indicators of size, and these measurements therefore do not consist of the sum of the individual sclerotized parts. Total length as presented is from tip of chelicerae to tip of aculeus, and length of tail from its junction with the body to the tip of the aculeus. These two measurements, unlike all others, are only given to the nearest mm because of the flexibility of intersegmental portions.

Length of each of the first four tail segments is not that of the whole segment, but is that along the ventral keel as recommended by Vachon (1952: 54). Hence this measurement does not necessarily correspond with that given for the same specimen by previous authors, e.g. by Pocock for his holotypes.

Length of vesicle and aculeus is the single measurement from the ventral base of the vesicular segment straight across to the tip of the aculeus.

The measurements are taken according to the method recommended by Vachon (1952).

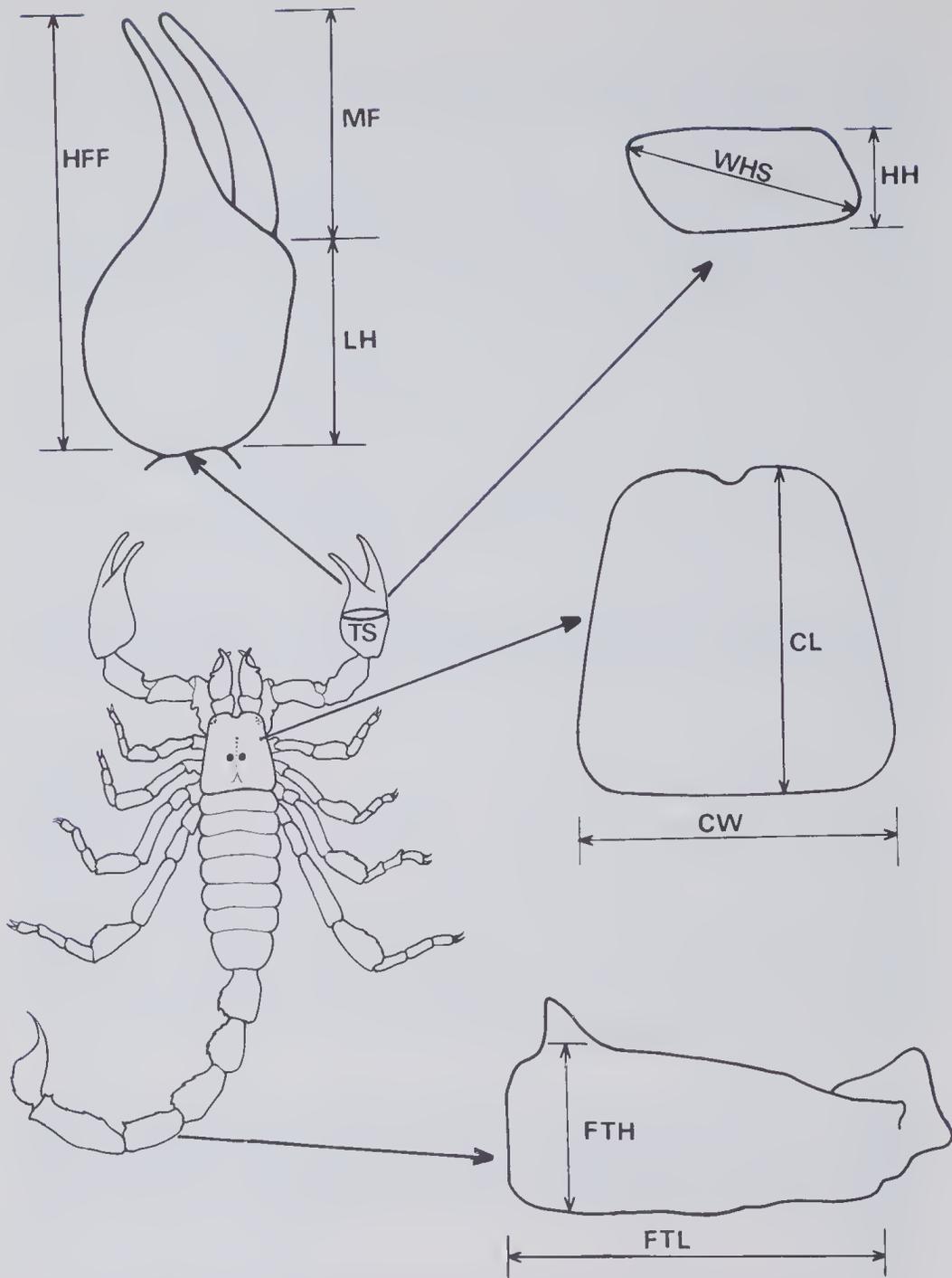


Fig. 1: Diagram of a scorpion showing the nine measurement characters. CL, carapace length; CW, carapace width; LH, length of hand; WHS, width of hand surface; HH, height of hand; HFF, length of hand and fixed finger; MF, length of movable finger; FTL, fourth tail segment length; FTH, fourth tail segment height.

B. The nine standard measurement characters, which are of carapace, hand and fingers, and a tail segment (Fig. 1) of adults, were taken as follows:

Carapace length (CL): Taken parallel to the longitudinal axis from the anterior edge of the carapace at the middle of frontal lobe on the right-hand side to the posterior edge of carapace.

Carapace width (CW): Greatest width, i.e. lateral edge to lateral edge distance, in posterior part of carapace. (Owing to variation in carapacial curvature as a result of preservation, measurements of this parameter are not always as reliable as the others.)

Length of hand (LH): Taken from keel at base to point of junction with base of movable finger.

Width of hand surface (WHS): Taken from anterodorsal keel to posteroventral keel at point of maximum width.

Height of hand (HH): The shortest measurement from finger keel to ventral surface of hand.

Length of hand and fixed finger (HFF): Taken from keel at base of hand to apex of fixed finger.

Length of movable finger (MF): Taken from base to apex of movable finger.

Fourth tail segment length (FTL): Taken along ventromedian keel from first transverse keel at proximal end of segment to distal edge of segment.

Fourth tail segment height (FTH): Taken from ventromedian keel to proximal base of posterior tooth.

For each species, ranges and means of the nine measurement characters are given for adult male and female specimens from all parts of the distribution. Standard deviations (SD) are given for every species/sex set having at least five specimens. These statistics are preceded by the number (n) of individual measurements, which unless otherwise stated for a particular measurement character, applies to all of them.

### Meristics

As pointed out in papers by Vachon, the characteristics of cheliceral teeth and the numbers of the trichobothria are well known to remain constant throughout the life of a scorpion. (The symbols used for the trichobothrial groups are included in the list of abbreviations.) In the species studied, in addition to constancy in these characters there was no evidence that the other recorded meristics, such as pectinal tooth count, of individual scorpions changed between the instars. This statement is based on an examination of specimens in various instars, obtained in association with their previously ecdysed skins. At least one species of each genus was investigated.

The species with most material available for such inspections were *U. novae-hollandiae*, *U. planimanus*, *U. yaschenkoi*, *Lychas marmoreus* and *Isometroides vescus*. Meristics are therefore presented of all instars except first instars (young) whose features are often difficult to discern. Except for pectinal tooth count, the meristics do not exhibit obvious sexual dimorphism and hence the values of these meristics for both sexes are pooled.

Meristics are incorporated with the descriptions, the most frequent and most rare counts of trichobothria being given in addition to the range of variation exhibited among the available material. During the course of the work, the frequency of occurrence of pectinal tooth count of some species/sex sets having adequate numbers of individuals was tabulated and the unimodal distributions obtained served as additional evidence that only one species was involved in each instance.

The ranges exhibited by the pectinal tooth counts (each sex separately) of the examined material are given with the descriptions of the individual species. Also given for every species/sex set having less than ten individuals are the means, and for those sets with more than ten individuals the means and SD of an unbiased sample of ten individuals (i.e. 20 pectinal sides). The pectinal tooth counts, with an indication of those selected for the SD calculations, are lodged with the raw data. The given statistics supplement the descriptions of the species. The range is that of all the counts of each species/sex set. The individual counts serve to illustrate local variation, but it is concluded that the variances exhibited by the samples of twenty counts are too high for further analysis.

Ranges and usual numbers of eight meristic features are given for all species of *Urodacus*. In this genus, the numbers and variability exhibited by many meristic features, e.g. some trichobothrial groups, were high. (The numbers of trichobothria in certain groups, e.g. *Et*, *Est*, are family characters.) In genera other than *Urodacus*, the numbers and variability of most of the meristic features corresponding to those employed in *Urodacus* were low.

Other meristics recorded (e.g. in *Urodacus*) are the inner and outer prongs on tarsomere II of the hind (fourth) pair of legs. Along the row of prongs on tarsomere I of the first pair of legs, the second proximal-most 'prong' often occurred in the form of a bristle, and occasionally some other bristles were present in this row. When this occurred these bristles were included as prongs in recording the count, following the procedure of other taxonomists (e.g. Pocock).

## GENERAL MORPHOLOGICAL FEATURES

### Taxonomic Use

Terminology of external features of scorpions was defined by Kraepelin (1899), and detailed general descriptions of external (as well as internal)

structure and terminology have been presented by Birula (1917a), Millot & Vachon (1949) and Vachon (1952). Usage of the basic terminology of Snodgrass (1952) would contribute towards consistent treatment within the phylum Arthropoda, but understandably his work does not include all structures of relevance to scorpion systematics. Stahnke (1970) in a comprehensive co-ordination of scorpion terminology attempts to standardize the English terminology of external features of scorpions after taking into consideration the German terms of Kraepelin (1899) and Werner (1935), the Spanish terms of Hoffmann (1931, 1932), and the French terms of Vachon (1952). In this study I have, as a rule, selected terms from those recommended by Stahnke (1970); Glauert (1925b) is also largely followed. However, unlike Glauert (1925b) and others (e.g. Gertsch & Soleglad 1966; and Pocock's descriptions) but like Vachon 1952, I use the terms dorsal and ventral instead of superior and inferior in describing the keels of the tail segments. As mentioned, two of the characters that remain constant throughout the life of a scorpion are (1) the shape and number of cheliceral teeth, and (2) the position and number of trichobothria. In the present study, special attention is paid to the description of these two characters especially in *Urodacus* species. In regard to these two and many other characters, all the previously known Australian species are described in more detail than hitherto. I follow Vachon (1963) in nomenclature of cheliceral teeth and Vachon (1952, 1962, 1973) for trichobothria.

Of the characters employed in the present study, the following require comment.

### Colour

Generally workers have described coloration in simple terms like brown, yellow, orange, red, and the variants such as orange-brown, bright yellow, and dark red (Gertsch & Soleglad 1966, 1972); this procedure is followed here. Initially I consulted Ridgeway Colour and Munsell Soil Colour Charts, but found them of little value for my purposes.

Newlands (1969, 1972) describes coloration in some African scorpions in general terms supplemented with values from Standard Soil Colour Charts. But Stahnke (1970) says that simplicity of expression is most effective and that the use of primary colours in a variable manner conveys as precise a concept as necessary, and Vachon (1952) is an excellent example; Stahnke found, moreover, that colour codes are unsatisfactory owing to surface conditions and consequent light reflections encountered.

The general statement on colour preceding details of any specific parts refers to the dorsal ground colour of the hands, tergites and first three tail segments.

## Chelicerae

When discussing the second and third cheliceral joints, I use the term jaws (in place of the term fingers) in order to avoid any confusion with fingers of the hands; and I regard usage of the term teeth (a recognized term for describing the chitinous projections used for mastication by invertebrates) as more appropriate than the term denticles, cf. Stahnke (1970).

Some workers (e.g. San Martin 1963; Gertsch & Soleglad 1966; Mitchell 1968, 1971) when describing cheliceral teeth have used the nomenclature proposed by Vachon (1963), whereas others (e.g. Lawrence 1966; Newlands 1972) have presented illustrations, with the teeth unlabelled. I present descriptions and drawings of chelicerae of the genera and species; lettering using Vachon's system is shown for representatives.

Vachon (1963) points out the value of employing the structure of cheliceral teeth in scorpion taxonomy at the generic level. Stahnke (1970) concludes that chelicerae are sometimes of value at both generic and specific levels. Except for a few workers (e.g. Mitchell 1968) cheliceral characters have not been used as diagnostic features at the specific level. In the genus *Urodacus* interspecific differences are adequate for diagnosis at the specific level, and details of the cheliceral teeth are presented. In the other Australian genera, the slight interspecific differences and the extent of intraspecific variation made it impractical to employ cheliceral characters at the specific level. Even in *Urodacus*, the teeth of some specimens were extensively worn, and an illustration is therefore provided of a clear example of the chelicerae of each *Urodacus* species with the proviso that cheliceral structure has to be used with caution as a taxonomic character. As pointed out by Stahnke (1970) setae on the chelicerae are of little taxonomic value; they are excluded from the illustrations in the present study.

## Surfaces of Humerus, Brachium and Hand

For the arm segments that some authors (e.g. Gertsch & Soleglad 1966) refer to as the femur and tibia, I prefer to use the terms humerus and brachium. This would avoid any confusion with the terminology of leg segments. Because of the range in shape of humerus, brachium and hand, and the variation in number of keels of the hands of scorpions, the literature is inconsistent in the treatment of the number of surfaces. For example, Kraepelin considered the hand either as having two surfaces, viz.; an inner (composed of the anterior, i.e. median surface, and the ventral surface) and outer (composed of the posterior, i.e. the lateral surface, and the dorsal surface), or three surfaces, viz., the dorsal, ventral and exterior (= 'hinterhand'). Vachon (1952) treats the hand as having three main surfaces, including a large ventral surface, and considers the brachium also of having three main surfaces: dorsal, ventral and lateral. Stahnke (1970) concludes that

it is generally possible to recognize three surfaces, viz., superior, inferior and exterior. However, in describing the humerus, brachium and hand (and the location of trichobothrial groups) I found it most useful to treat these structures as having four surfaces: (1) dorsal, (2) anterior (=inner, i.e. medial), (3) ventral, and (4) posterior (=outer or lateral). Thus the bounding keels on the dorsal surface are at the anterior (inner) edge (anterodorsal keel) and posterior (outer) edge (posterodorsal keel).

### Trichobothria

Vachon (1962) states that trichobothria are important taxonomic characters; and in this study the system of trichobothrial nomenclature developed by Vachon (1952, 1962, 1973) is followed as closely as practicable. Many modern workers (e.g. Mitchell 1968, 1971; Cekalovic 1965; San Martin & Cekalovic 1968b) use Vachon's symbols.

I have found that the trichobothrial nomenclature applies in the following manner to the members of the three scorpion families represented in Australo-Papua.

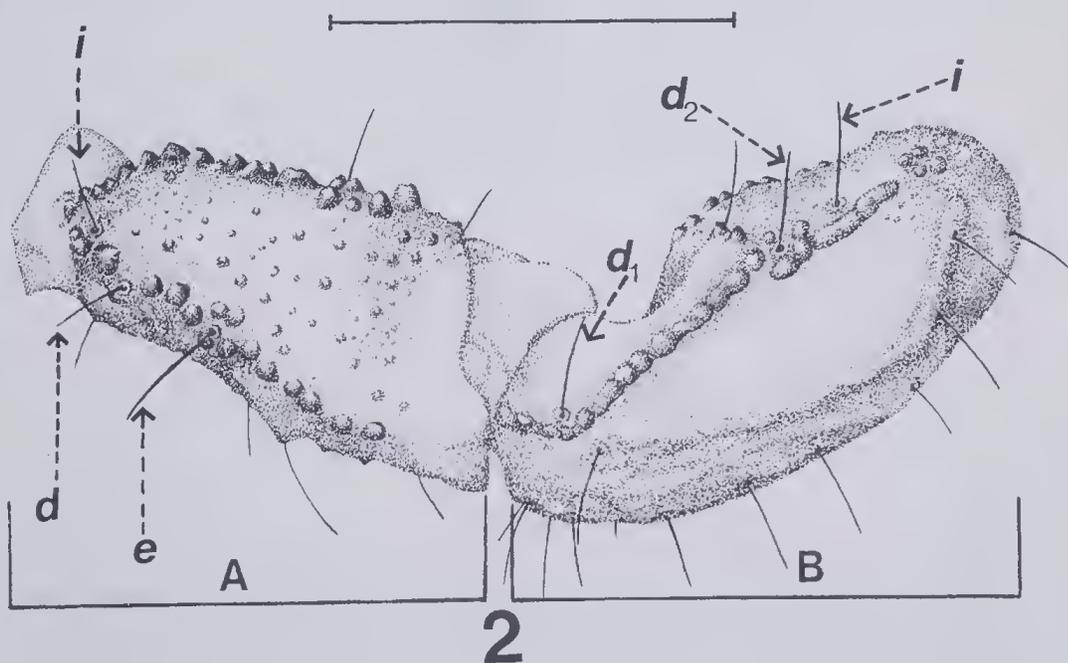


Fig. 2: Dorsal view of (A) humerus and (B) brachium of *Urodacus novaehollandiae* (Perth, W.A.) with trichobothria indicated (Scale line 5 mm).

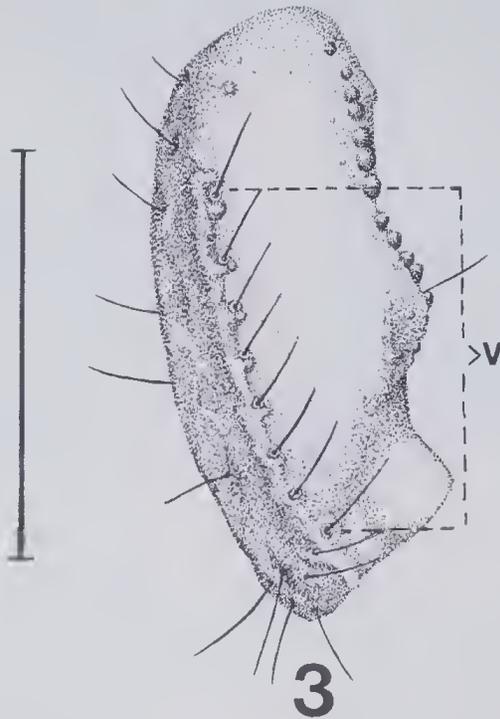


Fig. 3: Ventral view of brachium of *Urodacus novaehollandiae* (Perth, W.A.) with trichobothria indicated (Scale line 5 mm).

**Humerus:** In the Bothriuridae and Scorpionidae, on the dorsal surface of the humerus near the posterior (outer) edge close to the trochanter there is one trichobothrium, *d*; on the posterior surface near the trochanter there is one trichobothrium, *e*; and on the anterior (inner) surface near the trochanter there is one trichobothrium, *i* (Fig.2a). In the Buthidae, the dorsal surface has five trichobothria,  $d_1$ ,  $d_2$ ,  $d_3$ ,  $d_4$ , and  $d_5$ ; the posterior surface has two,  $e_1$  and  $e_2$ ; and the anterior surface has four trichobothria,  $i_1$ ,  $i_2$ ,  $i_3$ , and  $i_4$ , positioned close together near the trochanter. As usual the ventral surface has no trichobothria.

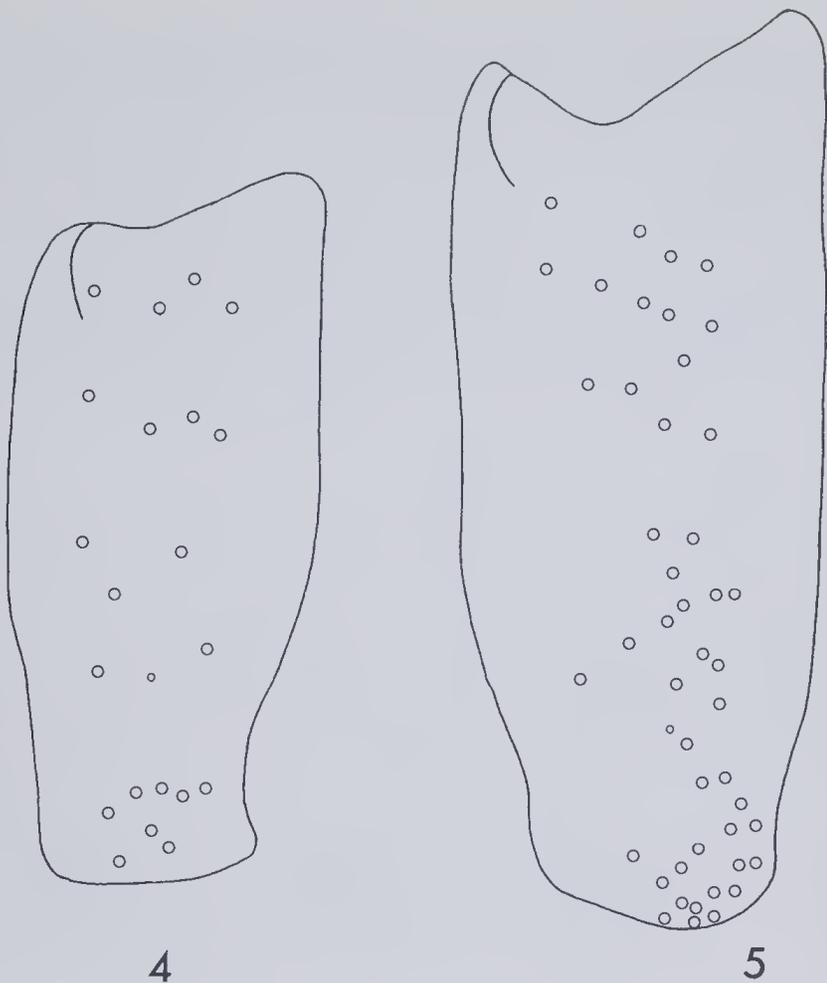
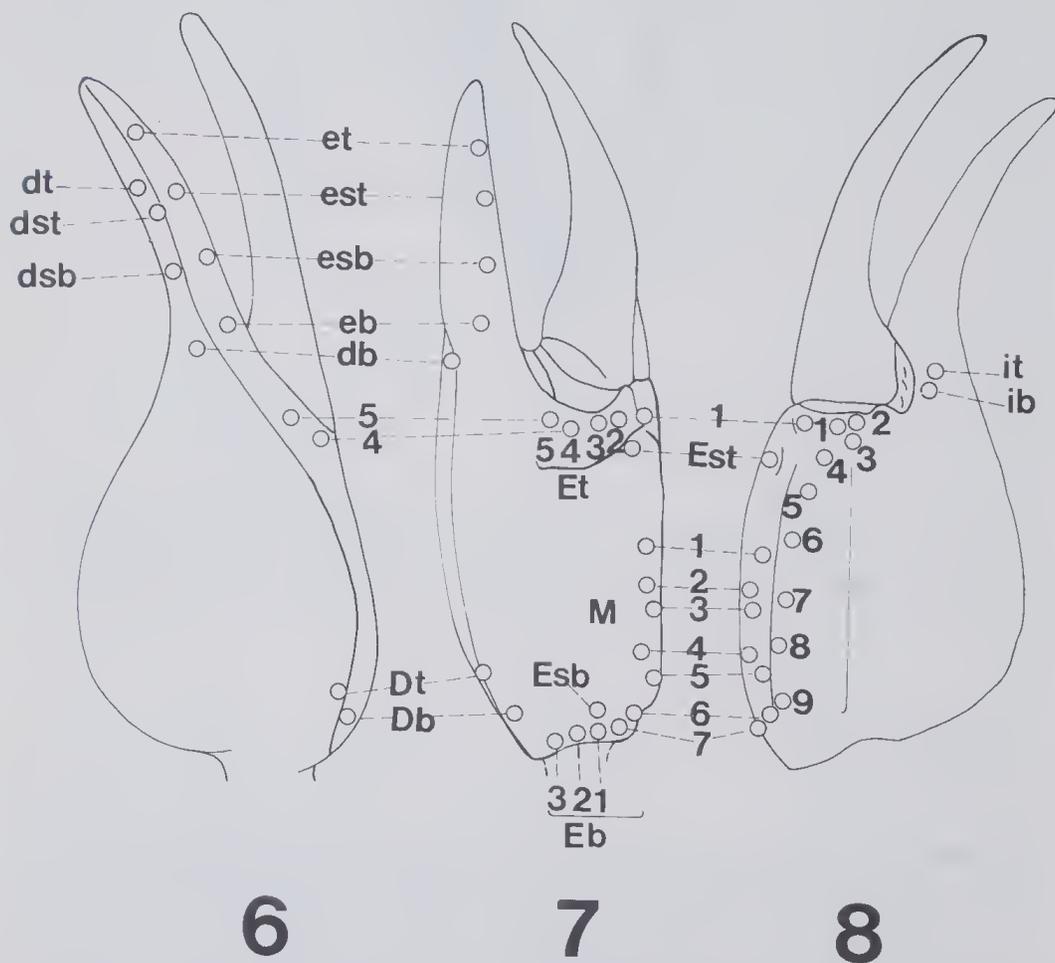


Fig. 4: Trichobothria of posterior surface of brachium of *Urodacus novaehollandiae* (Perth, W.A.).

Fig. 5: Trichobothria of posterior surface of brachium of *Urodacus yaschenkoi* (Broome, W.A.).

**Brachium:** In the Bothriuridae and Scorpionidae, on the dorsal surface,  $d_1$  is at the humeral end and  $d_2$  near the middle of the anterodorsal edge of the brachium; and on the anterior surface near the anterodorsal keel there is one trichobothrium,  $i$  (Fig. 2b). In the Buthidae, on the dorsal surface there are five trichobothria,  $d_1$ ,  $d_2$ ,  $d_3$ ,  $d_4$ , and  $d_5$ , and on the anterior surface  $i$  is present. In the Bothriuridae and Scorpionidae, the trichobothria that are along the posterior edge of the ventral surface are,

in this study, represented by the symbol  $v$  (Fig. 3); this  $v$  series is absent in the Buthidae. The posterior surface of the brachium has 13 trichobothria in the Bothriuridae and seven in the Buthidae. In the Scorpionidae, there are from a few to many (e.g. in *Urodacus* up to 54) scattered trichobothria which are usually most numerous on the more ventral half of this surface and at its edge near the humerus. Vachon (1962) groups the trichobothria of this surface into eight or nine categories ( $D_1$ - $D_4$ ,  $B_1$ - $B_4$ ,  $B_5$ ) based upon their transverse arrangement. Mitchell (1968, 1971) designates these trichobothria, and groups them into five categories; and Vachon (1973) employs five groups: terminal (*et*), subterminal (*est*), median (*em*), suprabasal (*esb*), and basal (*eb*). In *Urodacus*, there are often



Figs 6-8: Hand and fingers of *Urodacus novaehollandiae* (Perth, W.A.) to show trichobothria: 6, dorsal; 7, posterior; and 8, lateral views.

so many trichobothria on this surface that classification into discrete sub-groups may be easy in species with few trichobothria, e.g. *U. novae-hollandiae* (Fig. 4) but apparently impracticable in others, e.g. *U. yaschenkoi* (Fig. 5). Therefore, in the present publication, for each of the Australo-Papuan species, I state the total number but do not give a detailed sub-grouping of the trichobothria (*p*) on the posterior surface of the brachium.

**Hand:** In the Bothriuridae and Scorpionidae, on the dorsal surface of the hand there are two trichobothria, *Dt* and *Db* (the latter being near the proximal edge) (Fig. 6). The ventral surface has, along its posterior edge, from two to many trichobothria in a ventral (*V*) group, e.g. 7-32 in *Urodacus*. The trichobothria of the posterior surface are arranged as follows: distally, near the base of the fingers, there is a row of five trichobothria (*Et*<sub>1</sub>, *Et*<sub>2</sub>, *Et*<sub>3</sub>, *Et*<sub>4</sub>, and *Et*<sub>5</sub>); proximal to these there is *Est*; there is a basal row of three (*Eb*<sub>1</sub>, *Eb*<sub>2</sub>, and *Eb*<sub>3</sub>); distally from *Eb* row there is one trichobothrium, *Esb*. Between *Est* and the *Eb* group, there is a median (*M*) group (Figs 7, 8). The *M* group consists of 3-24 trichobothria in *Urodacus* (Scorpionidae, Urodacinae). They are referred to as accessory trichobothria by Vachon (1973). The *M* group is absent in the Bothriuridae and Buthidae, and in the studied species of *Liocheles* (Scorpionidae, Ischnurinae). In many species (especially of *Urodacus*) the trichobothria of the *Eb* group of the posterior surface and the *V* group of the ventral surface form a continuous row; the numbers of trichobothria in both these groups must be checked in relation to the keels between these two surfaces. In the Buthidae, *Et*, *Est*, and *Esb* are usually near the base of the fingers; and *Eb*<sub>1</sub>, *Eb*<sub>2</sub>, and *Eb*<sub>3</sub> are present. There are no dorsal trichobothria, and two ventral trichobothria (*V*), which are near the base of the fingers.

**Fingers:** In the Bothriuridae and Scorpionidae, on the dorsal surface of the fixed finger there are four trichobothria, *dt*, *dst*, *dsb*, and *db* (Figs 6, 7). On the posterior surface there are four trichobothria, *et*, *est*, *esb*, and *eb*, which are positioned along the finger. On the anterior surface there are two trichobothria, *it* and *ib*. The Buthidae has these trichobothria except that *dst*, *dsb*, and *ib* are absent.

(A detailed paper, incorporating illustrations, on the nomenclature of the trichobothria of Australo-Papuan scorpions is being prepared by Vachon & Koch.)

## Legs

Regarding the names of the terminal segments of the legs, I use the terms tarsomere I for the segment that Pocock (e.g. 1893b) and Birula (1917a) call the protarsus, that Hirst (1911) and Kraepelin (1916) call

the metatarsus, and that Vachon (1952) calls the basitarse; and the term tarsomere II for that which Vachon calls the tarse, Pocock and Birula (Birula 1917a) call the tarsus, and Pocock (e.g. 1891) calls the distal tarsal segment. This is in accordance with Stahnke (1970) who bases his system on Hoffmann (1931, 1932). Although various terms have continued to be used, e.g. protarsi by Gertsch & Soleglad (1966) and Tarsus III and IV by Lawrence (1961, 1966), the terms of Stahnke seem to be coming into standard use, e.g. Newlands (1972) uses the term tarsomere II. I consider it more appropriate to refer to the lateral claws of Stahnke (1970) as terminal claws.

## SEXUAL CHARACTERS

### Reproduction in Scorpions

The male genital structure of scorpions was referred to by Blanchard (1852) and Dufour (1856), and its morphology was first described by Pawlowsky (especially 1915a and b, 1917, 1921, and 1924). Pawlowsky (1917) was the first to use the term paraxial 'organ' for each one of the sclerotized pair of bilaterally symmetrical male structures arranged on either side of the longitudinal axis within the body cavity, and he described the histology of this structure in *Scorpio maurus*. (These structures are not organs in the strict sense, but this terminology has been retained by scorpion workers.)

The elaborate courtship of scorpions has been recorded by Maccary (1810) and incompletely observed by Brongniart & Gaubert (1891); Fabre (1923) did not observe the details of its final stages. It is only comparatively recently that several workers (Angermann 1955, 1956; Zolessi 1956; Alexander 1956, 1957, 1959; Shulov 1958; and Rosin & Shulov 1963) have shown convincingly that reproduction in scorpions involves the extrusion and discharge, from the male body cavity, of a spermatophore. Each half of the spermatophore forms within one of the paraxial glands and the two halves unite during the process of leaving the body. The workers found that the foot of the spermatophore adheres to the ground by glandular secretions. The genital opening of the female is then manoeuvred onto the capsular lobes of the spermatophore which is bent by this action resulting in expulsion of the seminal material into the female.

### Taxonomic Use of Male Genitalia

Of the male genital structures, the sclerotized interior of the paraxial organ has proved to be a valuable character in scorpion taxonomy.

The structure of the paraxial organs has been used in the taxonomic treatment of North African scorpions (Vachon 1952) and of many species of South American Bothriuridae (San Martin 1963, 1965a, b and c, 1966,

1967, 1968; Cekalovic 1965; San Martin & Gambardella 1967; San Martin & Cekalovic 1968a and b).

Vachon (1952) described the structures of the capsular area with terms such as basal, internal, external, and median lobes. Workers on the South American bothriurid species have presented detailed illustrations and terminology. Much additional terminology was included, and they retained those terms already used by Vachon (1952). The paraxial organs of scorpions from Israel, Jordan and Arabia are illustrated without comment (Levy *et al* 1973). Nevertheless, paraxial organs are employed as taxonomic features by only a small proportion of current workers. Unfortunately, the female gonotreme does not lead to a sclerotized structure that can be employed in taxonomy with the facility of the male paraxial organ.

The structure of the male genitalia of Australo-Papuan scorpions has not been previously used in taxonomy. I cannot overemphasize the value of the detailed structure of the capsular region of the paraxial organs in the taxonomic differentiation of these species.

#### Dissection of Paraxial Organs and Orientation in Drawings

The paraxial organs are situated at about the level of the pleuron and extend into the body cavity from the gonotreme. The procedure adopted for dissecting this structure for taxonomic investigation was as follows. A slit was made along the pleural membranes (of the right-hand side of the anterior half of the body from the region of the third and fourth pairs of legs to beside the third to fifth tergite) and the entire paraxial organ (first drawing) of that side was removed with forceps. The paraxial capsule was then carefully dissected (while being viewed through a microscope) with fine needles to expose the detailed cuticular structures (second drawing). Each of the dissected paraxial organs has been stored in 70-80% alcohol in a labelled tube within the jar containing the relevant scorpion.

In the drawings each structure is drawn as though it is removed from the scorpion lying with its dorsal surface on the page and its ventral surface uppermost. The head of the scorpion is lying towards the reader. The term inner is applied to the admesial side of the organ since each organ illustrated is from the right side; the inner edge is towards the left-hand side of the page. The main lobes of the capsule are orientated differently *in situ* in different groups, e.g. they tend to be admesial in the Urodacinae.

#### Terminology for Capsular Structures of Paraxial Organs

In the terminology I apply to the paraxial structures described in the present study, I employ those appropriate names previously used by other workers, especially Vachon and San Martin. However, the paraxial organs of *Urodacus*, a recently evolved genus, have a complex capsular structure with

many features that are additional to those for which terms were provided by the workers on other scorpion genera. Therefore it has been necessary to present additional and more detailed terms.

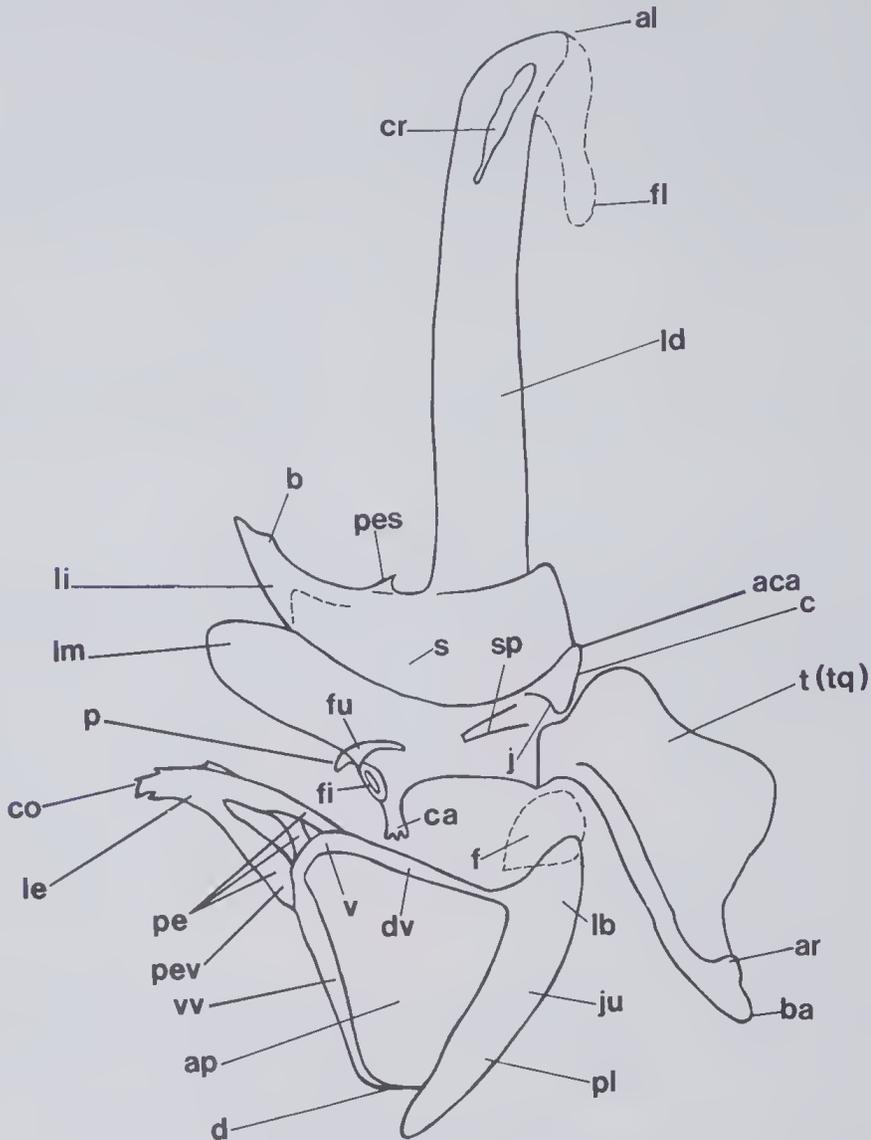


Fig. 9: Diagram of a generalized paraxial capsule and lamina to explain terminology. aca, apex of carina; al, apex of lamina; ap, apotheca; ar, arch of toca; b, back-plate of inner lobe; ba, base of ampulla; c, carina; ca, caulis; co, comb of external lobe; cr, crest; d, diaphragma; f, flap; fi, fission; fl, flagellum; fu, fulcrum; j, junction between carina and toca; ju, juxtum; lb, basal lobe; ld, lamina; le, external lobe; li, inner lobe; lm, median lobe; p, prong; pe, pedunculi, pes, spiniform protuberance of inner lobe; pev, ventral pedunculus; pl, proximal lobe, s, saccus; sp, sclerotized plate; t, toca; tq, toquilla; v, vinculum; dv, dorsal vinculum; vv, ventral vinculum.

The terms used in this study are explained below and shown in a drawing of a generalized scorpion capsule (Fig. 9).

Apotheca (ap)—sac bounded at bottom by diaphragma. May be weakly or strongly defined (excluded in descriptions where weakly sclerotized or not obvious in present series of dissections).

Basal lobe (lb) (of Vachon 1952)—partly flattened plate attached to end of dorsal vinculum and usually at about a right angle to it.

Carina (c)—deflected plate at other end of median lobe. Its distal (i.e. dorsal) part is called its apex (aca). Sometimes there is a distinct suture (the junction, j) between it and the toca.

Caulis (ca)—projecting structure usually lobed (tri-lobed) at the very base of median lobe.

Crest (cr) (of San Martin and Gambardella 1967)—anterior expansion at apex of lamina.

Diaphragma (d)—floor of capsule (excluded in descriptions where weakly sclerotized or not obvious in present series of dissections).

External lobe (le) (of Vachon 1952)—well-developed structure, variable in size and shape, often hook-like and/or modified into comb-like structure (co) with few to many teeth.

Fissure (fi)—slit-like opening between fulcrum and caulis; usually absent or poorly defined, sometimes well defined.

Flap (f)—plate-like structure, represented in the Urodacinae in one species (*U. similis*, sp. n.).

Fulcrum (fu)—a plate, usually triangularly curved, and pointing towards base of median lobe.

Juxtum (ju)—the middle portion of the structure that at one end is the basal lobe and at the other the proximal lobe (the lobes being referred to as its arms). It is a partly flattened plate attached to the end of dorsal vinculum and usually at about a right angle to it.

Inner lobe (li)—(of Vachon 1952) sometimes has a back-plate (b) and a spiny protuberance (pes) (of San Martin and Gambardella 1967) along its edge between its point and the base of lamina.

Lamina (ld)—(=distal lamina Vachon 1952, and San Martin, e.g. 1965a) flattened portion from capsule pointing away from gonotreme. In the Urodacinae, the lamina ends at the apex (al), but in other scorpions, e.g. members of the Buthidae, it has an elongation referred to in the literature as the flagellum (fl).

Median lobe (lm)—(of Vachon 1952) funnel shaped structure between inner and external lobe; formed by curved folding of cuticular layers.

- Pedunculi (pe)—rod-like structures at base of external lobe, referred to as dorsal (ped), median (pem), and ventral (pev) according to orientation.
- Prong (p)—small projection (usually somewhat directed outwards) from median lobe near the base of fulcrum.
- Proximal lobe (pl)—extension from dorsal vinculum in opposite direction to basal lobe.
- Saccus (s)—pouch that may occur between inner lobe and median lobe.
- Sclerotized plate (sp)—structure of variable shape (often triangular) on back-plate of median lobe near the junction.
- Toca (t)—auricula-shaped structure joining median lobe near carina; its lowest part is the base (ba), the curve near this is the arch (ar).
- Toquilla (tq)—large shell-shaped structure; probably an extreme form of toca.
- Vinculum (v)—curved rod-like structure at proximal end of external lobe. Consists of an upper arm (the dorsal vinculum, dv) and a ventral arm (the ventral vinculum vv).

## GROWTH CHARACTERS (INSTARS AND MATURITY)

### Adult Stage Measured

Koch (1975) has shown, using principal components analysis, that in Australian scorpions change in shape does occur between the penultimate and the ultimate (adult) instars. The relationship between CL and FTL in male *Urodacus planimanus* is shown as an example (Fig. 10). Because of change in shape it is important to use a corresponding life-cycle stage when comparing the dimensions of species and so that any discussion of intra-specific or interspecific differences in shape can be meaningful. In the present study, determination of the adult instar has been reasonably easy—definite proof of maturity is available through dissection (see below). Because of sexual dimorphism, the adult male and female dimensions are given separately. Non-measurement characters change little if at all from the second instar onwards, and data from these instars have been incorporated in the general descriptions.

### Determination of Maturity

The reproductive system of both sexes was inspected (in most specimens without removal) through a small slit made along the pleural membranes on the right-hand side of the body. For this purpose, a slit extending beside the third to fifth abdominal tergites was usually adequate.

Male: Smith (1966) had found that in dissected males of *U. manicatus*, the reproductive system was evident in the fifth instar and was mature in

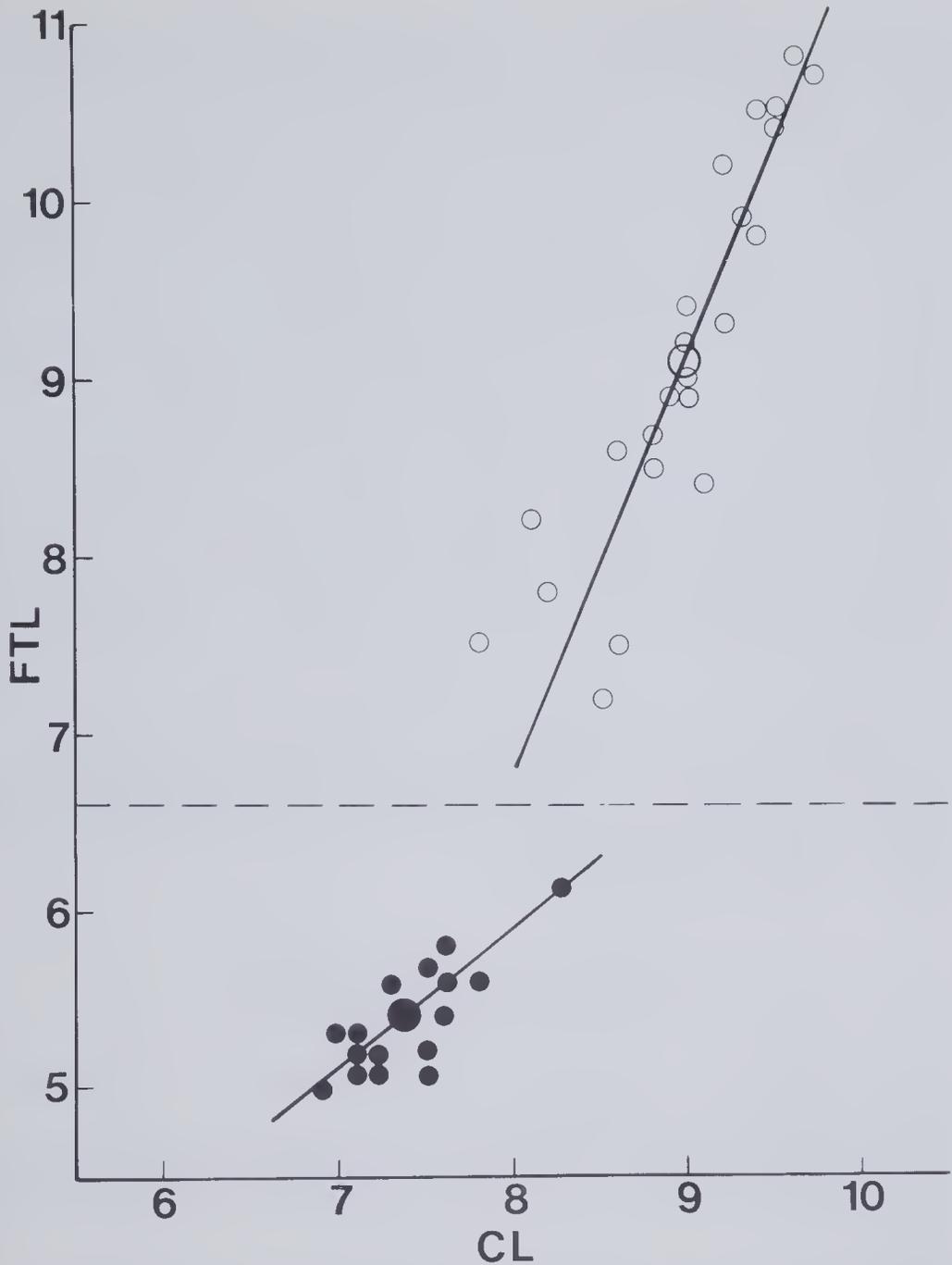


Fig. 10: Slopes fitted as a result of principal components analysis to ultimate (open circle) and penultimate (closed circle) instars of male *Urodaeus planimanus*. Paraxial organs were present in the specimens above, but not below, the broken horizontal line. Large symbols, means. CL, carapace length; FTL, fourth tail segment length (mm).

the sixth (i.e. ultimate) instar. In all the species examined in the present study, the male ultimate instar, unlike previous instars, had paraxial organs; and even if the structures had recently been extruded in mating, their empty sheaths were usually detectable in the body. It takes at least a few days for new spermatophore halves to form within the paraxial organs.

Female: Smith (1966) said that in females of *U. manicatus* the reproductive system is not evident until the sixth (i.e. ultimate) instar. However, it is my experience that the female reproductive system of the scorpions studied is evident before the ultimate instar. Maturity is determinable in a variety of ways: (1) association with young, (2) possession of a spermatocleutrum (this is present in the operculum after mating and can be detected without dissection), (3) presence of embryos, (4) presence of conspicuous diverticulae, (5) obviously post-parturition, (6) of similar size to adult females from the same locality, especially when collected with them.

The nature and length of time of preservation of some female specimens in old collections was such that the state of development of the genital systems (and hence maturity) could not be determined with surety. Measurements of these specimens have been excluded, i.e. it was not possible always to determine the exact lower limit of adult female size in all the available material.

## TAXONOMY, VARIATION AND DISTRIBUTION OF SPECIES

Sixty of the characters of diagnostic value in separating taxa into categories (e.g. families, species-groups) are shown for the individual species in Table 1. Dendrograms and other results obtained from the statistical analysis of this data will be published elsewhere.

### FAMILY BOTHRIURIDAE Simon, 1880 Subfamily Bothriurinae Maury, 1971 Genus *Cercophonius* Peters

*Cercophonius* Peters, 1861: 509. Type species *Scorpio* [*Telegonus?*] *squama* Gervais, 1844: 227 (by monotypy).

*Acanthochirus* Peters, 1861: 509. Type species *Acanthochirus testudinarius* Peters, 1861: 509 (by monotypy). [= *Cercophonius squama* (Gervais, 1844).]

#### Distribution

Australia and Tasmania.

#### Species included

*Cercophonius squama* (Gervais, 1844).

TABLE 1:  
CHARACTERS SEPARATING TAXA

	BOTHRIRIIDAЕ		BUTHIDAE				SCORPIONIDAE																								
	<i>Cercophonius squama</i>	<i>Lychas marmoreus</i>	<i>L. variatus</i>	<i>L. alexandrinus</i>	<i>Isometroides vescus</i>	<i>Isometrus maculatus</i>	<i>L. melanodactylus</i>	<i>Locheles australasiae</i>	<i>L. waigiensis</i>	<i>L. karschii</i>	<i>Trodacus manicatus</i>	<i>U. elongatus</i>	<i>U. novaeollandiae</i>	<i>U. planimanus</i>	<i>U. centralis</i>	<i>U. armatus</i>	<i>U. koolanensis</i>	<i>U. megamastigus</i>	<i>U. varians</i>	<i>U. hoplurus</i>	<i>U. gilvianii</i>	<i>U. carinatus</i>	<i>U. macrurus</i>	<i>U. excellens</i>	<i>U. spinatus</i>	<i>U. lowei</i>	<i>U. similis</i>	<i>U. hartmeyeri</i>	<i>U. yaschenkoi</i>		
General Size																															
1. Overall size (based on adult male CL): (1) Small, (2) Large.	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
2. Trunk width in relation to its length: (1) Slender, (2) Robust.	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
3. Tail width in relation to trunk width: (1) Small, (2) Intermediate, (3) Large.	2	2	2	3	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Colour	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
4. Variegation: (1) Present, (2) Absent.	3	3	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
5. Background colour of tergites, hands and first three tail segments: (1) Dark, (2) Medium, (3) Light.																															
Carapace																															
6. Frontal notch: (1) Present, (2) Absent or practically absent.	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7. Frontal lobes: (1) Truncate, (2) Rounded.	2	1	2	1	1	1	2	2	2	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8. Interocular areas: (1) Smooth, (2) Sparsely granulate, (3) Densely or coarsely granulate.	1	3	3	3	3	3	1	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9. Posterior two-thirds: (1) Smooth or with some fine scattered granules, (2) Granulate.	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10. Median sulcus: (1) Uninterrupted, (2) Intermediate, (3) Interrupted or slightly interrupted, (4) Widely interrupted.	1	4	4	4	4	4	4	1	1	3	3	1	1	2	3	2	3	1	2	1	2	1	2	1	2	1	1	1	1	2	









## Description

Carapace with ocular tubercle closer to anterior than to posterior edge. Chelicerae (Fig. 13) having fixed jaw with median tooth larger than basal tooth. Movable jaw with distal external tooth wide, rounded at apex; subdistal tooth small; median tooth large usually wide at apex; basal tooth wide. Last sternite from smooth to with granulate longitudinal ridges. Subaculear prong absent. Hand of male with prong near base of fixed finger. Movable finger of hand with along edge one to five main rows of granules often reducing to one row at apex; a transverse accessory row of 6 teeth along inner edge of the main row(s). Legs with tarsal spine small. Terminal claws of legs equal. Ventral surface of tarsomere II of fourth pair of legs with an inner and an outer row of prongs, and with dense fine moderately long white hairs. Pectines with central lamellae rounded, arranged as a single series.

## Affinities

Maury (1971, and personal communication) rejects Birula's (1917a) suggestion of a separate subfamily for *Cercophonius* and the name Cercophoninae of Birula (1917b). Maury (personal communication) says that from the specimens he has examined it is not possible to classify the Australian genus *Cercophonius* in a separate subfamily from the other bothriurid genera (which are in South America).

I find that in many features of external morphology *Cercophonius* appears closest to *Urophonius* Pocock, 1893. The two genera differ only in minor features, a comparison of salient differences between *C. squama* and two *Urophonius* species, *U. jeheringi* Pocock, 1893, and *U. brachycentrus* (Thorell, 1877) being as follows:

	<i>Cercophonius</i>	<i>Urophonius</i>
Ocular tubercle	closer to anterior than to posterior edge of carapace	at middle of carapace
Last sternite	ranging from smooth to with granulate longitudinal ridges	coarsely granulate anteriorly
Teeth along movable finger	close-set irregular granules in 1-5 rows	granules in 2 irregular rows
Ventral surface of tarsomere II of the two posterior pairs of legs	clothed in moderately long hairs and armed with 2 pairs of prongs	clothed in long hairs and armed with 5-6 pairs of prongs

In some of these features *Cercophonius* is closer to the other genera than to *Urophonius*, e.g. with regard to the prongs on the two posterior pairs of legs *Cercophonius* is closer to *Timogenes* Simon, 1880. The structure of the paraxial organ of *Cercophonius* is close to that of *Bothriurus flavidus* (Maury 1971) but is simpler than that of most bothriurid genera in South America, e.g. *Bothriurus rochensis* and *B. bucherli* (San Martin 1965a) (e.g. it lacks a well-developed spiniform process on the internal lobe). In many features, however, the paraxial capsule of *Cercophonius* is somewhat more complex than that of the newly described Chilean genus *Tehuankea* Cekalovic (1973).

I am satisfied that the above generic distinctions are of the same order as the generic differences that I see between other genera in Australia.

*Cercophonius squama* (Gervais)  
(Figs 13, 39, 68, Maps 1, 31)

*Scorpio* [*Telegonus?*] *squama* Gervais, 1844: 227; Walckenaer & Gervais, 1844: 64.

*Cercophonius squama* (Gervais) Peters, 1861: 509; Thorell, 1877: 178; Karsch, 1879: 22; Keyserling, 1885: 36; Kraepelin, 1894: 236; Kraepelin, 1899: 199; Takashima, 1945: 102; Maury, 1971: 32.

*Acanthochirus testudinarius* Peters, 1861: 509.

*Cercophonius michaelsoni* Kraepelin, 1908: 102; Takashima, 1945: 102; Glauert, 1963b: 183. *Syn. n.*

*Cercophonius granulatus* Kraepelin, 1908: 103; Takashima, 1945: 102; Glauert, 1963b: 182. *Syn. n.*

*Cercophonius sulcatus* Kraepelin, 1908: 103; Takashima, 1945: 102; Glauert, 1963b: 182. *Syn. n.*

*Cercophonius kershawi* Glauert, 1930: 109; Takashima, 1945: 102. [Holotype examined.] *Syn. n.*

Range (Map 1)

Western Australia, mainly south-western, furthest north at Learmonth-Exmouth, also at Cue. South Australia, south-eastern including Kangaroo I. Victoria, furthest north at Merbein. Tasmania, widespread except in south-west; present on Flinders I. and King. I. New South Wales, eastern. Queensland, south-eastern; furthest north-west at Yarraman. Northern Territory, only a relict population at Alice Springs.

Measurements (mm)

♀. Hobart, Tasmania, AM. Total length 39, of tail 20; carapace, length 4.1, width 4.3; tail segments one to five (in that order), length 2.3, 2.6, 2.9, 2.8, 4.5, width 2.6, 2.2, 2.3, 2.2, 2.1, height, 2.2, 2.0, 2.0, 1.9, 1.7; length of vesicle and aculeus 5.1; width of vesicle 1.9; length of humerus 2.9; bra-

chium, length 3.5, width 1.5; hand, length 3.0, width of hand surface 1.9, height 1.6; length of hand and fixed finger 6.8; length of movable finger 3.9; length of pectine 2.8.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=16)									
Min.	2.6	2.6	2.0	1.2	0.9	4.0	2.8	1.9	1.1
Max.	3.6	3.8	3.1	2.1	1.6	6.0	4.3	2.8	1.7
Mean	3.1	3.2	2.6	1.6	1.3	5.4	3.3	2.4	1.4
SD	0.30	0.34	0.32	0.26	0.22	0.57	0.37	0.31	0.19
Female (n=49)									
Min.	3.2	3.3	2.4	1.3	1.1	4.7	2.7	2.0	1.4
Max.	4.5	5.2	4.3	2.9	2.3	8.2	5.0	3.1	2.7
Mean	3.8	4.1	3.0	1.9	1.6	6.2	3.7	2.5	1.8
SD	0.31	0.44	0.37	0.27	0.22	0.67	0.47	0.24	0.21

#### Diagnosis

As given in description of genus.

#### Description

Colour light creamy yellow to orange-brown with darker variegations of light to dark brown. Fewer variegations in specimens from more northern parts of range. Tergites with light median stripe wide and continuous to continuous in anterior tergites but narrowing anteriorly in posterior tergites. Ventral aspect mainly light cream. Hand keels sometimes defined by dark colouring. Vesicle yellow with or without dark brown sulci, lateral stripe or patchy lines.

Carapace with frontal notch absent to shallow, usually scarcely defined. Frontal lobes gradually rounded at outer edge. Interocular areas smooth. Lateral and posterior two-thirds of carapace smooth, occasionally with some scattered granules especially laterally. Median sulcus uninterrupted. Triangular depression deep centrally. Sides of triangular depression swollen inwards. Ocular tubercle large. Median eye furrow not deep when crossing ocular tubercle. Median eyes slightly closer to anterior than to posterior edge of carapace. Median eyes large, distance apart slightly more than eye diameter. Lateral eyes three, anteriormost near edge of carapace.

Chelicerae (Fig. 13) as for genus.

Tergites of first six abdominal segments smooth, sometimes with granules posterolaterally. Pretergite narrow, of practically uniform width. Tergite of last abdominal segment with scattered fine to coarse granules enlarging posteriorly and present mainly near keels. Median and lateral keels granulate with granules enlarging posteriorly.

First four sternites smooth, shining, unkeeled. Last sternite varying from smooth to having granules posteriorly in keel areas. Keels ranging from absent to faintly ridged to irregularly ridged and indefinite to well defined by coarse granules.

Tail long, thick. First four tail segments (Fig. 39) squat. Dorsal, and dorsolateral intercarinal surfaces smooth, irregularly smooth, or mainly smooth with some scattered fine to coarse granules especially posteriorly. Ventral intercarinal surfaces irregularly smooth, irregularly ridged, or with fine to coarse scattered granules especially posteriorly in more proximal segments. Dorsal keels with prominent rounded denticles to moderately coarse irregularly spaced granules. Terminal denticle or granule scarcely enlarged. Lateral keels granulate to crenulate. Ventral keels ranging from absent to weakly defined by granules to well defined by spaced coarse granules or crenulations. Accessory keel in first segment present mainly posteriorly, in second segment weak, in third and fourth segments practically absent. First tail segment ventrally ranging from smooth to irregularly smooth to irregularly ridged. Ventrolateral keel absent to strongly irregularly ridged. Ventromedian keels ranging from absent to weakly ridged to strongly irregularly ridged to prominently denticulate. Median sulcus enclosed between ventromedian keels from absent to wide. Fifth tail segment with lateral and ventrolateral intercarinal surfaces smooth, sometimes with a few scattered granules, coarse posteriorly; ventral intercarinal surfaces smooth to with coarse denticles usually centrally and especially posteriorly. Ventrolateral keels with coarse denticles increasing in size posteriorly. Ventromedian keel granulate to coarsely denticulate, bifurcating posteriorly often at extremity; sometimes with additional denticles posteriorly and a row of denticles along posterior edge of segment.

Vesicle small, moderately elongate. Smooth except for being ventrolaterally rugose to granulate, especially proximally.

Aculeus moderately short, moderately curved.

Humerus smooth, sometimes with some granules. Keels crenulate to granulate.

Brachium smooth. Anterodorsal keel smooth to crenulate, sometimes partly denticulate mainly distally. Ventral group, *v*, with 3 trichobothria.

Hand small, squat. Intercarinal surfaces smooth. Keels smooth. Ventral group, *V*, with 5 trichobothria.

Fingers long. Along edge of movable finger 1-5 rows of granules along base and middle often reducing to 1 row at apex. A transverse accessory row of 6 teeth spaced along inner edge of main longitudinal row(s).

Legs with tarsomere I of first pair dorsally with 0-2 prongs, usually 1 (centrally positioned). Ventral surface of tarsomere II of fourth pair of legs

with 2 (sometimes 3) inner and 2 (sometimes 1) outer prongs, and with dense fine moderately long white hairs.

Pectinal teeth 13-20 (Mean 16.8, SD 0.54), in male; 11-18 (Mean 14.6, SD 1.32) in female.

Paraxial organ (Figs 68, 69) with lamina broad, moderately short, with a prominent long but narrow crest at apex; inner lobe short; external lobe moderately pointed, a small spiniform process present; basal lobe long, well developed, pointed at apex; a well-developed spiniform process present at base of basal lobe.

#### Material examined

61♂, 338♀ (Map 1).

#### WESTERN AUSTRALIA

Albany, ix.1923, (J. Clark) 1♀, 23/223, WAM. Amery, 24.xi.1928 (Whiteford) 2♀, 28/1146-7, WAM. Applecross, 12.v.1963 (G.M. Riley) 1♀, 66/261, WAM. Augusta, 20.iii.1930 (E.W. Bennett) 1♂, 30/239, WAM; Jewel Cave, 1.ii.1963 (P. Sundstrom) 1♀, 73/801, WAM. Babakin, 21.vii.1925 (J. Pollard) 1♀, 25/499, WAM. Balla, near Ogilvie, 30.vi.1933 (A.J. Horan) 2♀, 33/1577-8, WAM. Beedelup Falls, 27.vii.1969 (J.A. Springett) 1♂, 73/295, WAM. Bencubbin, 16.vi.1924 (V.J. Hawkins) 1♀, 24/593, WAM. Bindoon, South, 23.iv.1927 (L. Glauert) 1♀, 27/675, WAM. Black Snake (Camp 57) 28.iv.1924 (D.G. Page) 1♀, 24/351, WAM. Bolgart, 13 km W of, 14.v.1963 (W.H. Butler) 1♀, 73/313, WAM. Boranup, 10.ix.1965 (G.M. Riley) 1♀, 66/250, WAM; 11.ix.1965 (G.M. Riley) 2♂, 1♀, 66/247-9, WAM; 10.ix.1969 (G.M. Riley) 1♀, 73/362, WAM. Bulong, 21.vii.1925 (F. Jones) 1♀, 25/497, WAM; 10.viii.1931 (F. Jones) 1♀, 31/804, WAM. Byford, 16.ii.1969 (K.F. Fletcher) 1♂, 73/299, WAM. Caladenia Cave, Gingin, 7.vi.1973 (R. Roe & S. Sofoulis) 1♀, 73/351, WAM. City Beach, 19.vi.1963 (L.N. McKenna) 1♀, 73/316, WAM. Cocklebidy, 23 km ESE of, 4.ix.1969 (W.K. Youngson & A. Baynes) 1♂, 73/288, WAM. Cue, 14.iii.1924 (Goeldner) 1♀, 24/189, WAM. Dalkeith, 1.v.1963 (J. Lawson) 1♀, 73/309, WAM. Darkan, 8 km SW of, 5.vi.1917 (W.J. Wunnenberg) 2♀, 17/194-5, WAM; 7.vi.1924 (W.J. Wunnenberg) 4♀, 24/574-7, WAM; iii.1925 (W.J. Wunnenberg) 1♀, 25/200, WAM. Deepdene, cliffs area, 15.xi.1969 (M. Archer & E. Jefferys) 1♀, 73/291, WAM. Denmark, 28.ii.19??, 1♂, 73/361, WAM. Devils Lair, 14.ii.1972 (C. Dortch, D. Merrilees et al) 2♀, 73/349-50, WAM; 6-21.iii.1973 (A. Baynes et al) 5♂, 14♀, 73/330-48, WAM. Drummond Cove, 11 km N of Geraldton, 12.viii.1972 (N. McFarland) 1♀, 73/276, WAM. Dwellingup, 12.v.1972 (J.A. Springett) 1♀, 73/310, WAM; 5 km E of, 24.iii.1971 (W.H. Butler) 1♂, 2♀, 73/293, 73/290, 73/311, WAM. Esperance, 7.vi.1973 (T. McNeill) 1♂, 1♀, 73/326-7, WAM. Frankland River, near Circular Pool, 25.i.1968 (G.W. Kendrick) 1♀, 73/365, WAM. Freshwater Bay, 3.vi.1924

(L. Glauert) 2♀, 24/551-2, WAM. Geraldton, 3.vi.1970 (A. Smythe) 1♂, 73/294, WAM. Glen Forrest, 18.v.1973 (S.M. Wade) 1♂, 73/318, WAM. Harvey, 1♀, K10836, AM. Helena River, 26.vi.1963 (J. Dell) 3♀, 73/265-7, WAM. Hoffmans Bush (Yarloop), x.1925 (G.H. Granger) 1♀, 25/796, WAM. Hyden, v.1969 (Green) 2♂, 73/263-4, WAM. Jarrahwood, 1.viii.1967 (R.H. Smith) 1♀, 73/319, WAM. Jeramungup, N of, 9.vii.1963 (A. Robinson) 1♀, 73/283, WAM. Kalbarri, 6.vi.1973 (M.M. Marsh) 1♂, 73/646, WAM; Red Buff, pres. vi.1972 (D. Bellairs) 1♂, 73/284, WAM. Kalamunda, 5.vi.1960 (R.P. McMillan) 1♀, 73/363, WAM. Karrinyup, 1.v.1963 (K. May) 1♀, 73/353, WAM. Kings Park, 7.vii.1968 (E.G. Cockett) 5♀, 73/354-8, WAM. Learmonth-Exmouth, v.1969 (N. Cross) 1♀, 73/277, WAM. Ludlow, 30.x.1923 (J. Clark) 1♀, 23/224, WAM. Manjimup, 8.vii.1924 (G. Betty) 1♀, 24/637, WAM; 21.v.1945 (K. Howell) 1♀, 45/292, WAM. Margaret River, SW of, 4.iii.1967 (A. Baynes) 2♀, 73/314-5, WAM. Merredin, 8 km SE of, 27.vii.1927 (J. Teasdale) 1♀, 73/268, WAM. Mosman Park, 15.ii.1966 (G. W. Kendrick) 1♀, 73/312, WAM. Mt Burnside, near Shannon Mill, 5.iii.1970, 1♀, 73/300, WAM. Mt Cooke, 12.v.1968 (E.G. Cockett) 3♀, 73/305-6, 73/317, WAM. Mt Helena, 28.vii.1927 (C.F. Mottram) 2♀, 27/874-5, WAM. Mt Mathilda, Wongan Hills, 2.vi.1963 (G.F. Mees) 2♀, 73/278-9, WAM. Mt Yokine, 28.iv.1957 (I. Murray) 2♂, NM. Mundaring, 20.vii.1967 (L.E. Koch & K.T. Zwicky) 1♀, 73/321, WAM; 6.v.1972 (J.A. Springett) 2♀, 73/269-70, WAM. Mundaring Weir, 1.vii.1962 (J. Dell) 2♀, 73/274-5 WAM; 2 km W of, 10.vii.1963 (J. Dell) 1♂, 73/324, WAM. Nornalup, 3.v.1924 (G.E. Nicholls) 1♂, 1♀, 24/408-9, WAM; 31.xii.1932 (Nicholls) 3♂, 5♀, 34/2808-12, 12a, 12b, 13, WAM. North Tarin Rock Reserve, 17-27.v.1971 (D. Kitchener, L.A. Smith & R. Johnstone) 1♀, 73/352, WAM; 23.v.1971 (A. Baynes) 1♂, 1♀, 73/281-2, WAM. Pemberton, 24.v.1928 (R.C. Whiteford) 2♂, 2♀, 28/517-20, WAM; 6.iii.1970 (G.W. Kendrick) 1♀, 73/292, WAM; 9.xi.1971 (J.A. Springett) 1♂, 73/301, WAM; 3.xi.1971 (J.A. Springett) 1♂, 73/289, WAM; 5 km N of, 13.v.1969 (G.W. Kendrick) 1♀, 73/360, WAM. Pemberton-Vasse, 23.ix.1971 (J.A. Springett) 1♂, 2♀, 73/302-4, WAM. Perth, 4♀, SAM. Perup and Tone Rivers, between upper reaches of, 6-12.v.1972 (W.H. Butler) 3♀, 73/296-8, WAM. Porongurups, 20.i.1932 (E. W. Bennett) 1♀, 32/221, WAM. Quindalup, viii.1925 (G.F. McGregor) 1♀, 25/527, WAM. Roleystone, 15.iii.1924 (G. Clark) 1♀, 24/192, WAM. Rottnest I., 1♀, SAM. Salmon Gums, 15.viii.1941 (A.R. Brown) 1♀, 31/819, WAM. Scarborough, vi.1958 (D. Stewart) 1♀, 66/340, WAM. Serpentine Falls, 27.vii.1969 (G.W. Kendrick & S. Slack-Smith) 2♀, 73/272-3, WAM. Sorrento, 25.v.1971 (N. Coleman) 1♀, 73/322, WAM. Southern Cross, 16.vi.1924 (W.E. Richards) 1♀, 24/594, WAM. Stirling Range, north side of Bluff Knoll, 22.i.1970 (G.W. Kendrick) 1♀, 73/285, WAM; 1.iii.1970 (G.W. Kendrick) 2♀, 73/286-7, WAM. Spearwood, 4.vii.1968 (L.M. Marr) 1♀, 73/325, WAM. Walk Walkin, 48 km NE of Dowerin, 2.vi.1924 (G.F. Best) 1♀, 24/539, WAM. Walpole, 2.iv.1963 (H.F.C. Thomas) 1♀, 73/320, WAM;

20.i.1968 (G.W. & P.G. Kendrick) 1♀, 73/307, WAM; 28.i.1971 (P.G. & Kendrick) 1♀, 73/308, WAM. Westonia, 1.vii.1969 (W. Bishop) 1♀, 73/271, WAM. Yallingup, 1♀, 26/794, WAM. Yanchep, 23.iv.1969 (M. Archer, A. Baynes & M.E. Finch) 1♀, 73/323, WAM.

#### SOUTH AUSTRALIA

Kangaroo I., x.1905 (A.J. Campbell) 1♀, NM. Lucindale, 2.vii.1900 (E. Feuerhardt Crower) 5♀, SAM. Mt Lofty Range, Nortons Summit (A. Zietz) 3♀, NM. Port Augusta, 22.vi.1899 (W.R. Kirton) 1♀, SAM. Purnong, 30.vi.1911 (M. Fulton) 2♂, 3♀, NM. 'Tanunda & Murray Flats', 1907-1911 (Krismann) 2♀, E.3, SAM. Wynarka (L.G. Thorpe) 1♀, SAM.

#### VICTORIA

Ararat, iv.1927 (H.W. Dave) 2♀, 27/825-6, WAM. Bairnsdale, v.1934, 1♀, NM. Belgrave, 15.vii.1948 (G. Bland) 1♀, 18.ix.1948 (G.A. Crocker) 1♀, NM. Blackburn, 23.v.1958 (R. Sieger) 1♂, NM. Boronia, ix.1955 (Fleet) 1♀, NM. Brighton, 1♀ and 3 young, NM; near, 2♂, 2♀, NM. Bruthen, 3.i.1918 (J. Barling) 6♀, NM. Camberwell, 6.ii.1921 (Roberts) 1♀ and 17 young, NM. Cape Otway, 9.x.1952 (E.M.) 1♀, NM; 1♀, NM. Castlemaine, 31.v.1926 (J.E. Dinoir) 1♀, 26/298, WAM. Cockatoo, xii.1926 (G. Hill, Jnr) 2♀, NM. Dandenong Range 3♀, NM. Donvale, 23.iv.1969 (R. Warnecke) 1♂, NM. Emerald, viii.1904 (C.A. Jarvis) 1♀, NM, 4♀, 73/366-9, WAM. Fern Tree Gully, 12.ix.1913 (A. Burns) 1♀, NM; 16.ix.1947 (K. Pyle) 1♀, NM; 2♀, NM. Forrest, 19.xii.1946 (C.W.B.) 1♀, NM. Gellibrand, 19-23.i.1932 (J. Clark) 1♀, NM. Gippsland, 31.v.1926 (J.E. Dinoir) 3♀, 26/295-7, WAM. Glenbrook (?), (C. French) 1♂, 1♀, NM. Grampian Range, xi.1887 (W. Kershaw) 2♀, NM; Zumsteins, 30.ix.1954 (Neboiss) 1♀, NM; x.1954 (H.A. Morrison) 1♀, NM. Hawthorn, 24.ix.1952 (L.H. Burgess) 1♀, NM. Healesville, 25.v.1914 (R. Kelly) 1♂, 2♀, NM; 12.vi.1914 (R. Kelly) 2♀, NM; 10.i.1915 (R. Kelly) 3♀, NM. Kallista, 26.viii.1950 (A.N. Burns) 1♀, NM. Lake Hattah, Mallee (J.E. Dixon) 1♀, NM. 'Mallee', 23.ii.1914 (C. French) 1♀, NM; C. Frost Coll. (D. Best) 5♀, NM. Melbourne, near, 26.iii.1962 (McCarthy) 1♀, NM. Merbein, 12.vi.1948 (C.Oke) 1♀, NM. Mordialloc, 1.viii.1912 (F.W. Baillie) 2♀, NM. Mt Baw Baw, 24-27.i.1914 (Armytage) 1♂, NM. Neerim, Gippsland, 20.iv.1906 (S.W. Fulton) 1♂, 1♀, NM. Outtrim, S. Gippsland, 31.iii.1900 (F.E. Kitson) 1♀, NM. Ouyen, 22.vi.1912 (Hall) 1♀, NM (holotype of *Cercophonius kershawi*); 4.xi.1912 (W.A. Hall) 1♀, NM. Paradise Beach, near Sale, iv.1962 (Gray) 1♂, NM. Raymond I., near Bairnsdale, 10.viii.1906 (Wilson) 1♀, NM. Redcliff, pres. 1.xii.1923 (A.S. Cudmore) 1♀, 73/364, WAM. Ringwood, 15.viii.1948 (A.B.) 1♀, NM. Rosebud, 6.i.1968 (J.C. Le Souef) 1♂, 73/359, WAM; 20.i.1968 (J.C. Le Souef) 1♀, 73/328, WAM. Sale, 15.vi.1949 (J. Mitchell) 1♀, NM. Sandringham, 1893, 1♂, 1♀, NM. Snowy & Broadbent Rivers, xii.1947 (C.W.B.) 1♀, NM. Stoney Creek, vii.1953 (C.W.B.) 1♂, 1♀, NM. Upper Fern Tree Gully, iv.1927, 1♀ and

14 young, 27/824, WAM. 'Victoria', 12.iii.1909 (Preston) 1♀, NM; (Preston) 1♀, NM; 1♀, NM. Walpeup, vi.1928 (S. Butler) 1♀, 28/617, WAM; 1♀, NM. Warburton, 11.iv.1905 (J.A. Kershaw) 1♀, NM; 28-29.ix.1946 (C.W.B.) 1♀ and 4 young, NM. Warburton & Corods Point Track, 1.i.1902 (Fulton) 1♀, NM. Wilsons Promontory, xii.1905 (J.A. Kershaw) 1♂, 3♀, NM.

## TASMANIA

Ansons Bay, 2.i.1967 (A.J. Dartnall) 1♀, J550, TM. Babel I., Furneaux Group, 24.vii.1968 (J. Whinray) 1♀, NM. Bald Hill (?), 10.vii.1951, 2♀, 1951.13.12, QVML. Battery Point, xii.1962 (J.F. Greenhill) 1♀, 16988/J503, TM; (Downing) 1♀ and 8 young, J433/651, TM. Blackmans Bay, 10.ix.1937 (Rodway) 1♀, J480, Sa4, TM. Boat Harbour, 11.i.1949 (T. Greaves) 1♀, AM. Bridport, xii.1915, 1♀, AM. Brighton, 15.ix.1937 (T. Mitchell) 1♂, J485, Sa5, TM. Bruny I., ii.1972 (N. Coleman) 1♀, 73/329, WAM. Cascades, 29.viii.1937 (D.T.) 3♀, J488, Sf 31, TM. Devonport, 3.ii.1938 (A. Webber) 1♂, J478, Sa7, TM. Dunrobbin, 16.ix.1963 (R. Mawbey) 1♀, 18102/J293, TM. Flinders I., 3♀, 1957-13-102, QVML; 24-31.v.1962, 1♂, NM. Hobart, 26.xi.1943 (Bower) 1♀, J489, TM; x.1961, 1♀, 17584/J284, TM; (M.W.F. Tweedie) 1♀, AM: Huon Road, 3.ix.1937 (D.C. Pearse) 1♀, J490, Sa2, TM. 'Islands Bass Strait' (J.A.K.) 1♀, 12:08, NM. King I., xii.1906 (J.A. Kershaw) 1♀, NM; 15.xii.1946 (A.D. Hardy) 1♂, NM. Launceston, 4.i.1928, 2♀, NM; (N. Plomley) 1♀, 1957.13.107, QVML; (E. Butler) 1♀, 1957.13.108, QVML. Lawrence Vale Road (?), i.1951 (C.C. Lawrence) 1♀, 1951.13.3, QVML. Marion Bay, 14.iii.1964 (E. Aves) 1♂, J371, TM. Moina, 3.xii.1964 (R. Mawbey) 3♀, J459, TM. Montrose, Glenorchy, xi.1963 (M. Flame) 1♀, 18578/J344, TM. Moorina, 22.i.1962, 1♀ and 24 young, 1962.13.2., QVML. Mt Rumney, 6.ix.1937 (A.W.G.P.) 1♀, J481, Sa3, TM. Mt Wellington, 20.iv.1928 (G.E. Nicholls) 1♂, 28/451, WAM. Naracoopa, King I., i.1938, 1♂, NM. New Town, Hobart, 17.v.1963, 1♀ and 9 young, 18113/J295, TM. Notley Gorge (E. Scott) 1♀, 1957.13.105, QVML. Orford, ix.1938 (J.W. Evans) 1♀, J482, Sa8, TM; iv.1948 (M. Winch) 1♀, NM. Penguin, 27.viii.1964 (L.N. McKenna) 2♀, 66/263-4, WAM. Ridgeway, 10.v.1948 (C. Oke) 2♀, NM; viii.1948 (Tagg) 2♀, NM. Snowy Mountains, Huon, i.1939 (C.D. King) 3♂, J479, Sa32, TM. Spreyton, xi.1937 (State School) 2♀, J483, Sa33, TM. Stanley (W. Partridge) 1♀, 1957.13.104, QVML. Swanport, 23.viii.1966 (Museum Staff) 1♀, J569, TM. Taroon, Hobart, 30.i.1952 (J. Lane) 7 young, J477, TM. 'Tasmania', 2♀, J484, Sa1, TM; 1♀, AM. Tunnell, 1♀ and 21 young, 1957.13.101, QVML. West Tamar (E. Butler) 1♂, 1957.13.110, QVML. Wilmot, 8.xii.1964 (R. Mawbey) 3♀, J460, TM.

## NEW SOUTH WALES

Antonio, via Rydal, 1♀, K19349, AM. 'Bourke and Wilcannia, Darling River floods', v.-vi.1890, 1♀, K48681, AM. Chatswood, 1♀, K42283, AM.

Collaroy, 8.viii.1927, 1♀, 27/1553, WAM. Como, 1♀, K12964, AM. Dee Why, vi.1949 (N.J. Nelson) 1♀, AM. Duckmoloi, i.1934, (J.C. Wilburd) 1♀, AM. Engadine, Illawarra line, 22.viii.1929 (H. Blackers) 1♀, AM. Goulburn, 1♀, K8125, AM. Island Bend, 26.xi.1952 (J. Armstrong) 1♀, AM. Lake Burrill, 12.x.1931 (W.W. Thorpe) 1♀, AM. Lane Cove, vii.1935 (Patterson) 1♀, AM. Laurieton, 22.vi.1961 (A. Holmes) 1♀, AM. Manning River, 6 km from Tubrabucca, Upper Hunter Dist., 12.i.1948, 1♀, AM. Mt Irvine, Blue Mountains, 14.xi.1944 (Troughton) 1♀, AM; (W. Smart) 1♀, AM. Narara, 30.xii.??1♀, NM. Newport, Pittwater, 3.x.1927 (E. Langhorne) 1♀, K56861, AM. 'N.S.W.', 2♀, K13329, AM. Oberon, Blue Mountains, 5.vi.1956 (F.B. Dann) 1♀, AM; 42 km S of, Jaunter Range, 18.iv.1965 (J. Walsh) 1♀, AM. Pymble, near Sydney, xi.1954 (K. Shipway) 1♀, AM. Rockton, 1937 (A.J. Barrett) 1♀, AM. Roseville, 1♀, K17878, AM. Sydney, 1♀, K3683, AM. Wahroonga, 11.iv.1956, 2♀, AM. Wiangaree State Forest, 28.xi.1970 (G.B. Monteith) 1♀, UQ.

#### AUSTRALIAN CAPITAL TERRITORY

Brindabella Range, 21.ii.1971 (G.B. Monteith) 1♀, UQ. Mt Aggie, 3 km N of, 25.viii.1966 (R.W. Taylor) 1♀, AM. Mt Ginini, Brindabella Range, 14.iv.1963, 1♀, AM.

#### QUEENSLAND

Brisbane, 22.vi.1958 (R. Bucknell) 1♀, UQ. Bunya Mountains, 5.vi.1959, 1♀, UQ. Lamington National Park, 5.vi.1958 (E.M. Exley) 1♂, 2♀, UQ; v.1958, 2♀, UQ; 26.v.1959, 1♂, 1♀, UQ; 27.v.1959, 1♀, UQ; 13.vi.1971 (E. Jefferys & M. Archer) 1♀, 73/280, WAM. Mt Tamborine, 9.v.1949 (A. Burns) 2♀, NM; (A.M. Lea) 1♀, SAM. Tamborine, 4.vi.1959 (F.A.P.) 1♀, UQ. Yarraman, 19.iv.1957, 1♀, UQ.

#### NORTHERN TERRITORY

Alice Springs, 7.vi.1969 (J.C. Le Souef) 1♀, NM.

#### (?) NEW HEBRIDES

3♀, 532, AM.

#### Remarks

Kraepelin (1908) described the three nominal species, *C. michaelsoni*, *C. granulatus* and *C. sulcatus*, but stated that they were based on small series which did not enable him to come to definite conclusions on the extent of the variation nor to state positively that the slight differences from the typical *C. squama* must in all cases be considered as specific. In the present study, the variation exhibited by all the *Cercophonius* material examined is found to be of a continuous intraspecific nature.

The slight morphological differences from southern forms that is exhibited by the specimen from Alice Springs, N.T., is consistent with the expected variation due to its geographic location, i.e. it shows the same trends exhibited by the members of *C. squama* that occur at low latitudes in Western Australia, e.g. the specimens from Learmonth-Exmouth. This specimen from Alice Springs is considered to belong to a relict population from a once continuous distribution of *C. squama*. The implications of a somewhat parallel finding of a leptodacylid frog, *Pseudophryne occidentalis*, from the Everard Range, S.A., are discussed by Tyler (1971); and an even better example is the lizard, *Lerista frosti* (Storr 1972).

The three females from Stirling Range, W.A., are large (adult CL 4.4, 4.5, 5.5 mm). The plotted scores of the specimen (WAM Reg. No. 74/286) used in the multivariate analysis of shape appears as an isolated point in the graph even though it is the specimen with CL 4.5 and hence not the largest specimen. Inspection of all the measurement characters of these three specimens indicates that they are aberrant rather than merely large or larger than specimens from elsewhere. Morphologically, these specimens from Stirling Range are closest to specimens in Tasmania and Victoria, e.g. they are smooth ventrally and have up to five rows of teeth along the movable finger of the hand. I determine these specimens as *C. squama*, but no males are available to allow an indisputable checking of identity.

After considering the variation in genitalia and external characters, I conclude that all the forms constitute a single species, and furthermore these forms are best regarded as informal segments of that species and not as formal subspecies.

*C. squama* exhibits a great range of variation in two obviously independent characters of external morphology: (1) the texture of the ventral surface of the last sternite and of the first tail segment and the extent of development of ridges on these surfaces; (2) the intensity of colour and amount of variegation.

The ventral texture of the last sternite and first tail segment ranges from smooth to granulate and the ventral keels from absent to well defined by coarse granules. The colour variation ranges from orangish brown with dark variegations and a narrow light discontinuous mid-tergal stripe to greatly reduced variegation and a wide light continuous mid-tergal stripe.

Based upon the nature of these ventral textures and extent of definition of the ventral keels, six forms tabulated overleaf can be distinguished. These correspond as follows to the nominal species which in this study are included within the one valid species, *C. squama*.

Form	Surface texture	Keels	Previous (nominal) species
Last sternite			
1	smooth and shiny	absent	'squama'
2	smooth and shiny or coarsely granulate posteriorly	absent or with short granulate keels	'sulcatus'
3	smooth	faintly ridged	'kershawi'
4	somewhat granulate or irregularly ridged	granulate	'michaelseni'
5	coarsely granulate	absent	'granulosus'
6	granulate	granulate	'a form at Bourke and Wilcannia, N.S.W.'
First tail segment			
1	usually smooth and shiny	absent or with indications in posterior half	'squama'
2	irregularly ridged	duplicated ventral keel	'sulcatus'
3	smooth	strong and irregularly ridged	'kershawi'
4	smooth	irregularly ridged or indistinctly granulate	'michaelseni'
5	coarsely and irregularly ridged and granulate	absent	'granulosus'
6	smooth	granulate	'a form at Bourke and Wilcannia, N.S.W.'

A high proportion of the examined material of each of these forms occurs in certain segments of the distribution of *C. squama* (Map 31) as follows:

Tasmania, New South Wales, Queensland and south-east Victoria have 100% Form 1. (Segment G).

North-west Victoria (i.e. Lake Hattah, Merbein, Ouyen, Walpeup) has 100% Form 3. (Segment F).

South Australia has 77.8% Form 3 and 22.2% Form 1. (Segment E).

Northern Territory (Alice Springs) has 100% Form 5. (Segment D).

In Western Australia the distribution *C. squama* is divided for the present purpose into three segments, A, B and C, having the following locality limits (Map 31), and the forms of *C. squama* occur therein in the stated percentages.

Segment A.: North of 28°00'S, including Cue and reaching North West Cape. 100% Form 2.

Segment B.: South-west of a line through Jurien Bay, Moora, Merredin, Hyden and Hopetoun. 89.7% Form 2, 8.3% Form 4, 2.0% Form 1.

Segment C: Localities immediately to the east of Segment B. 100% Form 4.

Practically all the specimens belonging to the above forms of *C. squama*, which are based upon ventral texture, can be placed in two categories with regard to their colour and variegation characteristics. The amount of variegation was still evident in faded specimens enabling allotment of these specimens to the correct category on the basis of variegation. The two categories are:

- (1) Forms 1 and 2—dark with much variegation,
- (2) Forms 3, 4, 5 and 6—light with little variegation.

FAMILY BUTHIDAE Simon, 1879  
Subfamily Buthinae Kraepelin, 1899  
Genus *Lychas* Koch

*Lychas* Koch, 1850: 92 (not *Lychas* Koch, 1845: 1 = *Isometrus* Hemprich and Ehrenberg, 1828). Type species *Lychas scutillus* Koch, 1845: 3 (by subsequent designation).

*Archisometrus* Kraepelin, 1891: 75. Type species *Tityus marmoreus* Koch, 1845: 36 (by subsequent designation). [= *Lychas marmoreus* Koch, 1845].]

Distribution

Eastern Africa, part of Asia to Australia and Fiji.

Species included

In Australo-Papua: *Lychas marmoreus* (Koch, 1845); *variatus* (Thorell, 1877); *alexandrinus* Hirst, 1911.

Outside Australo-Papua: species in eastern Asia include—*L. mucronatus* (Fabricius, 1798); *L. scutillus* Koch, 1845; *L. variatus* (Thorell, 1877); *L. perfidus* (Keyserling, 1887); *L. infuscatus* (Pocock, 1890); *L. flavimanus* (Thorell, 1888); *L. shoplandi* Oates, 1888; *L. feae* (Thorell, 1889); *L. scaber* (Pocock, 1893); *L. rugosus* (Pocock, 1897); *L. laevifrons* (Pocock, 1897); *L. hendersoni* (Pocock, 1897); *L. nigrimanus* (Kraepelin, 1898); *L. nigriternis* (Pocock, 1899); *L. shelfordi* (Borelli, 1904); *L. gravelyi* Henderson, 1913; *L. albimanus* Henderson, 1919; *L. tweediei* Kopstein, 1937.

## Description

Carapace with keels absent or weak. Frontal lobes truncate to rounded, sloping inwards to mid-line. Chelicerae (Fig. 14) having fixed jaw with apex of subdistal tooth distant from median tooth and basal tooth which are long to extremely long; internal tooth present ventrally. Movable jaw ventrally with distal internal tooth, median internal tooth and basal internal tooth present; dorsally with distal external tooth large, subdistal tooth small but with base wide; median tooth large and pointed; basal teeth, two, small, close to each other but far removed from median tooth. Tergites of first six abdominal segments with central keel present, longitudinal (median and lateral) keels weak or absent. Last sternite of abdomen with one ridge, seldom three. Fifth tail segment with keels. Subaculear prong small to extremely large. Movable finger of hand with along edge one central row of teeth extending about one-third to half length of finger; central row followed distally by six to seven oblique rows of granules, including lateral granules. Tibial spurs present on third and fourth pairs of legs. Sternum longer than wide.

## Affinities

*Lychas* is close to *Isometrus* Hemprich & Ehrenberg, 1828.

### *Lychas marmoreus* (Koch)

(Figs 14, 40, 70, 71, Map 2)

*Tityus marmoreus* Koch, 1845: 36.

*Archisometrus marmoreus* (Koch) Kraepelin, 1891: 84; Kraepelin, 1899: 49.

*Isometrus bituberculatus* Pocock, 1891: 243. [Holotype examined.] *Syn. n.*

*Archisometrus bituberculatus* (Pocock) Kraepelin, 1895: 85; Kraepelin, 1899: 48.

*Lychas bituberculatus* (Pocock) Glauert, 1925b: 109; Takashima, 1945: 80; Glauert, 1963b: 183.

*Lychas marmoreus* (Koch) Kraepelin, 1908: 87; Kraepelin, 1916: 26; Kopstein, 1921: 124; Glauert, 1925b: 95; Takashima, 1945: 80; Glauert, 1963b: 183.

*Lychas marmoreus typicus* [sic] [= *L.m. marmoreus*] (Koch) Kraepelin, 1916: 27; Glauert, 1925b: 97; Glauert, 1963b: 183.

*Lychas marmoreus obscurus* Kraepelin, 1916: 27; Glauert, 1925b: 97.

*Lychas marmoreus nigrescens* Kraepelin, 1916: 27; Glauert, 1925b: 97.

*Lychas marmoreus splendens* Kraepelin, 1916: 28; Glauert, 1925b: 98; Glauert, 1963b: 183.

*Lychas jonesae* Glauert, 1925b: 110; Takashima, 1945: 84; Glauert, 1963b: 183. [Holotype examined.] *Syn. n.*

#### Range (Map 2)

Western Australia, western and southern; furthest north at Tambrey. South Australia, widespread including Greenly I. and Kangaroo I. Victoria, furthest south at Abbotsford. New South Wales, eastern, furthest north at Bourke. Northern Territory, south-western, furthest north at Napperby Hills.

#### Measurements (mm)

♂. Wangaratta, Vic., NM. Total length 33, of tail 21; carapace, length 3.6, width 3.1; tail segment one to five (in that order), length 2.9, 2.7, 2.7, 3.4, 5.1, width 1.6, 1.5, 1.3, 1.3, 1.2, height 1.5, 1.5, 1.7, 1.2, 1.3; length of vesicle and aculeus 4.1; width of vesicle 1.3; length of humerus 2.9; brachium, length, 3.3, width 1.2; hand, length 2.3, width of hand surface 1.1, height 0.9; length of hand and fixed finger 5.3; length of movable finger 3.5; length of pectine 3.4.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=2)									
Min.	3.6	3.1	2.3	1.1	0.9	5.3	3.5	3.4	1.2
Max.	3.6	3.2	2.4	1.1	1.0	5.7	3.6	3.8	1.5
Mean	3.6	3.2	2.4	1.1	0.9	5.5	3.5	3.6	1.3
Female (n=6)									
Min.	3.1	3.1	1.4	0.9	0.7	4.9	3.2	2.5	1.3
Max.	4.0	4.3	2.6	1.1	1.0	5.5	3.9	3.1	1.6
Mean	3.5	3.6	2.0	1.0	0.9	5.2	3.6	2.8	1.4
SD	0.31	0.41	0.42	0.81	0.10	0.28	0.27	0.27	0.10

#### Diagnosis

Distinguished from *L. variatus* and *L. alexandrinus* by the following combination of characters: colour light brownish yellow with dark dense

variegations; tail segments moderately squat to moderately elongate; vesicle moderately large and elongate, practically unkeeled subaculear prong triangular to elongate, blunt at apex.

### Description

Colour light brownish yellow with dark brown dense variegations, progressively darkening along tail segments with fifth tail segment and vesicle darkest.

Carapace with frontal notch absent to weak. Frontal lobes truncate, sloping inward to midline. Interocular areas and lateral and posterior two-thirds of carapace densely granulate. Median sulcus widely interrupted. Triangular depression extremely deep. Sides of triangular depression conspicuously swollen inwards. Ocular tubercle pronounced. Median eye furrow moderately deep where crossing ocular tubercle. Median eyes large, considerably closer to anterior than to posterior edge of carapace; distance apart slightly greater than eye diameter.

Chelicerae (Fig. 14) as for genus. Fixed jaw with the joined median tooth and basal tooth slightly longer than in *L. variatus* and *L. alexandrinus*. Movable finger with median tooth and basal tooth further apart than in *L. variatus* and *L. alexandrinus*.

Tergites of first six abdominal segments densely granulate with granules moderately coarse to coarse. Pretergite narrow. Central keel prominent, granulate, sharply defined. Median and lateral pairs of keels scarcely indicated. Tergite of last abdominal segment densely granulate. Central keel granulate, prominent mainly in middle of segment. Median and lateral pairs of keels granulate and prominent along most of segment length, with the granules slightly increasing in size posteriorly.

First four sternites smooth, with indications of indented lateral keels. Posterolateral part of third sternite granulate, fourth sternite with fine granules laterally. Posterior edge weakly granulate. Last sternite densely granulate. Median and lateral pairs of keels granulate and prominent in posterior three-fourths of segment.

Tail long, thick. First four tail segments (Fig. 40) moderately squat to moderately elongate. Intercarinal surfaces densely granulate with granules dorsally and dorsolaterally fine to coarse, ventrolaterally and ventrally fine. Dorsal keels of prominent denticles. Terminal denticle enlarged. Other keels granulate. Ventromedian keels double, widely separate. Accessory keel prominent, in first three segments extending whole length of segment, in fourth segment present mainly anteriorly. Fifth tail segment moderately short. Intercarinal surfaces granulate and denticulate. Keels weakly denticulate. Ventromedian keel extending whole length of segment, not bifurcating.

Vesicle moderately large, moderately elongate, practically unkeeled, smooth. Subaculear prong with apex bluntly rounded. Subaculear prong ranging from large with thorn in middle, through moderately large with thorn subterminal, to elongate with thorn weak or practically absent.

Aculeus long, moderately curved.

Humerus moderately long. Dorsal, anterior and posterior surfaces densely granulate, ventral surface less densely granulate to smooth. Keels with small denticles.

Brachium moderately long. Anterior surface densely granulate. Other surfaces ranging from with scattered granules to smooth. Anterodorsal keel with mainly small denticles, some coarse denticles.

Hand small, squat. Practically unkeeled. Surfaces smooth.

Fingers very long (about 2½ times hand length). Along edge of movable finger basally central row of teeth extending about one-third length of finger. Central row followed distally by 7 sets of teeth, with a total of 8 external and 6 internal accessory teeth spaced along these sets.

Legs with tarsomere I of first pair dorsally with no prongs. Ventral surface of tarsomere II of fourth pair of legs with no inner or outer prongs, but with dense long white hairs.

Pectinal teeth 14-22 (Mean 16.8, SD 0.48) in male; 12-18 (Mean 15.0, SD 0.93) in female.

Paraxial organ (Figs 70, 71) with apex of flagellum moderately coiled; inner lobe moderately separated from external lobe; external lobe widening at apex, slightly rounded centrally with a slight lobe on inner side, rounded on outer side.

#### Material examined

116♂, 278♀ (Map 2).

#### WESTERN AUSTRALIA

Aldersyde, 18.x.1924 (J. Pollard) 1♀, 24/878, WAM. Applecross, 29.viii.1958 (A. Smith) 1♀, 73/624, WAM. Araluen, 7.xii.1965 (L.N. McKenna) 1♀, 73/513, WAM; xii.1967 (J. Lake & L.N. McKenna) 2♀, 73/446-7, WAM. Armadale, 23-26.v.1917 (R.D.) 1♂, 71/1754, WAM; 1.x.1972 (R. Johnstone) 1♀, 73/443, WAM. Baudin I., Shark Bay, 1 juvenile, BMNH (holotype of *Isometrus bituberculatus*). Beverley, 21.vii.1925 (J. Pollard) 1♀, 25/498, WAM. Bickley, 22.vi.1963 (L.N. McKenna) 1♀, 73/496, WAM. Bindoon, 8 km from Berrets Crossing, 16.ii.1969 (R.A. Menner) 1♀, 73/508, WAM. Booylgoo Spring, Sandstone, ii.1925 (E.H. Michel) 1♀, 25/88, WAM.

Boya, 24.v.1967 (L.E. Koch & L.N. McKenna) 1♂, 73/512, WAM; 3.iv.1968 (Harold Hall Bird Expd. No. 5) 1♂, 1♀, 73/465-6, WAM. Boyangin Reserve, 27.i-6.ii.1972 (W.H. Butler) 1♀, 73/420, WAM. Bridgetown, 1♀, K9029, AM. Brown Bone Cave, near Pinnacles, 10-11.iv.1971 (M. Archer & E.A. Jefferys) 1♂, 73/468, WAM. Bruce Rock, 7.ix.1927 (F.C. Plant) 1♀, 27/952, WAM. Brunswick, 7.x.1905 (139 Hambg. S.W. Austral. Expd. 1905) 1♀, 4359, WAM. Bulong, 19.v.1924 (F. Jones) 1♂, 24/446, WAM (holotype of *L. jonesae*); 4.vii.1930 (F. Jones) 1♀, 30/438, WAM; 9.iv.1940 (F. Jones) 1♂ 40/815, WAM. Bunbury, 4.iv.1956 (Snell) 1♂, NM; 3.vii.1967 (B. Robson) 1♂, 73/498, WAM. Buniche, 3 km N of (E of Lake Grace) 6.iv.1968, 1♂, 1♀, 74/500-1, WAM. Byford, viii.1969 (M. Archer) 1♀, 73/504, WAM. Cape Range, v.1965 (G.W. Kendrick) 1♀, 73/562, WAM. Carnarvon, 23 km E of, 17.vii.1964 (L.E. Koch) 1♂, 73/517, WAM. Churchmans Brook, 4.xi.1967 (G.W. Kendrick) 1♂, 73/539, WAM. City Beach, 7.iv.1970 (M. Keetley) 1♀, 73/481, WAM. Collie, 7.iv.1966 (G. Kontoolas) 1♀, 73/482, WAM. Como, 14.i.1972 (Sanfilippo) 1♂, 73/516, WAM. Cottesloe, 20.xi.1924 (McDougall) 1♀, 24/919, WAM. Culcurdoolin (?), 3.xii.1968 (R.B. Humphries) 1♂, 73/422, WAM. Culham, 14.v.1959 (R.P. McMillan) 1♀, 73/563, WAM. Dandaragan, ix.1925 (L. Glauert) 5♂, 17♀, 25/614-33a, b, c, WAM; 23.iii.1962 (D. Gordon) 1♂, 73/438, WAM. Darlington, v.1928 (L. Glauert) 2♀, 28/531-2, WAM. Dongara, iv.1931 (D.C. Swan) 4♀, 31/740-3, WAM. Donnybrook, 19.iv.1928 (H.W. Davey) 5♂, 5♀, 28/436-46, WAM. Drummond Cove, 11 km N of Geraldton, 26.x.1972 (N. McFarland) 1♀, 73/543, WAM. Dumblebung, 1961 (H. Udell) 1♂, 3♀, 73/531-4, WAM. East Victoria Park, iv.1967 (Windsor) 1♀, 73/515, WAM. East Cannington, xii.1924 (C.E. Chivers) 1♀, 24/963, WAM. Esperance, v.1914 (W.B. Alexander) 2♀, 14/1000a, b, WAM; vii.1971 (Lernon) 1♂, 73/426, WAM. Euro (Mt Margaret), 18.ii.1924 (R.C.S. Brandon) 1♀, 24/75, WAM. Fitzgerald River, 19.vii.1970 (Uni. Zool. Survey) 1♀, 73/463, WAM. Frazer Range (Elder Expd.) 1♀, SAM. Garden I., viii.1966 (D.S. Adair) 1♂, 73/484, WAM; (D.S. Adair) 1♂, 73/431, WAM; south end, 22.xii.1968 (R. Humphries & D. Adair) 3♀, 73/509-11, WAM. Geraldton, 3.xi.1967 (M. Criddle) 1♀, 73/503, WAM; 4 km S of, 31.x.1972 (J. Johnson & A. Baynes) 2♀, 73/518-9, WAM. Green Head, 11 km N of, xii.1971, 1♀, 73/655, WAM. Gingin, 6.iv.1969 (M. Archer & E.A. Jefferys) 1♀, 73/502, WAM; 27 km NW of, vii.1970 (S. Roe) 3♀, 73/455-7, WAM. Gosnells, 13.ix.1964 (L.E. Koch) 2♂, 73/485-6, WAM. Gooseberry Hill, 31.i.1965 (E.J. Car) 1♂, 73/487, WAM; 17.v.1965 (E.J. Car) 1♀, 73/564, WAM; 28.vi.1965 (E. Mullins) 1♂, 73/561, WAM; 8.xi.1965 (E.J. Car) 2♀, 66/244-5, WAM; 26.ii.1970 (J. Lowry) 1♀, 73/469, WAM; 18.iv.1972 (J.W.J. Lowry) 1♂, 73/507, WAM. Gngara, 17.iii.1971 (J.A. Springett) 1♀, 73/520, WAM. Harvey, 13.x.1972 (L. Waters) 1♀, 73/454, WAM. High Wycombe, 9.iii.1970 (J. Cousins) 1♀, 73/483, WAM. Hyden (Kings Rock) 9.iv.1971 (B. Evans) 1♀, 73/525, WAM. Irwin River, S of Dongara, 19.xii.1967, 1♀, 73/537, WAM. Irwin, 28.iv.1924

(F. Brady) 1♀, 24/356, WAM; 28.v.1924 (F. Brady) 1♀, 24/514, WAM. Israelite Bay, 15.xii.1953 (B.Y. Main) 1♀, 1953/S9, BYM; 29.iii.1968 (A. Baynes & J. Bannister) 1♀, 73/536, WAM. Kalamunda, 13.iv.1963 (J. Dell) 1♂, 73/477, WAM; 29.vii.1967 (D. Merrilees) 1♀, 73/467, WAM. Kalbarri, 15.v.1965 (R. Humphries) 1♀, 73/558, WAM; Red Bluff, 21.viii.1971 (B. Bellairs) 1♀, 73/529, WAM; 5.iv.1973 (B. Bellairs) 1♂, 73/692, WAM. Kebaringup, 5.xi.1969 (D.D. Giuliani) 1♀, 70/269, WAM. Kelmscott, 1969 (G. Thick) 1♀, 73/464, WAM. Kings Park, 29.vi.1954 (G. Bornemissza) 1♀, 1954/S1, BYM; (G.B.) 2♀, 1954/S3-4, BYM; 7.vii.1968 (E.G. Cockett) 3♂, 3♀, 73/471-6 WAM. Konnongorring, vi.1925 (G.A. Whitfield) 6♂, 16♀, 25/449-465, WAM. Koojan, 5.vi.1966 (R. Humphries) 3♀, 73/540-2, WAM. Kulin, viii.1971 (R. Giles), 1♀, 73/441, WAM. Lake Mooliabeenee, 9.viii.1970 (A.M. Douglas) 1♀, 73/526, WAM. Lake Arromel, 23.viii.1962 (R.P. McMillan) 1♀, 73/554, WAM. Lake Richmond, Point Peron, 17.iv.1968 (R. Humphries) 1♂, 2♀, 73/461-3, WAM. Landor Stn, Gascoyne, viii.1922 (L. Glauert) 1♀, 29/1217, WAM. Long Reach Bore, Moogooree, viii.1969 (H.R. Thompson) 1♀, 73/530, WAM. Maddington, 1.xii.1964 (M. Langdon) 1♀, 73/436, WAM. Maida Vale, 16.iv.1973 (D.J. Kitchener) 1♀, 73/654, WAM. Millrose Stn, 28.x.1970 (M. Thomas) 1♂, 73/521, WAM. Moora, 13.i.1924, 1♂, 25/2, WAM. Moore R., 2 km from (14 km from Regans Ford) 8.xi.1968 (N.B. Tindale & N. McFarland) 1♀, 73/514, WAM. Mosman Heights, 31.vii.1967 (D. Joyce) 1♀, 73/444, WAM; 27.viii.1967 (D.A. Joyce) 1♀, 73/478, WAM; 6.ix.1967 (D.A. Joyce) 1♀, 73/433, WAM. Mt Cooke, 23.iii.1968 (E.G. Cockett) 1♀, 73/506, WAM; 31.iii.1968 (E.G. Cockett) 2♀, 73/448-9, WAM; 20.iv.1968 (L.E. Koch, E.G. Cockett & F.H.U. Baker) 3♀, 73/423-5, WAM; 12.v.1968 (E.G. Cockett) 2♂, 1♀, 73/427-9, WAM. Mt Helena, 17.iv.1968 (S.J.J.F. Davies) 1♂, 73/453, WAM. Mt Yokine, 24.iii.1957 (I. Murray) 1♀, NM; 26.iii.1957 (I. Murray) 1♂, NM. Mundaring, 4.iv.1924 (J. Clark) 1♂, 1♀, 24/358a, b, WAM. Mundaring Weir, 1.vii.1962 (J. Dell) 2♀, 73/434-5, WAM; 1.v.1963 (J. Dell) 1♂, 73/418, WAM; 24.iv.1963 (J. Dell) 1♀, 73/421, WAM. Murchison R., 32 km N of, 15.i.1972 (K.T. Richards) 1 young, 73/553, WAM. Needilip, vi.1925 (J.H.R. Jones) 2♂, 5♀, 25/479-85, WAM. New Norcia, 11 km N of, 11.iv.1965 (R. Humphries) 1♀, 73/566, WAM. North Dandalup, 17.xi.1969 (F.H.U. Baker) 1♂, 73/488, WAM. Nyabing, 24 km W of, 12.iv.1963 (R.P. McMillan) 1♀, 73/560, WAM. Perth, 64 km along Albany Highway, 11.v.1958 (R.P.M.) 1♀, 73/452, WAM; 260 km along Augusta Road, 1.xi.1970. (M. Archer & E. Jefferys) 1♀, 73/505, WAM. Phillip River Stn, 28.ii.1971 (B. Evans) 1♂, 73/437, WAM. Pingelly, 8.vii.1924 (Senex) 1♂, 24/641, WAM. Point Peron, 19.iv.1971 (K. Fletcher) 1♂, 73/450, WAM; 3.vii.1967 (N.P. Cox) 1♀, 73/451, WAM. Red Hill, 17.ix.1964 (L.E. Koch) 1♀, 73/559, WAM. Rottneest I., 13.ii.1932, 1♂, 1♀, 32/3195-6, WAM; 31.iii.1933 (L. Glauert) 1♀, 33/1019, WAM; 17.ii.1959 (R.W. George) 1♂, 73/445, WAM; 1♂, 5♀, SAM. Sawyers Valley, 13.iii.1924 (Eder) 1♀, 24/182, WAM. Sorrento,

25.v.1971 (N. Coleman) 1♀, 73/522, WAM; 30.i.1973 (P.G. Kendrick) 1♀, 73/523, WAM. South Perth, 28.i.1925 (W.H. Matthews) 3♂, 2♀, 25/23-7, WAM. South Stirlings, 17.viii.1964 (G. Lullfitz) 1♀, 73/556, WAM. Spearwood, 23.xii.1967 (G.W. Kendrick) 1♂, 73/495, WAM; 13.viii.1968 (L.M. Marr) 1♀, 73/442, WAM. Subiaco, 21.vi.1924 (Prout) 1♀, 24/603, WAM. Swan View, i.1924 (J. Clark) 1♂, 24/22, WAM. Tambellup, 25.vi.1937 (F.R. Bradshaw) 1♀, AM; viii.1969 (J. Penglase) 3♀, 73/458-60, WAM; 39 km S of, 10.viii.1963 (W.D.L. Ride) 2♂, 1♀, 73/439-40, 73/432, WAM. Tambrey, 27.vii.1958 (W.B.) 1♀, 73/565, WAM. Tammin, 26.vi.1924 (J.P. Riddlesden) 1♀, 24/613, WAM. Tarin Rock Reserve, 17.v.1971 (D. Kitchener, R. Johnstone, L. Smith & K. Youngson) 2♀, 73/527-8, WAM. Toodyay, 1963 (J. Davidson) 2♀, 73/479-80, WAM. Toompup, 28.vi.1970 (F.H.U. Baker) 4♂, 2♀, 73/489-94, WAM. Victoria Park, ii.1926 (Senex) 1♀, 26/27, WAM. Walyahmoning Rock, 4.iv.1922 (A. Baynes & A. Chapman) 1♀, 73/538, WAM; 8.x.1972 (R. Humphries & A. Baynes) 1♀, 73/419, WAM. Whicher Range, 4.iii.1963 (P.G., A.J. & G.W. Kendrick) 1♂, 73/524, WAM. Wickepin, x.1967 (K. Milton) 1♀, 73/535, WAM. Wundowie, 5.vii.1967 (N.A. Gardener) 1♀, 73/499, WAM. Yanchep Park, 23.iv.1969 (M. Archer, A. Baynes & M.E. Finch) 1♀, 73/497, WAM.

#### SOUTH AUSTRALIA

Alligator Gorge National Park, Flinders Range, 20.xi.1969 (D.D. Giuliani) 2♀, 70/271-2, WAM. Black Rock I. (?), ii.1925 (F. Wood Jones) 1♀, 25/80, WAM; iii.1925 (F. Wood Jones) 1♂, 2♀ and 2 young, 25/150, 25/151a-d, WAM. Blackwood, vi.1916 (E.L. Savage) 10♂, 3♀, SAM. Ceduna, 21.xii.1952 (B.Y. Main) 1♀, 1952/S6, BYM. Clare (L.G. Thorpe) 4♂, 3♀, SAM. Echunga, 9.x.1902 (C. Smith) 1♂, SAM. Emu Camp, Lake Eyre, 17.viii.1903 (J.W. Gregory) 1♀, NM. Greenly I., ii.1925 (F. Wood Jones) 1♂, 25/79, WAM; iii.1925 (F. Wood Jones) 1♀, 25/149, WAM. Kangaroo I., Cýgnet Bay, 1♂, SAM; Vicorme Bay (A.M. Lea) 1♀, SAM. Koonalda, 19 km E of, 18.xi.1969 (D.D. Giuliani) 1♂, 70/270, WAM. Kychering Soak, 24 km W of, xi.1908 (Chandler) 1♀, NM. Lucindale, 2.vii.1900 (E. Feuerhardt Crower) 1♀, SAM. Maralinga, 48 km NE of, 16.v.1970 (J. Dell) 1♀, 73/593, WAM. Marree, 1♂, SAM. Mt Lofty, 24.iv.1884 (Tepper) 2♂, 1♀, SAM. Nuriootpa, 3♀, SAM. Olary (T. Emery) 1♂, 1♀, SAM. Wilpena Pound, 22.viii.1970 (W.H. Butler & W.D.L. Ride) 1♀, 73/594, WAM. Wynbring (F.U. Mack) 1♀, SAM.

#### VICTORIA

Abbotsford, 15.vii.1903 (D. Murdoch) 1♀, NM. Ararat, 11.i.1904 (G.F. Hill) 1♀, NM. Castlemaine, 31.v.1926 (J.E. Dinoir) 2♀, 26/299-300, WAM. Glenrowan and Euroa, xi.1893 (J.R.) 1♂, 1♀, NM. Hattah, xi.1923 (C. Oke) 1♀, NM. Karn, Broken R. (?), v.1926 (H.W. Davey) 2♂, 26/313-4, WAM. Kergunyah, near Albury, ii.1957 (J.W. Wallace) 1♀, NM. 'Little Desert', 21.x.1948, 1♀, NM. 'Mallee', 23.ii.1914 (C. French) 1♂, NM. Mansfield,

18.ix.1953 (A. Burns) 1♀, NM. Mt Arapiles, 9.vi.1927 (H.W. Davey) 1♀, 27/823, WAM. Mt Rothery, 2.vii.1953, 1♀, NM. Moyston, 8 km SW of, 15.xii.1966 (Neboiss) 3♀, NM. Northcote, 26.xi.1925 (pres. H.C. Brookes) 1♀, NM. Ouyen, 12.x.1911 (pres. W.A. Hall) 1♂, NM. 'Victoria', 2♀, NM. Wangaratta, 18.ix.1953 (A. Burns) 1♂, NM.

#### NEW SOUTH WALES

Arncliffe, near Sydney, ii.1928 (G. Worth) 1♀, K57513, AM. Bankstown, 1♂, 1♀, K58241, AM. Belmore, 19.vii.1955, 1♀, AM. Blakehurst, near Sydney, 21.xi.1930 (Rhodin) 1♀, K63004, AM. Bourke, 1♂, K11936, AM. Bungaree, 27.ii.1885 (pres. E. Beaton) 13♀, SAM. Chatswood, 20.v.1930 (R.A. Eagles) 1♀, AM. Cobbadah, xi.1933 (T. Iredale) 1♂, AM. Como West, 9.iv.1965 (Williams) 1♀, AM. Deniliquin, 2.i.1968 (V.B. Squires) 1♀, 73/599, WAM; 24.ii.1969 (V.B. Squires) 1♀, 73/598, WAM. Epping, 20.vi.1940, 1♀, AM. Forest Reefs (?), (A.H.T. Lea) 1♂, SAM. Glenbrook Creek, 2.vi.1941, 1♂, AM. Jenolan, ii.1932 (J.C. Wiburd) 1♀, AM. Jenolan Caves, 1♀, K12899, AM. Llangothlin, 11 km from Guyra, i.1933 (A.J. Whan) 1♂, AM. Miranda, near Cronulla, 7.iv.1954, 1♀, AM. National Park, 30.i.1965 (J. Dixon) 2♀, AM. Nepean R., x.1931 (A. Musgrave) 1♂, AM. Normanhurst, 11.iv.1930 (C.V. Lloyd) 1♂, K61733, AM. 'New South Wales', 1♀, K13324, 3♀, A18714, 1♂, 2♀, K57434, AM; (J.A.K.) 1♀, NM. Orange, ix.1937 (I. Denham) 1♀, AM. Penrith, St. Peters, 1♀, K3676, AM. Raymond Terrace, near Newcastle (A.F. D'Ombra) 1♀, AM. South Hurstville, Sydney, x.1951 (F.S. Roberts) 1♀, AM. South Kensington, (R. Hulme) 1♀, AM. Sydney, 1♀, K2075, AM. Yass, 1.ii.1932, 1♀, AM.

#### AUSTRALIAN CAPITAL TERRITORY

Canberra, xii.1971 (R. Nation) 1♂, 73/597, WAM. Crobar Hill, near Mt Painter, 2.viii.1961, 1♀, AM. Mt Ainsley, Canberra, 16.v.1971 (M. Archer) 1♂, 1♀, 73/595-6, WAM.

#### NORTHERN TERRITORY

Alice Springs, 27.iv.1970 (Erlick) 1♀, NTMB345, NT; 8 km S of, 30.iii.1970 (D.J. Nelson) 1♂, NTMB282, NT. Ayers Rock, 20.v.1954, 1♀, NM. Docker River Settlement, 27.x.1970 (C. Dunlop) 1♀, NTMB737, NT. Ellery Creek Gap (D.F. McMichael) 2♀, AM. Glen of Palms, 2 km upstream from, Finke River, 27.xii.1969 (P. Wyatt Haines) 1♀, NTMB157, NT. (?) Groote Eylandt, vi.1948 (J.E. Bray) 1♀, AM. Napperby HS, 13.iv.1970 (Sheppard) 1♂, NTMB343, NT.

#### Remarks

I found very few adults, less than 3%, among the material examined.

The *Lychas* specimen labelled as being from Groote Eylandt, N.T., is *L. marmoreus* and not, as would be expected, *L. variatus*. I therefore regard the data with this specimen as incorrect and question this locality record for *L. marmoreus*.

Glauert (1925b) exactly followed Kraepelin (1916) regarding the number of subspecies of *L. marmoreus* and their characteristics. These authors regarded *L. marmoreus* as occurring throughout Australia and New Guinea. Glauert (1925b) gives the following distributions for the subspecies that he and Kraepelin (1916) recognized.

*L.m. marmoreus*—New Guinea, Queensland, New South Wales, Victoria, South Australia and the south of Western Australia (as far north as Moora and Boorabbin).

*L.m. variatus*—Western Australia, mainly north-western.

*L.m. splendens*—Western Australia (Geraldton, Moora, Tammin, Balladonia, Sandstone, and Euro); South Australia (Greenly I., Black Rock I.).

*L.m. kimberleyanus*—North Western Australia (Kimberley District).

*L.m. obscurus*—Victoria (Grampian Ranges, Abbotsford, Ararat).

In this study, I regard some of these nominal subspecies of *L. marmoreus* as belonging to other species of *Lychas*, viz., I include *L.m. variatus* and *L.m. kimberleyanus* in *L. variatus*; and I consider the New Guinea and Queensland records of *L.m. marmoreus* as applying to *L. variatus*. *L.m. splendens* is a form of *L. marmoreus*. However, I have found this form to have a greatly extended distribution compared to that recognized by Kraepelin and Glauert for *L.m. splendens*.

*Lychas variatus* (Thorell)  
(Figs 41, 72, 73, Map 3a and b)

*Isometrus variatus* Thorell, 1877: 136; Keyserling, 1885: 9.

*Isometrus thorelli* Keyserling, 1885: 12. *Syn. n.*

*Isometrus variatus papuanus* Thorell, 1888: 407. *Syn. n.*

*Isometrus armatus* Pocock, 1890b: 439. [2 syntypes examined.] *Syn. n.*

*Archisometrus armatus* (Pocock) Kraepelin, 1895: 85; Kraepelin, 1899: 47.

*Archisometrus variatus* (Thorell) Kraepelin, 1899: 49.

*Lychas marmoreus variatus* (Thorell) Kraepelin, 1916: 28; Glauert, 1925b: 98; Glauert, 1963b: 183. *Syn. n.*

*Lychas papuanus* (Thorell) Kraepelin, 1916: 29; Kopstein, 1921: 124; Glauert, 1925b: 99; Giltay, 1931: 18. *Syn. n.*

*Lychas marmoreus kimberleyanus* Kraepelin, 1916: 28; Glauert, 1925b: 98; Glauert, 1963b: 183. *Syn. n.*

*Lychas spinatus* Kraepelin, 1916: 32; Glauert, 1925b: 102; Takashima, 1945: 84. *Syn. n.*

*Lychas armatus* (Pocock) Glauert, 1925b: 100; Takashima, 1945: 79. *Syn. n.*

*Lychas spinatus besti* Glauert, 1925b: 193. [6 syntypes examined.] *Syn. n.*

*Lychas spinatus pallidus* Glauert, 1925b: 105. [4 syntypes examined.] *Syn. n.*

*Lychas lappa* Glauert, 1954: 4. [Holotype examined.] *Syn. n.*

### Range (Map 3a and b)

Western Australia, northern and central; furthest south at Well 13, Canning Stock Route; present on Barrow I. Victoria, north-western. New South Wales, widespread. Queensland, eastern. Northern Territory, northern; furthest south at Connells Lagoon bore. New Guinea. Fiji Is. Bougainville I.

### Measurements (mm)

♂. Mitchell Plateau, W.A., 73/657, WAM. Total length 38, of tail 25; carapace, length 4.4, width 4.4; tail segments one to five (in that order), length 2.5, 3.0, 3.1, 3.7, 5.6, width 2.5, 2.4, 2.1, 2.3, 2.5, height 2.2, 2.1, 2.1, 2.0, 2.1; length of vesicle and aculeus 5.0; width of vesicle 2.0; length of humerus 3.5; brachium, length 4.7, width 1.5; hand, length 3.0, width of hand surface 1.8, height 1.5; length of hand and fixed finger 7.4; length of movable finger 4.6; length of pectine 4.2.

Adult size	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=8)									
Min.	3.7	3.3	2.1	1.1	1.0	5.8	3.9	3.2	1.6
Max.	4.5	4.4	3.1	1.8	1.7	7.5	4.8	3.7	2.3
Mean	4.1	3.8	2.5	1.4	1.2	6.5	4.3	3.5	1.9
SD	0.29	0.37	0.41	0.26	0.25	0.73	0.35	0.21	0.27
Female (n=62)									
Min.	3.5	3.3	1.7	0.9	0.8	4.8	3.5	2.7	1.6
Max.	6.6	6.5	3.5	2.2	1.9	10.5	7.4	5.3	3.2
Mean	4.5	4.4	2.5	1.4	1.2	6.7	4.6	3.4	2.0
SD	0.53	0.60	0.30	0.24	0.21	0.92	0.75	0.49	0.34

### Diagnosis

Distinguished from *L. marmoreus* and *L. alexandrinus* by the following combination of characters: colour yellowish with light brown to brown

variegation; carapace with frontal notch absent, frontal lobes truncate; tail segments short, squat; vesicle small, globose with granulate keels; subaculear prong large, pointed at apex.

### Description

Colour light creamy yellow to bright yellow with light brown to brown variegations. Tergites more brownish often with five spaced darker markings along posterior edge. Tail with spots along keels.

Carapace with frontal notch absent. Frontal lobes truncate, sloping inward to midline. Interocular areas and lateral and posterior two-thirds of carapace granulate, with mainly coarse granules. Median sulcus widely interrupted. Triangular depression extremely deep. Sides of triangular depression conspicuously swollen inwards. Ocular tubercle pronounced. Median eye furrow moderately deep where crossing ocular tubercle. Median eyes large; closer to anterior than to posterior edge of carapace; distance apart slightly greater than eye diameter.

Chelicerae (Fig. 14) as for genus.

Tergites of first six abdominal segments densely granulate with fine to coarse granules. Pretergite moderately wide. Central keel prominent, especially in posterior half of segment, granulate and sharp. Median and lateral pairs of keels weakly indicated by wide granulate areas. Tergite of last abdominal segment densely granulate. Central keel granulate, most conspicuous and wide in middle of segment. Median and lateral pairs of keels prominent along most of segment length.

First four sternites smooth, with indications of indented lateral keels. Posterolateral part of second and third sternites weakly granulate, fourth sternite with a wide lateral area and posterior edge weakly granulate. Last sternite with dense fine granules. Median and lateral pairs of keels granulate and prominent in posterior half of segment.

Tail long, moderately thick to extremely thick. First four tail segments (Fig. 41) squat. Intercarinal surfaces densely granulate with fine to coarse granules. Dorsal keels prominently denticulate to with large crenulations. Terminal denticle enlarged. Other keels prominently granulate to denticulate. Ventromedian keels double, widely separate. Accessory keel in first segment extending whole length of segment, in second segment less clearly defined, in third segment weakly defined, in fourth segment scarcely evident. Fifth tail segment moderately short. Intercarinal surfaces mainly with granules of various sizes but some denticles present. Keels granulate to denticulate. Ventromedian keel extending whole length of segment, not bifurcating.

Vesicle small, globose, with several granulate keels. Subaculear prong large (and high), laterally compressed, triangular, narrowing to pointed

apex, sometimes widely blunt; a small, weakly defined thorn present on aculear side.

Aculeus long, slightly curved.

Humerus moderately long. Dorsal surface of faint scattered granules. Anterior and posterior surfaces with some scattered fine to coarse granules. Ventral surface with faint scattered granules. Keels well defined with coarse granules.

Brachium moderately long. Surfaces dorsally finely granulate, ventrally smooth. Anterodorsal keel with moderately coarse to coarse granules.

Hand small, squat. Anterior surface with some scattered granules, other surfaces smooth. Anterodorsal keel granulate. Other keels weak to absent.

Fingers very long (about 2½ times hand length). Along edge of movable finger basally central row of teeth extending about half length of finger. Central row followed distally by 6 sets of teeth, with a total of 9 external and 7 internal accessory teeth spaced along these sets.

Legs with tarsomere I of first pair dorsally with no prongs. Ventral surface of tarsomere II of fourth pair of legs with no inner or outer prongs, but with dense light brown hairs.

Pectinal teeth 12-24 (Mean 18.0, SD 2.53) in male; 10-24 (Mean 16.5, SD 3.36) in female.

Paraxial organ (Figs 72, 73) with apex of flagellum tightly coiled; inner lobe widely separated from external lobe; external lobe widening at apex, slightly rounded centrally with a slight lobe on inner side, rounded on outer side.

#### Material examined

71♂, 187♀ (Map 3a and b).

#### WESTERN AUSTRALIA

Anna Plains, 80 km NE of, 22.ix.1969 (D.D. Giuliani) 1♀, 69/2052, WAM. Argyle Downs HS, 11 km W of, 20-28.x.1971 (E. & M. Archer) 1♂, 3♀, 73/389-92, WAM. Barrow I., i.1947 (W.H. Butler) 1♂, 73/393, WAM; 2.iv.1971 (W.H. Butler & A.A. Burbidge) 1♂, 3♀, 73/397, 73/394-6, WAM; 23.v.-14.vi.1964 (W.H. Butler) 2♂, 1♀, 66/303-5, WAM; 20.viii.1973 (L. Smith & W.H. Butler) 1♀, 73/658, WAM; 22.viii.1973 (L. Smith) 1♀, 73/659, WAM. Canning Stock Route, Well 13 (D. Williams) 1♀, 73/660, WAM; Karara Well, 2 km W of, 2.vi.1971 (J. Dell) 1♀, 73/399, WAM. Dale Gorge Creek, 12.vii.1958, 1♂, 73/555, WAM. Dale Gorge, 24.viii.1967 (J. Stamp) 1♀, 73/557, WAM. Derby, 8.viii.1967 (W.R. Lowe) 1♂, 73/546, WAM. Dorre I., 1959 (A.M. Douglas) 1♀, 73/415, WAM. Forrest River Mission, 6.i.1954

(K.J. Coaldrake) 1♀, NM; v.1954 (K.J. Coaldrake) 1♀, NM. Gogo Stn, Longs Spring, 21.vii.1967 (K.G. Butler & G.W. Kendrick) 1♀, 73/414, WAM. King Sound, 6♂, 1♀; 1♀ and 13 young, MM. Kununurra, 14.i.1969 (P.J. Michael) 2♀, 73/547-8, WAM. Kuri Bay, 16 km ESE of, 28.viii.1971 (N. McKenzie & L. Smith) 1♀, 73/430, WAM. Lawley and Mitchell Rivers, between, 2.ix.1967 (W.R. Lowe) 1♀, 73/410, WAM. Lissadell Stn (old HS) 5.x.1971 (W.H. Butler) 1♀, 73/400, WAM. Mitchell Plateau, 19.i.1973 (L. Smith & R. Johnstone) 1♀, 73/656, WAM; 20.vii.1973 (W.H. Butler) 1♂, 73/657, WAM. Mt Bell, Leopold Range, 7-20.vi.1968 (Hall Expd.) 1♀, 73/402, WAM. 'North West Australia', 1952 (Aust. Mus. Party) 1♂, 630, 2♀, 542, AM. Point Coulomb, vi.1971 (W.H. Butler) 1♀, 73/412, WAM. Port Hedland, 12.x.1972 (P.A. Haug) 1♂, 73/413, WAM. Roebourne, 72 km S of, 11.v.1970 (L.E. Koch & A.M. Douglas) 1♀, 73/403, WAM. Tambrey, 16.i.1933 (C. Cusack) 1♀, 33/43, WAM; 27.vii.1958 (W.B.) 1♀, 73/565, WAM; 7.v.1970 (L.E. Koch) 1♀, 73/411, WAM. Turkey Creek, 29.x.1930 (F. May) 1♂, NM. Wotjulum Mission, 16.i.1956 (A.M. Douglas) 1♂, 3♀, 56/150-3, WAM; x.1955 (A.M. Douglas) 1♂, 73/404, WAM. Yannarie River, 23.vii.1965 (L.N. McKenna) 1♂, 4♀, 73/405-9, WAM.

#### VICTORIA

Ararat, 9.vi.1927 (H.W. Davey) 1♀, 27/830, WAM. Echuca, 27.i.1925 (W.D. Chapman) 1♀, NM. Grampians Range, 2♀, NM. Kewell, xi.1892 (J.A. Kershaw) 1♂, 66/341, WAM. Lake Hattah, 1♂, 11♀, 26/303, 26/301-2, 26/304-312, WAM; National Park, 4.iv.1969 (G.B. Monteith) 1♀, UQ. 'Mallee' pres. 12.x.1915 (D. Best) (C. Frost Collection) 2♂, 6♀, NM (syntypes of *L. spinatus besti*). Murray R., 6♀, 26/315-20, WAM.

#### NEW SOUTH WALES

Bankstown (C. Lawler) 5♂, 5♀, K50047, AM; 1♀, K43282, AM. Berowra, 25.i.1966 (A. Carttling) 1♂, AM. Bourke and Willcannia, Darling River floods, v.-vi.1890, 1♂, 2♀, K48682, AM. Brawlin, 2♀, K48680, AM. Broken Hill Dist., 1951 (C. Rawlings) 1♀, AM. Inverell, 12.iii.1966 (G.A. Holloway) 5♀, AM. Junee, 48 km W of, 5.iv.1969 (G.B. Monteith) 1♂, UQ. Leeton, 31.viii.1932 (C.D. Bateman) 1♀, AM. 'New South Wales', 1♂, 1♀, MM (syntypes of *L. spinatus pallidus*); 1♂, 1♀, K13333, AM (syntypes of *L. spinatus pallidus*). Pilliga Scrub, 48 km S of Narrabri, 22.viii.1969 (G.B. Monteith) 2♂, 1♀, UQ. St Ives, 1.i.1964 (J. Yaldwyn) 1♂, AM; 28.ii.1967 (J.C. Yaldwyn) 1♀, AM. Tamworth, 4.vii.1956, 1♀, UQ. Turramurra, 1♀, K3361, AM. Uki, viii.1950, 1♀, AM. Wagga Wagga, 1♂, 2♀, AM. Yanco, 27.ix.1932 (K.C. McKeown) 1♂, 1♀, AM.

#### QUEENSLAND

Almaden, xi.1925-ii.1926 (W.D. Campbell) 1♂, 1♀, K53369, AM; iv.1927 (W.D. Campbell) 1♀, K56286, AM. Atherton, 1.iii.1960 (G.W. Saunders) 1♀,

Sc.1, QM. Black Mountain, near Kuranda, 27.vi.1951 (A. Musgrave) 2♀, AM. Bon Accord Falls, Montville, 25.ix.1955 (R. Dobson) 1♀, AM. Boyne Valley, 6.ix.1960 (R.M. Muspratt) 1♀, UQ. Boonah, 22-23.xii.1971 (A.M. & M.J. Douglas) 1♀, 73/552, WAM; Heads, 22-23.xii.1971 (A.M. & M.J. Douglas) 1♀, 73/551, WAM. Brigalow, 21.viii.1959 (C.H. Middleton) 1♂, UQ. Brisbane, 1885 (pres. J. Frost, 1915) 1♀, NM; i.1922; (C. Smith) 2♀, QM; i.1925, 1♀, NM; v.1936, 1♀, UQ; 30.x.1945 (H. Naylor) 1♀, QM; 18.v.1949 (L. Wassell) 1♀, UQ; 25.ix.1959 (C. Martin) 1♂, UQ; 6.xi.1959 (J.B. Stephens) 1♀, UQ; 1.x.1965, 1♀, UQ; 13.xii.1968 (McPherson) 1♀, Sc.5, QM; (H. Hacker) 2♂, 6♀, QM; (E.R. Waite) 2♂, 2♀, NM. Bundaberg (Lea) 1♀, SAM. Bymount, 17.viii.1963 (T.E. Telford) 1♂, UQ. Cairns, 3♀, MM. Cape York, 1♀, MM. Carnarvon Range, iii.1944 (N. Geary) 1♀, AM. Chester River, Silver Plains, east coast of Cape York Pen., 5.xii.1961 (J.L. Wassell) 1♀, AM. Chinchilla Rifle Range Reserve, 29.v.-4.vi.1971 (M. Archer & J. Covacevich) 2♀, 73/549-50, WAM. Condamine, 1♀, K57433, AM. Cooktown, 20.vii.1968 (J.C. Le Souef) 1♀, 73/544, WAM. Cooper Creek, 21 km N of Daintree River, 14.xi.1969 (B. Cantrell) 1♀, UQ; 29 km N of Daintree River, 21-22.vi.1969 (G.B. Monteith) 1♀, and 12 second instars, UQ. Currumbin, 2.xii.1927, 1♀, UQ. Eidsvold, 1♀, SAM. Eubenangee, 27.xi.1949 (J.G. Brooks) 1♀, 73/652, WAM. Eumundi, x.1910 (J.A. Kershaw) 1♀, NM. Glen Aplin, 10.iii.1960 (P. Beal) 1♀, UQ. Gordonbrook, 3.vi.1959, 1♂, UQ. Gundiah, 13.iv.1959 (W.W. Abell) 1♂, QM. Harlin, v.1945, 1♂, 1♀, UQ. Homehill, xii.1940, 1♂, UQ. Iron Range, 29-30.iv.1963 (P. Ogilvie) 1♀, QM. Kallangur, 3 km SE of, 4.iii.1960 (R. Atkinson) 1♀, UQ. Kingaroy, 14.vi.1968 (E.M. Exley) 1♂, UQ. Kuranda, 30.x.1949 (G. Brooks) 1♀, NM. Lamington National Park, 28.v.1959, 1♀, UQ; 2.vi.1959, 1♀, UQ. Lappa Junction, 24.i.1954 (W. Hosmer) 1♀, 64/62, WAM. (holotype of *L. lappa*). Leo Creek (McIlwraith Range, near Coen) 2-3.xi.1969 (B. Cantrell) 2♂, UQ. Lockerbie, Cape York, 6-10.iv.1969 (G.B. Monteith) 1♂, 2♀, UQ. Montville, ix.1929 (H.C. MacCartney) 1♀, AM. Mt Coot-tha, 26.viii.1959 (R.P. Johnston) 1♀, UQ. Mt Emlyn, 12.v.1949 (A. Burns) 1♀, NM. Mt Glorious, 3.iii.1959 (T. Langton) 1♀, UQ; 17.iv.1960, 2♂, UQ. Mt Mulligan, 12.viii.1962 (I.R. Straughan) 1♀, UQ. Mt Nebo, 3.xi.1961 (S. Breeden) 1♂, 1♀, QM. Mt Tamarind (?) 1912 (D.P.) 1♀, SAM. Mt Tozer, Iron Range, 30-31.v.1971 (G.B. Monteith) 2♀, UQ. Mungar Junction (A.M. Lea) 1♀, SAM. Nanango, 30.xi.1953 (A.L. Peterson) 1♀, QM. Prince of Wales I., Torres Strait, 15.viii.1938 (T.C. Marshall) 1♀, W857. QM. 'Queensland' (A.M. Lea) 1♀, NM. Samford, 28.v.1951, 1♀, UQ; 1958, 2♀, UQ. Searys Creek, 17-18.x.1970 (G.B. Monteith) 1♀, UQ. Scarborough, 7.x.1953 (C.D. Healy) 1♂, QM. Springbrook, viii.1956 (P. Aland) 1♀, UQ. Taroom, 10.ix.1947, 1♂, UQ. Thorntons Gap, 29.viii.1971 (J. Bailey) 1♀, 73/545, WAM. Toogoolawah, 16.vi.1958 (Sabine) 1♀, UQ. Toowoomba, 14.iii.1939 (W.H. Barnard) 5♀, 39/1733-7, WAM. Tully, 12.i.1935 (A. Burns) 1♀, NM.

Woombye, vi.1960 (J. Badham) 1♂, UQ. Yaamba, 15.vii.1935 (G.P. Whitley) 1♀, AM.

#### NORTHERN TERRITORY

Cape Arnhem, vii.-viii.1948 (J.E. Bray) 1♂, AM. Connells Lagoon bore, 19.iv.1970 (P. Latz & D. Howe) 1♂, NTMB344, NT. Daly River (H. Wesselman) 2♂, SAM. Groote Eylandt, Gulf of Carpentaria, 1930 (Warren) 2♂, 2♀, AM. Island opposite Centre I., 20.vii.1971 (K.F. Adams) 1♂, 1♀, 73/416-7, WAM. Mary River (W.D. Dodd) 1♂, 1♀, SAM. Port Essington, from Dr Richardson's Coll., 1♂ (dry, pinned), 1♀, BMNH (syntypes of *Isometrus armatus*); 1♀, K12869, AM; 1♀, 66/345, WAM. Yirrkala (*L. Chaseling*) 1♂, 3♀, AM.

#### PAPUA NEW GUINEA

Kerema, vi.-x.1950 (G.A.V. Stanley & R.F. Murrell) 1♂, AM.

#### BOUGAINVILLE I.

Bougainville I., iii.1961 (W.W. Brandt) 1♀, AM.

#### Remarks

Besides being morphologically close to *L. marmoreus* and *L. alexandrinus*, *L. variatus* is morphologically close to *L. mucronatus* (Fabricius, 1798), which is absent in Australo-Papua but is widespread in areas to the north including China, Japan, Burma, Philippine Is., Celebes, and Indonesia. I consider that a direct common ancestor species was possessed by the ancestor of *L. mucronatus* and the ancestor of the Australo-Papuan *Lychas* species.

In *L. variatus*, the tail segments of 3.7% of specimens, most of which are juveniles, are narrower and more elongate than usual.

Large crenulations are present along the dorsal keels of the first four tail segments in 11.8% of the specimens.

In some areas (e.g. Barrow I., W.A.) the specimens (n=10) exhibit considerable individual variation of subaculear prong shape, whereas in other areas all the specimens have the same kind of subaculear prong (e.g. wide in all specimens, n=5, at Yannarie, W.A.).

The lightest coloured specimens occur in parts of N.S.W. (Broken Hill district) and Victoria (Lake Hattah).

At first sight it seemed that size decreased from north to south, but a multivariate analysis of specimens in five geographically separated regions revealed no significant trend between the regions.

*Lychas alexandrinus* Hirst

(Figs 42, 74, 75, Map 4)

*Lychas (Hemilychas) alexandrinus* Hirst, 1911: 464; Glauert, 1925b: 111; Takashima, 1945: 84 [Holotype examined.]

*Lychas mjobergi* Kraepelin, 1916: 24; Glauert, 1925b: 108; Takashima, 1945: 84; Glauert 1963b: 183. *Syn. n.*

*Lychas truncatus* Glauert, 1925a: 85; Glauert, 1925b: 106; Takashima, 1945: 85. [Holotype and 3 paratypes examined.] *Syn. n.*

*Lychas annulatus* Glauert, 1925b: 107; Takashima, 1945: 85. [Holotype examined.] *Syn. n.*

Range (Map 4)

Western Australia, furthest north at Koolan I., furthest south at Harri-smith. South Australia, northern. Victoria, at Pyramid Hill. New South Wales, western. Queensland at Cunnamulla and 37 km NW of Dajarra. Northern Territory, southern.

Measurements (mm)

♂. Cunnamulla, Qld, i.1953, AM. Total length 29, of tail 18; carapace, length 3.6, width 3.0; tail segments one to five (in that order), length 2.0, 2.3, 2.3, 2.7, 3.9, width 1.9, 1.6, 1.6, 1.6, 1.6, height 1.6, 1.5, 1.6, 1.6, 1.7; length of vesicle and aculeus 3.9; width of vesicle 1.3; length of humerus 3.2; brachium, length 3.6; width 1.3; hand, length 2.0, width of hand surface 1.9, height 1.8; length of hand and fixed finger 5.1; length of movable finger 3.8; length of pectine 3.4.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=12)									
Min.	3.5	3.0	1.6	1.1	1.0	4.7	2.7	2.6	1.3
Max.	4.7	4.5	2.5	1.9	1.8	6.2	4.2	4.0	2.2
Mean	4.0	3.8	2.2	1.4	1.2	5.5	3.7	3.3	1.8
SD	0.35	0.46	0.25	0.23	0.24	0.47	0.47	0.41	0.27
Female (n=4)									
Min.	3.6	3.4	1.8	1.1	0.8	5.3	3.3	2.7	1.6
Max.	4.5	4.3	2.5	1.5	1.4	7.0	4.5	3.1	2.0
Mean	4.0	3.8	2.2	1.3	1.1	5.8	3.7	3.0	1.8

Diagnosis

Distinguished from *L. marmoreus* and *L. variatus* by the following combination of characters. Colour mainly uniform light orangish brown, with vesicle, fourth or fifth, or both, tail segments darker; carapace with frontal notch usually deep, frontal lobes often rounded; vesicle small to

moderately large, smooth to weakly keeled; subaculear prong large to minute, truncate.

### Description

Colour yellowish brown to light orangish brown with conspicuous dark orangish brown on tergites, fourth or fifth tail segments or both, and vesicle.

Carapace with frontal notch slight to wide and deep, usually deep. Frontal lobes rounded to truncate, often rounded, sloping inward to midline. Interocular areas and lateral and posterior two-thirds of carapace densely and coarsely granulate. Median sulcus widely interrupted. Triangular depression shallow to deep. Sides of triangular depression swollen inwards. Ocular tubercle pronounced. Median eye furrow moderate to deep where crossing ocular tubercle. Median eyes large; slightly closer to anterior than to posterior edge of carapace; distance apart about the same or slightly greater than eye diameter.

Chelicerae (Fig. 14) as for genus. Movable finger with median tooth relatively longer than in *L. marmoreus* and *L. variatus*.

Tergites of first six abdominal segments densely granulate with fine to coarse granules, coarse granules in posterior half. Row of coarse granules along posterior edge. Pretergite moderately wide. Central keel prominent, upraised, smooth but slightly denticulate. Median pair of keels weak with denticles more prominent in posterior half. Lateral pair of keels weakly indicated by granules. Tergite of last abdominal segment with fine to coarse granules, mainly fine. Central keel prominent, smooth to denticulate and granulate, present mainly in anterior half of segment. Median and lateral pairs of keels prominent, granulate, with granules increasing in size posteriorly; present in posterior three-fourths of segment.

First four sternites smooth. Last sternite smooth. Median and lateral pairs of keels finely denticulate to granulate, prominent in posterior half of segment.

Tail long, very thick. First four tail segments (Fig. 42) moderately squat. Intercarinal surfaces with scattered granules, mainly fine. Keels denticulate to with spaced rounded denticles. Terminal tooth scarcely enlarged. Ventromedian keels double, widely separate. Accessory keel of first three tail segments present along entire length, in fourth segment present but weak. Fifth tail segment with intercarinal surfaces granulate to with coarse scattered denticles. Keels denticulate. Ventromedian keel extending whole length of segment, not bifurcating.

Vesicle small to moderately large, globose to moderately elongate, smooth to weakly keeled. Subaculear prong moderately short to small, truncate; thorn absent.

Aculeus moderately short, slightly to sharply curved.

Humerus moderately long. Dorsal and posterior surfaces with some granules. Anterior surface with some coarse granules and denticles. Ventral surface smooth. Keels denticulate to strongly granulate.

Brachium moderately long. Dorsal surface granulate. Anterior surface with a few coarse denticles, other surfaces smooth. Anterodorsal keel with a few coarse granules.

Hand small, squat, smooth, unkeeled.

Fingers very long (about 2½ times hand length). Along edge of movable finger basally central row of teeth extending about half length of finger. Central row followed distally by 7 sets of teeth, with a total of 8-9 external and 6-7 internal accessory teeth spaced along these sets.

Legs with tarsomere I of first pair dorsally with no prongs. Ventral surface of tarsomere II of fourth pair of legs with no inner or outer prongs, but with moderately dense to dense long to very long white to light brown hairs.

Pectinal teeth 17-29 (Mean 22.6, SD 2.49) in male; 14-27 (Mean 21.2, SD 3.00) in female.

Paraxial organ (Figs 74, 75) with apex of flagellum tightly coiled; inner lobe close to external lobe; external lobe prominently indented centrally, with an extremely well-developed lobe on inner and outer side.

#### Material examined

37♂, 30♀ (Map 4).

#### WESTERN AUSTRALIA

Aerodrome Lake (?), 17.viii.1971 (W.H. Butler) 1♀, 73/653, WAM. Argyle Downs Stn, 3 km E of Ord River Dam site, v.1971 (C. Dortch) 2♂, 73/588-9, WAM. Barrow I., 23.v.-14.vi.1964 (W.H. Butler) 3♀, 66/301-2, 303A, WAM. Billabong Road House, 732 km peg, 2.ii.1970 (R.B. Humphries, J.R. Ross & J.G. Gilbert) 1♂, 73/591, WAM. Canning Stock Route, Well 27, 1♀, 59-42, 73/600, WAM; Well 42, 1♂, 1♀, 66/67-42, 73/601-2, WAM; Various wells, 2♂, 57/58-42, 73/603-4, WAM. Carnarvon, 4-5.ii.1953 (Bunbury Expd.) 1♀, NM. Coburn Station (near Hamelin Pool) iv.1967, 1♂, 73/582, WAM. Coordewandy, 29.viii.1966 (R. Humphries) 1♀, 73/398, WAM. Fitzroy and Margaret Rivers junction, 1896 (G.A. Kearsland) 1♂, SAM. Forrest, i.1930 (J. Williams) 1♂, 30/22, WAM. Harrismith, 22.xii.1970 (K. T.Richards) 1♂, 73/579, WAM. Holt Rock, 4.v.1970 (G. Harold) 1♂, 73/574, WAM. Killagurra Springs, Durba Hills, Canning Stock Route, 20.v.1972 (M. de Graaf) 1♀, 73/575, WAM. Konnongorring, vi.1925 (G.A. Whitfield) 1♀, 25/448, WAM. Kookynie, 18 km N of, 1.ix.1954 (B.Y. Main) 1♀, 1954/S6, BYM. Koolan I., 7.ix.1969 (O. Milton) 1♂, 73/590, WAM. Laverton, 32 km E of, ix.1967 (R. Cable) 1♂, 73/585, WAM. Marloo Stn, 31.i.1968 (L.E.

Koch) 1♂, 73/572, WAM. Millstream, 22.vii.1958, 1♀, 73/586, WAM. Millrose Stn, 28.x.1970 (M. Thomas) 1♂, 73/521, WAM. Minilya, 26 km N of, 4.ii.1970 (R.B. Humphries, J.P. Ross & J.G. Gilbert) 1♀, 73/587, WAM; 108 km N of, 4.ii.1970 (R.B. Humphries, J.P. Ross & J.G. Gilbert) 1♀, 73/592, WAM. Mt Aloysius, 17.vii.1967 (K.T. Richards) 1♀, 73/583, WAM. Mt Bell, Leopold Ranges, 7-20.vi.1968 (Hall Expd.) 1♂, 73/401, WAM. Mt Herbert Spring, 4.viii.1958 (H.W.B.) 1♀, 73/607, WAM. Mt Jackson, 19.v.1969 (M. de Graaf) 1♀, 73/573, WAM. Mt Magnet, 64 km W of, 29.iv.1970 (L.E. Koch & A.M. Douglas) 1♀, 73/584, WAM. 'Murchison Dist.' (R. Helms) 1♂, SAM. Newman Rocks, 9.xii.1953 (B.Y. Main) 1♀, 1953/S5, BYM. Norseman, 47 km E of, 7.xii.1953 (B.Y. Main) 1♀, 1953/S4, BYM. 'North Western Australia', 10.xi.1953 (A.R. Main) 1♀, 1953/S2, BYM. Pintharuka and Morawa, between 20.ii.1955 (B.Y. Main) 1♀, 1955/S1, BYM. Three Springs, viii.1926 (E.W. Franklin) 1♀, 26/53, WAM. Wallal Downs, 153 km SE of, 11.i.1970 (M. de Graaf) 1♂, 1♀, 73/577-8, WAM. Warburton Ranges, 16.iii.1963 (M. de Graaf) 1♂, 73/576, WAM. Yellowdine, 29 km S of, x.-xi.1970 (W.H. Butler) 1♂, 73/581, WAM.

#### SOUTH AUSTRALIA

Canniwaukaninna Dune, east edge of, 14 km W of Canniwaukaninna Bore, ix.-x.1972 (M. Archer) 1♂, 73/567, WAM. Emu, 127 km E of, 14.v.1970 (J. Dell) 1♂, 73/580, WAM. Etadunna Stn, Birdsville Track, 3.x.1972 (M. Archer & K. Oldfield) 1♂, 73/568, WAM; x.1971-ix.1972 (B. Oldfield) 1♂, 73/569, WAM. Kychering Soak, 24 km W of, xi.1908 (M. Chandler) 1♀, NM (holotype of *L. annulatus*). Lake Ngapakaldi, 2 km E of, 2.vii.-2.viii.1971. (M. Archer) 1♂, 73/570, WAM; vii.1971 (M. Archer) 1♂, 73/571, WAM. 'Millers Creek and Coopers Creek' (F. Wood Jones) 1♂, 25/152, WAM. (paratype of *L. truncatus*). 'North Western S.A.', 1903 (H. Basedow) 1♀, SAM.

#### VICTORIA

Pyramid Hill, 18.ix.1890 (E.H. Hennell) 2♂, NM (holotype and paratype of *L. truncatus*); 1♂, 66/338, WAM (paratypes of *L. truncatus*).

#### NEW SOUTH WALES

Deniliquin, 4.xii.1967 (V.R. Squires) 1♂, 73/606, WAM. Willandra National Park, 50 km W of Hillston, 30.ix.1973 (S.R. Morton) 1♂, 73/777, WAM.

#### QUEENSLAND

Cunnamulla, i.1953 (H. Geary) 1♂, AM; Dist., 9.i.1941 (N. Geary) 1♂, 2♀, AM. Dajarra, 37 km NW of, ix.1930 (T. Hodge-Smith) 1♀, AM.

## NORTHERN TERRITORY

Alexandria, 1907. 2.2.1. (W. Stalker, c.; Sir W Ingram, Sir John Forrest, p.) 1♂, BMNH (holotype of *L. alexandrinus*). Musgrave and Petermann Ranges, vi.1926 (H. Basedow's Expds.) 1♂, SAM. Tanami, 2.ix.1970 (P.K. Latz, S.A. Parker & C. Dunlop) 1♀, NTMB580, NT. Wallace Rock Hole, 32 km SE of Hermannsburg, 20.ix.1970 (D.W. Haines) 1♂, NTMB581, NT.

### Remarks

Hirst (1911) erected the monotypic subgenus *Hemilychas* mainly on the grounds that the only known specimen, the holotype of *L. (H.) alexandrinus*, had on its carapace a strongly developed posteromedian pair of keels. These keels were indistinct or absent in all other *Lychas* specimens that Hirst had examined. But various other *Lychas* species (e.g. some specimens of *L. marmoreus*) also have these keels strongly developed. Hence I do not consider this subgenus as valid.

The specimen from Tanami, N.T., was in semi-desert. The specimen from Hillston, N.S.W. was on a grassy plain. Specimens from the Kimberley area were collected under the bark of *Eucalyptus*.

The holotype, which is from Alexandria, N.T., has large punctures on its fifth tail segment and vesicle. This rare surface condition is present to varying extent in the specimens from Cunnamulla, Qld. The extremely reduced and blunt subaculear prong is also rare, and is present in such extreme parts of the distribution as at the Fitzroy and Margaret River location in north-western Australia and at Dajarra in Queensland.

According to Glauert's labelling the holotype of the nominal species *Lychas truncatus* (a synonym of *L. alexandrinus*) is the larger of two males from Pyramid Hill, Vic., in the National Museum.

### Genus *Isometroides* Keyserling

*Isometroides* Keyserling, 1885: 16. Type species *Isometrus vescus* Karsch, 1880:56 (by subsequent designation).

#### Distribution

Australia.

#### Species included

*Isometroides vescus* (Karsch, 1880).

#### Description

Carapace with anteromedian and posteromedian keels. Frontal lobes truncate. Chelicerae (Fig. 15) having fixed jaw with distal tooth wide,

moderately short, subdistal tooth small, wide at base, pointed at apex curved towards base of chelicerae. Median tooth and basal tooth pointed, of about equal size, separating from each other after about half their length. Large internal tooth present ventrally. Movable jaw ventrally with distal internal tooth large and pointed; median internal tooth and basal ventral tooth each large, wide at base, rounded at apex. Dorsally with distal external tooth small, wide; subdistal tooth large and wide; median external tooth extremely large and wide at base; the two basal teeth small, positioned close to each other, moderately close to median external tooth. Tergites with strongly developed central keel. Tergite of last abdominal segment with central keel and longitudinal (median and lateral) keels present. Fifth tail segment without keels. Subaculear prong absent. Movable finger of hand with along edge basally one central row of teeth extending about half length of finger; this central row sometimes with large tooth externally at about three-fourths length from base; central row followed distally by six oblique overlapping sets of teeth, each set ending externally in two large teeth and internally in one tooth. Tibial spur present on third and fourth pairs of legs. Sternum about as wide as long.

#### Affinities

*Isometroides* is closely related to *Lychas* Koch, 1850.

#### *Isometroides vescus* (Karsch)

(Figs 15, 43, 76, 77, Map 5)

*Isometrus vescus* Karsch, 1880: 56.

*Isometroides vescus* (Karsch) Keyserling, 1885: 17; Kraepelin, 1899: 40; Pocock, 1890a: 120; Hirst, 1907: 209; Glauert, 1925b: 113; Glauert, 1963b: 181; Takashima, 1945: 78; Main 1956: 158.

*Isometroides angusticaudus* Keyserling, 1885: 19; Kraepelin 1899: 40; Hirst, 1907: 209; Kraepelin, 1916: 21; Glauert, 1925b: 115; Takashima, 1945: 78; Glauert, 1963b: 183.

#### Range (Map 5)

Western Australia, furthest north at Halls Creek, furthest west at Denham, Shark Bay, furthest south at Ongerup. South Australia, at Coober Pedy, Koonalda and Nundroo. New South Wales, at Wilcannia. Queensland, at Peak Downs. Northern Territory, in Alice Springs area.

#### Measurements (mm)

♂. Armadale, W.A., 71/1752, WAM. Total length 47, of tail 29; carapace length 4.9, width 5.5; tail segments one to five (in that order), length 2.9, 3.7, 3.8, 4.2, 6.5, width 3.3, 3.0, 2.9, 2.9, 2.7, height 2.8, 2.8, 2.7, 2.6, 2.4;

length of vesicle and aculeus 6.2; width of vesicle, 1.6; length of humerus 2.9; brachium, length 4.1, width 1.5; hand, length 1.6, width of hand surface 1.2, height 1.0; length of hand and fixed finger 5.7; length of movable finger 4.1; length of pectine 4.9.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=32)									
Min.	4.0	4.0	1.0	0.9	0.8	4.5	3.1	3.2	2.1
Max.	5.5	6.2	2.1	1.3	1.3	6.3	4.6	4.5	2.8
Mean	4.7	5.0	1.7	1.1	1.0	5.3	3.8	3.8	2.4
SD	0.41	0.61	0.23	0.10	0.11	0.49	0.43	0.34	0.21
Female (n=31)									
Min.	4.3	4.5	1.5	1.0	1.0	5.0	3.7	3.4	2.3
Max.	6.1	7.2	2.3	1.5	1.5	7.2	5.5	5.4	3.3
Mean	5.4	5.8	1.9	1.3	1.2	6.0	4.4	4.3	2.8
SD	0.41	0.64	0.20	0.13	0.13	0.51	0.46	0.48	0.24

#### Diagnosis

As given in description of genus.

#### Description

Colour light yellowish to greyish brown, with most of fourth tail segment, and the fifth tail segment and vesicle and aculeus darkest and usually orangish brown to dark reddish brown; tergites often darkish sometimes with dark pattern on carapace and tergites, sometimes with median keel dark, and one, two or three subrectangular blackish markings along posterior edge on each side of median keel. Legs sometimes with indistinct darker dorsal markings.

Carapace with frontal notch practically absent. Interocular areas and lateral and posterior two-thirds of carapace coarsely granulate. Median sulcus widely interrupted, scarcely evident. Triangular depression short, but wide at base, sides curved inwards to shallow central depression. Posteromedian keels prominent, extending from basal angles of triangle at right angles to posterior edge and reaching about one-third of the length from posterior edge to median eyes.

Chelicerae (Fig. 15) as for genus.

Tergites of first six abdominal segments granulate. Posterior edge with granules scarcely enlarged. Pretergite narrow, not continuing laterally. Central keel well developed, granulate. Tergite of last abdominal segment granulate. Row of granules alongside posterior edge. All keels granulate. Central keel most pronounced in middle. Median and lateral pairs of keels curving out towards anterior edge.

First four sternites smooth to rugose, sometimes with scattered granules

matt to shiny, somewhat pitted. Last sternite usually granulate or with scattered granules. Median and lateral pairs of keels crenulate, often weak.

Tail large, very thick, and robust. First four tail segments (Fig. 43) squat. Intercarinal surfaces granulate in first three segments; mainly pitted and smooth to granulate or rugose in fourth segment. Dorsal and dorsolateral keels in first two segments notched, in third tending towards smooth, in fourth smooth. Terminal spine of dorsal keels absent. Ventrolateral keels in first segment notched, in others smooth. Ventromedian keel smooth in all segments. All keels of fourth segment usually weak. Accessory keels in first three segments notched, in fourth smooth. Fifth tail segment moderately long, rounded, with a dorsomedian depression. Surface uniformly pitted, smooth to rugosely patterned, dorsomedian part smooth.

Vesicle small, sometimes long; narrow mainly smooth, unkeeled with some pitting laterally and ventrally; with long setae ventrally. Subaculear prong absent; sometimes slightly indicated.

Aculeus long, moderately curved.

Humerus dorsally with scattered granules; coarser granules along keels. Dorsally bounded at anterior and posterior edges by a spaced row of coarse granules.

Brachium dorsally with some fine scattered granules. Posteroventral keel weak or absent.

Hand short, mainly smooth and rounded, unkeeled.

Fingers very long. Teeth along edge of movable finger as given in description of genus.

Legs with tarsomere I of first pair dorsally with no prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with no inner or outer prongs but with a thick brush of hairs.

Pectinal teeth 20-28 (Mean 24.6, SD 1.37) in male; 20-27 (Mean 23.6, SD 1.59) in female.

Paraxial organ (Figs 76, 77) with apex of flagellum tightly coiled; inner lobe close to external lobe; external lobe prominently indented centrally with an extremely well-developed lobe on inner side and an extremely well-developed lobe on outer side.

#### Material examined

52♂, 47♀ (Map 5).

#### WESTERN AUSTRALIA

Albion Downs, 1.i.1967 (S. Armstrong) 1♂, 71/1302, WAM. Armadale, 23-26.v.1912 (R.D.) 1♂, 1♀, 71/1752-3, WAM. Baandee, 27.ix.1924 (R.

Macpherson) 1♂, 24/882, WAM. Bolgart, 18.vi.1952 (B.Y. Main) 1♀, 52/S8, BYM. Booanya, ii.1932 (A.E. Baesjou) 1♂, NM; (A.E. Baesjou) 1♀, AM. Boulder, 1♂, K10825, AM. Bruce Rock, 13.iv.1927, 1♂, 27/495, WAM. Bulong, 7.xi.1924 (F. Jones) 1♂, 24/892, WAM; 8 km SE of, 29.i.1956 (B.Y. Main) 1♂, 56/S9, BYM. Bungulla (near Kellerberrin) 4.iii.1925 (J. Clark) 1♀, 25/167, WAM. Buntine, 29.viii.1972 (A. Chapman) 1♂, 73/648, WAM. Carnegie Stn, 4.vi.1968 (B.M. Doube) 1♀, 71/1306, WAM. Coonana, 3.xi.1946 (R.L. Jones) 1♂, 46/1699, WAM. Cundelee, vi.1967 (W.H. Butler) 1♀, 71/1289, WAM. Dedari, 21.i.1966 (A.M. Douglas & L.N. McKenna) 1♂, 66/320, WAM. Denham, Shark Bay, ix.1971 (J.A. Springett) 1♂, 73/651, WAM. Dundinin, 12.xi.1924 (A. Gray) 1♀, 24/893, WAM. Ellavalla Stn, via Carnarvon, 22.ii.1955 (A. Snell) 1♂, NM. Gleneagle, xii.1967 (W.H. Butler) 1♀, 71/1294, WAM. Goddards Creek, trans. line, 2 km E of, 30.x.1956 (A.R. Main) 1♀, 56/S7, BYM. Golden Ridge, W of, 6.x.1956 (A.R. Main) 1♂, 56/S6, BYM. Goomalling, 30.xii.1924 (H.E. White) 1♀, 24/1059, WAM. Greenough area, 1851-1881 (F.W. Pearson) 1♂, 66/246, WAM. Halls Creek, 30.x.1968 (N. Page) 1♀, 71/1296, WAM. Jarrahdale, 18.xi.1929 (J. Pollard) 1♀, 29/1410, WAM. Kambalda, 6 km W of, 30.i.1968 (R.E. Elkington) 1♂, 71/1297, WAM. Kalbarri, 14.vi.1971 (B. Bellairs) 1♀, 71/1757, WAM; 22.ix.1968 (W. J. Marsh) 1♂, 71/1300, WAM. Kalbarri, Red Bluff, viii.1970 (B. Bellairs) 2♂, 71/1755-6, WAM; 27.vii.1971 (B. Bellairs) 1♀, 71/1758, WAM. Karonie, 8.x.1926, 1♀, 26/729, WAM; 18.iv.1928 (W.J. Mills) 1♀, 28/430, WAM; 2.ix.1929 (W. Mills) 1♀, 29/1221, WAM. Kathleen Valley (T. Moriarty) 1♂, 60/S1, BYM. Kununoppin, 5.xii.1924 (J.F. Rance) 1♀, 24/937, WAM. Lake Barker Reserve, 1967 (W.H. Butler) 1♂, 71/1304, WAM. Lake Violet, v.1927 (P. Hopegood) 1♂, 27/661, WAM. Lake Kirk, 13 km S of, 18.v.1956 (A.R. Main) 1♀, 56/S5, BYM. Madura, 50 km E of, on Eucla coastal plain, 28.viii.1965 (B.Y. Main) 1♂, 55/S5, BYM. Magooinya on Balladonia Stn, 11.xii.1953 (B.Y. Main) 1♂, 57/S7, BYM. Marloo Stn, 2.ii.1968 (A.M. Douglas) 1♀, 71/1307, WAM. Marvel Loch, 31.viii.1927 (C.H. Andre) 1♀, 27/947, WAM; 3.ix.1972 (M.J. Douglas) 1♀, 73/650, WAM. Merkanooka, 11.v.1953 (B.Y. Main) 1♂, 1♀, 53/S1, 53/S11, BYM. Merredin, 6.xii.1924 (J. Scarlett) 1♂, 24/1033, WAM; 5.xii.1953 (W.B. Malcolm) 1♂, 53/S3, BYM. Morawa, S of, 1.x.1952 (B.Y. Main) 1♀?, 52/S3, BYM. Minnivale, 20.vii.1954 (B.Y. Main) 1♀, 53/S5, BYM. Mt Dick, 17.vi.1952 (A.R. Main) 1♀, 52/S1, BYM. Mt Fisher, 14.ix.1961 (A.M. Douglas) 1♂, 71/1303, WAM. Mt Jackson, 19.v.1969 (M. de Graaf) 1♀, 71/1292, WAM. Mt Ragged, 14.xii.1953 (B.Y. Main) 1♂, 53/S8, BYM. Mukinbudin, 20.ii.1929 (A.H. Rutherford) 1♀, 29/242, WAM. Mullewa, 19 km W of, 6.ix.1954 (B.Y. Main) 1♀, 54/S7, BYM. Mundaring Weir, 8.v.1963 (J. Dell) 1♀, 71/1305, WAM. Narembeen, 25.ii.1929 (G. Vincent) 1♂, 29/254, WAM. Naretha, 13 km W of, 3.ix.1967 (P.J. Fuller) 1♂, 71/1293, WAM. Needilup, 25.v.1925 (J.H.R. Holmes) 1♂, 25/433, WAM. Newdegate, 42 km E of, 23.v.1955 (B.Y. Main) 1♂, 1♀, 55/S3, 55/S2, BYM. Newman Rocks, 10.xii.1953 (B.Y. Main) 1♂,

53/S10, BYM. Noondoonia Stn, 30.ix.1970 (T. Yetman) 1♂, 71/1295, WAM. Norseman, 72 km N of, 26.xii.1968 (W.H. Butler) 1♂, 71/1301, WAM; 117 km E of, 9.xii.1953 (B.Y. Main) 1♂, 53/S6, BYM. Ongerup, 14.iii.1971 (K. Newby) 1♀, 71/1290, WAM. Peak Charles, 25.v.1955 (B.Y. Main) 1♂?, 1♀, 55/S4a-b, BYM; 17.v.1956 (A.R. Main) 1♂, 56/S3, 1♂?, 56/S4, BYM. Perenjori, 8.iv.1927, 1♂, 27/435, WAM. Perth, 20.iii.1963 (M. Graham) 1♂, 71/1291, WAM; 407 km along Great Northern Highway, vii-viii.1957 (W.H. Butler) 1♂, 57/S1, BYM. Randalls Stn, 19.xi.1925 (F. Jones) 1♀, 25/787, WAM; 24 km E of, 25.i.1956 (B.Y. Main) 1♂, 1♀, 56/S1, 56/S2, BYM. Red Hill Road, 56 km E of, 12.x.1952 (B.Y. Main) 1♀, 52/S4, BYM. Roe Plains (26 air km from Cocklebidy Tank on bearing of 128°, i.e.c. ESE) 1.ix.1969 (A. Baynes & K. Youngson) 1♂, 69/S1, BYM. Serpentine, 12.iii.1925 (A. Baldwin) 1♀, 25/173, WAM. Sorrento, 15.xi.1972 (P.G. & A. J. Kendrick) 1♀, 73/649, WAM. Southern Cross, 12.iv.1924 (W.E. Richards) 1♀, 24/435, WAM; 2.vi.1924 (E.H. Richards) 1♀, 25/544, WAM. Tammin, 26.vi.1924 (J.P. Riddlesden) 1♀, 24/612, WAM; vii.1952, 1♂, 52/S2, BYM. Tarin Rock Reserve, 26.v.1971 (W.K. Youngson) 1♀, 71/1309, WAM. Walyahmoning Rock, 4 km S of, 8.x.1972 (R. Humphries & A. Baynes) 1♀, 73/647, WAM. Wanneroo, 29.iii.1963 (E. Holm) 1♀, 71/1288, WAM. Warriedar Stn, near Lake Monger, 3.viii.1923 (S. Oliver) 1♀, 23/192, WAM. White Peak (via Geraldton) 23.vi.1924 (H.E. Carey) 1♀, 24/605, WAM. Woolgangie, 27.i.1971 (K.T. Richards) 1♂, 71/1759, WAM.

#### SOUTH AUSTRALIA

Coober Pedy, 16 km E of, 31.iii.1970 (W.D.L. Ride & W.H. Butler) 1♀, 71/1298, WAM. Koonalda, 19 km E of, 18.xi.1969 (D.D. Giuliani) 1♂, 70/273, WAM. Nundroo, 13 km N of, 1.ii.1965, 1♂, 65/S1, BYM. Wigunda Tank, 106 km E of, 23.xii.1952 (B.Y. Main) 1♂, 52/S7, BYM.

#### NEW SOUTH WALES

Wilcannia, 8 km E of, 20.xi.1952 (W.B. Malcolm) 1♂, 52/S5, BYM.

#### NORTHERN TERRITORY

Alice Springs area, early 1970, 1♀, NTMB374, NT.

#### Remarks

Although Main (1956) stated on the basis of a few characters, including the pectinal tooth count of 23 specimens, that only one species is present in *Isometroides*, Glauert (1925b, 1963b) maintained the possibility that two species are involved. In the present study, where much larger numbers of specimens are available, the unimodal nature of the pectinal tooth count of 51 males and 47 females has supported the other evidence that only one species is involved.

*Isometroides* is morphologically extremely close to *Lychas*. *I. vescus* is closest to *L. alexandrinus* with regard to most features of external morphology; e.g. of the three Australian *Lychas* species, *L. variatus* has the largest subaculear prong and *L. alexandrinus* the smallest (the subaculear prong is absent in *I. vescus*.) With regard to structure of the paraxial organ, *I. vescus* shows the following relationship to the three Australo-Papuan *Lychas* species.

- (1) There is progressive specialization of external lobe structure in the sequence: *L. marmoreus*, *L. variatus*, *L. alexandrinus*, *I. vescus*.
- (2) *I. vescus* has similar flagellar development to *L. variatus* and *L. alexandrinus*, and all three are more advanced in this character than is *L. marmoreus*.
- (3) The extent of separation of the inner and external lobes increases in *Lychas* in the sequence: *L. marmoreus*, *L. variatus*, *L. alexandrinus*; but in this character *I. vescus* is more similar to *L. marmoreus* than to *L. variatus* and *L. alexandrinus*.

*I. vescus* is a terrestrial, vagrant species, which roams mainly at night; it is normally cryptozoic during the day, and is occasionally found under objects on the ground. It does not construct burrows but, as Main (1956, 1957) has shown, is specialized for feeding on burrowing spiders, especially the so-called true trapdoor spiders (Mygalomorphae: Ctenizidae). It feeds within the victims' burrows, where it spends most of its time. *Lychas alexandrinus* has been occasionally found in spiders' burrows, and hence is the closest of the three Australian *Lychas* species to *I. vescus* in this regard.

*I. vescus* has been associated with two of the families, Ctenizidae and Dipluridae, in the Mygalomorphae (trapdoor spiders), and with one family, Lycosidae (the wolf spiders), in the Araneomorphae. The *Lycosa* species (Lycosidae) preyed upon also has burrows with trapdoors. This indicates that *I. vescus* is adapted for feeding on a wide range of burrowing spiders, and especially those that have burrows with trapdoors. Various *Lycosa* species have a wide distribution over many parts of the world, but *I. vescus* is the only scorpion known to have specialized as a feeder within the burrows of spiders (B.Y. Main, personal communication).

From Main (1956, 1957), and data associated with the material examined in the present study, it is found that *I. vescus* has been collected in burrows of the following ten species of spiders.

Mygalomorphae: Ctenizidae    *Aganippe cupulifex* Main  
  *Aganippe occidentalis* Hogg  
  *Aganippe raphiduca* Rainbow and Pulleine  
  *Anidiops manstridgei* Pocock  
  *Anidiops villosus* (Rainbow)  
  *Arbanitis hoggi* (Simon)

? *Conothele* sp.

*Eucyrtops latior* (Cambridge)

Mygalomorphae:Dipluridae    *Dekana diversicolor* Hogg

Araneomorphae:Lycosidae    *Lycosa* sp.

Of these, *I. vescus* was actually observed feeding on *Dekana* and *Lycosa*. The *Anidiops* burrows were sealed in the middle by a defensive flap (sock). Hence the spider, in the lower part, was protected from the scorpion.

*I. vescus* occurs in woodland and semi-arid inland country but not in the wetter forested south-western corner of Australia. Within the entire distribution, the Perth area has the highest rainfall. From the map of distribution it might be expected that *I. vescus* would be present continuously across the central arid part of the continent, but there are no records of it from this area. The only locality record in Queensland, Peak Downs (Keyserling, 1885) (22°56' S, 148°05' E), which is the type locality of *I. angusticaudus*, a synonym, is far removed from the other points of distribution of *I. vescus*.

Because the list of prey species of *I. vescus* includes *Lycosa* (a widespread genus in Australia), the main factors ultimately responsible for the limits of the particular pattern of distribution of *I. vescus* seem not to be the presence of its various prey species but to be other components of the environment, mainly climatic (aridity) factors. Nevertheless, detailed distribution patterns and the abundance of *I. vescus* within the climatically suitable area would be dependent upon the availability of suitable burrowing spiders as prey. The distribution of *I. vescus* is therefore discussed below in terms of what is known of the distribution (Main 1957, 1967) of the trapdoor spiders.

*Dekana diversicolor* occurs from about Geraldton on the west coast of Western Australia eastwards to the Flinders Ranges and thence north-east into south-west Queensland; it does not occur in south-eastern or north-western Australia.

*I. vescus* is most abundant in south-western Australia where the ctenizid trapdoor spiders *Aganippe*, *Anidiops*, and *Eucyrtops*, especially *Aganippe cupulifex*, *Aganippe occidentalis* and *Eucyrtops latior*, are distributed. *Aganippe raphiduca* is also present in part of these areas. In the more northern areas of *I. vescus* distribution, *Aganippe occidentalis*, *Aganippe raphiduca*, *Anidiops manstridgei*, *Anidiops villosus* and *Arbanitis hoggi* are present. *I. vescus* is apparently absent over most of the area (a section of the western coast and extending somewhat inland in south-western Australia) where the two ctenizid species, *Idiosoma sigillatum* and *Idiosoma nigrum* are present; this genus is apparently not a prey of *Isometroides*. Across the Nullarbor Plain, *Aganippe occidentalis* and *Aganippe manstridgei* are present; of these *Anidiops manstridgei* occurs as far east as the Flinders Range. In

Eyre Peninsula, South Australia, a ctenizid, *Blackistonia aurea* Hogg, is plentiful and probably serves as prey of *I. vesus*. In New South Wales *I. vesus* is present where *Aganippe* occurs.

All in all, the most abundant area of *I. vesus* best fits the distribution of the genus *Aganippe* which is summarized by Main (1967: 35) as being southern Australia (excluding extreme south-west and south-eastern corners and Tasmania); common through sclerophyllous forests, woodlands, mulga and inland river systems, and saltbush steppe of Nullarbor Plain.

In *I. vesus*, there is no marked sexual dimorphism in size (including tail dimensions), but there is intraspecific variation in (1) the presence and amount of pigmentation, (2) the vesicle length, and (3) the tendency sometimes to develop a slight indication of a prong beneath the aculeus. The percentages of specimens (45♂, 47♀, both sexes combined) showing these features are as follows:

Tergites: black to highly patterned 27.2%, spotted 43.5%, plain 29.3%. Fourth tail segment: dark 46.7%, medium 41.3%, light 12.0%. Vesicle: moderately to extremely long 53.3%, not long 46.7%. Aculeus notch: no trace of subaculear prong 75.0%, slight indication of a subaculear prong 25.0%. Brachium: spotted 23.9%, light 76.1%. Proximal leg segments: spotted 28.3%, light 71.7%.

#### Genus *Isometrus* Hemprich & Ehrenberg

*Isometrus* Hemprich & Ehrenberg, 1828: 3. Type species *Buthus (Isometrus) filum* Hemprich & Ehrenberg, 1828: 3 (by subsequent designation).

*Atreus* Walckenaer and Gervais, 1844: 52. Type species *Buthus (Isometrus) filum* Hemprich & Ehrenberg, 1828: 3 (by subsequent designation) [= *Isometrus maculatus* (De Geer, 1778).]

*Lychas* Koch, 1845: 1 (not *Lychas* Koch, 1850: 92 = *Lychas*). Type species *Scorpio maculatus* De Geer, 1778: 346 (by subsequent designation) [= *Isometrus maculatus* (De Geer, 1778).]

#### Distribution

*I. maculatus* (De Geer, 1778) is tropicopolitan, other 11 species from Madagascar, India and Indo-China, through South-east Asia, the Lesser Sundas, and New Guinea to Australia.

#### Species included

In Australo-Papua: *I. maculatus* (De Geer, 1778), *I. melanodactylus* (Koch, 1867).

Outside Australia-Papua: *I. maculatus* (De Geer, 1778); *I. basilicus* Karsch, 1879; *I. assamensis* Oates, 1888; *I. thurstoni* Pocock, 1893; *I. formosus* Pocock, 1893; *I. rigidulus* Pocock, 1897; *I. thwaitesii* Pocock 1897; *I. brachycentrus* Pocock, 1899; *I. acanthurus* Pocock, 1899; *I. vittatus* Pocock, 1900; *I. madagassus* Roewer, 1943.

### Description

Carapace with frontal lobes truncate. Chelicerae (Fig. 16) having fixed jaw with distal tooth wide, apex blunt; subdistal tooth wide; median tooth slightly larger than basal tooth. Internal tooth present ventrally. Movable jaw ventrally with distal internal tooth, median internal tooth and basal internal tooth pointed; median internal tooth and basal internal tooth moderately small; dorsally with distal external tooth small; subdistal tooth and median tooth blunt, moderately large, wide; basal teeth, two, moderately large, close to each other and to median tooth. Tergites of first six abdominal segments with a central keel. Tergite of last abdominal segment with central keel and longitudinal (median and lateral) keels present. Subaculear prong large. Movable finger of hand with along edge basally one central row of teeth followed distally by four to six inclined, non-overlapping rows of teeth, each row laterally with an internal and an external tooth. Sternum from about the same length as width to noticeably longer.

### Affinities

*Isometrus* is close to *Lychas* Koch, 1850.

#### *Isometrus maculatus* (De Geer)

(Fig. 44, Map 6a and b)

*Scorpio maculatus* De Geer, 1778: 346.

*Scorpio dentatus* Herbst, 1800: 55.

*Scorpio americanus* Herbst, 1800: 60.

*Buthus (Isometrus) filum* Hemprich & Ehrenberg, 1828: 3.

*Atreus filum* (Hemprich & Ehrenberg) Walckener & Gervais, 1844: 52.

*Lychas maculatus* (De Geer) Koch, 1845: 1.

*Lychas americanus* (Herbst) Koch, 1845: 1.

*Scorpio (Lychas) gabonensis* Lucas, 1858: 430.

*Scorpio (Lychas) guineensis* Lucas, 1858: 432.

*Centrurus (Isometrus) americanus* (Herbst) Peters, 1861: 515.

*Isometrus maculatus* (De Geer) Thorell, 1876: 8; Pavesi, 1881: 537; Keyserling, 1885: 6; Thorell, 1888: 405; Kraepelin, 1891: 103; Pocock, 1893a: 88; Lönnberg, 1897: 185; Kraepelin, 1899: 66; Simon, 1899: 120;

Werner, 1902: 599; Kraepelin, 1916: 34; Glauert, 1925b: 117; Mello-Leitão, 1945: 241; Glauert, 1963b: 183; Vachon, 1972: 169.

### Range (Map 6a and b)

Queensland, north-east coast, furthest south at Townsville, also at Low Is and Cairns, and on islands in Torres Strait. Northern Territory, at Darwin. New Guinea.

Outside Australo-Papua. Widespread throughout the zone of distribution of extant Scorpionida (Vachon 1972).

### Measurements (mm)

♀. Low Is, Qld, 39/1729, WAM. Total length 38, of tail 24; carapace, length 4.3, width 4.5; tail segments one to five (in that order), length 3.2, 3.4, 4.0, 4.0, 5.1, width 2.3, 1.9, 1.7, 1.6, 1.4, height 1.7, 1.7, 1.7, 1.5, 1.5; length of vesicle and aculeus 4.2; width of vesicle 1.2; length of humerus 4.5; brachium, length 4.9, width 1.3; hand, length 2.5, width of hand surface 1.3, height 1.3; length of hand and fixed finger 7.8; length of movable finger 5.4; length of pectine 3.3.

Adult size: No adults available among material examined.

### Diagnosis

Distinguished from *I. melanodactylus* by the following combination of characters: last sternite densely granulate, median keels present; second to fifth tail segments, humerus, and brachium very long, i.e. length  $> 4$  times height.

### Description

Colour generally uniformly pale yellowish brown to pale yellow, and ranging from non-variegated to having sparse dark variegations on dorsal aspect and tail. Variegation intense black in unfaded specimens. Tail segments not darkening; dark brown only on extremities of cheliceral teeth and on aculeus. Brown pigment in eye areas.

Carapace with frontal notch absent. Frontal lobes sloping inward to midline. Interocular areas and lateral and posterior two-thirds of carapace densely granulate. Median sulcus widely interrupted. Triangular depression deep. Sides of triangular depression swollen inwards. Ocular tubercle large. Median eye furrow moderately deep where crossing ocular tubercle. Median eyes moderately large; distance apart about equal to eye diameter.

Chelicerae (Fig.16) as for genus. In cheliceral characters, *I. maculatus* and *I. melanodactylus* are very similar.

Tergites of first six abdominal segments densely granulate, anterior granules small, granules increasing in size posteriorly but no distinct granulate row along posterior edge. Pretergite narrow. Median keel granulate,

very prominent, present in posterior half of segment. Tergite of last abdominal segment densely granulate, granules increasing in size posteriorly. Distinct row of granules near posterior edge. Keels granulate. Central keel wide, prominent, present in anterior and middle of segment. Median pairs of keels prominent, curving outwards from about three-fourths length from posterior edge of segment. Lateral pairs of keels curving outwards from posterior edge and extending to about half length of segment.

First four sternites smooth and shining, the fourth slightly granulate. Last sternite slightly granulate. Keels granulate and prominent. Median keels present in posterior half, lateral keels centrally.

Tail extremely long in male, long in female; thick. First four tail segments (Fig. 44) long to extremely long (4-6 times height). Intercarinal surfaces with scattered granules, rugose. All keels finely denticulate. Terminal denticle of dorsal keels slightly larger than other denticles, but not much enlarged, pointing somewhat posteriorly. Accessory keel in first segment present along entire length, in other segments absent or short. Ventromedian keel double. Fifth tail segment extremely long (> 8 times height). Intercarinal surfaces rugose. Keels finely denticulate. Ventromedian keel not bifurcating.

Vesicle small, elongate (length about 3 times height). Subaculear prong large, conical, triangular, pointed at apex; a small pointed thorn present on aculear side, no thorn at apex. Subaculear prong pointing towards from distal half to apex of aculeus. Curve between aculeus base and subaculear prong wide and large.

Aculeus long, gradually curved.

Humerus extremely long (about 5 or more times height). Surfaces finely denticulate, except for smooth ventral surface. Keels granulate. Central keel present along anterior surface.

Brachium extremely long (about 5 or more times height). Surfaces with a few granules but mainly smooth. Keels finely denticulate. Central keel along anterior surface with fine to coarse denticles. Dorsal accessory keel present.

Hand moderately narrow, elongate in male. Intercarinal surfaces with few granules but mainly smooth. Keels weak, smooth, but anterodorsal keel granulate.

Fingers extremely long (nearly 3 times hand length). Along edge of movable finger basally central row of teeth extending about half to three-fourths length of finger. Central row followed distally by 4-5 sets of teeth, with a total of 7-8 external and 6-7 internal accessory teeth spaced along these sets.

Legs with tarsomere I of first pair dorsally with no prongs. Ventral surface

of tarsomere II of fourth pair of legs with no inner or outer prongs, but with long white hairs in a moderately dense arrangement.

Pectinal teeth 17-19 (Mean 17.8) in male; 17-19 (Mean 17.9) in female.

Paraxial organ. Absent in material examined.

Material examined

6♂, 11♀ (Map 6a and b).

#### QUEENSLAND

Cairns, 1♀, NM. Low Is, iii.1939 (G.E. Nicholls) 1♀, 39/1729, WAM; 14.vii.1954 (M.J. Mackerras & E.N. Marks) 1♀, AM. Torres Strait, 1879 (Gray) 2♂, 2♀, A5189, AM. Townsville, vi.1953 (D. Asmussen) 1♂, QM.

#### NORTHERN TERRITORY

Darwin, ix.1912 (Spencer) 1♂, NM; 1930, 1♀, NM; iv.1952 (E. Crawford) 1♀, NM.

#### PAPUA NEW GUINEA

Goldie River, 20.x.1968 (R. Mackay) 1♂, PNGM. 'New Guinea' (Hookworm Campaign) 1♂, 3♀, UQ.

#### NO LOCALITY DATA

17.i.1930 (Deakin) 1♀, K61055, AM.

#### Remarks

As a result of being carried unwittingly during man's travels, *I. maculatus* is found sporadically at ports around the world. From the number of records in the present study, the area of permanent establishment of the species includes most of the northern localities where it has been found in the area of study, viz. Darwin (N.T.), north Queensland (i.e. Townsville to islands in Torres Strait) and New Guinea.

Takashima (1948, 1950) has identified *Isometrus* species from West New Guinea as *I. europaeus* and *I. formosus*; but he uses the name *I. europaeus* for *I. maculatus*, and his description of *I. formosus* fits that of *I. melanodactylus*, e.g. on pectinal tooth count.

#### *Isometrus melanodactylus* (Koch)

(Figs 16, 45, 78, 79, Map 7a and b)

*Lychas melanodactylus* Koch, 1867: 239; Karsch, 1879: 10.

*Isometrus melanodactylus* (Koch) Keyserling, 1885: 3 (as *I. melanophysa*); Kraepelin, 1891: 106; Kraepelin 1899: 68; Werner, 1902: 599; Kraepelin, 1916: 33; Glauert, 1925b: 116; Takashima, 1945: 86; Glauert, 1963b: 183.

*Isometrus gracilis* Thorell, 1877: 139.

*Isometrus papuensis* Werner, 1916: 88. *Syn. n.*

*Isometrus melanodactylus inflatus* Glauert, 1925b: 117. [Holotype and 5 paratypes examined.]

#### Range (Map 7a and b)

New South Wales, far north-eastern, furthest south at Lawrence. Queensland, east of the Great Dividing Range, furthest south-west at Brookfield, New Guinea.

#### Measurements (mm)

♂. Brisbane, Qld, 10.viii.1959, UQ. Total length 39, of tail 25; carapace, length 3.8, width 3.3; tail segments one to five (in that order), length 2.7, 4.0, 4.4, 4.5, 5.3, width 1.4, 1.3, 1.2, 1.2, 1.3, height 1.3, 1.4, 1.3, 1.3, 1.4; length of vesicle and aculeus 4.0; width of vesicle 1.2; length of humerus 3.3; brachium, length 3.9, width 1.3; hand, length 3.0, width of hand surface 1.5, height 1.1; length of hand and fixed finger 6.5; length of movable finger 4.1; length of pectine 2.8.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=7)									
Min.	2.8	2.6	2.3	1.0	0.7	5.0	2.6	3.4	1.1
Max.	4.2	3.7	3.1	1.5	1.1	6.9	4.2	5.2	1.3
Mean	3.4	3.0	2.7	1.2	0.9	5.6	3.5	4.2	1.2
SD	0.49	0.38	0.29	0.20	0.17	0.74	0.56	0.55	0.09
Female (n=10)									
Min.	3.0	2.4	2.1	0.9	0.7	4.6	2.7	2.7	1.2
Max.	4.0	3.8	2.8	1.3	1.8	6.5	4.0	3.6	1.5
Mean	3.5	3.2	2.4	1.1	1.0	5.5	3.5	3.0	1.3
SD	0.36	0.44	0.21	0.12	0.31	0.63	0.44	0.30	0.11

#### Diagnosis

Distinguished from *I. maculatus* by the following combination of characters: last sternite smooth, median keels absent; second to fifth tail segments, humerus, and brachium long, i.e. length 3-4 times height, but not very long.

#### Description

Colour light brownish cream with darker variegations on dorsal aspect and tail. Tail segments progressively darkening distally with fifth tail segment, vesicle and aculeus reddish brown. Brown pigment in eye areas.

Carapace with frontal notch absent. Frontal lobes sloping inward to midline. Interocular areas and lateral and posterior two-thirds of carapace densely granulate. Median sulcus widely interrupted. Triangular depression

deep. Sides of triangular depression swollen inwards. Ocular tubercle large. Median eye furrow deep where crossing ocular tubercle. Median eyes moderately large; closer to anterior than to posterior edge of carapace. i.e. positioned at about two-thirds of carapace length from posterior edge; distance apart about equal to or slightly less than eye diameter.

Chelicerae (Fig. 16) as for genus.

Tergites of first six abdominal segments densely granulate with fine to coarse granules with a row of coarse spaced granules along posterior edge. Pretergite moderately wide. Median pair of keels prominent, granulate, about half length of segment. Tergite of last abdominal segment densely granulate. Central keel granulate, wide, prominent, present in middle and towards anterior part of segment. Median and lateral pairs of keels granulate and prominent along whole of segment-length except anteriorly, the granules slightly increasing in size posteriorly.

First four sternites smooth, except for granules along lateral edges. Median keels absent. Lateral keels granulate. Last sternite smooth except for granules along lateral edges. Median pairs of keels absent. Lateral pair of keels present in anterior three-fourths of segment.

Tail long to very long, thick. First four tail segments (Fig. 45) with first segment long, second to fourth very long (about 4 times height). Intercarinal surfaces ranging from with scattered granules to smooth. Dorsal keels denticulate. Terminal denticle of dorsal keels of first, second and third segments triangular pointing posteriorly, and much enlarged, especially in second and third segments, in fourth not enlarged. Other keels denticulate. Accessory keel in first segment present along entire length, in other segments absent. Ventromedian keel double. Fifth tail segment very long. Intercarinal surfaces faintly granulate. Keels weakly denticulate. Ventromedian keel not bifurcating.

Vesicle moderately small, elongate (length about 3 times height). Subaculear prong large, laterally compressed, triangular, bluntly rounded at apex; a small pair of blunt thorns present on aculear side and also a small thorn on aculear side at apex. Subaculear prong points towards middle of curve of aculeus. Curve between aculeus base and subaculear prong narrow and small.

Aculeus short, abruptly curved.

Humerus very long (about 4 times height). Surfaces densely granulate. Keels finely denticulate.

Brachium very long (about 4 times height). Anterior surface with denticles of various sizes. Other surfaces ranging from with scattered granules to smooth. Anterodorsal keel mainly finely denticulate but with some coarse denticles. Dorsal accessory keels present.

Hand moderately narrow and elongate. Intercarinal surfaces ranging from with scattered granules to smooth. Keels weak and smooth except for anterodorsal keel and area along it which has small denticles.

Fingers long (about 1¼ times hand length). Along edge of movable finger basally central row of teeth extending somewhat less than half length of finger. Central row followed distally by 5 sets of teeth with a total of 7 external and 6 internal accessory teeth spaced along these sets.

Legs with tarsomere I of first pair dorsally with no prongs. Ventral surface of tarsomere II of fourth pair of legs with no inner or outer prongs, but with long white hairs in a moderately dense arrangement.

Pectinal teeth 11-17 (Mean 13.0, SD 1.45) in male; 10-17 (Mean 12.1, SD 1.30) in female.

Paraxial organ (Figs 78, 79) with flagellum in the form of a wide structure with slightly circular portion at apex with an elongation extending along lamina towards lobes and sharply bent at extremity; inner lobe close to external lobe; external lobe wide at apex, lobe on inner side long and curving to a point, lobe on outer side broad and blunt, indented between these lobes.

#### Material examined

32♂, 68♀ (Map 7a and b).

#### (?) WESTERN AUSTRALIA

(?) King Sound, 1♂ (holotype of *I. melanodactylus inflatus*), 1♂, 4♀ (paratypes of *I. m. inflatus*) MM.

#### NEW SOUTH WALES

Lawrence, 19.xi.1966 (A. Holmes) 1♀, AM. Tooloom Plateau, 31.x.1970 (G.B. Monteith) 1♀, UQ.

#### QUEENSLAND

Bamaga, Cape York, v.1968 (R. Trundle) 1♀, UQ. Bell, 25.ix.1960, 1♂, UQ. Biggenden, 5.i.1961 (D. Randall) 1♂, UQ. Blue Mountains, 14.xi.1945 (Wassell) 1♂, UQ. Brisbane, 16.xi.1955, 1♂, UQ; 18.ix.1956 (C.A. Muir) 1♀, UQ; 13.iv.1957 (E. Russell) 1♀, UQ; 10.viii.1959 (T. Tonga) 1♂, UQ; near (E. Shaw) 1♂, QM. Brookfield, 28.iv.1958, 1♂, UQ. Caboolture, 10.x.1960 (W.J. Tomlins) 1♀, UQ. Cairns, 1♀, MM. Cape York, 14.iii.1939 (W.H. Barnard) 2♂, 1♀, 39/1730-2, WAM. Chinchilla, 27.v.1963, 1♂, UQ. Condamine, 10.iii.1937 (N. Geary) 1♂, 1♀ and 5 young, AM. Dalby, 13.ii.1961 (I.E. Hiddins) 1♂, QM. Dawson River (E.D. Barnard) 1♀, SAM. Dorrigo, Heron (?), 2♂, SAM. Dulacca, 28.v.1957 (L.E. Jackson) 2♀, UQ. Endeavour River, 2♀, MM. Finch Hatton, i.1935 (L. Dexter) 1♂, W537, QM. Gatton, 15.i.1957, 1♀, UQ. Helidon, 28.iv.1945, 1♀, UQ. Iron Range, 29-30.iv.1968 (P. Ogilvie) 1♂, QM; 26.vii.1968 (J.C. Le Souef) 1♀, 73/370,

WAM; 26-31.v.1971 (G.B. Monteith) 1♂, 1♀, UQ; 1-9.vi.1971 (G.B. Monteith) 2♂, 4♀, UQ. Lamington National Park, 1968 (P. Ogilvie) 1♀, QM. Lockhart River Mission, Cape York, 12.vi.1956 (E.N. Marks) 1♀, UQ. Mt Garnet, 18.x.1960 (Y.W. Saunders) 1♀, Sc.4, QM108, QM. Pittsworth, viii.1958, 1♀, UQ. Rockhampton, 1945 (I.F.B. Common) 1♀, Sc.2, QM 106, QM. Rocky River, 19.vi.1960 (J.L. Wassell) 1♀, AM. 'S.E. Qld.', 1936, 1♀, UQ. Springbrook, 2.v.1960, 1♀, UQ. Stradbroke I., 23.iv.1966, 1♀, UQ; 7.v.1966, 1♀, UQ. Taroom, 10.ix.1947, 3♂, 5♀, UQ. Yeppoon, viii.1960 (S. Sinnamon) 2♀, UQ.

#### PAPUA NEW GUINEA

Ameria (Madang Dist.), 5.xi.1972 (B. Gray) 1♂, 1♀, No. 36, 1♀, No. 38, DFNG. Beenleigh, 22.ix.1970 (B. Gray) 1♂, S.20, 12♀, S.15-19, S.21, DFNG. Beipa'a (Central Dist.) 7.v.1969 (H. Ivagai) 1♀, No. 4, DFNG. Bulolo, 16.vii.1969 (B. Gray) 1♀, S.2, 1♀, S.3, 1♂, 1♀, S.4, DFNG; 2.v.1970 (B. Gray) 1♂, S.9, DFNG; 3.vii.1970 (M. Gamea) 1♂, S.28, DFNG; 18.viii.1970 (H. Ivagai) 1♂, 1♀, S.11, DFNG; 18.viii.1970 (B. Gray) 1♂, S.12, DFNG; 17.ix.1970 (M. Gamea) 1♀, S.13, 3.229, DFNG; 18.ix.1970 (B. Gray) 1♀, S.14, 5.589, DFNG. Dagi River (New Britain), 5.ii.1971 (B.C. Peters) 1♀, No. 9, DFNG. Izzy Dizzy, 24.ix.1970 (B. Gray) 1♂, S.22, DFNG. Kinjingini, 19.i.1969 (N. Gough) 1♂, 1♀, S.24, DFNG. Mugmump, Jimi Valley, 20.vii.1972 (B. Gray) 1♂, S.33, 1♀, S.29, 1♀, S.32, DFNG.

#### NO EXACT LOCALITY

'Qld or N.S.W.' (R. Stein) 1♀, QM.

#### Remarks

Marked sexual dimorphism in shape was revealed by multivariate analyses (Campbell & Koch, in preparation), but within each sex little intraspecific variation in non-shape characters is exhibited among the large amount of material examined.

The King Sound location is not in keeping with the rest of the data and is questioned. If specimens are found to confirm the record and are also found in the north of the Northern Territory it could mean that *I. melanodactylus* has a similar distribution in Australia to *Liocheles waigiensis*.

Vachon (personal communication) is working towards a subgeneric grouping of *I. melanodactylus* and other *Isometrus* species.

#### FAMILY SCORPIONIDAE Pocock, 1893

##### Subfamily Ischnurinae Pocock, 1893

##### Genus *Liocheles* Sundevall

*Liocheles* Sundevall, 1833: 31 (as a subgenus). Type species *Scorpio australasiae* Fabricius, 1775: 399 (by monotypy).

*Ischnurus* Koch, 1838: 69. Type species *Ischnurus complanatus* Koch, 1838: 73 [= *Sisyphus complanatus* (Koch, 1837: 37)] (by subsequent designation). [= *Liocheles australasiae* (Fabricius, 1775).]

*Hormurus* Thorell, 1876: 14. Type species *Ischnurus caudicula* Koch, 1867: 237 (by subsequent designation). [= *Liocheles waigiensis* (Gervais, 1844).]

#### Distribution

From India and Korea, through Southeast Asia, northern and eastern Australia and islands of the tropical west Pacific, to Tahiti.

#### Species included

In Australo-Papua: *Liocheles australasiae* (Fabricius, 1775); *L. waigiensis* (Gervais 1844); *L. karschii* (Keyserling, 1885).

Outside Australo-Papua: *L. australasiae* (Fabricius, 1775); *L. waigiensis* (Gervais 1844); *L. karschii* (Keyserling, 1885); *L. nigripes* (Pocock, 1897).

#### Description

Carapace tapering sharply from two-thirds the distance from posterior edge. Sides of carapace moderately depressed laterally. Triangular depression shallow to moderately deep. All three lateral eyes on very edge of carapace. Chelicerae with faint secondary serrations or none. Sternites smooth, shiny, finely pitted, with two lateral sulci widely forked anteriorly. Tail small, short and moderately slender. Vesicle small to moderately small; many long setae present ventrally especially towards aculeus. Brachium with keels of anterior surface terminating proximally either in three processes with the central process large and triangular (trifid) or terminating in two processes (bifid). Hands flat, not elongate to elongate. Movable finger of hand with along edge two parallel rows of teeth. Movable finger in male, but not in female, with a large rounded outcurved portion near base with a corresponding incurved portion in fixed finger. Legs with tarsomere I of first pair dorsally with a row of 2-5 setae, not prongs (c.f. *Urodacus*, which has a row of prongs). Terminal claws equal. Tarsomere II ventrally with two lateral rows of setae, not prongs; rarely some of these developed into prongs, viz. sometimes in the fourth pair of legs of *L. karschii*. Leg distally with a down-pointing prong (median claw) near terminal claws. Base of tarsomere II with one spine (pedal spur). Sternum of about same length as width.

#### Affinities

*Liocheles* appears to be closest to *Iomachus* Pocock, 1893, and less close to *Hadogenes* Kraepelin, 1894, and *Opisthacanthus* Peters, 1861.

*Liocheles australasiae* (Fabricius)

(Figs 17, 46, 80, 81, Map 8a and b)

*Scorpio australasiae* Fabricius, 1775: 399.

- Scorpio (Liocheles) australasiae* (Fabricius) Sundevall, 1833: 31.
- Ischnurus australasiae* (Fabricius) Koch, 1838: 71.
- Ischnurus complanatus* Koch, 1838: 73.
- Scorpio gracilicauda* Guérin-Meneville, 1843: 11.
- Scorpio cumingii* Walckenaer & Gervais, 1844: 69.
- Ischnurus pistaceus* Simon, 1877a: 93.
- Hormurus australasiae* (Fabricius) Thorell, 1877: 251; Keyserling, 1885: 22; Thorell, 1888: 419; Pocock, 1893a: 96; Simon, 1893: 328; Thorell, 1894: 1; Kraepelin, 1894: 133; Kraepelin, 1897: 1; Kraepelin, 1899: 154; Simon, 1899: 120; Pocock, 1900: 79; Kraepelin, 1901: 272; Werner, 1902: 603; Kraepelin, 1913: 163; Kraepelin, 1914: 328; Werner, 1916: 91; Kopstein, 1921: 135; Kopstein, 1923: 185; Kopstein, 1926: 111; Giltay, 1931: 9.
- Liocheles australasiae* (Fabricius) Simon, 1887: 113; Takashima, 1945: 95; Takashima, 1948: 86; Takashima, 1950: 17.
- Hormurus australasiae suspectus* Thorell, 1888: 419; Kraepelin, 1899: 154; Kraepelin, 1913: 163.
- Buthus brevicaudatus* Rainbow, 1897: 107. [4 syntypes examined].
- Hormurus boholiensis* Kraepelin, 1914: 333.
- Hormurus caudicula boholiensis* (Kraepelin) Giltay, 1931: 12.

#### Range (Map 8a and b)

Queensland, northern (eastern Cape York Peninsula); Thursday I. Northern Territory, Darwin. Western Australia, at Prince Regent River Reserve. New Guinea. Aru Is.

Outside Australo-Papua: Himalayas, Assam, Delta of the Ganges, Andaman Is, Nicobar Is, Korea, China, northern Thailand, southern South Vietnam, Poulo Condore, Philippine Is, Mariana Is, Malaya, Nias, Sumatra, Sebesi I., Java, Borneo, Celebes, Salayer, Buru, Batjan, Ternate, Halamahera, Amboina, Madura, Flores, Timor, Cocos Is, Christmas I., New Britain, Solomon Is, New Hebrides, Vanikoro (Santa Cruz Is), Loyalty Is, New Caledonia, Funafuti (Ellice Is), Fiji Is, Samoa, Tonga, Tahiti.

#### Measurements (mm)

♂. S.E. Papua, NG, QM. Total length 35, of tail 14; carapace, length 5.8, width 5.4; tail segments one to five (in that order), length 1.2, 2.1, 2.0, 2.4, 2.9, width 1.4, 1.1, 1.1, 1.1, 1.1, height 1.4, 1.5, 1.5, 1.5, 1.2; length of vesicle and aculeus 3.7; width of vesicle 1.2; length of humerus 4.6; brachium, length 5.3, width 3.6; hand, length 6.9, width of hand surface 4.6,

height 2.2; length of hand and fixed finger 10.0; length of movable finger 5.4; length of pectine 3.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=3)									
Min.	5.8	5.4	6.0	3.5	2.2	10.0	5.4	2.2	1.1
Max.	6.1	6.5	7.7	4.6	2.7	11.7	5.5	2.9	1.7
Mean	5.9	5.9	6.9	4.2	2.4	10.7	5.4	2.5	1.4
Female (n=25)									
Min.	3.6	3.8	3.9	2.4	1.2	6.2	2.9	1.5	0.8
Max.	5.2	5.6	6.3	3.7	1.8	9.6	4.4	2.3	1.3
Mean	4.6	4.8	5.4	3.2	1.5	8.2	3.7	2.0	1.1
SD	0.42	0.42	0.54	0.11	0.16	0.81	0.35	0.13	0.13

### Diagnosis

Distinguished from *L. waigiensis* and *L. karschii* by the following combination of characters: small size (adult CL<5.9 mm); terminal spine present along dorsal keel of third tail segment and also usually of fourth tail segment; carapace and tergites minutely pitted throughout.

### Description

Colour brown to light brown, sometimes light yellowish brown; ventral surface light brown; arms and hands usually brown; sometimes light brown; vesicle orangish yellow; legs lighter than tergites and orangish yellow.

Carapace with frontal notch wide, usually shallow. Frontal lobes rounded, sometimes tending to be pointed along anterior edge. Interocular areas smooth and minutely pitted. Lateral and posterior two-thirds of carapace smooth and finely pitted somewhat rugose. Median sulcus uninterrupted. Triangular depression usually shallow. Sides of triangular depression (sometimes poorly defined) swollen towards base. Median eyes closer to anterior than to posterior edge.

Chelicerae (Fig. 17) with little tendency for secondary serrations. All teeth often sharply pointed. Fixed jaw with sub-basal tooth moderately to widely distant from median tooth. Median tooth and basal tooth about same size. Movable jaw with subdistal tooth moderately large, median tooth large and basal tooth small. Secondary serration along proximal edge of distal external tooth.

Tergites of first six abdominal segments smooth and minutely pitted throughout with a rugose patterning and with wide median keel better defined in more posterior segments. Pretergite not prominently continued laterally. Tergite of last abdominal segment pitted; sometimes granulate laterally; median and longitudinal keels usually not evident, never prominent.

Tail short and slender. First four tail segments (Fig. 46) short and squat. Intercarinal surfaces pitted and granulate. Dorsal keels with small denticles

terminating in a triangular spine in third segment and usually also in fourth segment, sometimes also in second segment. Lateral keels granulate and poorly defined. Ventral keels and transverse distal edge of first two segments with prominent spines, especially large in second segment; ventral keels of third and fourth tail segments denticulate to poorly defined. Accessory keels practically non-existent. Fifth tail segment with dorsal intercarinal surfaces mainly smooth; dorsolateral intercarinal surfaces sometimes weakly granulate, usually pitted, especially posteriorly; ventral intercarinal surfaces granulate. Ventromedian keel with spines. Ventrolateral keels with large spines.

Vesicle small, somewhat elongate, sides rounded; smooth and minutely pitted. Sulci usually poorly defined.

Aculeus short, moderately curved.

Humerus with dorsal surface usually both pitted and granulate; sometimes not granulate, rarely smooth; ventral surface smooth, often pitted along anterior portion; keels denticulate.

Brachium dorsally rugose and pitted, ventrally mainly smooth, pitted often mainly along anterior half. Keels denticulate. Dorsal and ventral keels of anterior surface each terminating proximally in a pointed triangular process curving at apex in direction of hand (i.e. anterior surface has a bifid structure). Base of each process with a seta. Ventral group, *v*, with 3 trichobothria. Posterior surface, *p*, with 13 trichobothria.

Hand flat, not elongate. Dorsal intercarinal surface rugose, granulate and pitted; posterior intercarinal surfaces with large granules, slightly denticulate; anterior intercarinal surfaces granulate, pitted, rugose, no defined keels; intercarinal surfaces smooth and pitted. Main (bounding) keels of larger granules and denticles. Dorsal surface faintly bounded at anterior edge by denticles, and bounded at posterior edge by granules and denticles. All main keels usually dark. Posterior surface with faint median keel. Ventral group, *V*, with 4 trichobothria. 5 trichobothria proximally: *Esb*, *Db*, *Eb*<sub>1</sub>, *Eb*<sub>2</sub>, *Eb*<sub>3</sub>.

Fingers very short. Trichobothria *dst*, *dsb*, and *db* in a weakly defined groove, with smooth areas around each of these trichobothria. Fixed finger hooked at apex; notch present near apex.

Legs with tarsomere I of first pair dorsally with usually 3 prongs. Ventral surface of tarsomere II of fourth pair with a row of 4 inner and 4 outer setae.

Pectinal teeth 8-9 (Mean 8.6) in male; 4-8 (Mean 6.0, SD 0.40) in female.

Paraxial organ (Figs 80, 81) with lamina moderately long, uniformly wide, bluntly rounded at apex; inner lobe narrowing towards the rounded to pointed apex; median lobe moderately long, pointed at apex, wide at base;

supporting enlargements at base moderately elongate; external lobe without elongations at apex; apotheca sclerotized.

#### Material examined

3♂, 87♀ (Map 8a and b).

#### (?) NEW SOUTH WALES

(?) Moolah, 1♂, K13332, AM.

#### QUEENSLAND

Cairns, 2♀, MM. Claudie River, xi.1913-ii.1914 (J.A. Kershaw) 1♀, NM. Lankelly Creek (McIlwraith Range near Coen) 28-31.x.1969 (B. Cantrell) 1♀, UQ. Leo Creek (McIlwraith Range near Coen) 2-3.xi.1969 (B. Cantrell) 2♀, UQ; 13.viii.1972 (B. Gray & R. Stevens) 2♀, S.35, DFNG. Neneba (?), xi.1896, 1♀, QM. Peach Creek (McIlwraith Range near Coen) 3-4.xi.1969 (B. Cantrell) 1♀. UQ.

#### NORTHERN TERRITORY

Darwin, 1912 (Spencer) 1♀, NM.

#### PAPUA NEW GUINEA

Ameria (Madang Dist.) 5.xi.1972 (B. Gray) 1♀, S.37, DFNG. Brown River (Central Dist.) 10.ii.1969 (H. Ivagai) 2♀, No. 3, DFNG. Bulolo (Morobe Dist.) (Crooked L.A.) 21.i.1969 (F.R. Wylie) 1♀, No. 2, DFNG; (Middle Creek, L.A.) 15.vii.1969 (B. Gray) 1♀, S.1, DFNG; (Middle Creek, L.A.) 16.vii.1969 (B. Gray) 8♀, 6 young, S.2, 4-6, DFNG; (2 km E of Heads Hump, L.A.) 2.v.1970 (B. Gray) 9♀, S.7-9, DFNG; (1 km E of Heads Hump, L.A.) 4.v.1970 (B. Gray) 2♀, S.10, DFNG. Jimi Valley (Western Highlands Dist.) 17.ix.1968 (F.R. Wylie) 3♀, No. 1, DFNG. Kikori (sea level) 18.ix.1956 (Dawson) 1♀, AM. Lae, viii.1959 (A.C. Robinson) 1♀, UQ. Madang (Madang Dist.) 13.i.1969 (F.R. Wylie) 1♀, S.23, DFNG. Mapos (Morobe Dist., Buang Mountains) 21.i.1969 (F.R. Wylie) 1♀, S.25, DFNG. Mugmump, Jimi River Valley (Western Highlands Dist.) 20.vii.1972 (B. Gray) 4♀, S.30, S.31a, S.31b, S.34, DFNG. 'New Britain', 1♂, 2♀, K13325, AM; 2♀, SAM. 'S.E. Papua', x.1914, 1♂, QM. Volcanic I. (?) (M. Bay Dist.) 16.vi.1970 (B. Gray & J. Dobunaba) 1♀, S.27, DFNG. Vudal (Rabaul) (Gazelle Pen., East New Britain Dist.) 8.v.1968 (F.R. Wylie) 2♀, No. 5, DFNG. Waramuri (Bulolo, Morobe Dist.) 14.ii.1969 (J. Dobunaba) 1♀, No. 7, DFNG.

#### CHRISTMAS ISLAND

Flying Fish Cove, vi.1961 (G.F. Mees) 6♀, 66/321-6, WAM; on plateau and levels above shore terrace, ix.1967 (S. Slack-Smith & A. Paterson) 4♀, 72/326-9, WAM.

## SOLOMON ISLANDS

Piva Riva (Empress Augusta Bay, Bougainville) xi.1945 (E.D. Watson) 1♀, AM. Ysabel I. (Solomon Group) 1.vi.1925 (N.S. Heffernan) 1♀, K53861, AM; 7.xii.1926 (N.S. Heffernan) 1♀, K56558, AM; (N.S. Heffernan) 1♀, K53935, AM.

## SANTA CRUZ GROUP

Vanikoro, 3.viii.1926 (T. & S.) 4♀, K55271, AM; 1926 (N.S. Heffernan) 5♀, K55270, AM.

## NEW HEBRIDES

Big Bay (Santo) 1930 (F.P. Newton) 1♀, AM. Malekula I., 4♀, K12781, AM.

## ELLICE ISLANDS

Funafuti (Atoll) 4♀ (not 1♂, 3♀ as stated by Rainbow, 1897), K2067, AM (syntypes of *Buthus brevicaudatus*).

## TONGA ISLANDS

Tonga, i.1930 (H.R. Rabone) 1♀, AM.

## Remarks

The Moolah, N.S.W., record is questionable because there are no other specimens of the species from south of Cape York Peninsula in North Queensland. The Melbourne (Kraepelin 1901) record is also questioned. If these records are correct it would indicate that in Australia the species at one time had a much wider distribution which has subsequently contracted leaving relict populations; but the view that within Australia the species is confined to northern parts seems much more feasible.

The *L. australasiae* specimens were found under the bark of trees, logs, and stumps; and in rotten stumps, viz., of *Tuan* sp. at Vudal (NG). They were found under the bark of teak (*Tectona grandis*) at Madang (NG), and coconut palm on Volcanic I. (NG). All the specimens collected by B. Gray at Bulolo (NG) were under the bark mainly of the middle and lower stems of *Araucaria hunsteinii* at heights of up to 40 m.

The small number of available male in relation to female specimens (3♂, 87♀) could indicate that females devour a high percentage of the males, or that there is selective predation of the sexes; but no explanation is possible from the available information on the distribution and behaviour of the species, and the view that the disparity might represent a true difference in the sex ratio cannot be ruled out.

Although the examined specimens are from a wide range of localities, there is little evident variation of surfaces and keels. There is, however, some variation in the amount of dark brown patterning and colour reticulation on most dorsal areas of the body and over a large area of the tail segments: e.g.

dark and plentiful coloration at Kikori (NG) and very faint at Malekula I. (New Hebrides), but these differences are regarded as individual variation because there are insufficient specimens to decide whether they are really instances of geographic variation.

There is no obvious geographic variation in adult size or pectinal tooth count. Adult CL ranges (mm) at various localities are as follows: Darwin (NT), Claudie R. (Qld) and Cairns (Qld) 4.3-5.2 (3♀); NG 5.8 (2♂), 4.3-5.2 (5♀); Christmas I. 5.0 (1♀); Solomon Is 5.1 (1♀); Vanikoro 4.2-5.0 (7♀); New Hebrides 4.4-5.1 (4♀); Funafuti 4.3-4.4 (2♀). Pectinal tooth counts at various localities are as follows: Australia (NT and Qld) 5-7 (9♀); NG 8-9 (2♂), 4-8 (38♀); Christmas I. 4-6 (10♀); Solomon Is 6-7 (4♀); Vanikoro 6-7 (9♀); New Hebrides 6 (5♀); Funafuti 6 (4♀); Tonga 6 (1♀).

*Liocheles waigiensis* (Gervais)

(Figs 18, 47, 82, 83, Map 9a and b)

*Scorpio (Ischnurus) waigiensis* Gervais, 1844: 237; Walckenaer & Gervais, 1844: 69.

*Ischnurus caudicula* Koch, 1867: 237.

*Hormurus caudicula* (Koch) Thorell, 1876: 14; Thorell, 1877: 249; Karsch, 1879: 21; Keyserling, 1885: 27; Thorell, 1888: 426; Kraepelin, 1894: 135; Kraepelin, 1897: 1; Kraepelin 1899: 155; Kraepelin, 1901: 272; Werner, 1902: 603; Kraepelin, 1914: 333; Kraepelin, 1916: 43; Kopstein, 1921:137; Werner, 1916: 92.

*Ischnurus neocalendonicus* Simon, 1877b: 237.

*Ischnurus dechangei* Becker, 1880, 143.

*Hormurus insculptus* Thorell, 1888: 422; Thorell, 1894: 356; Kopstein, 1921: 140.

*Hormurus weberi* Pocock, 1893a: 97; Kraepelin, 1914: 332.

*Hormurus caudicula weberi* (Pocock) Kraepelin, 1894: 138; Kraepelin, 1899: 155; Kopstein, 1921: 139; Giltay, 1931: 13.

*Hormurus caudicula insculptus* (Thorell) Kraepelin, 1894: 138; Kraepelin, 1897: 1; Kraepelin, 1899: 155; Kraepelin, 1901: 272.

*Hormurus sarasini* Kraepelin, 1914: 332.

*Hormurus caudicula caudicula* (Koch) Giltay, 1931: 13.

*Hormurus caudicula sarasini* (Kraepelin) Giltay, 1931: 13.

*Hormurus caudicula novaeguineae* Giltay, 1931: 11.

*Liocheles caudicula* (Koch) Takashima, 1945: 95; Takashima, 1948: 84; Takashima 1950: 17.

## Range (Map 9a and b)

Queensland, mainly east of Great Dividing Range, furthest south at Boonah, furthest south-west at Moolyember Gorge. Northern Territory, northern, at Cape Arnhem, Darwin and Yirrkala. New Guinea, Aru. Is.

Outside Australo-Papua: Philippine Is, Borneo, Celebes, Sulu Is, Ternate, Halmahera, New Britain, Solomon Is, New Caledonia.

## Measurements (mm)

♂. Ae Hills, Kerema, NG, 29/50, WAM. Total length 44, of tail 18; carapace, length 6.7, width 6.5; tail segments one to five (in that order), length 2.1, 2.4, 2.5, 2.8, 4.5, width 1.8, 1.5, 1.4, 1.3, 1.3, height 1.6, 1.6, 1.5, 1.5, 1.5; length of vesicle and aculeus 4.8; width of vesicle 1.8; length of humerus 6.1; brachium, length 6.0, width 3.6; hand, length 8.1, width of hand surface 5.2, height 2.9; length of hand fixed finger 12.7; length of movable finger 6.0; length of pectine 3.7.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=83)									
Min.	6.3	5.9	7.6	4.3	2.4	12.5	6.0	2.7	1.3
Max.	10.9	12.0	22.8	7.5	4.1	30.0	13.6	4.8	2.2
Mean	7.9	8.0	10.8	5.7	3.1	17.4	8.3	3.7	1.6
SD	0.96	1.14	2.86	0.65	0.39	3.41	1.43	0.47	0.19
Female (n=119)									
Min.	5.7	6.1	5.8	3.8	2.1	10.0	5.2	2.3	1.1
Max.	11.8	12.8	15.3	8.9	4.7	25.6	12.8	4.8	2.8
Mean	8.5	8.8	9.9	6.4	3.5	16.8	8.5	3.5	1.7
SD	1.08	1.25	1.76	0.86	0.47	2.75	1.35	0.44	0.24

## Diagnosis

Distinguished from *L. australasiae* and *L. karschii* by the following combination of characters: medium size (adult CL=6.6-11.8 mm); parts of carapace are both granulate and pitted.

## Description

Colour dark brown to reddish brown and light yellowish brown; carapace and especially arms and hands usually darker than tergites and dark brown to reddish brown; legs and ventral surface paler and yellowish brown; vesicle light yellowish orange.

Carapace with frontal notch wide and moderate to deep. Frontal lobes rounded to pointed at anterior edge which mesally is slightly truncate. Interocular areas often slightly rugose towards frontal edge; in female mainly smooth, also minutely pitted over a large part of the area, in male granulate to minutely granulate and less pitted than in female. Lateral and posterior

two-thirds of carapace granulate. Median sulcus uninterrupted, sometimes slightly interrupted. Triangular depression moderately deep. Sides of triangular depression practically straight. Median eyes about half way between anterior and posterior edges.

Chelicerae (Fig. 18) with secondary serrations. Fixed jaw with sub-basal tooth moderately distant from median tooth; median tooth larger than basal tooth; tendency for secondary serration on proximal base of sub-basal tooth. Movable jaw with subdistal tooth and basal tooth small, median tooth large and wide. Secondary serration at proximal base of subdistal, basal and median teeth. All teeth usually sharply pointed.

Tergites of first six abdominal segments minutely pitted, in male with granules especially towards posterior edge in more posterior segments; with a rugose patterning and with a narrow median keel. Pretergite wide, weakly continued laterally. Tergite of last abdominal segment rugose, minutely pitted, and granulate sometimes mainly in posterior portion; median keels and lateral longitudinal keels weak or absent.

Tail short, slender. First four tail segments (Fig. 47) moderately squat. Intercarinal surfaces rugose and granulate, sometimes with minute denticles dorsally. Dorsal and lateral keels poorly defined and granulate to denticulate. No terminal spine at end of dorsal keels. The two ventromedian keels better defined than the other keels. No spines ventrally on transverse distal edge of segments. Accessory keels weak and practically absent. Fifth tail segment dorsolaterally rounded. Intercarinal surfaces rugose and granulate, with minute denticles dorsally and large denticles ventrally towards posterior. Ventrolateral keels mainly composed of large pointed denticles especially posteriorly. Ventral keel composed of broad row of denticles usually present only towards middle and posterior end of segment.

Vesicle small, elongate, and tending to be laterally flattened; smooth and minutely pitted. Sulci weak, comprising (when evident) a faint ventromedian sulcus on each side, a faint ventrolateral sulcus, and a better defined dorsolateral sulcus.

Aculeus short, moderately to strongly curved.

Humerus with surfaces finely granulate, with bounding keels of large dark granules.

Brachium with surfaces granulate. Bounded at anterodorsal and anteroventral edges by a row of large dark denticles and at posterodorsal and posteroventral edges by a row of large dark granules. The dorsal and ventral keels of anterior surface terminate proximally in a large prominent triangular process curving at apex in direction of hand. On each side of the triangular process is a smaller triangular process (i.e. anterior surface has a trifold process). Base of each side process with a seta. Ventral group, *v*, with 3 trichobothria. Posterior group, *p*, with 13 trichobothria.

Hand elongate to very elongate in male, less elongate and often broad in female; flat. Dorsal and posterior intercarinal surfaces granulate to denticulate, other intercarinal surfaces with smaller granules. Main (bounding) keels of larger granules or denticles. Dorsal surface bounded at anterior edge by denticles, and at posterior edge by granules. Two non-parallel keels on anterior surface. All main keels dark. Each surface other than anterior with one faint median keel. Ventral group, *V*, with 4 trichobothria. 4 trichobothria proximally: *Db*, *Eb*<sub>1</sub>, *Eb*<sub>2</sub>, *Eb*<sub>3</sub>.

Fingers short to moderately short. Trichobothria *dst*, *dsb*, and *db* in a weakly defined granulate groove with smooth areas around each of these trichobothria. Fixed finger hooked at apex; notch present near apex.

Legs with tarsomere I of first pair dorsally with usually 4 setae. Ventral surface of tarsomere II of fourth pair with a row of 5 (sometimes 4) inner and 5 outer setae.

Pectinal teeth 6-11 (Mean 7.5, SD 0.68) in male; 4-10 (Mean 6.3, SD 0.59) in female.

Paraxial organ (Figs 82, 83) with lamina moderately long to long, narrow to moderately wide, apex often curved and pointed; inner lobe rounded at apex, sometimes bluntly rounded; median lobe long, narrow, usually rounded, sometimes wide; supporting enlargements at base moderately elongate; external lobe with apex developed into a small spout-shaped elongation; apotheca thickly sclerotized especially basally.

#### Material examined

164♂, 266♀ (Map 9a and b).

#### WESTERN AUSTRALIA

Prince Regent River Reserve, Stn E5(4), 15.viii.1974 (B.R. Wilson) 4♂, 4♀, 74/1545-52, WAM; Stn W6(1), 20.viii.1974 (B.R. Wilson) 1♀, 74/1544, WAM.

#### (?) VICTORIA

(?) Grampian Range, 2♂, 2♀, NM. (?) 'Victoria', 18.ix.1893 (C. French) 1♀, SAM.

#### QUEENSLAND

Acacia Ridge, 10.xii.1961 (R.G. Winks) 1♀, Sc.9, QM110, QM. Almaden (Chillagoe Dist.) xi.-xii.1925 (W.D. Campbell) 1♀, AM. Bamaga, 3-6.vi.1969 (G.B. Monteith) 4♀, UQ. Barcoo (McCarthy Metzger) 2♀, K56793, AM. Batavia R. (Wenlock) 2♂, AM. Beaudesert, 7.v.1954 (R.E. Harrison) 1♂, UQ. Biloela, ii.1929 (R. Henzell) 1♂, UQ; (A. Hauppila) 1♂, QM. Blue Mountains (Cape York Pen.) 6.xi.1945 (Wassell) 9♂, 4♀, UQ. Boonah, 22-23.xii.1971 (A.M. & M.J. Douglas) 4♂, 10♀, 72/297-310, WAM; 24 km S of, 27.xii.1971 (A.M. & M.J. Douglas) 6♂, 1♀, 72/290-6, WAM. Boraine (?), (at 455 m)

vii.1896, 1♂, QM. Brisbane, 23.vii.1916 (E. Shaw) 1♀, QM; i.1925, 1♂, NM; 18.v.1955 (D. Griffith) 1♀, UQ; 24.v.1955, 1♂, UQ; 27.iv.1957 (J.C. Morrow) 1♂, UQ; 27.x.1957 (Haseler) 2♀, UQ; 22.ix.1957, 1♂, 2♀, UQ; 21.xi.1957 (R. Metcalfe) 1♀, UQ; 11.x.1958, 1♀, UQ; 16.v.1959 (L.A. Powell) 1♀, UQ; 25.v.1959 (D.R.J. Densley) 1♀, UQ; 7.vii.1959 (W.L. Gibson) 1♀, UQ; viii.1959 (B. Yunibobo) 1♀, UQ; 14.ix.1959 (F.L. Lamberth) 1♀, UQ; 27.ix.1959 (G. Cassidy) 1♀, 4C, UQ; 5.x.1959 (A. Cameron) 1♀, UQ; 10.vii.1960 (G.D. Smith) 1♀, UQ; vii.1971 (T. Low) 1♂, 72/255, WAM; (H. Hacker) 4♀, QM; (E.R. Waite) 11 young, NM; (A.H. Fooks) 1♂, W60, QM; near (E. Shaw) 2♀, QM. Brookfield (Brisbane) 29.ix.1958, 1♂, UQ. Bundaberg (C.L. Corter) 1♀, W53, QM. Byfield (near Yeppoon) x.1924 (A. Musgrave) 1♂, 3♀, K51657, AM. Cairns, iii.1950 (J.G. Brooks) 1♂, NM; 17.vii.1970 (J.C. Le Souef) 1♀, NM. Calliope, 5 km N of Gladstone, 1940 (C.S. Ashby) 1♂, 1♀, AM. Cape Pallarenda (foothills of Many Peaks Range), 7.x.1967 (F. Breuer) 12♂, 14♀, 72/311-2, 72/262-85, WAM. Cape York, 3♀, MM. Childers Mill, Isis scrub, ix.1900, 2♀, AM. Claudie River (Cape York Pen.) 2.vi.1966 (D.K. McAlpine) 1♂, AM. Cooktown, 20.vii.1968 (J.C. Le Souef) 1♀, 72/258, WAM. Coolum, i.1955 (G. Lambert) 1♂, NM. Darnley I., 2♂, 1♀, MM. Dayboro, 1945 (P.C. Gallier) 1♀ and 26 young, QM. Deception Bay, 23.v.1960, 1♂, UQ. Dundowran, 28.v.1959 (Mungomery) 1♂, 1♀, UQ. Dunk I., 16.viii.1950 (R. Dobson) 1♂, AM; (Hamlyn-Harris) 6♀, QM. Eidsvold, 27.v.1960, 2♀, UQ; 4♂, 1♀, K33311, K31418, AM. Eubenangee, iii.1950 (G. Brooks) 1♂, NM. Eumundi, x.1910 (J.A. Kershaw) 17♂, 15♀, NM; 1♀, 66/334, WAM. Fraser I., 19.ix.1941, 3♀, UQ; (J.A. Thorpe) 2♂, 2♀, K48678, AM. Gayndah, 23.ix.1891 (Spencer Coll.) (pres. 23.iii.1916) 2♂, 4♀, NM; 6♂, 13♀, K228, AM. Goodna, 24.iii.1913 (H. Hacker) 1♀ and 18 young, QM. Gordonvale (W.C. Dormer) 1♂, QM. Guluguba, 2.v.1959 (D.F. Cameron) 1♀, UQ. Harlin, v.1945, 3♂, 3♀, UQ. Hayman I., xii.1933-i.1934 (F.A. McNeill) 1♀, K66873, AM. Helenvale (34 km S of Cooktown) 19.vi.1951 (A. Musgrave & J. Leary) 2♂, AM. Holland Park (Brisbane) 25.v.1937 (H. Richardson) 1♀, QM. Imbil State Forest, 28.v.1959 (I.C. Yeo) 1♀, UQ. Innisfail, 1925 (C.E. Simms) 1♀, K53156, AM. Ipswich, v.1959 (I.W. Barlow) 1♀, UQ; (M. Nicholson) 1♂, UQ. Iron Range (Cape York Pen.) 29-30.iv.1968 (P. Ogilvie) 3♀, QM; 11-17.v.1968 (G. Monteith) 1♂, UQ; 12.vii.1968 (Le Souef) 1♀, NM; 26.vii.1968 (J.C. Le Souef) 1♂, 1♀, 72/256-7, WAM; 10.iv.1971 (M. Moulds) 1♀, AM. Kuranda, i.1908 (pres. 2.iii.1908) (R.W. Armitage) 3♂, 2♀, NM; 2.iii.1908 (Armitage) 4♂, 3♀, NM; 12.vi.1951 (A.N.B.) 1♂, NM; area, 1951 (J.G. Brooks) 1♂, AM. Lockerbie, 6-10.vi.1969 (G.B. Monteith) 1♀, UQ. Maryborough, 9.viii.1959 (R. Harlock) 1♀, UQ; 17.vii.1959 (C.L. Smith) 1♀, UQ; 20.viii.1959 (M. Hamon) 1♂, UQ; 20.viii.1959 (G. Mason) 1♀, UQ. Millmerran, 19.xii.1958 (A. Macqueen) 1♀, UQ. Miriam Vale (Port Curtis) 2♂, 7♀, MM. Mission Beach (near Innisfail) 19.vii.1970 (J.C. Le Souef) 1♂, NM; 20.vii.1970 (J.C. Le Souef) 1♂, NM. Montville, 3.x.1955 (R. Dobson) 1♂, AM. Moolyember Gorge (via Injune)

9.iv.1948 (L. Wassell) 3♀, UQ. Mt Coot-tha, 10.x.1959 (H. Middleton) 2♀, UQ. Mt Fox (near Ingham) vii.1955 (J.A. Sandoz) 5♂, 17♀, AM. Mt Glorious, 29.ii.1947 (P.W. Slupley) 1♀, QM. Mt Tamarind (?), 1912 (D.P.) 1♂, SAM. Mt Tambourine, viii.1958 (K. Korboot) 1♀, 9B, UQ; 21.v.1960 (B. Watkins) 1♀, UQ. Munga Junction (A.M. Lea) 1♂, 3♀, SAM. Nambour, 7.ii.1962 (W.A. Smith) 1♀ and 19 young, Sc.10, QM111, QM. Nanango, 30.ii.1953 (A.L. Peterson) 3♀, QM. North Deep Creek (via Gympie) xii.1963 (R. Freebairn) 1♀, NM. Palm I., ix.1923 (H.A. Longman) 1♂, QM; (L. Bancroft) 1♂, 3♀, QM; 1♂, 2♀, MM. Peak Crossing, 8.vii.1960 (L. Winks) 2♂, 3♀, UQ. Portland Roads, 11.vii.1968 (J.C. Le Souef) 3♂, 72/259-61, WAM. Possession I. (Torres Strait) viii.1928 (M. Ward) 1♀, AM. Prince of Wales I. (Torres Strait) 27.v.1969 (Neboiss) 1♀, NM. 'Queensland', 1867, 2♂, 2♀, AM; xii.1887 (Godeffroy Coll.) 2♂, 1♀, 2244, NM, 24.iii.1913, 4 young, 72/286-9, WAM; 2♂, 8♀, 66/308-17, WAM; 'central', 6.xii.1957 (Jarret) 2♂, NM. Reedybrook, 2.viii.1967 (J.D. Brown) 2♂, 2♀, Sc.11, QM52, QM112, A3178, QM. Rockhampton, x.1957 (W. Jones) 1♂, UQ; viii.1959 (A.J. Jackson) 1♂, UQ. Rockhampton Stn, 1945 (I.F.B. Common) 1♂, Sc.3, QM107, QM. Rocky River (McIlwraith Range via Coen) 14.vi.1960 (C.N. Smithers) 1♂, 1♀, AM; 17.vi.1960 (C.N. Smithers) 1♀, AM; 6-8.xi.1969 (B. Cantrell) 1♂, UQ. Rossville (Cooktown) 5.vii.1970 (J.C. Le Souef) 1♀, NM. Samford, 28.v.1958, 2♂, 1♀, UQ; 9.viii.1958, 1♂, 1♀, UQ; x.1958, 2♀, UQ; 1958, 2♀, UQ; 26.iii.1960, 1♀, UQ. Searys Creek Rainforest, 17-18.x.1970 (G.B. Monteith) 1♂, UQ. South Johnstone, 5.vi.1960 (C.N. Smithers) 1♀, AM. St Johns Wood (Brisbane) 13.i.1962 (R. Freeman) 1♀, QM. Taringa (Brisbane) 5.iv.1939 (E. Needham) 1♂, QM. Townsville, 2.vii.1919 (G.F. Hill) 1♂, NM; 22.vii.1971 (A.V. Spain) 2♂, 9♀, 72/314-5, 72/313, 72/316-23, WAM; (G.F. Hill) 1♂, QM. Woolooga, 29.ix.1960 (J.W. Turner) 1♀, UQ. Yandina, 9.x.1959 (R.B. Parsons) 1♂, UQ. Yarrabah Mission (near Cairns) 26.x.1966 (R.W. Taylor) 1♂, 1♀, 66.18, AM. Yarwun, 2.vi.1959 (J. Guerassimoff) 1♂, UQ. Yeppoon, 13.vi.1960 (C.N. Smithers) 2♀, AM.

#### NORTHERN TERRITORY

Cape Arnhem, 21.vii.1948 (J.E. Bray) 1♀, AM; sea level, 23.vii.1948 (J.E. Bray) 1♀, AM; sea level, 25.vii.1948 (J.E. Bray) 2♀, AM; vii.viii.1948 (J.E. Bray) 1♀, AM. Darwin (near) 1.vii.1917 (G.F. Hill) 1♀, NM. Yirrkala (L. Chaseling) 2♂, 1♀, AM.

#### PAPUA NEW GUINEA

Ae Hills, Kerema, 8.i.1929 (F. Forman) 1♂, 3♀, 29/50-3, WAM. Doibu (Kikori) (Gulf Dist.) 22.viii.1956 (P. Dawson) 1♀, AM. Jimi Valley (Western Highlands Dist.) 17.ix.1969 (F.R. Wylie) 1♂, S.26, DFNG. Lae, 22.i.1961 (R. Ferrario) 1♀, UQ. 'New Britain' (Bismarck Arch.) 1♂, 1♀, K13326, AM. 'New Guinea', ii.1899 (C. Dagnall Clark) 1♀, SAM. Pimaga, 800 km S of (Southern Highlands Dist.) 25.xi.1969 (B. Gray) 1♂, No. 6, DFNG. Rabaul,

New Britain, 1♀, K40172, AM. Warasweet (L.A. Kui, Morobe Dist.) 10.ii.1970 (J. Dobunada & Anton) 1♀, No. 8, DFNG.

#### SOLOMON ISLANDS

Bilua, vii.1933 (A.A. Ward) 2♀, AM.

#### NEW CALEDONIA

Noumea, 1♂, 7♀ K5149, K5150, AM.

#### Remarks

The southern distribution limit of this species seems well defined in south Queensland, and it is doubted that the few specimens, all old, from Victoria bear correct labels.

Specimens from Reedybrook and Almaden, both inland localities in north-east Queensland, have atypical prominences on the brachium.

Specimens of *L. waigiensis* have been collected in Queensland under rocks and iron at Portland Roads, under stones at Yarwun and Maryborough, in a grass-tree stump at Acacia Ridge, in rotten logs at Maryborough, under bark at South Johnstone, Rossville, Millmerran, Mt Coot-tha and Brisbane, under rotten bark at Dundowran, under dry bark on a fence post at Nambour, and under logs at Boonah, Yandina, and Dunk I. In Western Australia the species was collected under stones in a sandstone area on the Prince Regent River Reserve. In New Guinea, the species was collected under logs at Lae, in rotten logs at Jimi Valley, and under the bark of *Cryptocarya* sp. at Warasweet. Thus the species apparently does not usually burrow, but occurs under and in objects on the ground and under bark; at Reedybrook (Qld) however, specimens were collected from burrows 15.2 cm deep. But *L. waigiensis* does not represent an extreme example for the genus *Liocheles* with regard to the burrowing habit; the Indian species, *L. nigripes*, has been recorded as having vertical burrows 40-60 cm deep with a terminal chamber (Tilak 1970).

The number of young specimens associated with a female among the material examined was 18 at Goodna, 19 at Nambour, and 26 at Dayboro (Qld).

*L. waigiensis* displays a wide range of individual variation in size, which is most evident in hand dimensions, especially at places where the largest specimens have been found, e.g. Mt Fox, Pallarenda, Palm I. (Qld). However, multivariate analysis revealed no obvious differences in the canonical variate scores corresponding with these places.

*Liocheles karschii* (Keyserling), comb. n.

(Figs 19, 48, 84, 85, Map 10)

*Hormurus karschii* Keyserling, 1885: 31; Thorell, 1888: 427 (as *H. waigiensis*); Kraepelin, 1899: 155; Kopstein, 1921: 138.

*Hormurus caudicula karschii* (Keyserling) Kraepelin, 1894: 137; Kraepelin, 1899: 155, Kraepelin, 1901: 272; Giltay, 1931: 13.

*Hormurus karschii keyensis* Kraepelin, 1914: 331; Kopstein 1921: 139; Giltay, 1931: 13.

*Hormurus papuanus* Kraepelin, 1914: 333; Hirst, 1914: 325; Kopstein, 1921:138.

*Hormurus caudicula papuanus* (Kraepelin) Giltay, 1931: 10.

#### Range (Map 10)

Queensland, far northern islands, e.g. Darnley I. New Guinea. Aru Is.

Outside Australo-Papua: Ceram, Key Is, New Britain, Solomon Is.

#### Measurements (mm)

♂. Kerema, NG, AM. Total length 82, of tail 37; carapace, length 13.6, width 13.7; tail segments one to five (in that order), length 4.5, 5.0, 5.0, 5.8, 7.9, width 3.3, 2.8, 2.6, 2.4, 2.4, height 3.0, 3.0, 3.0, 2.8, 2.7; length of vesicle and aculeus 9.7; width of vesicle 2.9; length of humerus 16.1; brachium, length 15.0, width 8.1; hand, length 18.0, width of hand surface 9.2, height 6.0; length of hand and fixed finger 30.0; length of movable finger 14.2; length of pectine 6.4.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=3)									
Min.	13.7	13.9	18.0	9.0	5.4	29.7	13.9	5.5	2.8
Max.	15.5	14.4	19.9	18.6	6.1	32.6	15.0	5.9	3.0
Mean	14.6	14.2	18.8	12.2	5.8	30.8	14.4	5.6	2.9
Female (n=6)									
Min.	13.4	12.9	15.3	8.6	5.5	25.9	13.1	4.9	2.6
Max.	17.3	14.6	17.5	9.8	6.2	29.6	15.0	6.0	2.8
Mean	14.5	13.9	16.3	9.3	5.8	27.8	14.2	5.5	2.7
SD	1.44	0.73	0.96	0.45	0.27	1.44	0.81	0.41	0.09

#### Diagnosis

Distinguished from *L. australasiae* and *L. waigiensis* by the following combination of characters: large size (adult CL>13.6 mm); absence of pitting on carapace and tergites.

#### Description

Colour dark brown to brown and light yellowish brown; carapace, arms and hands usually dark brown; legs, basal (second) segment of chelicera, ventral surface, and vesicle light yellowish brown.

Carapace with frontal notch wide and deep. Frontal lobes rounded somewhat pointed at anterior edge, sometimes tending to be truncate. Interocular

areas granulate, not pitted. Lateral and posterior two-thirds of carapace granulate. Median sulcus uninterrupted, sometimes slightly interrupted. Triangular depression shallow. Sides of triangular depression usually straight. Median eyes half-way between anterior and posterior edge.

Chelicerae (Fig. 19) with a few secondary serrations. Fixed jaw with sub-basal tooth widely distant from median tooth; median tooth larger than basal. Movable jaw with subdistal and basal teeth about equal sized, median tooth slightly larger than these. Secondary serration along proximal edge of distal external and subdistal teeth, and along middle of distal edge of median tooth. Most teeth usually sharply pointed.

Tergites of first six abdominal segments with a rugose patterning; usually granulate in male, and sometimes also in female; median keel wide anteriorly, narrow centrally and posteriorly. Frontal facing continued laterally but usually not prominently. Tergite of last abdominal segment rugose, finely granulate in male; median keel present, lateral longitudinal keels poorly defined.

Tail short and moderately slender. First four tail segments (Fig. 48) moderately short. Intercarinal surface with minute denticles dorsally, which are more numerous in proximal segments than in distal. Ventral intercarinal surfaces smooth. Dorsal keels rounded and practically non-existent. No terminating spine at end of dorsal keel. Ventral keels smooth. No spines ventrally on transverse distal edge of segments. Accessory keels practically non-existent. Fifth tail segment smooth, rounded.

Vesicle moderately small, moderately elongate to elongate, somewhat laterally flattened. Minutely pitted dorsally and laterally. Sulci not prominent.

Aculeus short, sharply curved at base.

Humerus with dorsal surface granulate; ventral surface less granulate, smooth distally; keels with large denticles.

Brachium with all surfaces granulate, keels denticulate. Dorsal and ventral keels of anterior (inner) surface terminate proximally in a large prominent triangular process curving in direction of hand. Small triangular process on each side of the triangular process (i.e. anterior surface has a trifid structure). Base of each side process with a seta. Ventral group, *v*, with 3 trichobothria. Posterior surface, *p*, with 13 trichobothria.

Hand moderately flat; elongate in male, less elongate in female; with intercarinal surfaces granulate to denticulate. Keels generally poorly defined except for denticulate posterolateral keel. Ventral group, *V*, with 4 trichobothria. 4 trichobothria proximally: *Db*, *Eb*<sub>1</sub>, *Eb*<sub>2</sub>, *Eb*<sub>3</sub>.

Finger moderately short. Trichobothria *dst*, *dsb*, and *db* in a continuous shiny groove. Both fingers hooked at apex. Fixed finger with a notch just before apex.

Legs with tarsomere I of first pair dorsally with usually 4 setae. Ventral surface of tarsomere II of fourth pair with a row of 3-6 inner setae, and 3-5 outer setae (the more proximal 1 to 4 of these outer setae are sometimes developed into prongs).

Pectinal teeth 10-12 (Mean 10.8) in male; 7-11 (Mean 9.4, SD 1.10) in female.

Paraxial organ (Figs 84, 85) with lamina moderately long, narrow, apex blunt; inner lobe long, narrow, rounded at apex; with a neck before apex; median lobe moderately long, wide, broad towards apex; supporting enlargments at base elongate; external lobe with a small anvil-shaped elongation at apex; apotheca sclerotized.

#### Material examined

8♂, 12♀ (Map 10).

#### PAPUA NEW GUINEA

Awala (Papua) iii.1959 (P. Searle) 1♀, UQ. 'British New Guinea', 1♂, 3♀, K8455, AM; 1♂, 1♀, 75/62-3, WAM. Goldie River, 20.x.1968 (R. Mackay) 1♀, PNGM. Kerema, vi.-x.1950 (G.A.V. Stanley & R.F. Murrell) 2♂, AM. Lae (E.L.T.) 1♀, AM. 'New Guinea', 2♂, 1♀, K13623, AM. Oro Creek, 1♂, 1♀, AM. Port Moresby (Papua) xi.1967, 1♀, PNGM; near, 1♀, AM. Rigo Plantation (48 km E of Port Moresby, Papua) (A.C. English) 1♂, K57383, AM. Vailala and Purari Rivers (between) (32 km from coast, Papua) 21.ix.1948 (F.R. Rickwood) 1♀, AM.

#### Remarks

The specimen from Awala, Papua, was collected from under a log. Specimens from near Port Moresby are nearly uniform black. The species is closely related to *L. waigiensis*.

#### Subfamily Urodacinae Pocock, 1893

#### Genus *Urodacus* Peters

*Urodacus* Peters, 1861: 511. Type species *Urodacus novaehollandiae* Peters, 1861: 511 (by monotypy).

*Ioctonus* Thorell, 1876: 14. Type species *Ioctonus manicatus* Thorell, 1876: 14 (by monotypy).

*Iodacus* Pocock, 1891: 245. Type species *Iodacus darwinii* Pocock, 1891: 245 (by monotypy). [= *Urodacus hoplurus* Pocock, 1898.]

*Hemihoplopus* Birula, 1903: 33. Type species *Hemihoplopus yaschenkoi* Birula, 1903: 33 (by monotypy).

## Distribution

Australia.

## Species included

19 species—listed under species-groups of *Urodacus*.

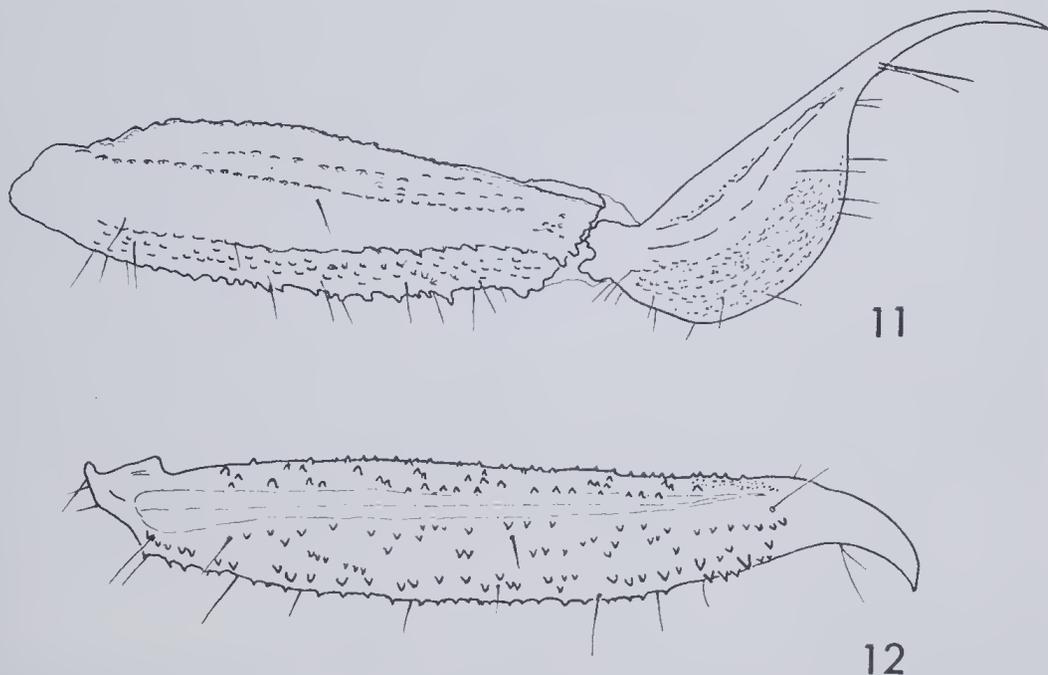
## Description

Carapace usually about as wide as long, gradually narrowing anteriorly. Frontal notch slight to deep, frontal lobes rounded to truncate. Area around anterior and anterolateral edges of carapace with a few large bristles and several fine short bristles in a row; in most species a large seta present on each side of notch. Sides of carapace depressed laterally. The more posterior of the lateral eyes is smaller of the two. Median eyes close-set. Median eye tubercle moderately high, about equi-distant from anterior and posterior edges of carapace, separated by deep median sulcus which extends longitudinally from frontal notch and widens behind eyes to form triangular depression; sulcus may or may not be interrupted (shallow). Chelicerae with or without secondary serrations. Teeth of fixed jaw with all teeth external: sub-basal tooth ranging from smooth to finely serrated on each side of it, especially distally: median tooth and basal tooth usually close and on same base. Movable jaw with distal internal tooth, and externally with distal tooth, subdistal tooth, median tooth and basal tooth: median tooth and basal tooth in some species bilobed. Tergites of first six abdominal segments anteriorly in mid-line generally with a low wide crest which divides posteriorly into three portions: middle portion pointed and side portions long and curving anteriorly towards sides of tergites. These crests and impressions better defined in more posterior tergites. Pretergite narrow to broad, continuing along lateral edges. Tergites of last abdominal segment with a central crest and four longitudinal keels extending from posterior edge, the two lateral of these being longer and better defined than the two median. Sternites smooth and shiny. Sulcus on each side smooth and situated medial to book lung. Sulci better defined towards anterior edge. Sternite of last abdominal segment with two smooth longitudinal lateral keels and usually also two less well-defined smooth longitudinal median keels. Tail thick, short to very long. First four tail segments with posterior (terminal) denticle of dorsal keels usually well-developed, often spine-like in male. Fifth tail segment with ventromedian keel single and often bifurcating posteriorly, or occasionally double. Vesicle usually wider than fourth tail segment. Small to very large; moderately elongate, in one species very elongate (Figs 11, 12). Two or three ventral sulci, one or two lateral sulci, dorsal sulcus weak. Subaculear prong absent. Humerus (Fig. 1) with dorsal surface usually bounded at anterior and posterior edges by a row of large dark denticles or granules. Brachium (Fig. 2) with dorsal surface bounded anteriorly by a row of granules. Posteroventral keel usually evident, ranging

from weak to strongly defined. Posterior (outer) surface smooth, often rugose with a broad longitudinal raised portion medially. The two anterior keels widely separated. Hand dorsally often with some reticulation of granules. Trichobothria of posterior surface includes a subdistal group, *Et*, with four to six (usually five in most species), and a basal group, *Eb*, with five (rarely six) trichobothria. Fingers with along edge one to five rows of granules at base reducing to one to two rows at apex. Transverse granules positioned along the finger edge usually in six to ten rows and mainly in distal part. Legs with tarsomere I (i.e. second last segment) of first pair dorsally (i.e. outwardly) with a row of four to eight prongs; second proximal-most prong often replaced by bristle of greater length than prongs. The two lateral terminal claws (ungues) of each leg varying from same length to very unequal; inner claw in one species reduced to a papilla. Tarsomere II of fourth pair of legs ventrally with two rows of small prongs: an internal (medial) row with seven to fourteen (inner) prongs, and an external (distal) row with three to eleven (outer) prongs often with two to six of these close together on distal part of flap. Sternum wider than long.

#### Affinities

The monotypic subfamily Urodacinae is closest to the Scorpioninae; *Urodacus* is closest to scorpionine genera such as *Palamnaeus*, *Opisthophthalmus*, *Scorpio* and *Pandinus*.



Figs 11, 12: Fifth tail segment and vesicle and aculeus of (11) *Urodacus novae-hollandiae* (Perth, W.A.). Vesicle and aculeus of (12) *U. megamastigus* (holotype).

## Species-groups of *Urodacus*

The varying lengths of the two terminal claws of the leg tarsi in the Urodacinae posed previous taxonomic workers with a difficult problem which remained unsolved. For example, Birula (1903), on the basis of the markedly unequal claw lengths in one of the urodacine species, proposed the new genus *Hemihoplopus*; whereas Kraepelin (1908) disagreed saying that urodacine claws showed all stages from very unequal (e.g. *U. yaschenkoi*) to equal (e.g. *U. novaehollandiae*). In the present study, I have found that the claw lengths form a pattern, and this is used to supplement the establishment of the following five moderately well-defined species-groups within the genus *Urodacus*. The other characteristics employed in the description of the species-groups are those of chelicerae, vesicle, teeth along edge of movable finger, and paraxial organ.

### Species-group *armatus* (Fig. 122)

#### Species included

*U. manicatus* (Thorell), *U. elongatus* sp. n., *U. novaehollandiae* Peters, *U. planimanus* Pocock, *U. centralis* sp. n., *U. armatus* Pocock, *U. koolanensis* sp. n.

#### Description

Chelicerae without secondary serrations, but sometimes with a secondary notch at proximal base of sub-basal tooth of fixed jaw and median tooth and rarely basal tooth of movable jaw. Vesicle small in *U. manicatus* and *U. elongatus*, moderately large in other species. Central teeth along edge of movable finger of hand in one to five rows at base and reducing to one to three rows at apex. Terminal claws of each leg of equal length. Paraxial characters: lamina moderate to extremely long; apex of lamina variable, usually pointed; inner lobe moderately short, simple, pointed and upcurved; inner lobe and median lobe moderately to widely separated; median lobe simple except in *U. elongatus* where walls tend to be dorsally incurved; median lobe protruding laterally at apex for at least same distance as external lobe; prong and carina usually large, often pointed at apex; toca large and well defined; external lobe moderately short; basal lobe shorter than proximal lobe.

### Species-group *megamastigus* (Fig. 123)

#### Species included

*U. megamastigus* sp. n.

#### Description

Chelicerae with few secondary serrations. Vesicle very elongate. Central teeth along edge of movable finger of hand in one row from base to apex.

Terminal claws of each leg of equal length. Paraxial characters: lamina long, broad; apex of lamina bluntly pointed; inner lobe complex with a rounded structure dorsally and ventrally; inner and median lobes moderately close together; median lobe with dorsally incurved walls; median lobe protruding laterally at apex to a shorter distance than does external lobe; prong small; carina small, with pointed apex and serrations along edge; toca rounded, usually moderately small, external lobe moderately long, curved at apex but moderately blunt; basal lobe with dorsal arm much shorter than proximal lobe, bulbous at apex of proximal lobe.

#### Species-group *hoplurus* (Fig. 124)

##### Species included

*U. varians* Glauert, *U. hoplurus* Pocock, *U. giulianii* sp. n., *U. carinatus* Hirst, *U. macrurus* Pocock, *U. excellens* Pocock, *U. spinatus* Pocock, *U. lowei* sp. n., *U. similis* sp. n.

##### Description

Chelicerae with few to many secondary serrations, usually numerous. Vesicle moderate to very large, usually large to very large. Central teeth along edge of movable finger of hand in one to four rows at base and reducing to one row at apex (*U. varians* has only one row along length; *U. similis* usually has only one row, but sometimes a tendency for two rows at base). Terminal claws of legs mostly slightly unequal, but they vary so that both claws are of equal length or only the first two pairs of legs have equal claws, or all legs have slightly unequal claws. Paraxial characters: lamina moderately short, except in *U. excellens* where it is long; apex of lamina usually rounded, but varies from pointed to rounded; inner lobe long, rounded to sharply pointed at apex; inner lobe close to median lobe which is complex and variable; median lobe at apex simply tapering to become extremely narrow and pointed or else plate-like; median lobe protruding laterally at apex to a distance varying from about same distance as external lobe to much shorter than it; prong absent; carina poorly defined, usually absent; toca or toquilla present, highly variable, sometimes poorly defined; external lobe moderately long, varying at apex from simply tapering to curved, or with one hook, or a flat comb with few to many serrations; basal lobe and proximal lobe variable, sometimes poorly defined, length variable.

#### Species-group *hartmeyeri* (Fig. 125)

##### Species included

*U. hartmeyeri* Kraepelin.

## Description

Chelicerae usually with many secondary serrations. Vesicle often large. Central teeth along edge of movable finger of hand in one row from base to apex. Terminal claws of legs very unequal in length, inner claw varying from a short claw to a claw two-thirds length of outer (claws usually longer in front legs). Paraxial characters: lamina moderately long; apex of lamina usually bluntly pointed; inner lobe large and wide; inner lobe and median lobe moderately to widely separated; median lobe sometimes with dorsally incurved walls; median lobe protruding laterally at apex to a shorter distance than does external lobe; prong moderately large; carina small to large, rounded at apex; toca large, rounded at base; external lobe long and prominent; basal lobe and proximal lobe about equal length.

### Species-group *yaschenkoi* (Fig. 126)

#### Species included

*U. yaschenkoi* (Birula).

#### Description

Chelicerae with many secondary serrations. Vesicle large to extremely large, rarely of moderate size. Central teeth along edge of movable finger of hand in one row from base to apex, sometimes a tendency for two rows at base. Terminal claws of legs markedly unequal, inner claw varying from a minute papilla to a claw two-thirds the length of outer claw, especially in third and fourth pairs of legs. Paraxial characters; lamina short to moderately short and wide; apex of lamina tending to be rounded; inner lobe wide with small sharp point at apex; inner lobe and median lobe moderately to widely separated; median lobe with moderately thick walls; median lobe abruptly sharp-pointed at apex; median lobe much shorter than external lobe; prong absent; carina poorly defined; toquilla large and shell-shaped; external lobe tapering to a pointed apex; basal lobe and proximal lobe absent.

### Species-group *armatus* *Urodacus manicatus* (Thorell) (Figs 20, 49, 86, 87, Map 11)

*Ioctonus manicatus* Thorell, 1876: 14; Thorell, 1877: 261. [2 syntypes examined.]

*Urodacus novaehollandiae* (non Peters, 1861) Keyserling, 1885: 34.

*Urodacus abruptus* Pocock, 1888: 174; Pocock, 1893b: 321; Pocock, 1898: 63; Kraepelin, 1899: 104; Kraepelin, 1901: 270; Takashima, 1945: 88; Southcott, 1954: 145; Smith, 1966: 383. [2 syntypes examined.]

Outline of chelicerae (Fixed jaw: i, internal; b, sub-basal. Movable jaw: bi, basal internal; de, distal external; di, distal internal; mi, median internal; sd, subdistal. Both jaws: d, distal, m, median; b, basal).

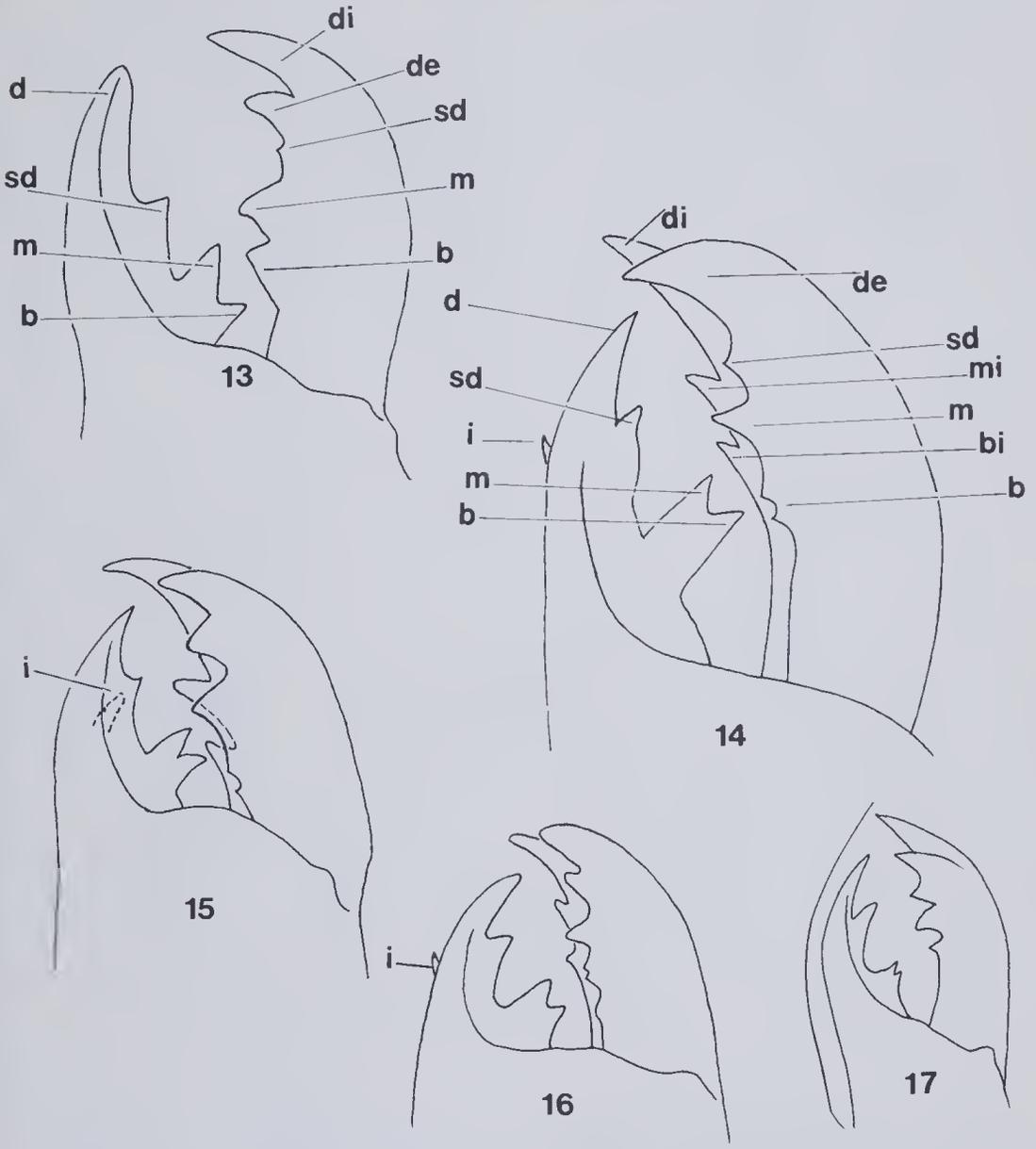


Fig. 13: *Cercophonius squama*. (Hobart, Tas.).  
 Fig. 14: *Lychas marmoreus*. (Point Peron, W.A.).  
 Fig. 15: *Isometroides vescus*. (Wanneroo, W.A.).  
 Fig. 16: *Isometrus melanodactylus*. (Brisbane, Qld).  
 Fig. 17: *Liocheles australasiae*. (Claudie River, Qld).

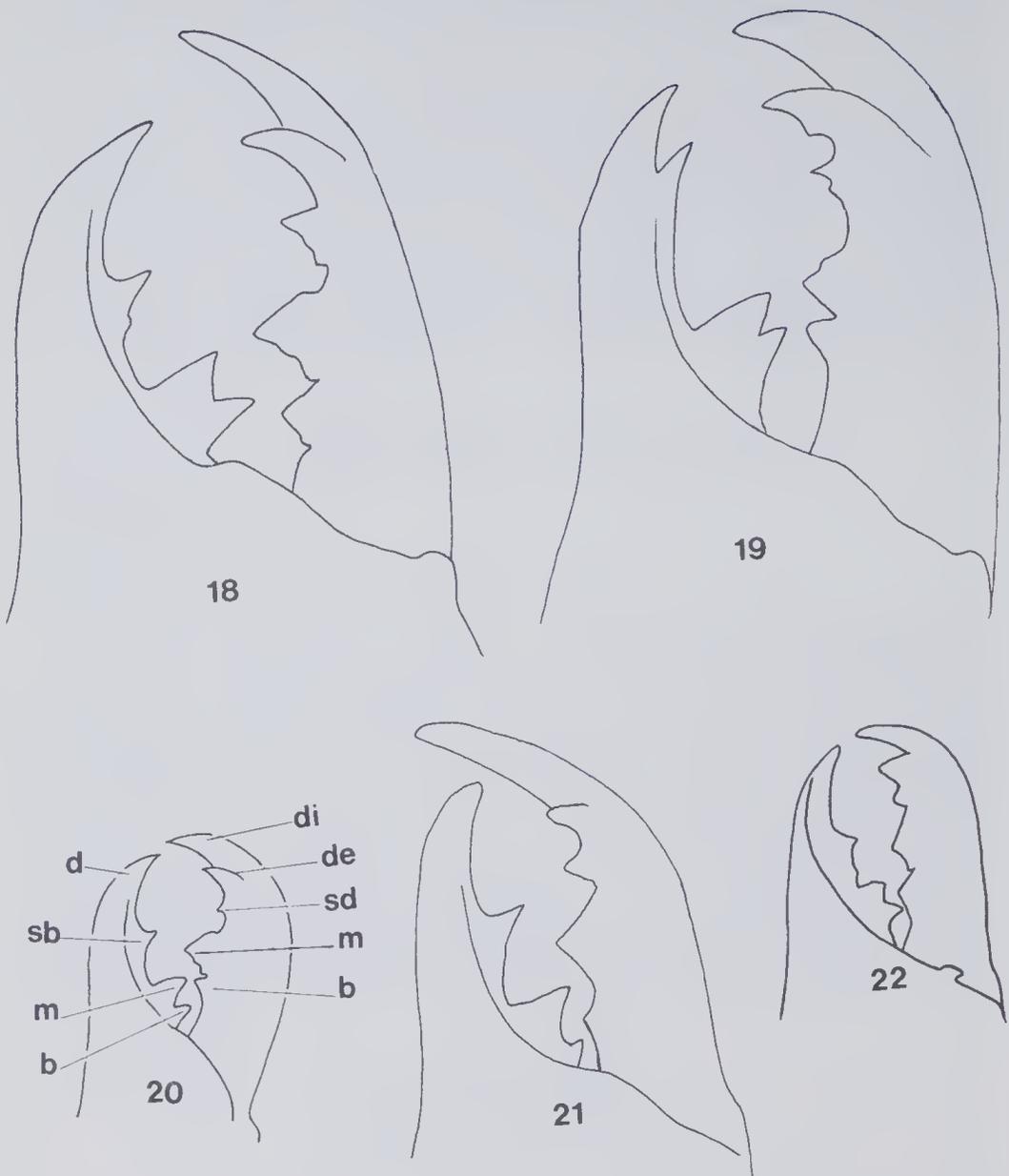
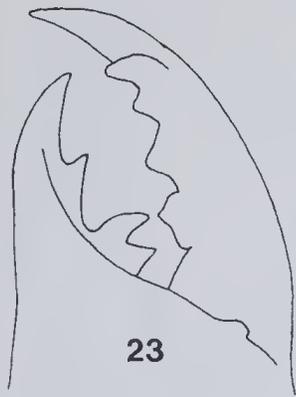
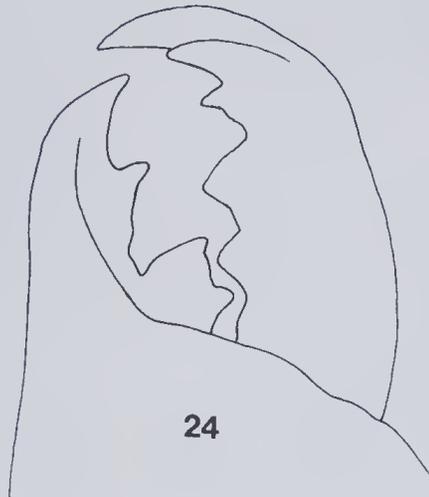


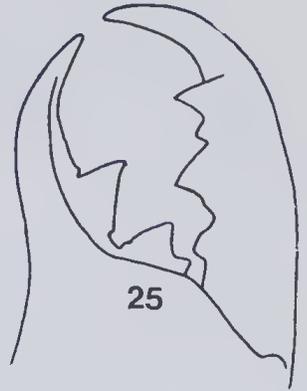
Fig. 18: *L. waigiensis*. (Pallarenda, Qld).  
 Fig. 19: *L. karschii*. (Kerema, Papua).  
 Fig. 20: *Urodacus manicatus*. (Kangaroo I., S.A.).  
 Fig. 21: *U. elongatus*. (Willowie, S.A.).  
 Fig. 22: *U. novaehollandiae*. (Dianella, W.A.).



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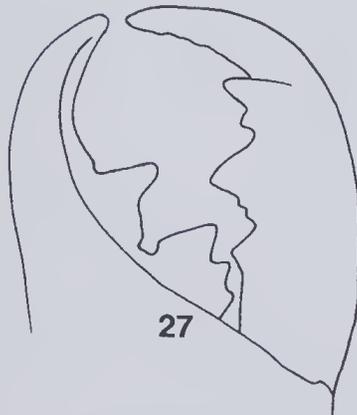
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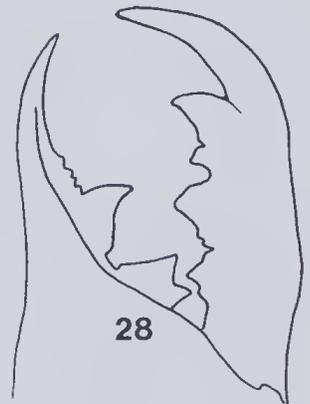
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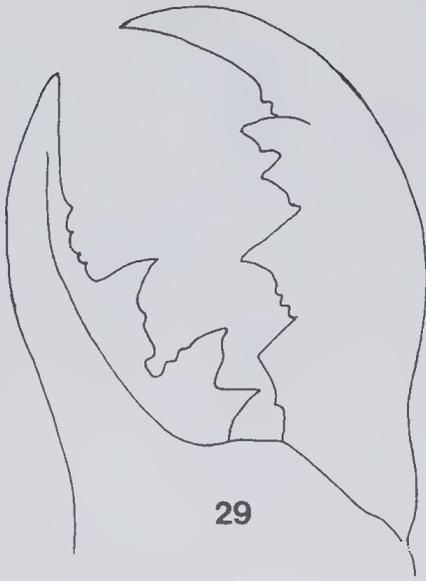


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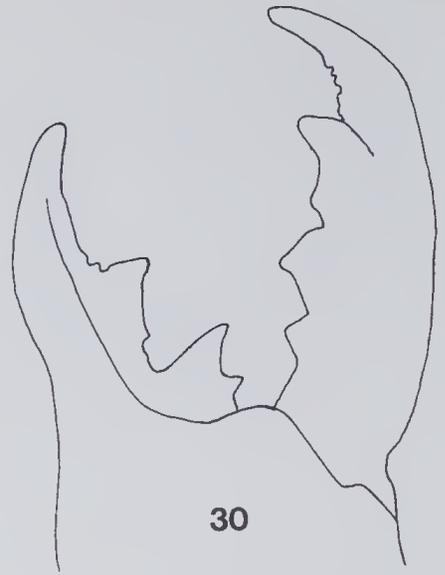


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- Fig. 23: *U. planimanus*. (Mundaring Weir, W.A.).  
 Fig. 24: *U. centralis*. (Palm Valley, N.T.).  
 Fig. 25: *U. armatus*. (Kalgoorlie, W.A.).  
 Fig. 26: *U. koolanensis*. (Koolan I., W.A.).  
 Fig. 27: *U. megamastigus*. (Mundiwindi, W.A.).  
 Fig. 28: *U. varians*. (Canning Stock Route, W.A.).



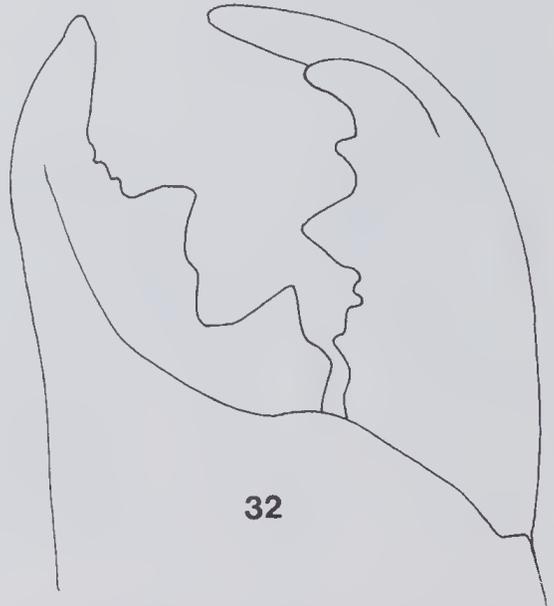
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Fig. 29: *U. hoplurus*. (E. Mollerin, W.A.).

Fig. 30: *U. giulianii*. (Mt Davies Camp, 8 km NW of, W.A.).

Fig. 31: *U. carinatus*. (Haasts Bluff, N.T.).

Fig. 32: *U. macrurus*. (Barcaldine, Qld).

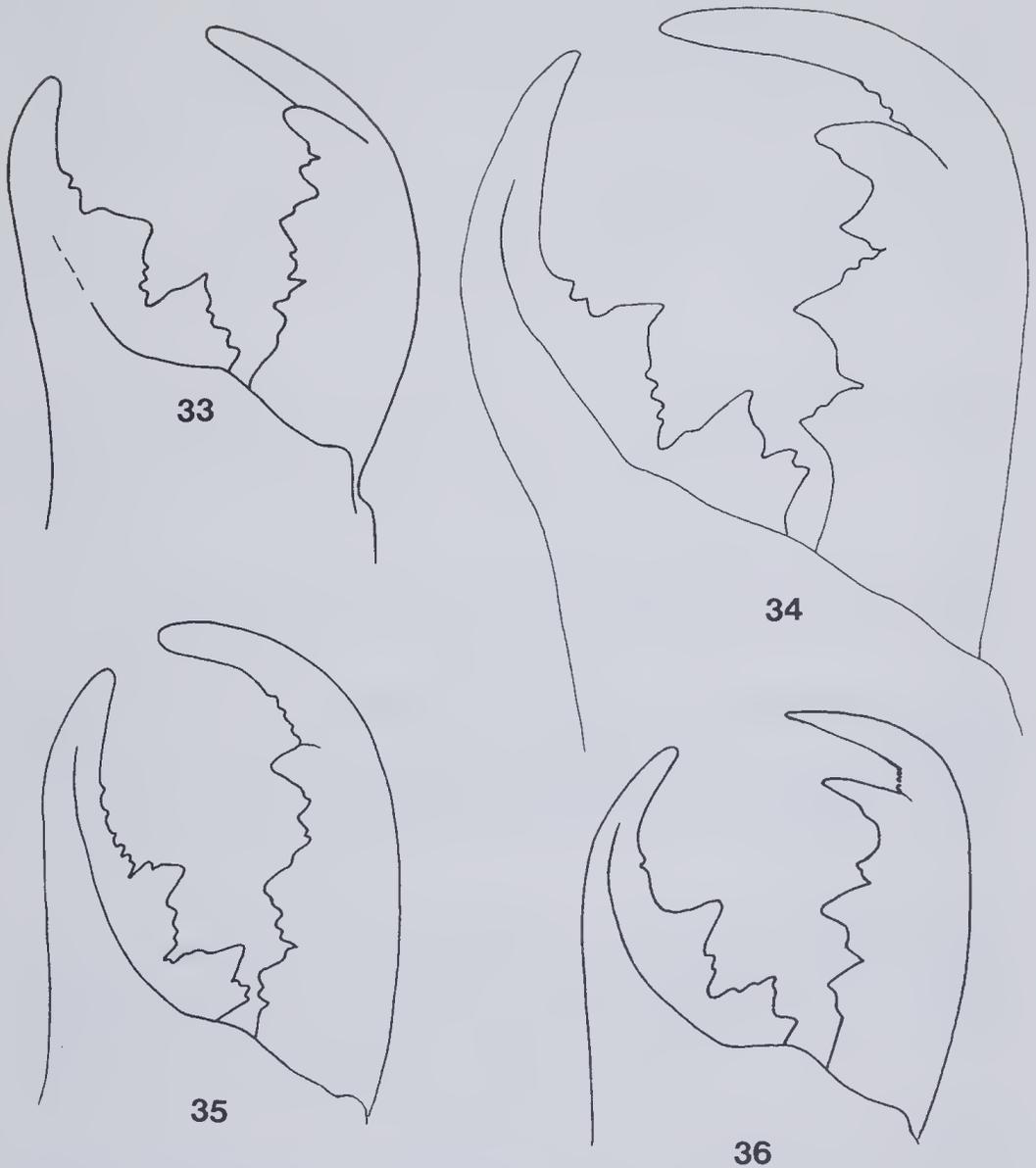
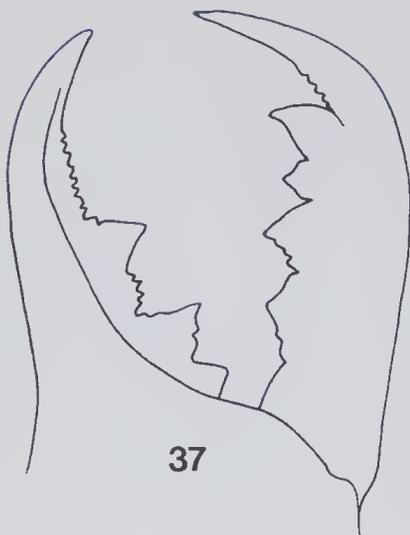


Fig. 33: *U. excellens*. (Port Essington, N.T.).

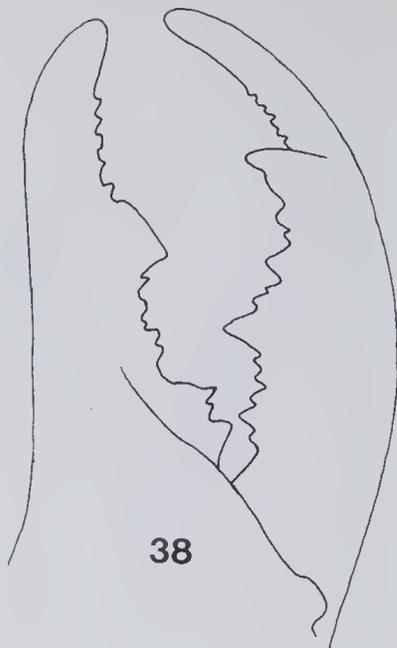
Fig. 34: *U. spinatus*. (Blue Mountains, Cape York Pen., Qld).

Fig. 35: *U. lowei*. (within 16 km of 14°58'S, 126°02'E, W.A.).

Fig. 36: *U. similis*. (Kathleen Valley, W.A.).



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Fig. 37: *U. hartmeyeri*. (Hamel, W.A.).

Fig. 38: *U. yaschenkoi*. (Broome, W.A.).

*Urodacus keyserlingi* Pocock, 1891: 245 [2 syntypes examined.] (see under remarks).

*Urodacus manicatus* (Thorell) Pocock, 1898: 67; Kraepelin, 1908: 91; Glauert, 1925a: 86; Glauert, 1963a: 134; (?) Takashima, 1945: 90.

#### Range (Map 11)

South Australia, south-eastern; furthest north at Umberatana, furthest south-west Yorke Peninsula and Kangaroo I. Victoria, furthest south at Melbourne. New South Wales, south-west, central, and eastern. In Queensland, far south-eastern; furthest north at Yarraman, furthest east at Warwick.

#### Measurements (mm)

♀. The larger syntype (smaller syntype: total length 42). Total length 54, of tail 27; carapace, length 6.5, width 6.7; tail segments one to five (in that order), length 3.7, 3.1, 4.0, 4.0, 5.5, width 3.1, 3.0, 2.9, 2.7, 2.5, height 2.1, 2.3, 2.5, 2.2, 2.0; length of vesicle and aculeus 5.9; width of vesicle 2.2; length of humerus 5.0; brachium, length 5.6, width 2.5; hand, length 5.5, width of hand surface 4.8, height 3.5; length of hand and fixed finger 10.0; length of movable finger 6.0; length of pectine 4.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=7)									
Min.	5.7	5.5	5.1	4.6	3.2	9.4	5.3	4.3	2.4
Max.	6.3	6.5	6.0	5.3	5.7	10.8	5.9	5.3	3.0
Mean	6.0	6.0	5.4	4.9	3.8	10.0	5.6	4.6	2.6
SD	0.38	0.38	0.33	0.27	0.87	0.54	0.25	0.38	0.19
Female (n=7)									
Min.	5.8	5.8	5.1	4.4	3.0	9.6	5.3	3.3	2.3
Max.	7.3	8.0	7.0	6.1	4.6	12.7	7.0	4.5	3.1
Mean	6.7	6.9	6.1	5.1	3.7	11.1	6.1	4.0	2.6
SD	0.61	0.79	0.71	0.59	0.60	1.24	0.72	0.44	0.28

### Diagnosis

Distinguished from other *Urodacus* species by the following combination of characters: small size; rounded frontal lobes; squat, rounded hands; usual dark coloration.

### Description

Colour brown (sometimes red-brown or yellow-brown) to dark pitch brown, ventrally yellowish, legs red-brown to yellow, sometimes with much dark patterning on carapace and tergites.

Carapace with frontal notch deep. Frontal lobes rounded; only slightly truncate, if at all. Interocular areas smooth, shiny, flat, and finely pitted. Lateral and posterior two-thirds of carapace with closely positioned fine granules and sharply laterally depressed. Median sulcus interrupted. Triangular depression moderately deep. Sides of triangular depression slightly retracted and swollen.

Chelicerae (Fig. 20) with practically no secondary serrations. Fixed jaw with long space and gentle curve between sub-basal tooth and median tooth. Movable jaw with all four external teeth about equally spaced; moderately flat edge between subdistal tooth and median tooth. Median tooth with a small suggestion of a secondary serration at each base (distal and proximal); basal tooth small. All cheliceral teeth tend to be pointed.

Tergites of first six abdominal segments finely granulate with frontal edge smooth and shiny, and with a faint median keel. Tergite of last abdominal segment with longitudinal and median pairs of teeth present posteriorly and granulate.

Tail moderately short. First four tail segments (Fig. 49) with intercarinal surfaces finely granulate. Keels well developed; dorsal and dorsolateral keel denticulate (more pronounced in male); terminal denticle of dorsal keel enlarged. The three ventral keels of each of the first three segments smooth,

keels of fourth segment finely denticulate. Accessory keels scarcely evident and mainly in posterior half of first and second segments. Fifth tail segment with dorsal intercarinal surfaces mainly smooth, sometimes with a reticulation of granules; lateral and ventral intercarinal surfaces with granules and small denticles. Dorsal surface distally flat; dorsal keels finely denticulate; the three ventral keels strongly denticulate. Ventromedian keel bifurcating distally from about half its length.

Vesicle moderately small, dorsally smooth, ventrally granulate.

Aculeus usually moderately curved.

Humerus with dorsal surface sparsely and coarsely granulate, and bounded at anterior and posterior edges by a row of large dark denticles.

Brachium dorsally almost smooth with a finely pitted reticulation. Posteroventral keel evident. Ventral group, *v*, with 7-11 (usually 7, 8, sometimes 9-11) trichobothria. Posterior group, *p*, with 17-23 trichobothria.

Hand short and squat. Dorsal surface with reticulation of fine granules in anterodorsal half. Hand dorsally with a smooth strongly developed finger keel. Ventral group, *V*, with 8-11 (usually 9) trichobothria. Median group, *M*, of posterior surface with 3-5 (usually 3) trichobothria.

Fingers moderately short to short. Along edge of movable finger 3-4 main longitudinal rows of granules along base, reducing to 2, sometimes 1, row(s) at apex. Around 8 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 4-6 (usually 5) prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-11 inner, and 7-10 outer prongs.

Pectinal teeth 13-19 (Mean 15.7, SD 1.09) in male; 10-15 (Mean 12.1, SD 0.90) in female.

Paraxial organ (Figs 86, 87) with lamina long, moderately wide, tapering abruptly to pointed apex; inner lobe wide, tapering abruptly at point; inner lobe and median lobe moderately to widely separated; prong tending to be sharp-pointed at apex; sclerotized plate and fulcrum usually poorly defined; carina moderately small, pointed at apex, tending to be rounded at base; toca narrow at top, wide at bottom, bottom of toca ending in a small blunt piece; external lobe sharp and hook-shaped; pendunculi evident; ventral vinculum uniformly wide, long; dorsal vinculum moderately short being met by dorsal pedunculus at about its middle; juxtum usually has inner edge wavy; basal lobe pointed; proximal lobe slightly longer than basal lobe; proximal lobe rounded at apex.

#### Material examined

147♂, 226♀ (Map 11).

## SOUTH AUSTRALIA

Adelaide, 59 52, 1♀ (dry, pinned) BMNH (syntype of *U. abruptus*). Ardrossan, Yorke Peninsula, 1♀, SAM. Bimbowrie (A. Zietz) 1♂, SAM. Bridgewater (E.L. Savage) 1♀, SAM. Clare (L.G. Thorpe) 1♂, 4♀, SAM. Edithburg, Yorke Peninsula, 1♂, SAM. Forrest Range (E.L. Savage) 1♀ and 24 young, SAM. Humbug Scrub (N. Bellchamber) 1♂, 1♀, SAM. Kangaroo I., 1886 (Tepper) 11♂, 11♀, SAM; x.1924, 2♀, SAM; ii.1925 (F. Wood Jones) 1♂, 25/77, WAM; 4.iii.1925 (F. Wood Jones) 1♀, 25/147, WAM; iii.1925 (F. Wood Jones) 5♂, 6♀, 25/153-63, WAM; 2♂, 3♀, SAM; 13.xi.1949 (A.N.B.) 1♂, 1♀, NM; i.1968 (F. Collett) 1♂, NM; 2.i.1970 (F. Collett) 2♂, NM; Birchmore Lagoon, 24 km from Kingscote, 100D, 2♂, 2♀, AM; Hogg Bay (J.R. Andersen) 2♂, 1♀, SAM; Kelly Hill Reserve, 2.i.1957 (P. Rawlings) 1♂, 1♀, AM; Kingscote, 15.ii.1910 (Syer) 1♀ and 18 young, SAM; 12.xi.1949 (A.N.B.) 4♀, NM; 13.xi.1949 (A.N.B.) 1♂, 1♀, NM; 14.xi.1949 (A.N.B.) 1♂ NM; Queenscliffe, 1888, 1♂, AM; Vicorme Bay (A. M. Lea) 40♂, 48♀, SAM. Lucindale, 2.vii.1900 (E. Feuerhardt Crower) 2♀, SAM. Meadows (Adcock) 2♂, 1♀, SAM. Mt Bryan East, 18.ix.1890, 1♀, SAM. Mt Compass, iv.1887, 2♂, 5♀, SAM. Mt Lofty, 28.vi.1909 (A. Fairhall) 1♀, SAM. (?) Musgrave Ranges, 1905 (H. Basedow) 1♂, 1♀, SAM. Onkapinga, Hacks Bridge, 1886, 1♀, SAM. Umberatana, iii.1903 (W.B. Greenwood) 2♂, SAM. 'South Australia', 5♂, 12♀, SAM.

## VICTORIA

Avoca Hill, Elmhurst, 4.vii.1904 (pres. S.W. Fulton) 4♂, 2♀, NM. Bendigo, 16.ix.1919 (A.S. Hardy) 1♀, 66/319, WAM; 20.iv.1933 (W.B. Barnard) 3♂, 2♀, (dry, pinned) 33/1090, 33/1092-3, 33/1091, 33/1094, WAM. Bright, viii.1925 (H.W. Davey) 1♂ (dry, pinned) 25/576, WAM. Castlemaine, viii.1925 (H.W. Davey) 1♀ (dry, pinned) 25/579, WAM; Dist. 31.v.1926 (J.E. Dixon) 2♂, 26/293-4, WAM. Cobram, v.1934, 1♀, NM. Dookie, 1.x.1913 (Kelly) 1♂, 2♀, NM. Eganstown (Dalesford) 1♀, NM. Glenrowan and Euroa, ii.1893 (J.K.) 4♂, NM. Glenrowan, xi.1893 (J.K.) 2♂, 5♀, NM. Grampian Range, xi.1885 (J.A. Kershaw) 4♀, NM; 1885 (W. Kershaw) 4♂, 7♀, NM; xi.1885 and xi.1887 (W. Kershaw) 2♂, 4♀, NM; xi.1887 (W. Kershaw) 2♀, NM; 19.i.1931, 1♀, NM; xi.1936 (F. Buller) 2♂, NM; 19.iv.1954 (M. Leahy) 1♂, NM; x.1954 (H.A. Morrison) 5♂, 9♀, NM; 4.ix.1961 (R.M. Ryan) 1♀, NM; 30.x.1970 (G. Barnes) 1♂, 1♀, NM. Inglewood, 31.v.1926 (J.E. Dinour) 2♂, 26/291-2, WAM; 26.xii.1944 (C. Oke) 2♀, NM. Kiata, 21.ix.1952, 1♂, 1♀, NM. Lake Albacutya, near lake, 9.vi.1927 (H.W. Davey) 5♀, 27/818-22, WAM. Maldon, viii.1966, 1♀, NM. Mt Arapiles, 31.v.1926 (H.W. Davey) 4♀, 26/287-90, WAM; 10/27, C13, 2♀, NM. Mt Mistake (?), 25.xi.1904 (W.R. Hill) 2♀, MM. Pyalong, 29.iv.1947 (pres. K. Bray) 1♂, 3♀, NM. Thornbury, 27.x.1955 (W.C. Banks) 1♂, NM. 'Victoria', 5.iii.1883 (du Boulay) 1♀, NM.

## NEW SOUTH WALES

Brawlin, K48679, 2♂, 1♀, AM. Cooma, 7.ii.1956 (R. McKay) 1♀ and 9 young, AM. Glencoe, via Glen Innes, 2♀, AM. Goomoo Forest, near Ballimore, near Dubbo, 25.i.1953 (V. Levitt) 1♂, AM. Guyra, 19.vii.1932 (N. McKie) K65474, 1♀, AM. Inverell, 12.iii.1966 (G.A. Holloway) 1♂, AM. Kandos, 31.i.1967 (G. Daniells) 1♀, AM. Lake George, 20.ii.1971 (G.B. Monteith) 2♂, UQ. Mt Bright, 515 m, Brookenback Range, Cessnock, 3.x.1943 (A. Musgrave) 1♂, 2♀, AM. Mt Kaputar, near Narrabri, 16.xii.1965 (W. McReaddie) 1♂, AM. Munghorn Gap, near Gilgandra, 11.ix.1967 (W. McReaddie) 9♀, AM. North Belmore, 31.x.1950 (S. Smith) 2♂ (dry, pinned) 50/4520-1, WAM. Round Hill Fauna Reserve, near Nymagee, vi.1967 (H.G. Cogger) 4♀, AM. Sydney (A.H.T. Lea) 1♀, SAM. Tamworth, K10901, 2♀, SAM. Tingha and Gilgai, between, 23.v.1957 (L.A. Johnson) 1♀, AM. Upper Turon River, 30.i.1954 1♂, AM. Warrumbungle Mountains, 18-19.iv.1954 (H.G. Cogger) 2♀, AM. Waterfall, 1956 (P.D. Steed) 1♀, UQ.

## AUSTRALIAN CAPITAL TERRITORY

Canberra, 10.iv.1955 (W. Irvine) 1♀, AM. Canberra Dist., vii.-viii.1929 (W.W. Froggatt) 3♂, 5♀, AM.

## QUEENSLAND

Stanthorpe, 1923, 1♀, QM. Toowoomba, 29.xii.1932 (T. Greaves) 1♀, NM; 3♂, 3♀, NM. Warwick, 10.vii.1960 (D.L. Lloyd) 1♀, UQ. Yarraman, 19.iv.1957, 1♂, UQ.

## (?) NORTHERN TERRITORY

(?) Darwin, i.1925 (O. Herbert) 2♂, 69/1449-50, WAM.

## NO EXACT LOCALITY

Australia, 1890.7.1.241-242, 2♀, BMNH (syntypes of *U. keyserlingi*). Australian States from C. French (Old. Colln.) 4.iv.1914, 1♂, 1♀, NM. New Holland, 44 105 n.h., 1♀ (dry, pinned) BMNH (syntype of *U. abruptus*). Nov. Hollandia (collectio T. Thorell) (A. Leuckart pres.) No. 35, 2♀, Naturhistoriska Riksmuseet, Stockholm (syntypes of *I. manicatus*). West G. 17/11, 1♂, 1♀, NM. G8/11, 1♂, 1♀, NM. 3♂, NM.

## Remarks

The synonymy of this species has been confused by previous workers, but is clarified by realizing that: Pocock (1891: 244-5) stated that Kraepelin's *U. novaehollandiae* specimens were wrongly determined and proposed for them the name *U. keyserlingi*, which Pocock (1893b: 321) treated as a synonym of *U. abruptus*.

The burrows are shallow and under small rocks (Smith 1966). The specimens from Glenrowan, Vic., were collected under logs.

A female from Kingscote, Kangaroo I., was collected with 18 young. Embryonic diverticulae averaged 15.7 at Canberra (Smith 1966).

Smith (1966) quotes an observation by R. Bustard of *U. manicatus* killing a small gecko, *Diplodactylus vittatus*.

The lightest coloured specimens occur in New South Wales and these are predominantly orangish to yellowish brown.

*Urodacus elongatus* sp. n.

(Figs 21, 50, 88, 89, Map 12)

Holotype

♂. South Australia: Mt Remarkable, 32°48'S, 138°10'E, x.1967 (J.C. Le Souef) 68/490, WAM.

Paratypes

14♂, 16♀. South Australia: Beetaloo (C. Bennell) 1♀, SAM. Flinders Range (W. Jack) 4♂, SAM. Leigh Creek, 1908 (Matheson) 1♂, SAM. Macumba Creek, 32 km N of, 22.xi.1909 (A. Giles) 1♀, SAM. Mt Brown, ix.1889 (Hargrave) 1♂, SAM. Mt Remarkable, x.1967 (J.C. Le Souef) 2♂, 5♀, 68/491-7, WAM. Parachilna, Flinders Range (E.G. Savage) 1♂, SAM. Port Germein Gorge (Melville) 2♀, SAM. Stoney Creek, Willowie Forest (?), xii.1888 (F. W. Malden) 3♂, 5♀, SAM. Willowie, ii.1888 (F.W. Malden) 2♂, SAM. Woolshed Flat, 2♀, SAM.

Range (Map 12)

South Australia, in far north at Macumba Creek, and in Flinders Range from Leigh Creek south to Beetaloo.

Measurements (mm)

♂. Holotype. Total length 116, of tail 71, carapace, length 11.0, width 11.3, tail segments one to five (in that order), length 9.9, 12.4, 13.5, 14.2, 17.4, width 4.4, 3.5, 3.4, 3.1, 2.8, height 3.6, 3.9, 3.8, 3.5, 2.9; length of vesicle and aculeus 9.9; width of vesicle 3.4; length of humerus 10.1; brachium, length 10.3, width 4.5; hand, length 10.6, width of hand surface 7.1, height 4.7; length of hand and fixed finger 20.8; length of movable finger 11.9; length of pectine 9.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=10)									
Min.	9.8	9.5	9.6	6.2	4.2	18.3	10.2	10.3	3.1
Max.	11.7	11.8	11.6	7.1	5.0	21.8	12.4	14.2	3.6
Mean	10.9	10.7	10.2	6.8	4.7	20.1	11.3	12.6	3.4
SD	0.59	0.85	0.60	0.35	0.24	0.99	0.65	1.18	0.16
Female (n=12)									
Min.	10.0	10.3	8.4	6.7	4.6	17.0	9.7	6.1	2.8
Max.	13.9	13.8	12.8	9.3	6.3	24.8	13.7	9.2	4.0
Mean	11.6	11.5	10.3	7.9	5.5	20.2	11.6	7.6	3.4
SD	0.96	0.98	1.08	0.69	0.50	4.50	3.40	2.76	1.85

## Diagnosis

Distinguished from other *Urodacus* species by the following combination of characters: large size, large tail (especially the long fifth tail segment of male), shape of tail spines, flat hands, and usually 14-16 (range 13-23) trichobothria in ventral, V, group of hand.

## Description

Colour yellowish brown (rarely very light) to dark reddish brown; tergites darker; hands, arms, and legs usually lighter and yellowish.

Carapace with frontal notch wide and deep. Frontal lobes rounded, especially towards notch, sometimes slightly truncate. Interocular areas smooth, but rugose towards anterior edge and with some fine scattered granules. Lateral and posterior two-thirds of carapace with fine to coarse granules. Median sulcus slightly interrupted. Triangular depression deep. Sides of triangular depression retracted, swollen inwards towards depression.

Chelicerae (Fig. 21) without secondary serrations. Fixed jaw with distal base of sub-basal tooth forming a right angle or obtuse angle. Movable jaw with subdistal tooth about same size as external distal tooth.

Tergites of first six abdominal segments finely granulate. Tergite of last abdominal segment with granules of various sizes. Longitudinal and median pairs of keels with small denticles, larger than the granules and half to three-fourths the length of segment.

Tail very long in male, moderately long in female. First four tail segments (Fig. 50) with intercarinal surfaces smooth with a few scattered granules. Dorsal and dorsolateral keels of denticles; terminal tooth of dorsal keels enlarged, triangular (often elongate in male); other keels smooth to notched. Accessory keel strong in first segment; scarcely indicated in second segment and only towards posterior edge; not evident in third and fourth segments. Fifth tail segment long, usually very long in male. Intercarinal surfaces

mainly smooth with some small denticles and granules. Ventromedian and ventrolateral keels strongly denticulate, other keels made up of smaller denticles. Ventromedian keel bifurcating distally at extremity.

Vesicle moderately small, fine to coarsely granulate especially ventrally. Finely granulate to smooth dorsally.

Aculeus moderately to strongly curved, sometimes weakly.

Humerus with dorsal surface fine to coarsely granulate with large dark denticles along anterior and posterior edges.

Brachium with dorsal surface smooth to finely granulate. Posteroventral keel evident and wavy. Posterior surface weakly corrugated, and sometimes with coarse dark granules, especially along median line. Ventral group, *v*, with 9-15 (usually 10-14; often 11) trichobothria. Posterior group, *p*, with 29-49 (usually 32-37) trichobothria.

Hand flat and usually narrow. Dorsal surface with a reticulation of fine granules. Anterodorsal edge with dark denticles; posterodorsal edge dark and mainly smooth. Anterior surface with fine scattered granules to smooth; with a central keel of larger granules. Ventral group, *V*, with 13-23 (usually 14-16; rarely 23) trichobothria. Median group, *M*, of posterior surface with 7-13 (usually 8-12) trichobothria.

Fingers long. Along length of movable finger 3-4 rows of granules along base, reducing to 1 or 2 row(s) at apex. Around 6-8 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-6 (usually 6) prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-13 (usually 11,12) inner, and 8-12 (usually 9) outer prongs.

Pectinal teeth 17-23 (Mean 20.0, SD 0.90) in male; 12-17 (Mean 13.5, SD 1.44) in female.

Paraxial organ (Figs 88, 89) with lamina long, tapering to curved and pointed apex; inner lobe large, curving to a point, very widely separated from long median lobe which is narrow at apex; prong pointed; sclerotized plate curved along edge; fulcrum poorly defined; fissure large and clearly sclerotized along border; caulis large and pointed at apex; carina moderate sized and rounded at apex; toca large, tending to be pointed at both ends; external lobe wide with a small point at apex; ventral vinculum short, tapering abruptly; dorsal vinculum sometimes wide; juxtum long and abruptly curved; basal lobe about one-third length of juxtum.

## Remarks

The specimen from Parachilna is clay-yellow and hence lighter coloured than other specimens. The paraxial organ structure is close to that of *U*.

*armatus* in shape of median lobe, prong, carina, and juxtal portions, also close to *U. koolanensis* in shape and length of inner lobe and lamina and in inner lobe being widely separated from median lobe.

*Urodacus novaehollandiae* Peters

(Figs 2, 3, 4, 6, 7, 8, 11, 22, 51, 90, 91, 122, Map 13)

*Urodacus novaehollandiae* Peters, 1861: 511; Thorell, 1876: 14; Karsch, 1879: 20; Pocock, 1888: 169; Kraepelin, 1894: 20; Pocock, 1898: 62; Kraepelin, 1899: 104; Kraepelin, 1901: 270; Kraepelin, 1908: 93, 96; Kraepelin, 1916: 35; Takashima, 1945: 87. [Holotype examined.]

*Iodacus orthurus* Thorell, 1877: 264; Pocock, 1898: 67. [Holotype examined.]

*Urodacus bicolor* Werner, 1936: 182; Takashima, 1945: 89. [3 syntypes examined.] *Syn. n.*

*Urodacus marianus* Roewer, 1943: 225. [Holotype examined.] *Syn. n.*

Range (Map 13)

Western Australia, southern; north to Irwin, Morawa, Muckinbudin, Merredin and Widgemooltha; and south to King George Sound, Mondrain I., Madura, and Eucla. South Australia, southern; at Wedge I., Eyre and York Peninsulas; furthest north-east at Bimbowrie.

Measurements (mm)

♀. Morley Park, near Perth, W.A. 66/286, WAM. Total length 90, of tail 47; carapace, length 10.9, width 11.0; tail segments one to five (in that order), length 4.6, 5.6, 6.5, 6.5, 10.0, width 4.9, 4.5, 4.5, 4.2, 4.0, height 4.0, 3.8, 3.7, 3.8, 3.3; length of vesicle and aculeus 10.0; width of vesicle 3.5; length of humerus 7.5; brachium, length 9.5, width 3.8; hand, length 8.6, width of hand surface 8.0, height 6.2; length of hand and fixed finger 18.7; length of movable finger 10.0; length of pectine 6.8.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=181)									
Min.	6.3	5.7	4.5	4.5	3.6	9.8	5.1	3.5	2.3
Max.	11.1	11.5	9.8	8.2	6.6	18.8	11.1	8.3	4.5
Mean	8.6	8.5	7.6	6.4	4.8	14.0	7.5	6.3	3.5
SD	0.75	0.86	0.74	0.57	0.53	1.37	0.87	0.81	0.37
Female (n=49)									
Min.	7.3	7.4	6.5	5.7	4.3	12.1	6.3	3.9	2.5
Max.	12.2	12.5	11.3	9.2	8.6	20.2	11.3	7.3	4.1
Mean	10.3	10.3	9.1	7.6	5.9	17.0	9.2	6.0	3.5
SD	0.99	1.13	1.09	0.88	0.85	1.79	1.12	0.72	0.37

## Diagnosis

Distinguished from the four similar species with which its distribution range partly overlaps by the following characters. *U. novaehollandiae* is smaller than *U. hoplurus* and unlike it has a notch at proximal base of sub-basal tooth of fixed jaw of chelicerae, and lower trichobothrial numbers, e.g. usually 9-12 on V group of hand. Compared to *U. armatus*, *U. novaehollandiae* is larger and has colour differences, e.g. darker and less pronounced spots on leg joints, and there are cheliceral differences such as the absence of a notch at the proximal base of the sub-basal tooth of the fixed jaw. Unlike *U. planimanus*, *U. novaehollandiae* has rounded hands. *U. novaehollandiae* is much larger than *U. manicatus* and has truncate frontal lobes.

## Description

Colour dark clay-yellow to red-brown to brown-black to greenish black; ventrally pale yellow to brown; legs and first and second segments of chelicerae yellow to clay-yellow; arms, hands, fingers, and anterior of carapace usually dark to very dark; sometimes with dark green sheen, mainly on humerus, brachium, hands, and anterior of carapace.

Carapace with frontal notch slightly to moderately deep, sometimes deep. Frontal lobes truncate and almost square. Interocular areas smooth, shiny, finely pitted and slightly rugose along anterior border, sometimes (especially anteriorly) shagreened. Lateral and posterior two-thirds of carapace usually granulate. Median sulcus uninterrupted (seldom slightly interrupted). Triangular depression deep. Sides of triangular depression not or slightly retracted.

Chelicerae (Fig. 22) without secondary serrations. Fixed jaw with sub-basal tooth notched at proximal base, distal base of sub-basal tooth obtusely angular. Movable jaw with simple teeth; proximal base of median tooth sharply notched.

Tergites of first six abdominal segments varying from completely granulate to partly smooth and shiny and partly with close-set granules. Females occasionally with some shiny spots in middle of segments. Median keel very smooth and scarcely discernible. Tergite of last abdominal segment with granules, especially in posterior half. Both pairs of longitudinal keels granulate: the median pair one-third of half the length of segment, the lateral pair about three-fourths length of segment.

Tail moderately long. First four tail segments (Fig. 51) with intercarinal surfaces mainly smooth with sparsely scattered fine granules; larger granules on dorsal and dorsolateral surfaces. Dorsal and dorsolateral keels denticulate. Dorsal keels with denticles larger in male, gradually enlarging to terminal denticle; rarely (e.g. at Bowgada, Three Springs, and Morawa, W.A.) terminal

denticle developed into a large prominent tooth. Ventrolateral and ventromedian keels usually smooth in first three segments, often slightly notched to denticulate in fourth segment. Accessory keel in first tail segment granulate; in second tail segment granulate and usually weakly developed; in other tail segments usually ill-defined or absent. Fifth tail segment (Fig. 11) with lateral intercarinal surfaces finely to coarsely granulate; ventral intercarinal surfaces denticulate. Dorsal keels denticulate; dorsolateral, ventrolateral, and ventromedian keels strongly denticulate. Ventromedian keel bifurcating distally from about middle of segment.

Vesicle (Fig. 11) moderately small, dorsally smooth to finely granulate, ventrally granulate, lateral surface intermediate in texture between dorsal and ventral.

Aculeus slightly to moderately curved.

Humerus (Fig. 2a) with dorsal surface sparsely covered with coarse and fine granules and bounded at anterior and posterior edges by a row of large dark denticles.

Brachium (Figs 2b, 3, 4) dorsally with scattered granules. Posteroventral keel wavy and strong. Ventral group, *v*, with 7-12 (usually 8-10, less usually 12) trichobothria. Posterior group, *p*, with 20-38 (usually 22-27) trichobothria.

Hand (Figs 6-8) tending to be rounded. Some reticulation of granules on dorsal surface especially near anterodorsal keel which consists of a wide band of irregularly placed small denticles. Finger keel and posterodorsal keels smooth, dark, and clearly defined. Anterior surface with scattered granules of various sizes, and a poorly-defined wide median keel. Ventral group, *V*, with 7-16 (usually 9-12) trichobothria. Median group, *M*, of posterior surface with 3-10 (usually 3-7) trichobothria.

Fingers moderately long to short (Figs 6-8). Along edge of movable finger 3-4 rows of granules at base, reducing to 1 row at apex. 6-8, sometimes up to 10, rows of transverse accessory teeth, mainly in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 (usually 6) prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-12 (rarely 13, usually 12) inner, and 8-11 (rarely 7) outer prongs.

Pectinal teeth 15-26 (Mean 18.6, SD 1.43) in male; 10-18 (Mean 13.5, SD 1.33) in female.

Paraxial organ (Figs 90, 91) with lamina long, almost uniformly wide, curved and bluntly pointed at apex; inner lobe pointed and with a broad back-plate which is sometimes rounded at the top edge that is nearer to lamina; inner lobe moderately distant from moderately long median lobe;

prong tending to be rounded; sclerotized plate often ill-defined; fulcrum thin; carina apically pointed; toca elongated, rounded at base and apex; external lobe narrow, moderately long and bulging (bulge sometimes large, e.g. in specimens from Morawa, W.A.); ventral vinculum narrow; dorsal vinculum wide; basal lobe short; proximal lobe long and thin; apotheca weakly sclerotized.

Material examined

298♂, 297♀ (Map 13).

WESTERN AUSTRALIA

Alfred Cove, 19.xii.1967 (B. Kemp) 1♀, 68/699, WAM. Allanson, 21.iii.1924 (O.E. Green) 1♂, 24/200, WAM. Applecross, 25.iii.1963 (V. Cooper) 1♂, 68/701, WAM; 14.i.1964 (T. Smith) 1♀, 68/686, WAM; 16.xii.1967 (C. Marshall) 1♂, 68/697, WAM. Araluen, xii.1967 (J. Lake & L.N. McKenna) 1♂, 68/637, WAM. Armadale, 27.ii.1924 (S.E. Carter) 1♀ and 14 young, 24/106, WAM; 2.vii.1967 (G. Sims) 1♂, 68/665, WAM; 15.x.1967 (G. Sims) 2♂, 68/757-8, WAM. Attadale, 4.iv.1967 (Robertson) 1♂, 68/698, WAM. Avon Valley, near Northam, 14.v.1969 (Aquinas College) 1♀, 69/1957, WAM. Bassendean, 6.x.1924 (H.S. Hyde) 1♀, 24/861, WAM; ix.1938 (G. Roberts) 1♂, 38/1796, WAM. Bayswater, ix.1924 (H. Atkins) 1♂, 24/822, WAM. Bedfordale, 25.ix.1967 (S. Hurst) 1♀, 68/677, WAM. Bedford Park, 28.ii.1969 (R. Bell) 1♀, 69/942, WAM. Beechboro, 14.i.1924 (Street) 1♂, 24/2, WAM; 7.vii.1967 (J.E. Culverwell) 1♀, 68/691, WAM. Bickley, 27.ii.1962 (B. Back) 1♂, 66/300, WAM. Black Snake (Camp 57) 28.iv.1924 (D.E. Page) 1♀, 24/352, WAM. Boddington, 28.iv.1924 (F.J. Gray) 1♂, 1♀, 24/362-3, WAM. Bowgada, 30.i.1929 (Campbell) 1♂, 29/139, WAM. Boya, 3.x.1965 (A.M. Douglas) 1♂, 1♀, 68/607-8, WAM; 24.v.1967 (L.E. Koch & L.N. McKenna) 4♂, 2♀, 68/601-2, 68/605-6, 68/603-4, WAM; 28.v.1967 (L.N. McKenna) 1♂, 68/609, WAM. Brancaster, Upper Blackwood Dist. (?), pres. iv.1909 (J.M. Whistler) 1♂ (not ♀ as stated by Werner, 1936), Zoologisches Museum, Hamburg (syntype of *U. bicolor*). Bridgetown, 5.iii.1924 (G.M. Cowen) 1♂, 24/153, WAM; vi.1928 (A.L. Bartlett) 2♂, 28/628-9, WAM. Bullsbrook, 17.iv.1969 (A.M. Douglas) 1♂, 69/777, WAM. Buniche, 16 km N of, 6.iv.1968 (A. Baynes & J.L. Bannister) 1♂, 1♀, 68/600, 68/599, WAM. Busselton, iv.1968 (A.G. Sayers) 1♀, 68/527, WAM. Byford 10.vii.1967 (B. Robinson) 1♂, 1♀, 68/632-3, WAM; 14.ix.1967 (A. Baynes) 1♂, 68/727, WAM; 13.vii.1969 (M. Archer & E.A. Jefferys) 2♂, 69/1927-8, WAM; ix.1969 (M. Archer & P. Hay) 1♂, 69/1926, WAM; 8 km SE of, 14.ix.1967 (A. Baynes) 3♂, 68/750-2, WAM. Calingiri, 26.iii.1924 (E.C. Cox) 1♂, 24/246, WAM; x.1929 (F.P. Halse) 1♀, 29/1341, WAM. Canning Dam, 3.ii.1936 (Hoddy) 1♀ and 12 young, 36/344, WAM; 7.ii.1966 (G. Kontoolas) 1♂, 68/736, WAM; 23.v.1968 (R.B. Humphries) 1♂, 1♀, 68/629, 68/628, WAM. Capel, iv.1924 (H. Turner) 1♂, 24/346, WAM;

27.vii.1925 (J. Lang) 1♂, 25/501, WAM; 14.xi.1927 (J.H. Turner) 1♀, 27/1571, WAM. Cape Naturaliste, 30.x.1969 (D.D. Giuliani) 1♀, 70/251, WAM. Carbarup, 11.v.1916 (E. Thomas) 1♀, 16/383, WAM. Cheyne Beach, 27.i.-5.ii.1970 (W.H. Butler) 1♂, 1♀, 70/338, 70/337, WAM. Chidlow, 16.iv.1967 (V. Martin) 1♀, 68/571, WAM; 17.vii.1967 (C. Martin) 1♂, 3♀, 68/572-3, 68/574a-b, WAM. Circle Valley, 19.i.1929 (R. Elliot) 1♀, 29/124, WAM. Clackline, v.1924 (E.W. Membery) 1♀, 24/522, WAM; xi.1924 (E.W. Membery) 1♂, 24/922, WAM; iv.1925 (E.W. Membery) 2♀, 25/284, 25/333, WAM. Cocklebidy, 26 km SE of, 4.ix.1969 (A. Baynes & W.K. Youngson) 1♀, 69/1947, WAM; about 23 km ESE of, on face of Hampton Scarp, 4.ix.1969 (W.K. Youngson & A. Baynes) 1♂, 69/1935, WAM. Coolup, 8.iii.1946 (R.H. Robinson) 1♀, 46/110, WAM. Corrigin, iv.1924 (A. Wilson) 1♀, 24/347, WAM; 20.vii.1967 (J.W. Vaughan) 1♀, 68/636, WAM; 1.xi.1967 (L.E. West) 1♀, 68/634, WAM. Cottesloe, 16.viii.1920 (W.A. Smith) 1♀, 20/135, WAM. Cranbrook, 24.iii.1920 (J.T. Tunney) 1♀, 20/119, WAM. Culham, 2.ix.1958, 2♀, 68/641, 73/663, WAM; 3.ix.1960 (R.P. McMillan) 1♀, 73/661, WAM; 30.vii.1961 (R.P. McMillan) 1♂, 73/662, WAM. Dalkeith, 31.iii.1963 (E. Pedler) 1♂, 68/690, WAM; 1.v.1963 (J. Lawson) 1♂, 68/703, WAM. Darkan, 5.vi.1917 (W.J. Wunnenberg) 1♂, 17/193, WAM; iii.1925 (W.J. Wunnenberg) 2♂, 25/198-9, WAM; viii.1925 (W.J. Wunnenberg) 5♂, 25/539, 25/541-4, WAM. Darling Range, 28.xii.1967 (M. Lefevre) 1♀, 68/658, WAM. Darlington, x.1924 (B. Liddell) 1♀, 24/874, WAM; 2.vi.1962 (W. Storm) 1♀, 68/613, WAM; 4.iii.1963 (T.G. Everett) 1♀, 68/612, WAM; 18.ix.1963 (M. Stephenson) 1♀, 68/611, WAM; 24.v.1967 (L.E. Koch & L.N. McKenna) 1♀, 68/610, WAM. Dianella, 25.vi.1960 (R.L. Atkins) 1♀, 68/700, WAM; 10.ii.1963 (L. Pianta) 1♂, 68/530, WAM; 24.xii.1964 (A. Cunningham) 1♂, 68/702, WAM; 2.xii.1967 (H. Oud) 1♂, 68/707, WAM; 17.xii.1966, 1♀, 68/692, WAM; 17.iv.1968 (J. Croft) 1♂, 68/685, WAM; 24.xi.1968 (B. Lush) 1♀, 68/650, WAM; 26.xi.1968 (B. Shilling) 1♀, 68/13, WAM. Donnybrook, xii.1924 (W.R. Carter) 1♀, 24/964, WAM. Dryandra State Forest, 12.x.1969 (G.W. Kendrick) 1♀, 70/346, WAM. Dudinin, iii.1925 (E. Farr) 1♀, 25/210, WAM. Dumbleyung, 5.xii.1914 (W. Elliot) 1♀, 14/1374, WAM; 1961 (H. Udell) 1♀, 68/526, WAM. East Cannington, xii.1924 (C.E. Chivers) 1♂, 24/962, WAM. East Fremantle, 29.vii.1917 (Key) 1♀, 17/251, WAM. East Perth, xii.1924, 1♀, 24/938, WAM. Embleton, 22.iv.1964 (J.A. Ward) 1♀, 68/753, WAM. Esperance, vi.1938 (F.R. Bradshaw) 1♀, AM. Eucla, vii.1914 (W.B. Alexander) 1♂, 1♀, 14/1003a-b, WAM; iii. 1924 (R. Counsel) 1♂, 24/259, WAM; 7.x.1964 (A.M. Douglas) 5♂, 68/539-43, WAM; 4.ix.1968 (A.G. Mathews) 2♂, 4♀, 68/544-9, WAM. Fitzgerald River, 2.ii.1970 (W.H. Butler) 1♂, 70/339, WAM. Floreat Park, 3.vi.1968 (O. Kay) 1♂, 68/647, WAM. Gidgegannup, 23.vi.1968 (L.V. Shields) 1♂, 68/518, WAM. Gingin, 2 km S of, 6.iv.1969 (M. Archer & E. A. Jefferys) 1♂, 1♀, 68/949-50, WAM. Gleneagle, 4.x.1967 (K.T. Zwicky) 4♂, 68/669-72, WAM. Glen Forrest, 19.xi.1967 (G.W. Kendrick) 1♂, 68/

708, WAM; 6.vi.1968 (R.J. McKay) 1♂, 68/649, WAM. Gngangara, 24.xi.1965 (L.E. Koch) 1♀, 66/349, WAM; east, 23.iv.1968 (L.E. Koch & A.M. Douglas) 1♀, 69/1934, WAM; 7.vi.1969 (A.M. Douglas) 1♂, 69/1925, WAM. Goomalling, i.1929 (H.E. White) 1♀, 29/138, WAM. Gooseberry Hill, 17.v.1915 (W.B. Alexander) 1♂, 15/505, WAM; 2.ix.1968 (E.J. Car) 1♂, 69/12, WAM; 7.iii.1969 (J. Pickering) 1♀, 69/943, WAM; 29.x.1969, 1♂, 70/347, WAM. Greenmount, 28.xi.1963 (K. Johnson) 1♀, 66/288, WAM; 30.vii.1967 (G.G. Allen) 1♂, 68/724, WAM. Harvey Agric. area, 1♂, K10837, AM. Helena River, 26.vi.1963 (J. Dell) 1♀, 68/657, WAM. Helena Valley, 10.iv.1968 (C. Frith) 1♂, 70/343, WAM. High Wycombe, 14.ix.1968 (D.S. Adair) 1♂, 68/689, WAM; 3.ii.1969 (C. Gibson) 1♀, 69/936, WAM. Hyden, 24 km E of, iii.1969 (J.W. Feehan) 1♂, 69/554, WAM; 27 km E of, 7.iv.1967 (N. Weir) 2♂, 68/519-20, WAM. Inglewood, vi.1924 (C.F. Eder) 10♂, 7♀, 24/579, 68/762-77, WAM; iii.1925 (F.R. Lidbury) 1♂, 25/201, WAM. Irwin, iii.1924 (F. Brady) 1♂, 3♀, 24/249-52, WAM; 4.vi.1924 (F. Brady) 5♂, 6♀, 24/554-8, 24/553, 24/559-63, WAM. Israelite Bay, iv.1925 (A.J.M. Cook) 4♂, 25/341-2, 25/344-5, WAM; 56 km W of, 13.xi.1969 (D.D. Giuliani) 1♀, 70/256, WAM. Jarrahdale, 27.ii.1925 (Haynes) 2♂, 3♀, 25/116, 25/118, 25/114-5, 25/117, WAM; 10.viii.1967 (K.T. Zwicky) 3♂, 3♀, 68/738-43, WAM. John Forrest National Park, 19.ix.1965 (K. Fletcher) 1♂, 68/754, WAM; 1967 (K.T. Zwicky) 4♂, 4♀, 68/663, 68/744-6, 68/664, 68/747-9, WAM. Kalamunda, 10.iv.1967 (D. Standon) 1♂, 68/615, WAM; 15.v.1968 (D. Jefferies) 1♀, 68/616, WAM; 16.ix.1968 (M.E. Sever) 1♀, 68/614, WAM. Kebaringup, 5.xi.1969 (D.D. Giuliani) 2♂, 2♀, 70/252-5, WAM. Kendenup, 4.viii.1969 (J. Saggars) 1♂, 1♀, 68/667-8, WAM. King George Sound, 2♀, MM. Kings Park, 1.iv.1963 (Easterbrook) 1♂, 68/529, WAM. Kojonup, 31.iii.1938, 1♀, 38/1071, WAM. Kondinin, 24.iii.1924 (A.D. Robens) 1♂, 24/234, WAM; 27.v.1924 (A.D. Robens) 1♀, 24/512, WAM. Koojan, 19.iii.1924 (R.L. Joyce) 1♀, 24/196, WAM; 5.vi.1966 (R.B. Humphries) 2♂, 3♀, 68/624-5, 68/623, 68/626-7, WAM. Kukerin, 3.iii.1924 (D. Murray) 1♀, 24/117, WAM; 4.xii.1924 (G. Bell) 1♀, 24/936, WAM; viii.1925 (G. Bell) 1♂, 25/586, WAM; 9.vii.1963 (G.F. Mees) 1♀, 68/640, WAM. Kulin, 31.iii.1924 (G. Wilson) 1♀, 24/260, WAM; 9.iii.1932 (N.A. Scadding) 1♀, 32/611, WAM. Lake Neerabub, 3.x.1969 (M. Archer & E.A. Jefferys) 2♀, 70/348-9, WAM; southern side of, 20.iv.1969 (M. Archer, E.A. Jefferys & I. Murray) 2♀, 69/951-2, WAM; SSE of, 10.v.1969 (M. Archer & E.A. Jefferys) 1♂, 1♀, 69/1936-7, WAM; western edge of, 29.iii.1969 (M. Archer & E.A. Jefferys) 5♂, 69/944-8, WAM. Lake Varley, 3.iv.1963 (R. Jewell) 1♂, 68/533, WAM; 3.iv.1963 (K. Brown) 2♂, 68/534-5, WAM. Lesmurdie, 28.iv.1968 (C. Mildren) 2♂, 4♀, 68/729-34, WAM. Lion Mill, x.1924 (D.L. Serventy) 1♂, 24/885, WAM. Madura, 20.x.1967 (J.C. Le Souef) 2♂, 4♀, 68/712-17, WAM; 24 km E of, 17.xi.1969 (D.D. Giuliani) 3♂, 1♀, 70/257-60, WAM; 43 km S of, 1.ix.1969 (A. Baynes & W.K. Youngson) 1♂, 2♀, 69/1929-31, WAM. Mahogany Creek, 21.vii.1947 (A.M. Douglas) 2♂, 47/

1028-9, WAM; 7.iv.1964 (P. Frost) 1♀, 68/536, WAM; 1.x.1967 (B. Simpson) 1♂, 1♀, 68/537-8, WAM; 26.viii.1968 (B. Simpson) 4♀, 68/651-4, WAM; 25.viii.1969 (B. Simpson) 2♂, 7♀, 69/1948-56, WAM. Marmion, 25.x.1963 (K. Bentley) 1♀, 66/295, WAM. Maylands, 16.iii.1916 (W.S. Brown) 1♂, 16/196, WAM. Melville, v.1938 (R.E. George) 1♂, 38/1364, WAM. Merredin, 25.iii.1924 (C.G. Allberry) 1♂, 24/244, WAM; xii.1924 (J. Scarlett) 1♂, 24/1029, WAM; 16.i.1929 (H.O. Brown) 1♀, 29/72, WAM. Midland, 10.iii.1924 (G. O'Dwyer) 1♂, 24/159, WAM. Mingenew, 7.ix.1967 (G. Gatfield) 1♀, 68/656, WAM. Mogumber, 10.iv.1958 (R.P. McMillan) 2♂, 4♀, 66/331-2, 68/476-8, 68/655, WAM. Mondrain I., Recherche Archipelago, 1♀, NM. Morawa, i.1968 (L. Castle) 2♂, 68/531-2, WAM. Morley Park, 17.xi.1963 (D. Kelly) 1♀, 66/286, WAM; 19.xii.1967 (J. Schneider) 1♂, 68/687, WAM; 3.i.1969 (J. Dunne) 1♀, 69/11, WAM; 9.xii.1969 (C.W. Westoner) 1♀, 70/344, WAM; 17.vi.1970 (J.M. Mackay) 1♀, 70/342, WAM. Mosman Park, 21.xii.1962 (M. Holder) 1♀, 66/294, WAM. Mt Bakewell, 9.xi.1968 (G.W. Kendrick) 1♂, 1♀, 68/659-60, WAM. Mt Cooke, 23.iii.1968 (E.G. Cockett) 3♂, 68/579-81, WAM; 31.iii.1968 (E.C. Cockett) 1♂, 68/578, WAM; 20.iv.1968 (L.E. Koch, F.H.U. Baker & E.G. Cockett) 1♀, 68/939, WAM; 18.viii.1968 (L.N. McKenna) 3♀, 68/575-7, WAM; xii.1967 (E.G. Cockett) 1♂, 68/582, WAM; 18.x.1969 (L.E. Koch & D.D. Giuliani) 8♀, 69/2060-7, WAM. Mt Helena, 17.ix.1967 (E. Jefferson) 1♀, 68/639, WAM. Mt Lawley, 13.x.1922 (S.P. Hall) 1♀, 22/563, WAM; 12.vi.1924 (Brabazon) 2♂, 24/588a-b, WAM; iii.1924 (W.T. Ashman) 1♂, 24/256, WAM; 12.xii.1929 (D. Hausen) 2♂, 29/1467-8, WAM; 3.x.1968 (Winterbottoms) 1♂, 68/705, WAM. Mt Pleasant, 20.ii.1963 (J. Skevington) 1♀, 68/693, WAM; 29.ii.1964 (K. Hines) 1♀, 68/694, WAM; 4.viii.1968 (Seth) 1♀, 68/688, WAM; 5.xii.1968 (R.S. Jones) 1♂, 68/682, WAM. Mt Solus, 10 km S of (R. Muir) 1♀, 68/737, WAM. Mt Yokine, 10.v.1960 (L. Glauert) 1♀, 66/266, WAM; 22.ix.1964 (L.A. Smith) 1♀, 68/706, WAM; 16.x.1967 (P. Alchin) 1♀, 68/684, WAM. Muckinbudin, 26.vii.1967 (H. Leyland) 1♀, 68/635, WAM. Mundaring, 18.ix.1916 (W.H. Nelson) 1♀, 16/444, WAM; 27.ii.1924 (A.W. Leggo) 2♀, 24/104-5, WAM; iv.1925 (Scott) 1♂, 1♀, 25/259, 25/258, WAM; iv.1925 (Davies) 1♂, 25/372, WAM; 12.v.1963 (L. Jamvold) 1♀, 68/585, WAM; 7.vii.1967 (Smith) 1♂, 68/584, WAM; 20.vii.1967 (L.E. Koch & K.T. Zwicky) 1♀, 68/583, WAM; 3.iv.1968 (K.T. Zwicky) 1♂, 68/586, WAM; 5.vii.1969 (R.B. Humphries) 2♂, 69/1941-2, WAM. Mundaring Weir, 23.i.1963 (J. Dell) 1♀, 68/597, WAM; 24.iv.1963 (J. Dell) 1♂, 68/594, WAM; 8.v.1963 (J. Dell) 1♀, 68/593, WAM; 24.iv.1965 (R.B. Humphries) 1♂, 68/598, WAM; 13.iii.1966 (N. Allen) 2♂, 1♀, 68/596, 69/937, WAM; 20.vi.1967 (K.T. Zwicky) 2♂, 1♀, 68/587-9, WAM; 1967 (K.T. Zwicky) 2♂, 1♀, 68/590-2, WAM; 17.v.1969 (M. Archer & E.A. Jefferys) 4♀, 68/1943-6, WAM; spring, 1♂, 69/938, WAM; 10 km E of, 15.v.1963 (J. Dell) 1♀, 68/570, WAM; Muradup, 1.v.1924 (W. Dawson) 2♂, 1♀, 24/402, 24/404-5, WAM. Munglinup, on Young River, vi.1969 (J.

Harley) 3♀, 69/1938-40, WAM. Myra (?), 14.xii.1965 (Beechman) 1♀, 66/348, WAM. Narrogin, 18.ix.1968 (A.M. Douglas) 1♂, 1♀, 68/643, 68/642, WAM. Nedlands, 24.iii.1924 (E.J. Lewis) 1♀, 24/235, WAM. New Norcia, 31.iii.1968 (R.B. Humphries) 1♂, 68/630, WAM; 11 km N of, 11.iv.1965 (R.B. Humphries) 1♀, 66/293, WAM; 30.v.1965 (R.B. Humphries) 1♂, 2♀, 66/297-9, WAM; 11.vi.1967 (R.B. Humphries) 5♂, 68/565-9, WAM. Northam, viii.1967 (G.K. Maskiell) 1♂, 68/528, WAM; 21 km W of, 19.v.1968 (D.S. Adair) 1♀, 69/940, WAM. 'Nullarbor Plain', 1966 (D. Edwards) 1♀, 68/525, WAM. Nyabing, 4.vii.1955 (V.F. McDougall) 2♂, 55/4884-5, WAM. Oldfield location 778 (?), 16.iii.1968 (A. Williams) 1♂, 68/661, WAM. Ongerup, 16.x.1967 (J.C. Le Souef) 1♀, 68/718, WAM. Osborne Park, ii.1924, 1♀, 24/65, WAM. Perth, 7.ix.1898 (H. Richards) 1♂, 1♀, K7822, AM; 5.i.1904, 1♀, MM; 6.vii.1914 (L. Deering) 1♀, 14/772, WAM; xii.1924 (W.A. Podmore) 1♂, 24/939, WAM; 31.i.1969 (M.E. Sever) 1♀, 69/941, WAM; 1♂, 1♀, K15258, AM; 1♂, SAM; 40 km along Albany Highway, 6.x.1968 (D.S. Adair) 1♀, 68/735, WAM; 51 km along Albany Highway, 6.viii.1967 (R.A. Saffrey) 1♂, 68/673, WAM; 76 km along York Road, 6.i.1968 (F.H.U. Baker) 1♀, 68/709, WAM; 87 km along Albany Highway, 4.xi.1968 (F.H.U. Baker) 2♂, 68/710-1, WAM; 103 km N of, xi.1949 (A.N. Burns) 1♂, NM. Pickering Brook, 1905 (W. Michaelsen) No. 4, 1926, 1♂, 1♀, Zoologisches Museum, Hamburg (syntypes of *U. bicolor*); 28.iv.1968 (C. Mildren) 2♂, 4♀, 68/618-22, 68/617, WAM. Pingrup, vi.1925 (F.C. Hull) 1♂, 25/478, WAM. Porongorups, 30.i.1970 (K.T. Richards) 2♂, 1♀, 70/350-2, WAM. Quairading, 12.iii.1963 (F.G.W. Glover) 1♂, 68/638, WAM. Queens Park, 21.i.1967 (J. Allen) 1♀, 68/683, WAM. Quindalup, xii.1925 (G.F. McGregor) 2♀, 25/797-8, WAM. Quinns Rocks, 18.x.1967 (A. Neille) 1♀, 68/564, WAM. Red Hill, 22.vi.1967 (L.E. Koch & L.N. McKenna) 4♂, 2♀, 68/523, 68/719, 68/721a-b, 68/522, 68/720, WAM; 17.viii.1967 (L.E. Koch & L.N. McKenna) 2♂, 68/722-3, WAM; 7.ix.1967 (L.N. McKenna) 1♂, 68/756, WAM. Riverdale, 2.iv.1925 (R. Blacklock) 1♂, 25/260, WAM. Riverton, xii.1924 (C.E. Clarke) 1♀, 24/956, WAM; vi.1965 (M. Jones) 1♂, 66/267, WAM; 8.xi.1966 (S.B. Malpars) 1♀, 68/755, WAM. Robbs Jetty, 8.iii.1924 (W.B. Bickford) 1♀, 24/158, WAM. Roleystone, 1.iii.1924 (G. Clark) 1♂, 24/108, WAM; 28.iv.1968 (R. Hadlow) 1♀, 68/631, WAM. Salmon Gums, 1968 (C. Pearce) 1♀, 69/935, WAM. Sawyers Valley, 4.vii.1967 (G. Joss) 1♂, 68/662, WAM. Scarborough, 24.ii.1967 (P. Hammond) 1♀, 68/678, WAM; 1.vii.1967 (P. Haseldine) 1♀, 68/679, WAM. Serpentine, 26.v.1924 (J.D. & H.M. Phillips) 3♂, 24/502-4, WAM; iii.1925 (A. Baldwin) 3♀, 25/170-2, WAM; iv.1925 (A. Baldwin) 4♂, 2♀, 25/355-6, 25/358-9, 25/352, 25/357, WAM; 3.iv.1964 (A. Schukowsky) 1♀, 68/728, WAM; ix.1969 (L.N. McKenna) 1♂, 1♀, 70/340-1, WAM. Stoneville, x.1928 (N. Tamblyn) 2♂, 3♀, 28/1009-13, WAM; 30.ix.1965 (W.H. Butler) 1♀, 66/272, WAM. Swanbourne, 3.viii.1923 (Ryan) 1♀, 23/190, WAM; 4.xii.1962 (P. Yewers) 1♂, 68/695, WAM; 16.iii.1968 (P. Southwood) 1♂, 68/681,

WAM. 'Swan River', 2♂, K8943, AM; 4♂, 2♀, K9034, AM. Tambellup, viii.1925 (F.R. Bradshaw) 1♀, 25/525, WAM; i.1934 (F.R. Bradshaw) 1♂, AM; vi.1935 (F.R. Bradshaw) 1♂, AM. Tammin, iv.1929 (R.C. Hobbs) 1♀, 29/387, WAM. Thompsons Lake Reserve, near Fremantle, 14.x.1969 (D.D. Giuliani) 1♀, 69/2059, WAM. Three Springs, ii.1926 (E.W. Franklin) 1♀, 26/52, WAM; 9.ix.1929 (J.J. Hebiton) 1♂, 29/1234, WAM; 17.iii.1963, 1♀, 68/524, WAM. Trayning, 14.ix.1967 (R. Gilbert) 1♀, 68/676, WAM. Trigg, 9.ii.1968 (Knight) 1♂, 68/680, WAM. Two People Bay, 15.ii.1970 (Survey Party) 1♂, 70/345, WAM. Victoria Park, 1957 (M.L. Adamson) 1♂, 68/696, WAM. Wagerup, 16.vii.1947 (K. Piggott) 1♀, 47/1024, WAM; xi.1967-i.1968 (R. Hayes) 1♀, 68/675, WAM; xi.1967-i.1968 (M. Partington) 1♀, 75/21, WAM. Wagin, 10 km W of, 8.vii.1963 (G.F. Mees) 1♂, 1♀, 68/725-6, WAM. Walyunga National Park, 4.v.1969 (M. Archer & E.A. Jefferys) 3♂, 69/955-7, WAM. Wanneroo, 2.vi.1968 (M. Archer) 1♂, 68/648, WAM. Waychinicup River, 9.vi.1967 (A. Baynes) 1♂, 68/778, WAM. Wembley Downs, 26.ii.1965 (V. Underwood) 1♂, 68/704, WAM. 'Western Australia', 16.ii.1875 (Webb) 1♀, NM; 1♂, 3♀, K17327, AM; 1♂, AM. Westaustralien, Zoological Museum, Berlin (holotype of *U. novaehollandiae*). West Guildford, 2.ii.1923 (G. Oakley) 1♂, 23/27, WAM. West Swan, 10.vii.1967 (E. Shepherd) 1♀, 68/666, WAM. Widgiemooltha, 30.vii.1968, 3♂, 11♀, 68/550-63, WAM. Woodanilling, 18.xi.1963 (O.V. Shaw) 1♂, 68/646, WAM. Woorooloo, 22.iii.1963 (J. Pollitt) 1♀, 68/674, WAM; 13.ix.1963 (J. Morald) 2♂, 2♀, 66/284, 66/290, 66/285, 66/291, WAM. Wubin, ii.1965 (O. Schultz) 1♂, 68/521, WAM. Yancheop, 19.iii.1966 (N. Allen) 2♂, 68/644-5, WAM. Yancheop Park, 23.iv.1969 (M. Archer, A. Baynes & E. Finch) 2♀, 69/953-4, WAM; 8.vi.1969 (M. Archer & E.A. Jefferys) 3♂, 2♀, 68/1958-62, WAM. Yarloop, x.1924 (L. Woodcock) 1♂, 24/884, WAM; 8.xi.1948 (A.B.) 1♂, NM.

#### SOUTH AUSTRALIA

Ardrossan (Cadd) 1♂, 3♀, SAM; 2♂, 3♀, SAM; 6♀, SAM. Balhannah (E. Guest) 1♂, SAM. Bimbowrie (A. Zietz) 1♂, SAM. Brentwood (E.M. Le Poideirn) 1♂, SAM. Elliston, xii.1883 (M. Schmitz) 1♂, SAM. Fowlers Bay (A. Zietz) 1♂, SAM. Glenelg, 1891 (C.E. Decley) 1♀, SAM. Highbury, viii.1886 (F. Farndell) 1♂, 1♀, SAM. Kadina (R.G. McDonald) 1♀, SAM. Murat Bay, W. coast of S.A., 1♂, SAM. Roseworthy, 10.viii.1891 (C.C. Deland) 1♀, SAM. Semaphore, ix.1891 (W. Ewan) 1♀, SAM. Wedge I., viii.1895 (W. Haigh) 1♂, SAM. Yorke Peninsula, 9.x.1913, 1♂, SAM; viii.1925 (E.R. Waite) 1♂, SAM; (Newbold) 2♂, SAM.

#### (?) MARIANA IS.

(?) Saipan, Arach. Coll. Rwr. Lfd. No. 8878, No. 220, 1♂, Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt (holotype of *U. marianus*).

## NO LOCALITY DATA

435 66, 1♂ (dry, pinned). Naturhistoriska Riksmuseet, Stockholm (holotype of *I. orthurus*).

## Remarks

Roewer (1943) gave the type locality of the nominal species *U. marianus* as Saipan in the Mariana Islands, and stated that previously all *Urodacus* species were thought to be native to the Australian mainland. Although I have not examined the paraxial organ of *U. marianus*, the external characteristics of the holotype indicate that it is *U. novaehollandiae*, a species confined to southern Australia. Hence I regard the holotype as having a wrong locality label, and synonymize the nominal species *U. marianus* under *U. novaehollandiae*.

*U. novaehollandiae* has a wide range in habitat and kind of burrow. The burrows are loosely spiralling and moderately deep (25-60 cm) and may or may not be under cover of rocks and logs: e.g. in Western Australia (1) under rocks in the hills, near Perth (at Boya and Darlington) (2) among roots of plants or under logs or in open (i.e. uncovered) ground in sandy coastal country (at Bullsbrook and Gnangara) (3) under logs in salmon gum leaf litter (near Buniche) (4) in open ground in sandhills with mallee (near Cocklebidy) and in coastal sand dunes (south of Madura). Burrows were as close as 64 cm in sand at Bullsbrook and Gnangara (in April 1969).

Females have been found with 20-33 developing embryos.

The chromosomes of *U. novaehollandiae* and the morphologically closely related species, *U. planimanus*, have been inspected. These two species have the same male chromosome number ( $2n = 68$ ) but their karyotypes are different. Details and further interpretation of these chromosome findings are presented in the section on zoogeography.

The Tawny Frogmouth, *Podagrus strigoides*, has been recorded as a predator in Kings Park, Perth (Serventy 1937).

I have observed *U. novaehollandiae* feeding on earthworms, and have found the remains of beetles, cockroaches, millipedes, spiders and centipedes in the burrows of various species of *Urodacus*.

Males of *U. novaehollandiae* from the north-westernmost parts of the distribution in Western Australia have the dorsal keels of the first four tail segments with prominent terminal denticles. Specimens in sandy areas tend to have lighter coloured bodies, although the hands, arms, and carapace may sometimes be dark. However, light forms have been found living under rocks in areas of dark loamy soil at Wanneroo. Specimens in the hills near Perth are mainly dark throughout.

Field observations indicate that where *U. novaehollandiae* and *U. plani-*

*manus* occur in close proximity their coexistence is facilitated by each species detecting sites with moisture levels that are more favourable for itself.

Geographic variation in shape of *U. novaehollandiae* has been investigated by multivariate analysis; the species displays no significant character displacement in nine measurements where it is sympatric with *U. planimanus* (Campbell & Koch, in preparation).

*Urodacus planimanus* Pocock

(Figs 10, 23, 52, 92, 93, Map 14)

*Urodacus planimanus* Pocock, 1893b: 321; Pocock, 1898: 61; Kraepelin, 1899: 105; Kraepelin, 1908: 92, 95; Kraepelin, 1916: 35; Takashima, 1945: 89. [Holotype examined.]

Range (Map 14)

Western Australia, south-western from Sorrento and Amery south to Waroona.

Measurements (mm)

♀. Holotype. Total length 64, of tail 35; carapace, length 8.5, width 8.5; tail segments one to five (in that order), length 4.4, 5.0, 5.3, 6.0, 8.9, width 3.0, 2.9, 2.9, 2.7, 2.5, height 2.7, 3.1, 3.0, 3.0, 2.3; length of vesicle and aculeus 7.0; width of vesicle 2.5; length of humerus 7.0; brachium, length 7.2, width 3.0; hand, length 7.2, width of hand surface 5.2, height 3.3; length of hand and fixed finger 15.0; length of movable finger 8.2; length of pectine 5.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=23)									
Min.	7.8	7.3	7.8	4.8	3.2	14.3	7.2	7.2	2.8
Max.	9.7	9.4	9.9	6.1	4.1	18.8	9.2	10.8	3.6
Mean	9.0	8.5	9.1	5.6	3.7	16.8	8.4	9.2	3.2
SD	0.50	0.56	0.54	0.32	0.19	1.23	0.61	1.10	0.23
Female (n=18)									
Min.	8.7	8.5	8.5	5.4	3.5	16.1	8.2	5.7	3.0
Max.	10.8	10.6	10.7	7.4	5.0	19.6	10.7	7.3	3.7
Mean	9.8	9.4	9.4	6.5	4.4	17.7	9.3	6.5	3.4
SD	0.55	0.51	0.61	0.46	0.36	0.89	0.64	0.40	0.15

## Diagnosis

Distinguished from *U. novaehollandiae* by flat hands and terminal spines of tail segments, and from *U. armatus* by large size, dark coloration, and hand measurements.

## Description

Colour light orangish brown to brown (usually brown) with dark brown arms and hands and clay-yellow legs; ventrally light brown; sometimes with dark green sheen mainly on arms, hands, and anterior of carapace.

Carapace with frontal notch deep to very deep. Frontal lobes rounded, scarcely truncate (sometimes central portion truncate). Interocular areas rugose, mainly shiny, finely pitted and sometimes finely granulate. Lateral and posterior two-thirds of carapace with close-set fine to coarse granules. Median sulcus uninterrupted. Triangular depression deep to usually extremely deep. Sides of triangular depression straight or slightly retracted.

Chelicerae (Fig. 23) with fixed jaw having a large distally pointed sub-basal tooth which has its distal edge approximately forming a right-angle with inner edge of distal external tooth; no notch at proximal base. Movable jaw with external distal tooth wide and basal tooth with tendency for one serration at each base (proximal and distal) and ending in a sharp point.

Tergites of first six abdominal segments with granules, fine to coarse, usually fine and closely spaced; median keel weak. Posterior part of segments with median keel about half the width of segments. Tergite of last abdominal segment with granules increasing in size posteriorly; median keel present in anterior part; the paired median and lateral keels of large granules especially posteriorly and of about same length as segment.

Tail very long in male, moderately long in female. First four tail segments (Fig. 52) with intercarinal surfaces of sparsely scattered fine granules. Keels strongly defined and darker than intercarinal surfaces. Posterior denticle of dorsal keel large, elevated in male; less in female, and triangular. Dorsolateral keel slightly notched with denticles. Lower lateral keels mainly smooth. Accessory keels practically non-existent except in first segment and posterior half of second segment. Fifth tail segment with intercarinal surfaces granulate and with a scattering of larger granules. Dorsal keel denticulate; ventrolateral and ventromedian keels strongly denticulate. Ventromedian keel bifurcating in distal fifth of segment.

Vesicle moderate-sized, dorsally smooth to finely granulate, ventrally granulate.

Aculeus moderately curved.

Humerus with dorsal surface of fine granules and sparsely scattered coarse granules, and bounded at anterior and posterior edges by an irregular row of dark denticles.

Brachium dorsally with a reticulation of granules and fine granules. Ventral group, *v*, with 6-9 trichobothria. Posteroventral keel well defined. Posterior group, *p*, with 19-25 (usually 21-25, often 23-24, sometimes as low as 19) trichobothria.

Hand moderately narrow, moderately long, dorsal and ventral surfaces flat and parallel. Dorsal surface slightly elevated towards smooth finger keel. Anterodorsal edge of hand with wide band of irregularly placed flat denticles; reticulation of small granules on dorsal surface. Anterior surface with reticulation of coarser granules; a weak central keel of larger granules. Ventral group, *V*, with 8-11 trichobothria. Median group, *M*, of posterior surface with 3-7 (usually 4) trichobothria.

Fingers long. Along edge of movable finger 3-5 rows of granules along base, reducing to 1, 2 or 3 row(s) at apex. 7 rows of transverse accessory teeth, all in distal part of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-6 prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-13 inner, and 9-12 outer prongs.

Pectinal teeth 17-25 (Mean 20.7, SD 1.34) in male; 9-17 (Mean 14.2, SD 0.97) in female.

Paraxial organ (Figs 92, 93) with lamina moderately long, wide, triangularly curved and blunt at apex; inner lobe sharp-pointed and basal area often enlarged; inner lobe is a moderate to long distance from median lobe, which is moderately short and deep; prong tending to be square at apex; sclerotized plate curved to a point; fulcrum curved to a point; carina somewhat pointed at apex; toca tends to be squat, warty and rugose on outside; external lobe wide, blunt to pointed, a double structure; pedunculi sometimes evident; ventral vinculum wide near external lobe; dorsal vinculum wide; basal lobe tapering to a blunt point; proximal lobe rounded to pointed at apex, somewhat longer than basal lobe; diaphragma slightly sclerotized.

#### Material examined

135♂, 168♀ (Map 14).

#### WESTERN AUSTRALIA

Amery, 24.xi.1928 (Whiteford) 1♀, 28/1145, WAM. Araluen, xii.1967 (J. Lake & L.N. McKenna) 1♀, 69/5, WAM; 22.iii.1968 (E. Garratt) 5♂, 1♀, 68/206, 68/208-10, 68/210a-b, 68/207, WAM; 4.iv.1968 (L.E. Koch & L.N. McKenna) 1♂, 2♀, 68/263, 68/262, 68/264, WAM. Bickley, 22.vi.1963 (L.

N. McKenna) 1♀, 68/261, WAM; 2 km N of Observatory, 17.v.1970 (A. Softly) 1♀, 70/288, WAM. Canning Dam, 23.v.1968 (R.B. Humphries) 1♂, 2♀, 68/365, 68/364, 69/10, WAM. Carmel, ii.1925 (A.E. Speck) 3♂, 1♀, 29/260, 29/262, 29/264, 29/263, WAM; 25.ii.1929 (A.E. Speck) 2♂, 29/258-9, WAM; 18.iv.1929 (A.E. Speck) 8♂, 10♀, 29/399-400, 29/407-8, 29/410-411, 29/413, 29/416, 29/401-6, 29/409, 29/412, 29/414-5, WAM. Coolup, 21.vii.1925 (D. Morgan) 1♀, 25/495, WAM; viii.1925 (D. Morgan) 2♂, 3♀, 25/517, 25/520, 25/516, 25/518-9, WAM; 26.vii.1926, 1♀, 26/477, WAM; 3.vii.1967 (D.E. Morgan) 6♂, 10♀, 68/157-8, 68/162, 68/164, 68/166, 68/168, 68/156, 68/159-61, 68/163, 68/165, 68/167, 68/171-3, WAM. Darlington, 15.x.1922 (L. Glauert) 1♂, 22/570, WAM; 28.iv.1924 (B. Liddell) 1♀, 24/353, WAM; 12.iii.1925 (L. Glauert) 1♀, 25/176, WAM. Dianella, 15.viii.1969 (Holland) 1♂, 1♀, 69/1932-3, WAM. Gleneagle, 4.x.1967 (K.T. Zwicky) 2♂, 1♀, 68/175-6, 68/174, WAM. Gooseberry Hill, 23.ii.1963 (D.L. Serventy) 1♂, 66/251, WAM; 9.iii.1963 (D.L. Serventy) 1♂, 66/205, WAM; 11.iii.1963 (V. Macha) 1♂, 68/204, WAM. Gosnells, quarry, 27.vi.1928 (T. Hardwicke) 1♂, 1♀, 28/638-9, WAM. Helena River, 5-6 km S of Mundaring Weir, 18.ix.1966 (G.W. Kendrick) 2♀, 68/192-3, WAM. John Forrest National Park, 1967 (K.T. Zwicky) 4♂, 4♀, 68/247, 68/249-51, 68/245-6, 68/248, 68/252, WAM. Kalamunda, The Knoll, 29.xi.1962 (A. McEvey) 1♀, NM. Kalamunda, 10 km E of, 17.iv.1963 (J. Dell) 1♀, 68/203, WAM; near Observatory, 19.viii.1967 (R.J. Eatts) 1♀, 68/184, WAM. Karragullen, 26 km SE of, 3.iv.1970 (A. Softly) 8♂, 6♀, 70/289-302, WAM. Lesmurdie, 12.vi.1926 (G.E. Nicholls) 2♂, 1♀, 26/329-30, 26/328; vi.1926 (G.E. Nicholls) 1♀, 26/327, WAM. Mt Cooke 26.vii.1967 (M. Parkin & M. Porter) 2♂, 3♀, 68/296-300, WAM; 23.iii.1968 (E.G. Cockett) 3♂, 3♀, 68/211-6, 1♀ and 24 young, 68/217, WAM; 31.iii.1968 (E.G. Cockett) 5♂, 18♀, 68/226-8, 68/230, 68/233, 68/221-5, 68/229, 68/231-2, 68/234-5, 68/237-44, WAM; 20.iv.1968 (L.E. Koch, F.H.U. Baker & E.G. Cockett) 14♂, 18♀, 68/267-9, 68/276-8, 68/281, 68/285, 68/288, 68/290, 68/291a-b, 68/383, 69/932, 68/265, 68/270-5, 68/279-80, 68/282-4, 68/286-7, 68/289, 68/384, 69/931, 68/933, WAM; 4.viii.1968 (E.G. Cockett) 1♂, 3♀, 68/363, 68/360-2, WAM; 18.viii.1968 (L.N. McKenna) 8♂, 9♀, 68/343-6, 68/348, 68/350, 68/353-4, 68/347, 68/349, 68/251-2, 68/355-9, WAM. Mt Solus, 10 km S of, 27.vi.1968 (R. Muir) 1♀, 68/382, WAM. Mundaring, 19.v.1926 (D.L. Serventy) 1♀, 26/273, WAM; 21.iii.1927, 1♂, 1♀, 27/361, 27/360, WAM; 20.vii.1967 (L.E. Koch & K.T. Zwicky) 4♂, 1♀, 68/178-82, WAM; 3.iv.1968 (K.T. Zwicky) 1♂, 68/292, WAM; 5.vii.1969 (B. Humphries) 1♀, 68/1979, WAM. Mundaring Weir, 15.v.1963 (J. Dell) 2♂, 2♀, 68/200, 68/202, 68/199, 68/201, WAM; 13.iii.1966 (N. Allen) 2♂, 68/191, 68/220, WAM; 20.vi.1967 (K.T. Zwicky) 1♀, 68/177, WAM; 1967 (K.T. Zwicky) 4♂, 2♀, 68/185-90, WAM; 2 km W of, 6.iii.1963 (J. Dell) 1♀, 68/198, WAM; 4 km S of, 25.iv.1969 (P.G. Kendrick) 1♀, 69/934, WAM. Northam, W of, ix.1954 (W.H. Butler) 1♂, 68/2872, WAM. 'Perth

(within 48 km of)' (H.W.J. Turner) 1893.7.4.29, 1♀, BMNH (holotype of *U. planimanus*). Piesse Brook, 6.vi.1965 (M. Smallman) 1♂, 2♀, 66/276-8, WAM. Roleystone, 1.iii.1924 (G. Clark) 1♂, 4♀, 24/109-13, WAM; vi.1928 (L. Glauert) 2♂, 3♀, 28/633, 28/635, 28/631-2, 28/634, WAM; 1968 (S. Stevens) 3♂, 1♀, 69/1-4, WAM. Serpentine, 24.iv.1925 (A. Baldwin) 1♂, 1♀, 25/347, 25/346, WAM; ix.1969 (L.N. McKenna) 2♂, 4♀, 70/364-9, WAM. Serpentine Dam, 14.ix.1969 (P. Macwilliam) 1♀, 69/1969, WAM. Serpentine Falls, 22.viii.1969 (L.N. McKenna) 6♂, 3♀, 69/1980-8, WAM; northern hillside, 27.vii.1969 (G.W. Kendrick & S. Slack-Smith) 2♂, 6♀, 69/1971, 69/1978, 69/1972-7, WAM; southern hillside, 27.vii.1969 (G.W. Kendrick & S. Slack-Smith) 1♀, 69/1970, WAM. Sorrento, xii.1969 (W.H. Butler) 3♀, 68/258-60, WAM. Waroona, xi.1967-i.1968 (R. Bracey) 2♂, 69/6-9, WAM. Waroona Dam, i.1968 (J. McDonald) 3♂, 2♀, 68/255-7, 68/253-4, WAM.

### Remarks

Lives in shallow burrows, up to 10 cm deep, under small rocks on the foothills and slopes of lateritic hills of the Darling Scarp, W.A.

A female from Araluen was collected with 22 young.

The male chromosome number  $2n$  is 68. This is the same as in *U. novae-hollandiae*, but the karyotypes are different in the two species (see remarks under *U. novae-hollandiae*).

All but one of the 35 specimens of *U. planimanus* from Carmel are a bright orange colour and hence considerably lighter than the usual colour of the species. Some specimens from other areas are also light, viz. at Darlington and Serpentine.

There is no obvious geographic variation in shape characters in *U. planimanus*. An adult male from Roleystone has a very long tail, but intermediate and normal tail lengths are represented among specimens from the same locality.

Instars. In graphs (each sex separately) of two characters (CL plotted against FTL) six clusters of points occur, indicating that there are six instars (1-6). The sixth instar is the adult. These instars separate because of differences in either or both the characters, and the range in size (mm) of the instars is as follows.

Instar	CL	FTL
	Male	
1	2.2-2.5	0.9- 1.2
2	2.7-3.5	1.5- 2.1
3	3.7-4.6	2.3- 2.9
4	5.0-6.9	3.3- 4.7
5	6.9-8.6	5.0- 6.1
6	7.8-9.7	7.2-10.8

Instar	CL	FTL
	Female	
1	2.4- 2.8	0.9-1.2
2	2.6- 3.5	1.5-2.2
3	3.7- 4.6	2.0-3.3
4	5.0- 6.2	3.1-3.8
5	6.4- 8.5	4.0-5.4
6	8.8-10.9	5.4-6.9

From inspection of the dates of collection of all the material examined, the periods during which the instars of *U. planimanus* have been collected in the field are as follows: first instars only in April; second instars in all months; third and fourth instars from January to August; fifth and sixth instars in all months. From this data it would appear that: (1) there is one short period of parturition (April) each year; (2) second instars moult to third instar by August, but some linger on as second instars and moult presumably between January and April the following year; (3) third and fourth instars moult by the end of August in the same year in which they appear; (4) duration of the fifth instar cannot be determined from the data; (5) the instars found from September to December are the second, fifth and sixth instars.

Fourth tail segment of males.

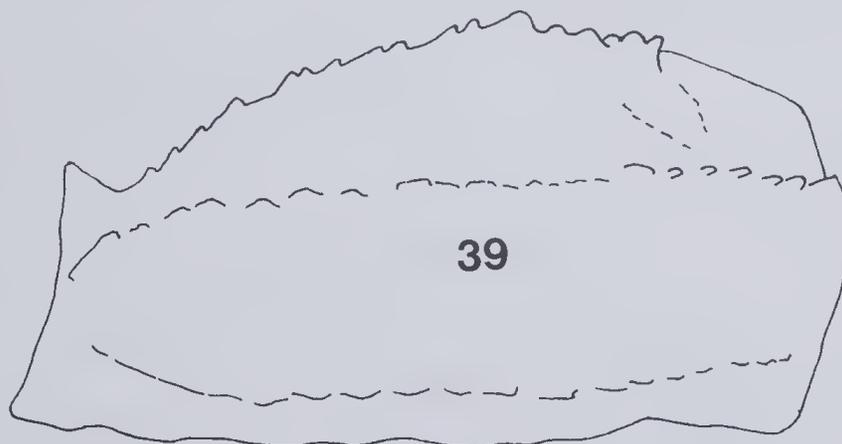


Fig. 39: *Cercophonius squama*. (Marion Bay, Tas.).

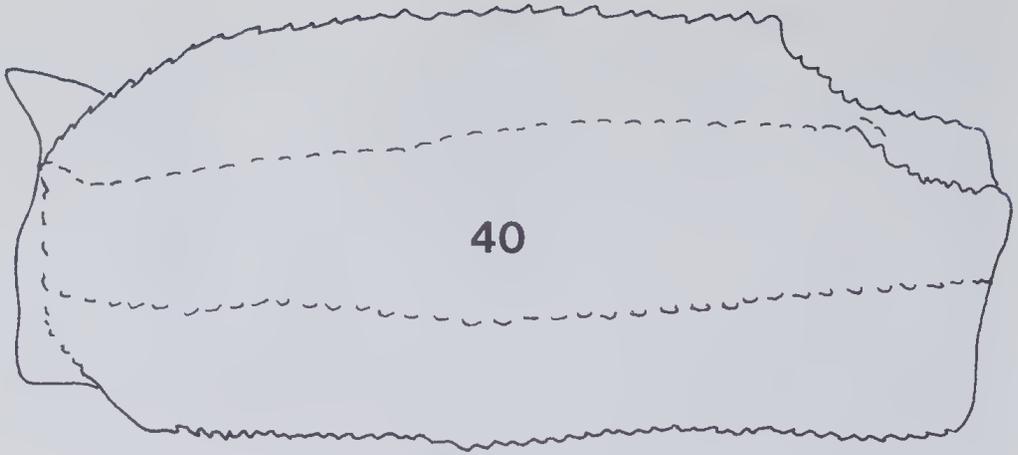


Fig. 40: *Lychas marmoreus*. (Point Peron, W.A.).

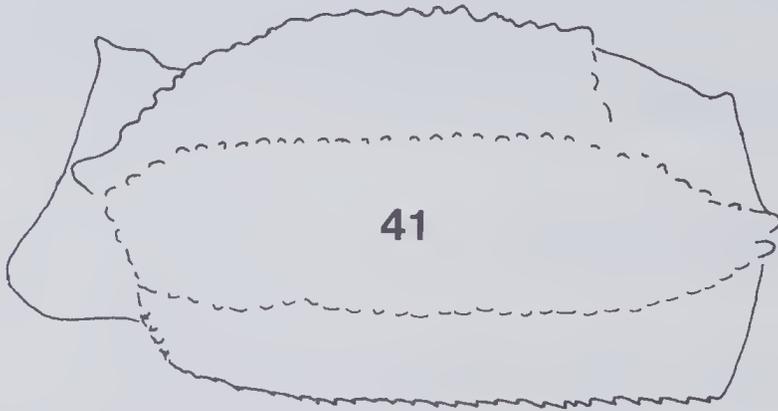


Fig. 41: *L. variatus*. (Cape Arnhem, N.T.).

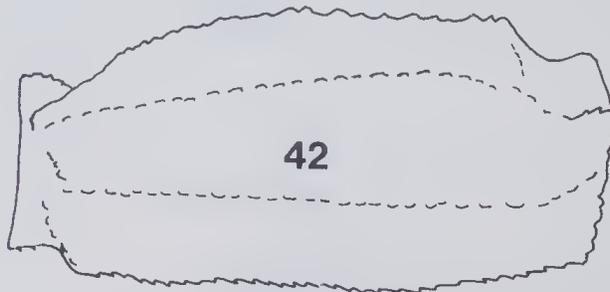


Fig. 42: *L. alexandrinus*. (Marloo Stn, W.A.).

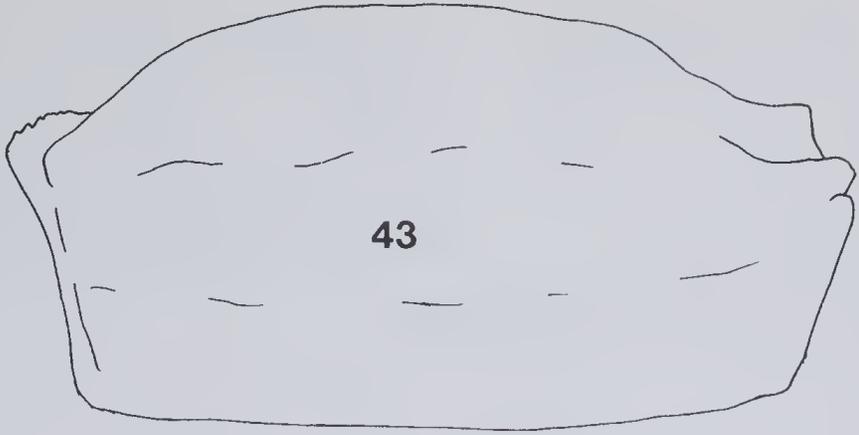


Fig. 43: *Isometroides vesus*. (Noonoonia, W.A.).

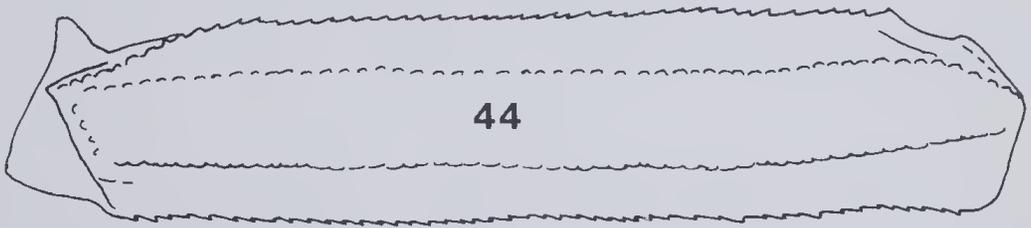


Fig. 44: *Isometrus maculatus*. (Darwin, N.T.).

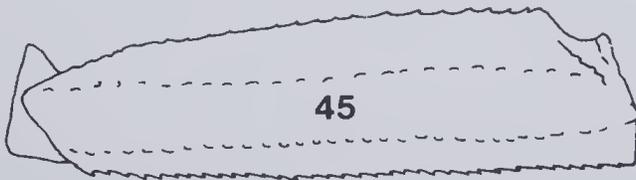


Fig. 45: *I. melanodactylus*. (Brookfield, Qld).

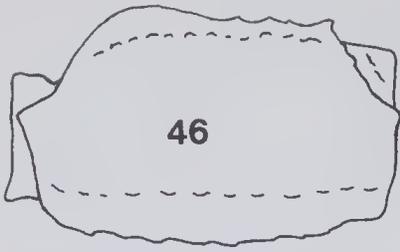


Fig. 46: *Liocheles australasiae*. (S.E. Papua).

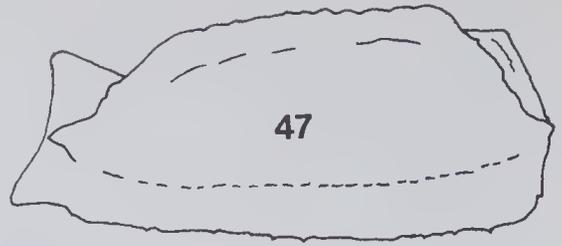


Fig. 47: *L. waigiensis*. (Yarwun, Qld).

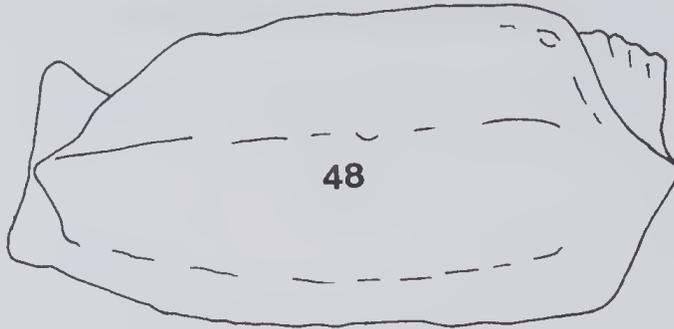


Fig. 48: *L. karschii*. (Port Moresby, 48 km E of, Papua).

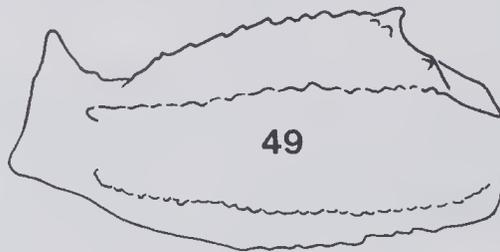


Fig. 49: *Urodacus manicatus*. (Kangaroo I., S.A.).

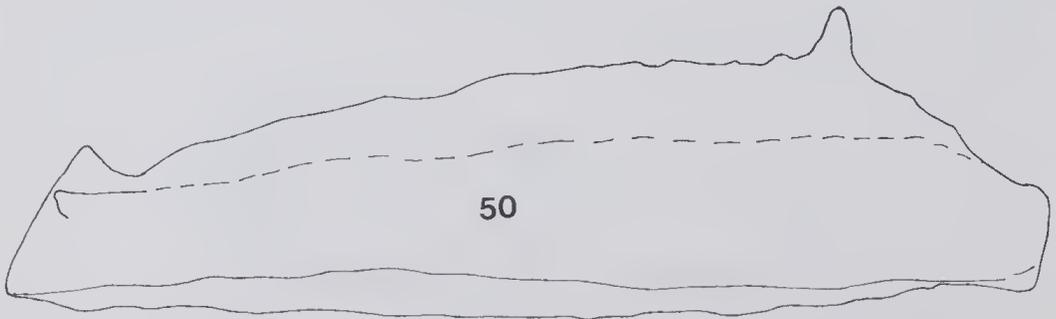


Fig. 50: *U. elongatus*. (Parachilna, S.A.).

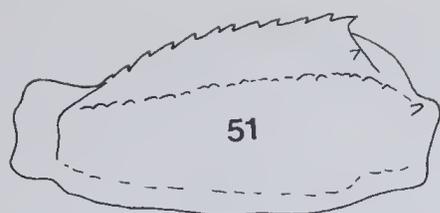


Fig. 51: *U. novaehollandiae*. (Dianella, W.A.).

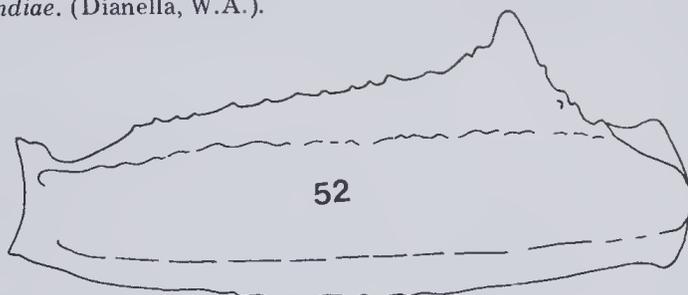


Fig. 52: *U. planimanus*. (Mundaring Weir, W.A.).

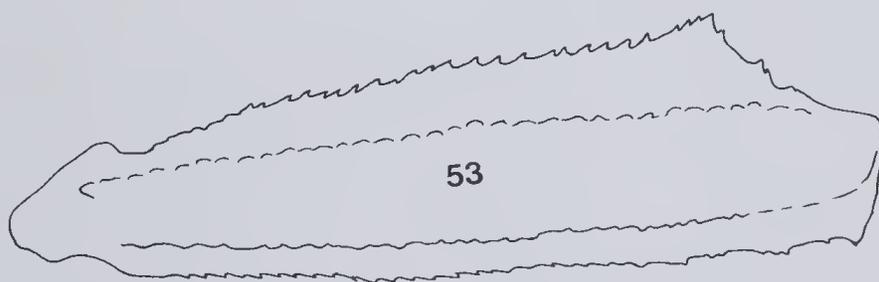


Fig. 53: *U. centralis*. (Palm Valley, N.T.).

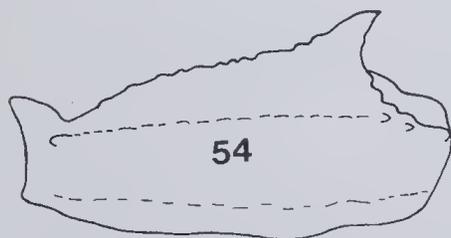


Fig. 54: *U. armatus*. (Port Lincoln, S.A.).

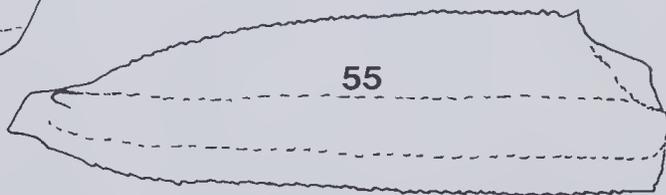


Fig. 55: *U. koolanensis*. (Koolan I., W.A.).

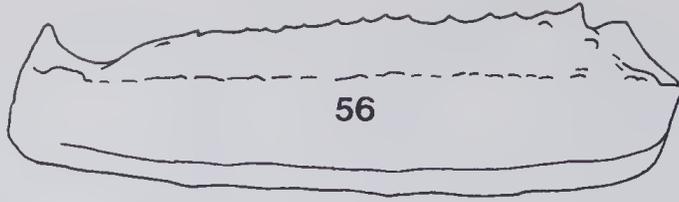


Fig. 56: *U. megamastigus*. (Mundiwindi, W.A.).

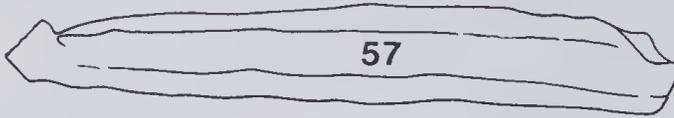


Fig. 57: *U. varians*. (Canning Stock Route, W.A.).

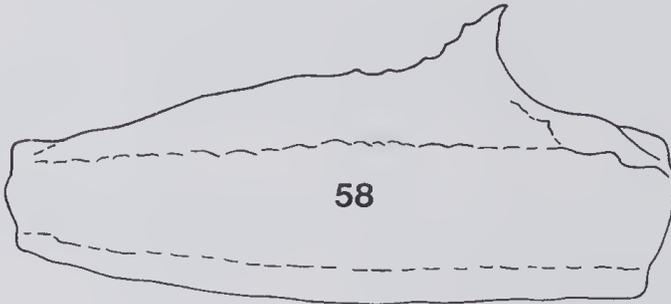


Fig. 58: *U. hoplurus*. (Lawlers, W.A.).

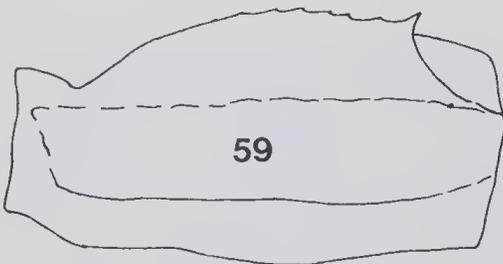


Fig. 59: *U. giulianii*. (Warburton Mission, 98 km E of, W.A.).



Fig. 60: *U. carinatus*. (around Hermannsburg, N.T.).

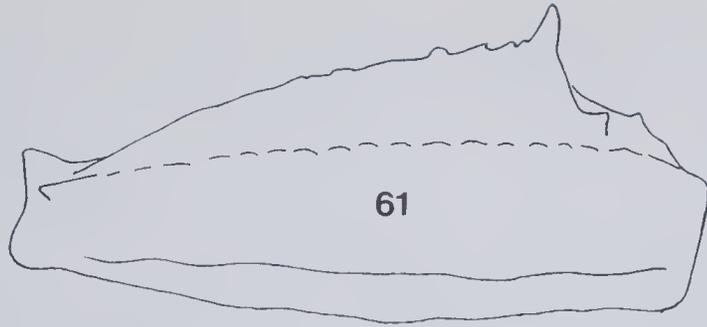


Fig. 61: *U. macrurus*. (Muckadilla, Qld).

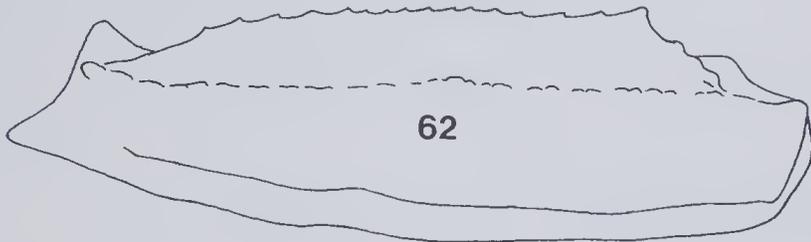


Fig. 62: *U. excellens*. (Darwin, 35 km S of, N.T.).

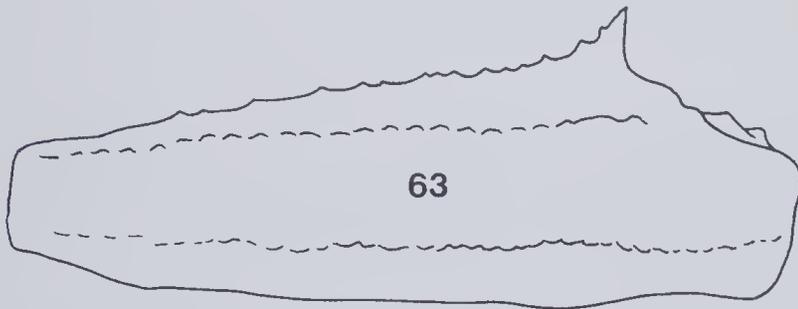


Fig. 63: *U. spinatus*. (Cape York Promontory, Qld).

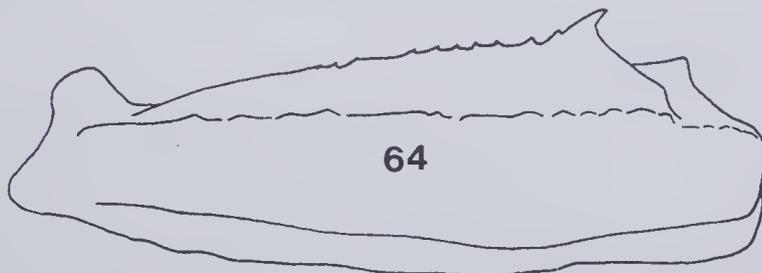


Fig. 64: *U. lowei*. (within 16 km of 14°58'S, 126°02'E, W.A.).

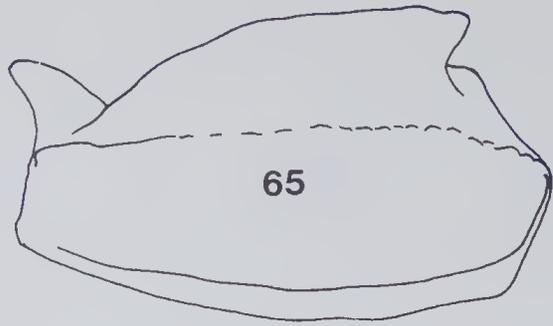


Fig. 65: *U. similis*. (Kathleen Valley, W.A.).

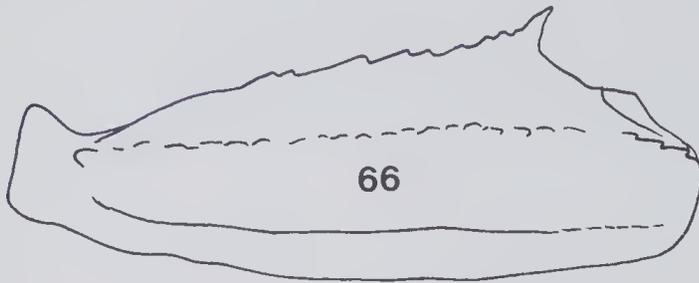


Fig. 66: *U. hartmeyeri*. (Bidgemia Stn, W.A.).

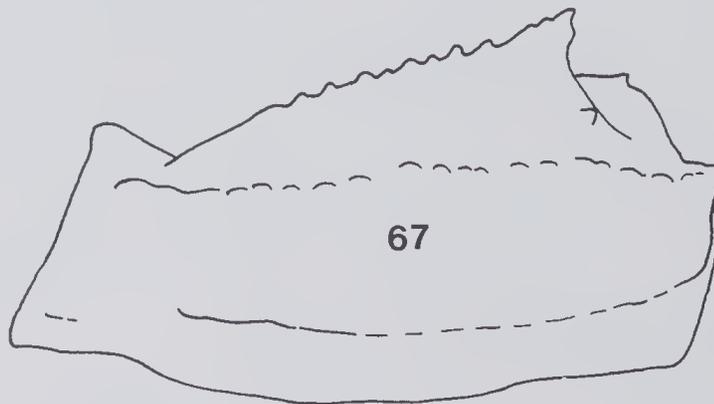


Fig. 67: *U. yaschenkoi*. (Broome, W.A.).

*Urodacus centralis* sp. n.  
(Figs 24, 53, 94, 95, Map 15)

#### Holotype

♂. Northern Territory: Palm Valley, 24°06'S, 132°43'E, 20.v.1973 (W.H. Butler) 73/775, WAM.

## Paratype

♂. Northern Territory: Palm Valley, 1952 (Troughton) AM.

## Range (Map 15)

Northern Territory, at Palm Valley.

## Measurements (mm)

♂. Holotype. Total length 112, of tail 63; carapace, length 10.8, width 10.4; tail segments one to five (in that order), length 7.7, 10.0, 10.5, 11.1, 13.0, width 3.8, 3.1, 3.0, 2.9, 2.7, height 3.5, 3.8, 3.7, 2.9, 2.9; length of vesicle and aculeus 9.3; width of vesicle 3.6; length of humerus 9.3; brachium, length 9.6, width 4.0; hand, length 10.0 width of hand surface 6.5, height 4.6; length of hand and fixed finger 19.5; length of movable finger 11.1; length of pectine 8.5.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=2)									
Min.	10.8	10.4	10.0	6.5	4.6	19.5	11.1	11.1	2.9
Max.	13.5	12.7	14.0	7.8	5.4	25.8	13.8	16.7	3.7
Mean	12.1	11.6	12.0	7.1	5.0	22.6	12.4	13.9	3.3

## Diagnosis

Distinguished from *U. elongatus* by truncate frontal lobes of carapace and long hands.

## Description

Colour reddish brown; carapace and tergites light to dark reddish brown; arms, hands, tail and vesicle paler orangish brown; ventral surface light yellowish brown; extremity of aculeus, fingers, hand keels, and articulation spots of legs dark brown.

Carapace with frontal notch wide and deep. Frontal lobes truncate. Interocular areas smooth. Lateral and posterior two-thirds of carapace granulate mainly with fine granules. Median sulcus slightly interrupted to uninterrupted. Triangular depression deep. Sides of triangular depression straight.

Chelicerae (Fig. 24) without secondary serrations. Fixed jaw with subdistal tooth large and notched basally; median tooth and basal tooth large; median tooth bluntly notched. Movable jaw with median tooth and basal tooth notched proximally.

Tergites of first six abdominal segments shagreened. Median keel present along whole of segment, but weak. Tergite of last abdominal segment with scattered granules posteriorly. Median and lateral pairs of keels mainly coarsely granulate, extending about two-thirds length of segment.

Tail very long, thin. First four tail segments (Fig. 53) with intercarinal surfaces mainly smooth with some scattered granules. Keels denticulate. Dorsal keels abruptly ending in large triangular terminal spine. Dorsolateral keels notched to denticulate. Ventrolateral and ventromedian keels smooth in first three segments, denticulate in fourth. Accessory keel present along whole length of first segment, absent in other segments. Fifth tail segment very long. Intercarinal surfaces with scattered granules. Keels denticulate, ventrolateral and ventromedian keels with large rounded widely spaced denticles. Ventromedian keel bifurcating slightly at distal extremity.

Vesicle small to moderately large. Surfaces with scattered granules.

Aculeus moderately short, strongly curved.

Humerus dorsally with fine scattered granules, and bounded at anterior and posterior edges by an irregular row of large dark denticles.

Brachium dorsally with fine scattered granules. Dorsal and ventral edges of anterior surface with large denticles. Posteroventral keel present, smooth. Ventral group, *v*, with 13-16 trichobothria. Posterior group, *p*, with 38-47 trichobothria.

Hand flat, long, narrow. Dorsal intercarinal surface with fine granules in a reticulation. Main keels strong. Anterior, ventral and posterior surfaces with weak keels. Finger keel strong. Anterodorsal keel defined by an irregular row of dark granules. Ventral group, *V*, with 17-24 trichobothria. Median group, *M*, of posterior surface with 10-12 trichobothria.

Fingers short. Along edge of movable finger 2-3 rows of granules along base and middle, reducing to 1 row at apex. 7 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 (usually 5) prongs. Terminal claws of legs equal. Ventral surface of tarsomere II of fourth pair of legs with 7-9 inner, and 7-11 outer prongs.

Pectinal teeth 21-24 (Mean 23.0) in male; (number in female unknown).

Paraxial organ (Figs. 94, 95) with lamina long, tapering abruptly at sharply curved and pointed apex; inner lobe enlarged, wide, pointed, widely separated from long median lobe which is narrow at apex; prong absent; sclerotized plate curved; fulcrum not evident; fissure large, weakly bordered; caulis wide weakly bifurcate at apex; carina enlarged, bluntly rounded at apex; toca large, moderately elongate, pointed at both ends; external lobe with a well-developed point at apex; ventral vinculum tapering; dorsal vinculum long, wide and wavy; juxtum long and curved; basal lobe about half length of juxtum.

#### Remarks

This species is closest to *U. elongatus*, in characters of paraxial organ as well as externals. In multivariate analysis of males of *Urodacus*, the holotype

of *U. centralis* falls among the *U. elongatus* specimens whereas the paratype is far removed; this is because of differences in the shape of their fourth tail segments.

*Urodacus armatus* Pocock

(Figs 25, 54, 96, 97, Map 16)

*Urodacus armatus* Pocock, 1888: 172; Pocock, 1898: 63; Kraepelin, 1899: 105; Kraepelin, 1901: 270; Kraepelin, 1908: 91, 94; Takashima, 1945: 88. [Holotype examined.]

*Urodacus woodwardi* Pocock, 1893b: 322; Pocock, 1898: 63; Kraepelin 1894: 20; Kraepelin, 1899: 104; Kraepelin, 1908: 93, 98; Rainbow, 1915: 773; Takashima, 1945: 88. [Holotype examined.] *Syn. n.*

*Urodacus granifrons* Pocock, 1898: 62; Kraepelin, 1908: 93. [Holotype examined.] *Syn. n.*

Range (Map 16)

Western Australia, north to Dolphin I., south to Perth (Wembley Downs), Norseman and Madura. South Australia, including Wedge and Althrope Islands. Victoria, far north-west. New South Wales, north-central. Northern Territory, furthest north at Hatches Creek.

Measurements (mm)

♂. Holotype. Total length 75, of tail 44; carapace, length 10.0, width 9.9; tail segments one to five (in that order), length 5.0, 5.8, 6.7, 6.9, 9.1, width 4.4, 3.9, 3.9, 3.6, 4.0, height 3.0, 3.5, 3.5, 3.2, 2.8; length of vesicle and aculeus 9.1; width of vesicle 3.6; length of humerus 6.4; brachium, length 7.5, width 3.4, hand, length 8.0, width of hand surface 6.5, height 5.1; length of hand and fixed finger 14.3; length of movable finger 9.0; length of pectine 8.3.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=39)									
Min.	5.2	5.0	4.1	3.3	2.2	7.2	4.0	2.6	1.7
Max.	9.5	8.9	8.2	6.1	4.6	16.7	10.1	7.2	3.1
Mean	6.6	6.4	5.5	4.4	3.1	10.3	5.8	4.9	2.4
SD	0.94	0.88	0.83	0.67	0.52	1.92	1.25	1.03	0.32
Female (n=35)									
Min.	4.9	5.2	3.9	2.7	1.9	7.0	4.1	2.6	1.4
Max.	9.1	9.5	7.7	5.8	4.5	15.1	9.7	5.2	2.8
Mean	6.9	7.0	5.6	4.2	3.1	10.5	6.2	4.0	2.2
SD	0.95	0.98	0.93	0.88	0.65	1.94	1.31	0.63	0.30

## Diagnosis

Distinguished from other *Urodacus* species by the following combination of characters: small size, light coloration, and pronounced red spots on leg joints.

## Description

Colour light ochre-yellow, sometimes reddish brown (rarely greenish grey, e.g. at Pinnacles, Broken Hill, N.S.W.). Fingers, keels of hands and arms, and spots at leg joints reddish brown; extremities of legs and the sternites lighter and more yellowish; tergites greyish brown; vesicle light yellow in specimens from parts of north-western Australia.

Carapace with frontal notch slight to deep. Frontal lobes truncate, rarely slightly rounded, viz. at Hampton Hill, W.A. Interocular areas tending to be rugose with coarse granules and with fine granules (which are sometimes larger towards anterior edge) sometimes totally smooth, or smooth except along anterior edge and centrally. Lateral and posterior two-thirds of carapace granulate; sometimes smooth, e.g. at Ouyen, Vic.; often much of carapace is finely shagreened. Median sulcus slightly interrupted. Triangular depression moderately deep to extremely deep. Sides of triangular depression unretracted to strongly retracted.

Chelicerae (Fig. 25) with all teeth, except the distal extremities and distal internal, usually sharp-pointed (sometimes rounded). Fixed jaw of chelicerae with slight tendency for a secondary serration at proximal base and distal base of sub-basal tooth and one at distal base of median tooth; sub-basal tooth wide and large. Movable jaw sometimes with secondary serrations on median tooth.

Tergites of first six abdominal segments finely and closely granulate, usually in posterior halves. In females often less granulate and tending to be shiny in middle. Tergite of last abdominal segment usually with both sets of longitudinal keels well developed with large denticles, sometimes undeveloped; median keels, as a rule, more than half length of segment; lateral keels nearly whole length of segment.

Tail moderately long, sometimes long in male. First four tail segments with intercarinal surfaces from smooth to with fine scattered granules. Dorsal and dorsolateral keels of small to large denticles. Dorsal keels raised posteriorly into a conspicuous sharp, terminal denticle (Fig. 54), which is sometimes moderately small and backward pointing, smaller in female. These keels are largest in some males from South Australia. Ventrolateral keels and ventromedian keels in first three segments smooth, in fourth segment usually crenated or notched. Accessory keels in first segment smooth, strong along whole length or along posterior three-fourths, sometimes weak; in second and third segments scarcely indicated, or weakly developed only in posterior one-third; in fourth segment absent. Fifth tail

segment with dorsal intercarinal surface smooth to granulate; lateral intercarinal surface and ventral intercarinal surface with few to numerous fine to coarse granules, sometimes practically smooth. Dorsolateral keels smooth and wavy, sometimes granulate, ventrolateral keels granulate and converging in front, ventromedian keel granulate. Ventromedian keel usually single, vaguely defined and bifurcating in distal half or less of segment; sometimes consisting of a double row of coarse granules.

Vesicle moderate-sized, dorsally smooth, ventrally granulate, laterally mainly smooth; sometimes smooth and shiny except for a few granules near base.

Aculeus slightly to sharply curved, usually moderately.

Humerus dorsally with numerous granules both coarse and fine, but sometimes with few granules or smooth, and bounded at anterior and posterior edges by an irregular row of coarse dark denticles.

Brachium dorsally with reticulation of granules, sometimes smooth. Posteroventral keel weak but present and wavy, sometimes granulate. Ventral group, *v*, with 5-15 (usually 8-12) trichobothria. Posterior group, *p*, with 19-46 trichobothria. Highest trichobothrial numbers occur in specimens from Well 31, Canning Stock Route, Innes District (27°S, 126°E) and Dolphin I., W.A.

Hand rounded but tending to be slightly flat. Dorsal surface with reticulation of granules, usually faint, with granules larger on anterodorsal part, sometimes surface is smooth. Hand keels strongly developed, sometimes weak, anterodorsal keel granulate to denticulate. Anterior surface granulate with a central keel which does not extend whole length of segment. Ventral group, *V*, with 7-25 (usually 10-13, rarely 17 to 25) trichobothria. Median group, *M*, of posterior surface with 3-17 (usually 3-10) trichobothria.

Fingers moderately short to moderately long. Along edge of movable finger usually 2-3 (sometimes 1 or 4) rows of denticles, reducing to 1 or 2 row(s) at apex. Around 7 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 4-7 prongs. Terminal claws of each leg of same length (rarely claws of first 2 pairs of legs unequal, e.g. at Well 31, Canning Stock Route, W.A.). Ventral surface of tarsomere II of fourth pair of legs with 7-12 inner, and 3-11 outer prongs (often with the 3 or 4 distal prongs close together and separated from the others).

Pectinal teeth 9-24 (Mean 19.0, SD 3.5) in male; 8-20 (Mean 12.2; SD 1.19) in female.

Paraxial organ (Figs 96, 97) with lamina very long (tapering to narrowest

point about three-fourths of its length where it dilates triangularly) pointed at end (not as triangular at end in some specimens, e.g. those labelled Yorke Peninsula and Kadina, S.A.); inner lobe large, moderately narrow, pointed at apex, and strongly back-curved towards lamina; inner lobe moderately distant from long median lobe; prong pointed; sclerotized plate strong and triangular; fulcrum usually not well defined; carina large, apically curved but sometimes pointed (e.g. at Kadina, S.A.); toca very elongated, rounded at base but sharp at apex; external lobe wide and pointed at apex, but sometimes rounded (e.g. at Warburton Range, W.A., and on Yorke Peninsula, S.A.); ventral vinculum narrow; dorsal vinculum wide and usually wavy; juxtum long and wide; basal lobe about one-third total length of juxtal arms.

#### Material examined

177♂, 190♀ (Map 16).

#### WESTERN AUSTRALIA

Ajana, 29 km W of, 8.i.1969 (Kalbarri Survey) 1♀, 69/551, WAM. Annean Stn, 15.iv.1925 (W.J. Butler) 2♂, 25/287-8, WAM. Balla, 30.vi.1933 (A.J. Horan) 1♂, 33/1563, WAM; 7.vii.1933 (G.M. Horan) 2♂, 6♀, 33/1585-92, WAM. Beverley (F.H. Du Boulay) 2♀, SAM. Bendering, 11.xi.1972 (W.A.M. Survey) 1♀, 73/776, WAM; 22.iii.1973 (J. Dell) 1♂, 73/688, WAM. Billabong Well, near Noreena Downs Stn, 19.vi.1970 (A.M. Douglas) 3♂, 3♀, 70/358, 70/360-1, 70/359, 70/362-3, WAM. Boondalup River, 4.viii.1970 (W.H. Butler) 1♂, 1♀, 73/675-6, WAM. Booylgoo Springs, Sandstone, 27.iii.1925 (E. Michel) 6♂, 25/215-20, WAM; 4.x.1926 (E.L. Michel) 1♂, 2♀, 26/647, 26/646, 26/644, WAM; 20.iii.1930 (E.L. Michel) 1♂, 30/284, WAM. Bowgada, 5.viii.1963 (J.F. O'Dea) 1♂, 68/472, WAM. Boya, 28.v.1967 (L.N. McKenna) 1♂, 68/444, WAM. Bulong, 21.vi.1969 (L.E. Koch & D.D. Giuliani) 1♀, 69/1081, WAM; 22.vi.1969 (L.E. Koch & D.D. Giuliani) 1♂, 69/1082, WAM. Byro Stn, 10.iv.1971 (A. Baynes) 1♂, 73/696, WAM. Camboon Park, near Morley Park, 22.iv.1957 (I. Murray) 1♂, 2♀, NM. Canning Stock Route, Well 10 (65-42) 1♂, 68/484, WAM; Well 31 (64-42) 1♀, 68/485, WAM. Carnegie, 21.v.1971 (M. de Graaf) 1♀, 73/682, WAM. Carnarvon, 3.viii.1956 (E. Herz) 1♀, 56/1386, WAM. Caron, 25.ii.1929 (N. Smith) 1♂, 29/256, WAM; 25.ii.1967 (W.P. Delane) 2♂, 68/446, 68/468, WAM. Chapman River (not Champman) 16 km NE of Geraldton, 1895.6.20.1, (Purchased by E.H. Saunders) 1♂, BMNH (holotype of *U. granifrons*). Cocklebidy, 11 km SE of, 8.x.1964 (A.M. Douglas) 1♀, 69/28, WAM. Comet Vale, 1.xi.1965 (W.H. Butler) 1♀, 66/260, WAM. Coorow, 28.iii.1938 (E. Ridler) 1♂, 38/1065, WAM. Cunderdin, 10.iv.1913 (Lundy) 1♂, 1♀, 7114a-b, WAM. Darlington, 8.x.1964 (L.E. Koch) 1♂, 68/445, WAM. 'Darling Range' (B.H. Woodward) 1892.6.12.2.3., 1♀, BMNH (holotype of *U. woodwardi*). Dolphin I., W side of, 7.vi.1962 (G.M. Storr) 1♂, 66/258, WAM. Eneabba, 9.ix.1973 (N.T. Allen & P. Thompson) 1♀, 73/699, WAM. Forrest, 1.i.1930 (J. Williams) 1♂, 1♀, 30/21a-b, WAM. Geraldton, ii.1926

(G.E. Nicholls) 1♂, 26/59, WAM. Glenorn, near, 17.vi.1969 (L.E. Koch & D.D. Giuliani) 1♂, 1♀, 69/1077-8, WAM. Hampton Hill Stn, 18.iii.1925 (F. Jones) 3♂, 3♀, 25/389-94, WAM; iv.1925 (F. Jones) 2♂, 5♀, 25/306-12, WAM; 25.v.1925 (F. Jones) 3♂, 9♀, 25/407-18, WAM; 21.vii.1925 (F. Jones) 1♂, 25/496, WAM; 20.iii.1930 (F. Jones) 2♂, 1♀, 30/233-5, WAM. 'Innes Dist.' (27°S, 126°E) v.-vi.1964 (M. Gillett) 1♀, 68/486, WAM. Jiggalong, 32 km E of, 1.ii.1965 (C. Snell) 1♂, 66/287, WAM. Junana Rock, 101 km S of Balladonia, 17-19.ii.1970 (W.H. Butler) 1♀, 70/355, WAM. Kalamunda, 10 km E of, 20.iii.1963 (J. Dell) 1♂, 2♀, 68/473-5, WAM. Kalbarri, 31.iii.1968 (M.M. Marsh) 1♂, 68/439, WAM; v.1968 (W.J. Marsh) 1♂, 68/440, WAM; 27.iii.1969 (W.J. Marsh) 1♂, 69/776, WAM; 20.iv.1969 (W.J. Marsh) 1♂, 69/775, WAM; 5.v.1970 (B. Bellairs) 2♂, 70/276-7, WAM; 21.viii.1971 (B. Bellairs) 1♀, 73/697, WAM; vi.1972 (B. Bellairs) 1♂, 73/693, WAM; 5.iv.1973 (B. Bellairs) 1♂, 1♀, 73/690-1, WAM; 28.vi.1973 (M.M. Marsh) 1♀, 73/695, WAM. Kalgoorlie, 10.iv.1969 (K.V. Mathews) 1♂, 46/258, WAM; 129 km NE of, v.1968 (S.F. Tonkin) 2♀, 69/16, 69/22, WAM. Karalundi, 21.iii.1970 (S. Armstrong) 2♀, 70/274-5, WAM; 6.iv.1970 (S. Armstrong) 1♀ and young, 70/281, WAM; iv.1970 (S. Armstrong) 1♀, 70/282, WAM. Kellerberrin, 5.i.1968 (L. Gardiner) 1♂, 68/467, WAM. Kondinin, 27.v.1924 (A.D. Robins) 1♀, 24/511, WAM. Landor, 13.vi.1926 (C. Hughes-Hallett) 1♂, 26/470, WAM. Laverton, 8 km S of turn-off from Laverton to Kalgoorlie, 18.vi.1969 (L.E. Koch & D.D. Giuliani) 1♀, 69/1080, WAM. Lawlers, 14.iv.1924 (H.S. Plant) 1♂, 24/343, WAM. Leonora, ii.-iii.1962 (B.J. Grover) 1♂, 68/393, WAM; 24 km E of, 18.vi.1969 (L.E. Koch & D.D. Giuliani) 1♀, 69/1079, WAM. Madura, 48 km E of, 7.x.1964 (A.M. Douglas) 1♀, 69/21, WAM. Meckering, 4.iii.1963 (B. Gillam) 1♂, 68/391, WAM; 22.iii.1963 (H. Lamont) 5♂, 68/479-83, WAM. Meekatharra, 26.x.1936 (A. Snell) 1♂, 1♀, 36/4126-7, WAM. Merredin, 13.v.1924 (J. Scarlett) 1♂, 24/442, WAM. Minilya 2 km S of, 4.ii.1970 (R.B. Humphries, J.P. Ross & J.G. Gilbert) 1♂, 70/356, WAM. Minnie Creek, 28.i.1967 (A.M. Douglas) 8♂, 68/397-404, WAM; 30.i.1967 (W.D.L. Ride & A. Baynes) 1♂, 1♀, 69/495-6, WAM. Moora, 26.v.1915 (F. Woods) 1♂, 15/566, WAM. Morawa, 1.vii.1967 (O. Roberts) 1♀, 68/469, WAM. Mt Magnet, 21.iv.1925 (J. Tippet) 1♂, 25/332, WAM. Mt Margaret Mission, viii.-xii.1962 (C. Mounsey) 1♀, 66/347, WAM. Mt Newman, 25.v.1971 (A.M. Douglas) 1♂, 73/694, WAM. Mt Remarkable, 14.vi.1969 (L.E. Koch & D.D. Giuliani) 2♀, 69/1073-4, WAM; 15.vi.1969 (L.E. Koch & D.D. Giuliani) 1♂, 1♀, 69/1075-6, WAM. Mt Vernon, 16.vii.1971 (K. & E. Carnaby) 1♂, 73/674, WAM. Mullewa (J.F. May) 1♂, SAM; 80 km from, 2.v.1958 (A. Snell) 1♂, NM. Murgoo Stn, 12.viii.1924 (R.W. Fremlin) 3♂, 2♀, 24/175, 24/177, 24/180, 24/174, 24/179, WAM. Norseman, 122 km SE of, 7.i.1968 (L. Smith & L. Allen) 1♀, 69/26, WAM. Northam (C.G. Jessup) 2♀, AM. North Quairading, 21.iii.1929 (J. Shenton) 1♂, 1♀, 29/290-1, WAM. Nullagine, 13 km W of, 23.v.1971 (A.M. Douglas) 1♀, 73/681, WAM. Ogilvie, 30.vi.1933 (A.J.

Horan) 4♂, 8♀, 33/1562-73, WAM. Pantapin, 17.ix.1929 (D. Wishart) 1♀, 29/1263, WAM. Perenjori, 8.iv.1927, 1♂, 27/434, WAM. Perry Lakes, 31.i.1968 (C. Bell) 1♂, 73/698, WAM. Red Hill, 17.viii.1967 (L.E. Koch & L.N. McKenna) 1♂, 69/32, WAM. Rudall River, 19.vi.1971 (K.T. Richards) 2♂, 1♀, 73/678-80, WAM; 5.xi.1971 (Piesse) 1♀, 73/689, WAM. Scarborough, iii.1968 (E. Baker) 1♀, 68/438, WAM. Southern Cross, 9.iv.1924 (W. Richards) 1♀, 24/335, WAM. Talawana, i.1971 (A.M. Douglas) 3♂, 71/692-4, WAM. Tambrey, ii.1925 (G. Cusack) 1♀, 25/44, WAM; 1♀, 29/1027, WAM; 4.viii.1958 (R.P. McMillan) 1♀, 68/396, WAM; 7.v.1970 (L.E. Koch & A.M. Douglas) 2♂, 4♀, 70/278-9, 70/284-7, WAM. Tammin, 10 km NW of, 21.iv.1925 (H.E. Walther) 1♀, 25/335, WAM. Thomas River, mouth of, 20.ii.1970 (W.H. Butler) 1♂, 1♀, 70/353-4, WAM. Three Springs, ii.1925 (E.W. Franklin) 1♀, 26/52, WAM; 8.iv.1927 (Campton) 1♂, 27/433, WAM. Walebing, 14.v.1923 (R. Whiteford) 1♂, 23/155, WAM. Wandagee, 1.xii.1961 (N.T. Herbert) 1♂, 4♀, 66/279-83, WAM. Walyahmoning Rock, 2 km SW of, 31.v.1970 (A. Baynes) 1♀, 70/357, WAM; 4.iv.1972 (A. Baynes & A. Chapman) 2♀, 73/683-5, WAM. Warburton Range, 1.iv.1962 (M. de Graaf) 2♂, 68/442-3, WAM; 16.x.1962 (M. de Graaf) 1♂, 1♀, 69/24-5, WAM; 16.iii.1963 (M. de Graaf) 1♂, 68/441, WAM; iii.1963 (M. de Graaf) 1♂, 68/405, WAM; 1.iv.1963 (M. de Graaf) 2♂, 68/392, 68/395, WAM; 20.x.1963 (M. de Graaf) 2♀, 69/29-30, WAM; 1963 (M. de Graaf) 1♀, 68/394, WAM; 306 km NW of, 1-11.i.1964 (M. Gillett) 1♂, 68/471, WAM. Wembley Downs, 25.v.1968 (E.G. Cockett) 1♀, 69/23, WAM. Windich Spring, 30.viii.1964 (W.H. Butler) 1♂, 68/408, WAM. Wongan Hills, iii.1965 (E.T. Shields) 1♂, 68/406, WAM. Wubin, 3.v.1963 (J. Rayner) 1♀, 68/470, WAM. Wyalkatchem, 23.vii.1929 (R.C. Whiteford) 2♀, 29/1033-4, WAM. Yalgoo, 19.v.1926 (G.E. Nicholls) 1♀, 26/272, WAM. Yarmarna, near HS, 28.i.1967 (W.D.L. Ride & A. Baynes) 1♂, 69/31, WAM. Yuna, 35 km NE of, iv.1966 (G. Hitchin) 3♂, 1♀, 69/17-20, WAM. Zanthus, near, 6.ii.1952 (D.W. Williams) 1♂, QM.

## SOUTH AUSTRALIA

Alligator Creek, Wilmington (V. H. Mincham) 1♂, AM. Althorpe I (E.R. Waite) 1♂, SAM. Ardrossan, 10♂, 8♀, SAM. Aroona Dam, 30.vii.1971 (M. Archer) 1♂, 1♀, 73/686-7, WAM. Buckaringa Gorge (?), viii.1962 (A. Holmes) 1♂, 1♀, AM. Copley, 2.i.1931 (R. Barlow) 1♂, K63102, AM. Emu, 18.v.1970 (J. Dell) 1♂, 70/283, WAM. Erliwunyawunga, Musgrave Ranges, 1.vi.1961 (Cogger, Hughes & Mackay) 1♂, 2♀, AM. Flinders Range (H.M. Hale) 1♀, SAM; 16-32 km S of Blinman, 15.viii.1969 (G.B. Monteith) 1♀, UQ. Fowlers Bay (A. Zietz) 1♂, 1♀, SAM; 5 km NW of, 19.xi.1969 (D.D. Giuliani) 2♀, 70/263-4, WAM; 11 km NW of, 19.xi.1969 (D.D. Giuliani) 2♀, 70/261-2, WAM. Kimba, 40 km W of, 20.ix.1969 (D.D. Giuliani) 1♀, 70/266, WAM. Kingston, 19 km SSW of, 30.xi.1969 (D.D. Giuliani) 2♀, 70/267-8, WAM. Kychering Soak (Chandler) 3♂, MM. Lake Callabonna, 1♀,

SAM; Sand Is, 2♂, 7♀, SAM. Leigh Creek (H.G. Stokes) 2♀, SAM; 2 km N of Copley, 23.viii.1970 (W.D.L. Ride & W.H. Butler) 2♀, 73/704-5, WAM; 32 km S of, 14.viii.1969 (G.B. Monteith) 1♂, UQ. Lilydale Stn, 10.iv.1968 (B.M. Doube) 1♂, 69/1966, WAM. Lucindale, 2.vii.1900 (E. Feuerhardt Crower) 1♂, 1♀, SAM. Marree, 1♀, SAM. Mernamerna, 2 km N of, 31.viii.1971 (M. Archer) 1♀, 73/677, WAM. Mt Ive, W of (S of Mt Gairdner) 12.xii.1962 (A. McEvey) 1♀, NM. Musgrave Ranges, 1905 (Basedow) 1♀, SAM. 'North-western South Australia', 1903, (pres. 29.viii.1904) (H. Basedow) 1♀, SAM. Observatory Hill, 23 km SW of, about 48 km S of Emu, 15.v.1970 (J. Dell) 1♀, 70/280, WAM. Olary (T. Emery) 3♂, SAM. Point Sinclair, near tip of, 21 km S of Penong, 19.xi.1969 (D.D. Giuliani) 1♀, 70/265, WAM. Port Augusta, 22.vi.1899 (W.R. Kirton) 1♂, SAM. Port Lincoln, 52.110, 1♂ (dry, pinned) BMNH (holotype of *U. armatus*). South Neptune I., iv.1970 (R.M. Warneke) 1♂, 5♀, NM. Tanunda and Murray Flats (Krisman) 11.i.1911, 2♂, 2♀, SAM. Wilpena Pound (H.M. Hale) 1♂, SAM. 'Woolshed Flat (Streaky Bay)' (Mills) 1♀, SAM; 5♂, 1♀, SAM. Wynbring (F. U. Mack) 1♂, 1♀, SAM. Yorke Peninsula (Newbold) 2♂, SAM.

## VICTORIA

Hattah, Mallee Dist., x.1913 (J.E. Dixon) 1♂, 2♀, MM. Karawinna, 25.iii.1929 (H. Ladd) 1♂, NM. Ouyen, 12.x.1911 (W.A. Hall) 2♂, 2♀, NM; 31.v.1926 (H.W. Davey) 2♀, 26/285-6, WAM.

## NEW SOUTH WALES

Bourke and Wilcannia, between, 1♀, K58247, AM. Coombah (D.J. Shorthouse) 1♀, 71/1070, WAM. Oxley, 11 km W of, near Juanbung Stn, 28.iii.1969 (D.J. Shorthouse) 1♂, 69/1099, WAM. Pilliga Scrub, 48 km S of Narrabri, 22.viii.1969 (G.B. Monteith) 1♂, 1♀, UQ. Pinnacles, Broken Hill, 1♂, K19911, AM. Wilcannia, 21.viii.1969 (G.B. Monteith) 1♀, UQ.

## NORTHERN TERRITORY

Alice Springs, 31.viii.1936 (H.O. Fletcher & W. Barnes) 1♂, 1♀, AM; viii.1936 (H.O. Fletcher & W. Barnes) 1♂, AM; 8.i.1958, 1♂, NTMB43, NT; 12.iv.1959 (P. Whiteridge) 3♂, NTMB39-41, NT; 2.x.1970 (P.K. Latz) 1♀, NTMB605, NT; (D. Borner) 1♀, AM. Hatches Creek, 1968 (R. Berry) 2♀, NTMB72-3, NT. Hermannsburg area, ix.1970 (D.W. Haines) 1♀, NTMB582, NT. 'North Australia', viii.1886 (Magarey) 1♀, SAM. Simpson Desert, edge of, 23°49'S, 135°33'E, 25.iv.1965 (H.J. Disney) 1♀, AM. The Gardens Stn. 10.viii.1969 (L. Corbett) 1♀, NTMB53, NT; 10.xii.1969 (H. Wakefield) 1♀, NTMB131, NT.

## Remarks

The female specimen from Well No. 31, Canning Stock Route, W.A., is atypical in having unusually high trichobothrial numbers, a low pectinal

tooth count, and unequal terminal claws on the first two pairs of legs. Agreeing with the first character are a female from Innes District and an immature male from Dolphin I., W.A., and agreeing with the last character is *U. varians* Glauert.

*U. armatus* occurs in a variety of habitats; e.g. in Western Australia it occurs in flat stony ground at Red Hill, in red soil in low-lying areas at Mt Remarkable, in somewhat stony ground at Bulong, and in yellow sand with mallee and acacia scrub at Caron. The burrows are under rocks (e.g. at Red Hill) or more often in open ground. They are loosely spiralling and about 36 cm deep.

*Urodacus koolanensis* sp. n.

(Figs 26, 55, 98, 99, Map 17)

**Holotype**

♂. Western Australia: Koolan I., 16°08'S, 123°45'E, 16.ix.1966 (O. Milton) 68/487, WAM

**Paratypes**

6♂, 4♀. Western Australia: Barker River Gorge, Napier Range, 5.vii.1966 (A.M. Douglas and G.W. Kendrick) 1♂, 68/488, WAM. King Sound, N.W. Australia, 4♂, 3♀, MM. Mt Bell, King Leopold Range, 20.vi.1968 (Hall Expd.) 1♂, 69/27, WAM. Windjana Gorge, Napier Range, 5.viii.1968 (A.M. Douglas and G.W. Kendrick) 1♀, 68/489, WAM.

**Range (Map 17)**

Western Australia, far north-west, south to King Sound and east to King Leopold Range.

**Measurements (mm)**

♂. Holotype. Total length 60, of tail 37; carapace, length 6.8, width 6.4; tail segments one to five (in that order), length 5.0, 5.8, 6.0, 6.7, 8.0, width 2.4, 2.1, 2.0, 1.8, 1.6, height 2.2, 2.4, 2.4, 2.2, 2.0; length of vesicle and aculeus 6.1; width of vesicle 2.0; length of humerus 6.4; brachium, length 6.9, width 3.3; hand, length 7.3, width of hand surface 4.4, height 2.8; length of hand and fixed finger 13.5; length of movable finger 7.3; length of pectine 5.4.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=6)									
Min.	7.0	6.4	6.9	4.0	2.5	12.8	6.8	4.7	1.9
Max.	9.5	8.7	9.9	5.8	3.8	18.2	9.5	7.8	2.4
Mean	7.7	7.1	7.9	4.6	3.0	14.6	7.8	6.0	2.3
SD	1.04	0.92	1.16	0.74	0.51	2.10	1.11	1.28	0.53
Female (n=4)									
Min.	6.7	6.1	6.5	4.0	2.3	12.6	6.8	4.0	1.7
Max.	9.2	8.4	8.9	5.3	3.5	16.7	8.9	5.5	2.4
Mean	7.5	7.1	7.3	4.3	2.8	13.7	7.4	4.5	2.0

### Diagnosis

Distinguished from all other *Urodacus* species by the following combination of characters: small to medium size, extremely high trichobothrial numbers, tail spine shape, pronounced finger keel, flat hands, and moderately small vesicle.

### Description

Colour yellowish brown with keels of arms and hands, and fingers dark reddish brown; vesicle usually light yellow.

Carapace with frontal notch wide and deep. Frontal lobes rounded (sometimes slightly truncate). Anterolateral edges of carapace tending to converge sharply towards frontal lobes in region of lateral eyes. Interocular areas rugose towards frontal edge, the rest granulate to smooth. Lateral and posterior two-thirds of carapace granulate. Median sulcus slightly interrupted to uninterrupted. Triangular depression deep to extremely deep. Sides of triangular depression unretracted, irregularly defined, swollen inwards towards depression.

Chelicerae (Fig. 26) without secondary serrations. Fixed jaw with subdistal tooth wide; median tooth and basal tooth large. Movable jaw with subdistal tooth large and notched proximally; median tooth wide; basal tooth pointed with point distinctly curving posteriorly.

Tergites of first six abdominal segments finely granulate. Tergite of last abdominal segment with granules. Both pairs of longitudinal keels with small denticles, larger than the granules and extending about half to three-fourths length of segment.

Tail moderately long. First four tail segments (Fig. 55) with intercarinal surfaces smooth to finely granulate. Dorsal and dorsolateral keels of small denticles; terminal tooth of dorsal keel slightly larger than the denticles and triangular; other keels smooth or notched in first and second segments, smooth, notched or denticulate in third and fourth segments. Accessory keel

faint to strong in first segment; scarcely indicated in second segment and only towards posterior edge; practically absent in third and fourth segments. Fifth tail segment with intercarinal surfaces smooth to granulate. Ventromedian and ventrolateral keels strongly denticulate, other keels made up of smaller denticles. Ventromedian keel bifurcating distally at extremity.

Vesicle moderately small, fine to coarsely granulate, especially ventrally and towards base. Finely granulate to smooth dorsally.

Aculeus moderately to strongly curved.

Humerus dorsally fine to coarsely granulate with large dark denticles along anterior and posterior edges.

Brachium dorsally smooth to finely granulate. Posteroventral keel evident and wavy, sometimes faint. Posterior surface with coarse granules especially as a few irregular bands along middle. Ventral group, *v*, with 14-18 trichobothria. Posterior group, *p*, with 41-62 trichobothria.

Hand flat, moderately narrow. Dorsal surface with a reticulation of fine granules. Finger keel pronounced. Anterodorsal edge with dark denticles; posterodorsal edge dark and mainly smooth. Anterior surface with fine scattered granules to smooth, with a central keel mainly of larger granules. Ventral group, *V*, with 18-25 trichobothria. Median group, *M*, of posterior surface with 11-18 trichobothria.

Fingers long. Along length of movable finger 2-3 rows of granules along base, reducing to 1-2 row(s) at apex. Around 5-8 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 6-7 (usually 6) prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-11 inner, and 6-8 (usually 8) outer prongs.

Pectinal teeth 18-22 (Means 19.2) in male; 15-17 (Mean 15.5) in female.

Paraxial organ (Figs 98, 99) with lamina long, wide at base tapering to a sharply pointed and curved apex; inner lobe very large and triangular, with only a small back-piece; inner lobe very widely separated from moderately long, moderately wide median lobe; prong small; sclerotized plate and fulcrum poorly defined; carina rounded at apex; toca large, long and tending to be pointed at ends; external lobe narrow, moderately long; ventral vinculum narrow and long; dorsal vinculum wide; juxtum moderately small and narrow, inner edge wavy; basal lobe upcurved and pointed at apex; proximal lobe much longer than basal lobe and tending to be pointed at apex.

#### Remarks

The specimens from Mt Bell in the Leopold Ranges are from eucalypt savanna, in quartzite and sandstone areas with the vegetation consisting of *Triodia* in the hills and other grasses in the valleys.

Species-group *megamastigus*  
*Urodacus megamastigus* sp. n.  
(Figs 12, 27, 56, 100, 101, Map 18)

**Holotype**

♂. Western Australia: Mundiwindi, 23°50'S., 120°10'E, 8.iv.1963 (A. Snell) 66/368, WAM.

**Paratypes**

3♂, 1♀. Western Australia. Mundiwindi, 1963 (A. Snell) 2♂, 68/366-7, WAM. Walgun, 21.v.1971 (A.M. Douglas) 1♂, 1♀, 71/1784-5, WAM.

**Range (Map 18)**

Western Australia, known only from Mundiwindi and Walgun in the arid central interior.

**Measurements (mm)**

♂. Holotype. Total length 75, of tail 48; carapace, length 7.7, width 7.6; tail segments one to five (in that order), length 5.6, 6.5, 6.9, 7.4, 11.7, width 2.5, 2.5, 2.3, 2.1, 2.1, height 2.1, 2.2, 2.0, 2.0, 1.5; length of vesicle and aculeus 10.8; width of vesicle 2.1; length of humerus 5.9; brachium, length 6.4, width 2.6; hand, length 6.3, width of hand surface 4.7, height 3.4; length of hand and fixed finger 12.9; length of movable finger 6.8; length of pectine 7.7.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=4)									
Min.	7.0	6.8	6.3	4.4	3.2	12.0	6.8	6.3	1.9
Max.	7.7	7.6	6.5	4.7	3.4	12.9	7.6	7.5	2.1
Mean	7.4	7.3	6.4	4.5	3.3	12.5	7.1	7.0	2.0
Female (n=1)	7.1	6.9	5.6	4.3	3.3	11.0	6.6	3.6	1.8

**Diagnosis**

Distinguished from all other *Urodacus* by excessively elongate vesicle.

**Description**

Colour clay yellow; brownish on tergites, femur and patella of legs, and tail segments; fingers and finger keels reddish.

Carapace with frontal notch shallow. Frontal lobes conspicuously truncate, their angles at the notch being well marked. Interocular areas mainly smooth but with some fine scattered granules, which are sometimes numerous (e.g. in holotype). Lateral and posterior two-thirds of carapace smooth to finely granulate. Median sulcus slightly interrupted. Triangular depression deep. Sides of triangular depression straight, swollen inwards to depression.

Chelicerae (Fig. 27) without secondary serrations except sometimes for one in fixed jaw near distal base of sub-basal tooth; in movable jaw usually two secondary serrations along proximal edge of median tooth. Fixed jaw with proximal edge of sub-basal tooth incurved; wide notch between sub-distal tooth and median tooth; basal tooth bilobed. Movable jaw with sub-distal tooth small.

Tergites of first six abdominal segments finely granulate, sometimes with coarser granules towards posterior edges; median keel slightly upraised. Tergite of last abdominal segment with both pairs of longitudinal keels of large granules; the median keels reach three-fourths or more along segment from posterior edge, the outer pair about one-third to half length of segment; there is also a faint granulate keel on each side of main smooth median keel of tergite. Sometimes these keels of last abdominal tergite are weakly defined.

Tail long, especially in male. First four tail segments (Fig. 56) with intercarinal surfaces smooth. Dorsal keels of small denticles which gradually increase in size posteriorly. Dorsolateral keels slightly corrugated with small denticles, other keels mainly smooth but slightly corrugated. Usually no secondary keels (sometimes one on each side of first segments). Fifth tail segment with dorsal intercarinal surfaces granulate, other intercarinal surfaces smooth. Keels denticulate with largest denticles along ventromedian and ventrolateral keels. Ventromedian keel slightly bifurcating distally at extremity.

Vesicle of moderate height but excessively elongate (Fig. 12), longer than each of first four tail segments. All surfaces with denticles of various sizes, tendency to be smooth laterally.

Aculeus short and thick, hardly curved along length, but sharply down-curved at extremity.

Humerus dorsally with scattered granules, with close dark denticles along anterior edge, and less close, more irregularly arranged dark denticles along posterior edge.

Brachium with dorsal surface mainly smooth. Posteroventral keel wavy but evident. Ventral group, *v*, with 8-11 trichobothria. Posterior group, *p*, with 22-27 trichobothria.

Hand narrow and flat. Dorsal surface with anterodorsal keel made up of an irregular row of dark granules with a reticulation of fine granules between this keel and the well-developed slightly granulate finger keel. Anterior surface with a few granules and a slight, granulate median keel. Ventral group, *V*, with 11-13 trichobothria. Median group, *M*, of posterior surface with 5-10 trichobothria.

Fingers moderately long. Along edge of movable finger 1 row of granules

from base to apex. Around 4-8 rows of transverse accessory teeth, mainly in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 4-7 prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-10 inner, and 6-8 outer prongs.

Pectinal teeth 19-22 (Mean 20.2) in male; 12-13 (Mean 12.5) in female.

Paraxial organ (Figs 100, 101) with lamina long, broad, widening towards apex which is bluntly rounded; inner lobe large, complex, with a rounded and pointed structure dorsally and a round structure ventrally, close to moderately long and well-defined median lobe; prong greatly reduced; sclerotized plate usually a bilobed structure, the larger, more ventral lobe being moderately square at apex, the other being pointed; fulcrum practically absent; carina small with sharp point at apex and with sharp serrations at base along outer edge; toca narrow dorsally, enlarging to rounded base; external lobe long, narrowing and curved to moderately blunt apex; ventral vinculum extremely thin; dorsal vinculum curved and moderately wide; basal lobe squat, curved and blunt at apex; proximal lobe large, about three times as long as basal lobe, wide, bulbous at apex.

#### Remarks

The paraxial organ is closest in structure to that in members of the *armatus* species-group, but differs by the unusual and complex development of the inner lobe.

The Walgun specimens were dug from burrows about 28 cm deep in an area of red soil, small stones, and spinifex.

Species-group *hoplurus*  
*Urodacus varians* Glauert  
(Figs 28, 57, 102, 103, Map 19)

*Urodacus varians* Glauert, 1963a: 132. [Holotype and 4 paratypes examined.]

#### Range (Map 19)

Western Australia, Canning Stock Route and 97 km E of Onslow (see Remarks).

#### Measurements (mm)

♂. Holotype. Total length 84, of tail 58; carapace, length 7.4, width 6.7; tail segments one to five (in that order), length 8.8, 10.1, 10.7, 10.7, 12.6, width 2.0, 1.4, 1.4, 1.4, 1.5, height 1.7, 2.0, 1.6, 1.4; length of vesicle and

aculeus 6.3; width of vesicle 1.8; length of humerus 6.5; brachium, length 7.8, width 2.7; hand, length 6.7, width of hand surface 3.2, height 2.4; length of hand and fixed finger 12.8; length of movable finger 7.0; length of pectine 7.2.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=4)									
Min.	6.9	6.1	5.4	2.7	1.9	10.9	6.1	7.6	1.4
Max.	7.4	6.7	6.7	3.2	2.4	12.8	7.0	10.7	1.6
Mean	7.1	6.3	5.8	2.9	2.0	11.6	6.5	9.1	1.5
Female (n=1)	6.1	6.0	4.5	2.4	1.9	9.6	5.8	3.5	1.6

### Diagnosis

Distinguished from other *Urodacus* species by the following combination of characters: light colour, very elongate tail segments of male, vesicle laterally flattened, high trichobothrial numbers, terminal claws of first and second pairs of legs slightly unequal.

### Description

Colour light clay yellow; carapace and hands brighter; legs, ventral surface and vesicle paler, dark spots on leg joints; fifth segment of tail slightly darker.

Carapace with frontal notch shallow to moderately deep. Frontal lobes truncate. Interocular areas with coarse granules and scattered pigment spots. Lateral and posterior two-thirds of carapace with fewer and finer granules than those of interocular areas. Median sulcus uninterrupted. Triangular depression deep. Sides of triangular depression slightly swollen inwards towards depression.

Chelicerae (Fig. 28) with teeth sharp and partly notched. Fixed jaw with 3-7 small secondary serration along edge of distal external tooth near base of sub-basal tooth; wide notch between subdistal tooth and median tooth; sub-basal tooth often has 3 or 4 serrations between its point and base of median tooth. Movable jaw with notch between bases of external distal and subdistal teeth; median tooth with 1 or 2 moderately large serration(s) at proximal base.

Tergites of first six abdominal segments finely granulate with smooth median keel. Tergite of last abdominal segment finely granulate with median pair of keels rounded; lateral pair of keels more pronounced and about half length of segment.

Tail very long in male, moderately short in female. Tail of male up to eight times as long as carapace; tail of female only three times as long as carapace (e.g. length of fourth tail segment of paratype female is 3.5 mm). First four tail segments (Fig. 57) with intercarinal surfaces smooth. Main

keels (including ventrals and ventrolateral keels) practically smooth, but slightly corrugated. Dorsal keels slightly more corrugated than other keels and with terminations rounded and no prominent terminal teeth. No accessory keels evident. Fifth tail segment with intercarinal surfaces smooth, except for ventral intercarinal surfaces which have scattered denticles especially in female. Ventromedian keel denticulate, with a few denticles on each side along its length, and strongly denticulate ventrolateral keels. Ventromedian keel bifurcating distally at extremity.

Vesicle moderately large (slightly wider than fifth tail segment) sides flat and high. Dorsally and laterally smooth with sparsely scattered fine pits. Ventral surface with scattered fine and coarse granules especially towards base.

Aculeus moderately short, moderately curved to curved.

Humerus dorsally with scattered granules, and bounded at anterior edge by an irregular dense row of large dark denticles and at posterior edge by a less dense and less distinct row.

Brachium dorsally with scattered granules, and bounded at anterior and posterior edges by large granules. Posteroventral keel from very weak to strongly defined. Ventral group, *v*, with 13-17 trichobothria. Posterior group, *p*, with 32-39 trichobothria.

Hand long, flat and extremely narrow. Dorsal surface smooth to with scattered granules. Finger keel well developed, mainly smooth. Anterodorsal keel made up of an irregular row of rather small dark denticles; a reticulation of fine granules between this keel and finger keel. Anterior surface with a slightly granulate median longitudinal keel. Ventral group, *V*, with 16-22 trichobothria. Median group, *M*, of posterior surface with 9-13 trichobothria.

Fingers long. Along edge of movable finger 1 row of granules from base to apex. 6-7 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 6-7 prongs. Terminal claws of each leg slightly unequal in length especially in first and second pairs of legs, but those of the third and fourth pairs of legs usually equal. Claws long and extremely thin. Ventral surface of tarsomere II of fourth pair of legs with 10-12 inner, and 2-3 outer prongs.

Pectinal teeth 24-26 (Mean 24.6) in male; 16 (Mean 16.0) in female.

Paraxial organ (Figs 102, 103) with lamina moderately long, widest at middle, slightly narrowing to moderately square, blunt apex; inner lobe triangular, pointed at apex, close to median lobe and external lobe which are roughly similar and far removed from base of lamina. Toquilla poorly defined but moderately thick at ventral edge and especially along outer edge near junction with base of inner lobe; ventral vinculum weakly defined;

dorsal vinculum short, narrowing towards junction with juxtum, which is small; basal lobe longer than proximal lobe both lobes tapering, the ventral abruptly, to apex.

#### Material examined

4♂, 1♀ (Map 19).

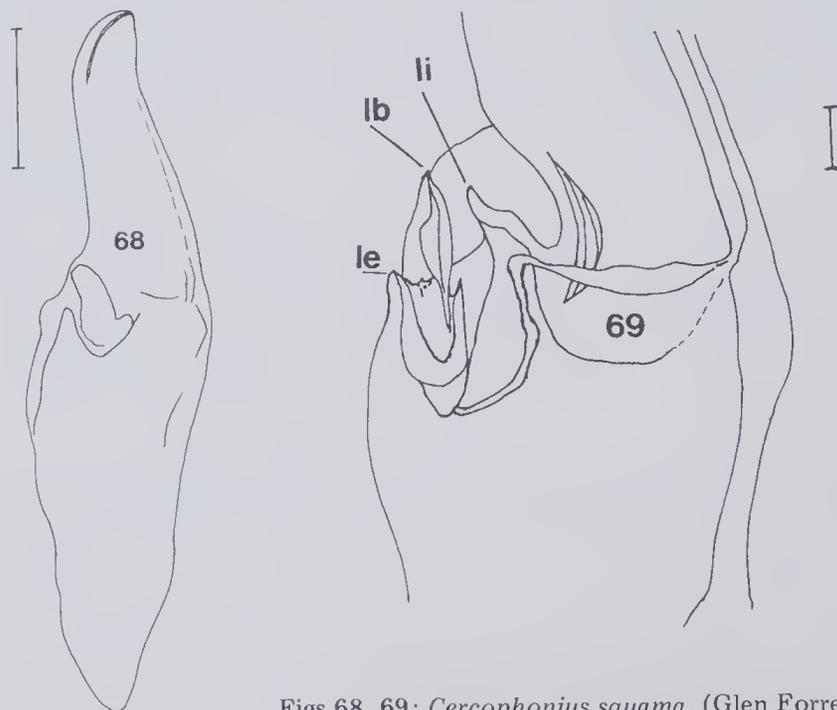
#### WESTERN AUSTRALIA

Canning Stock Route, 1930-1931 (O.H. Lipfert) 1♂, 62/1, WAM (holotype); 1930-1931 (O.H. Lipfert) 3♂, 1♀, 62/2-5, WAM (paratypes).

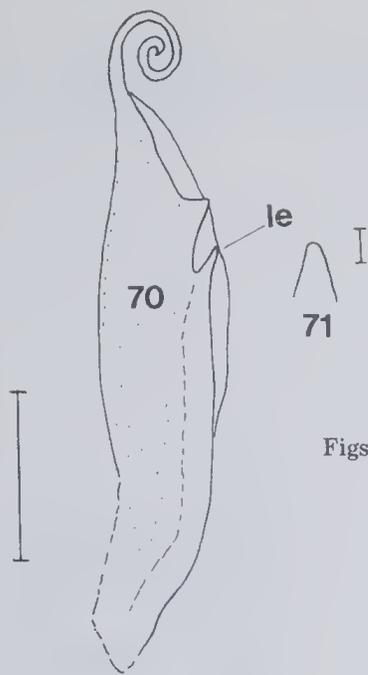
#### Remarks

The whole of the Canning Stock Route, W.A., which stretches from Wiluna in the south to Bililuna, a distance of 1377 km, is considered the type locality by Glauert (1963a). The holotype and the four paratypes were collected between April 1930 and October 1931. In June 1974, J. Dahlberg of Kalgoorlie, W.A., showed me two photographs he had taken of a specimen of *U. varians* that had been collected 97 km E of Onslow, W.A. Unfortunately he did not retain the specimen. The distribution of *U. varians* is represented in Map 19 by this point and by a point at the middle of the Canning Stock Route.

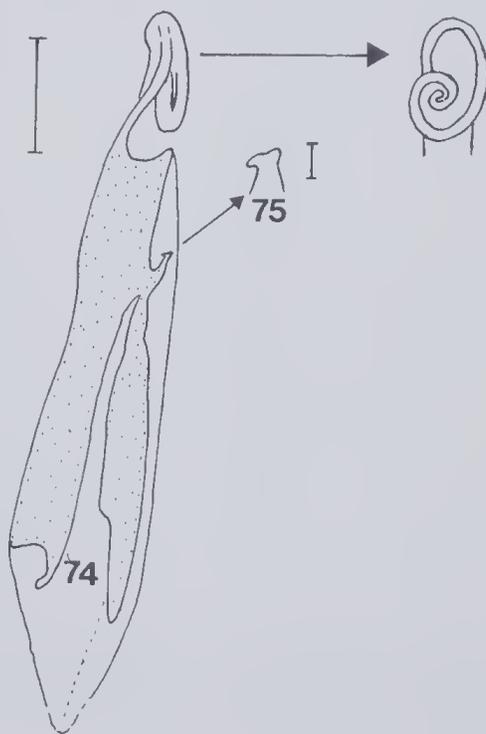
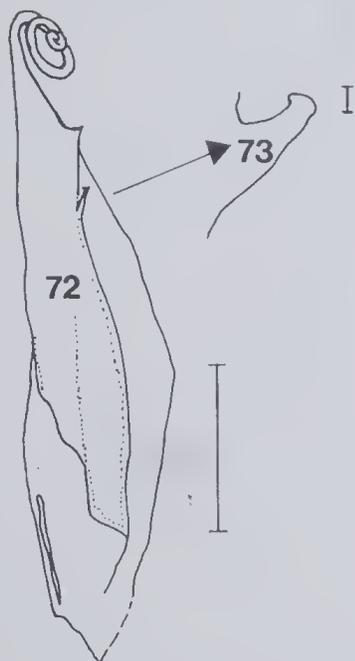
Paraxial organ (scale line 1 mm) and capsular area of paraxial organ (scale line 0.1 mm) (lb, basal lobe; le, exterior lobe; li, inner lobe).



Figs 68, 69: *Cercophonius squama*. (Glen Forrest, W.A.).



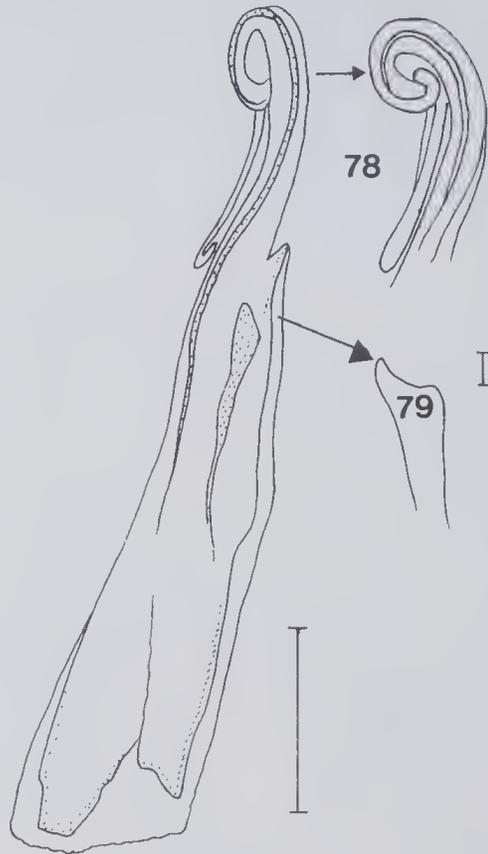
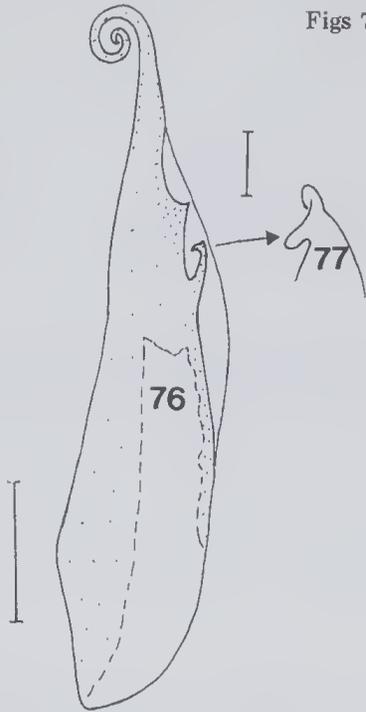
Figs 70, 71: *Lychas marmoreus*. (Bankstown, N.S.W.).



Figs 72, 73: *L. variatus*. (Mitchell Plateau, W. A.).

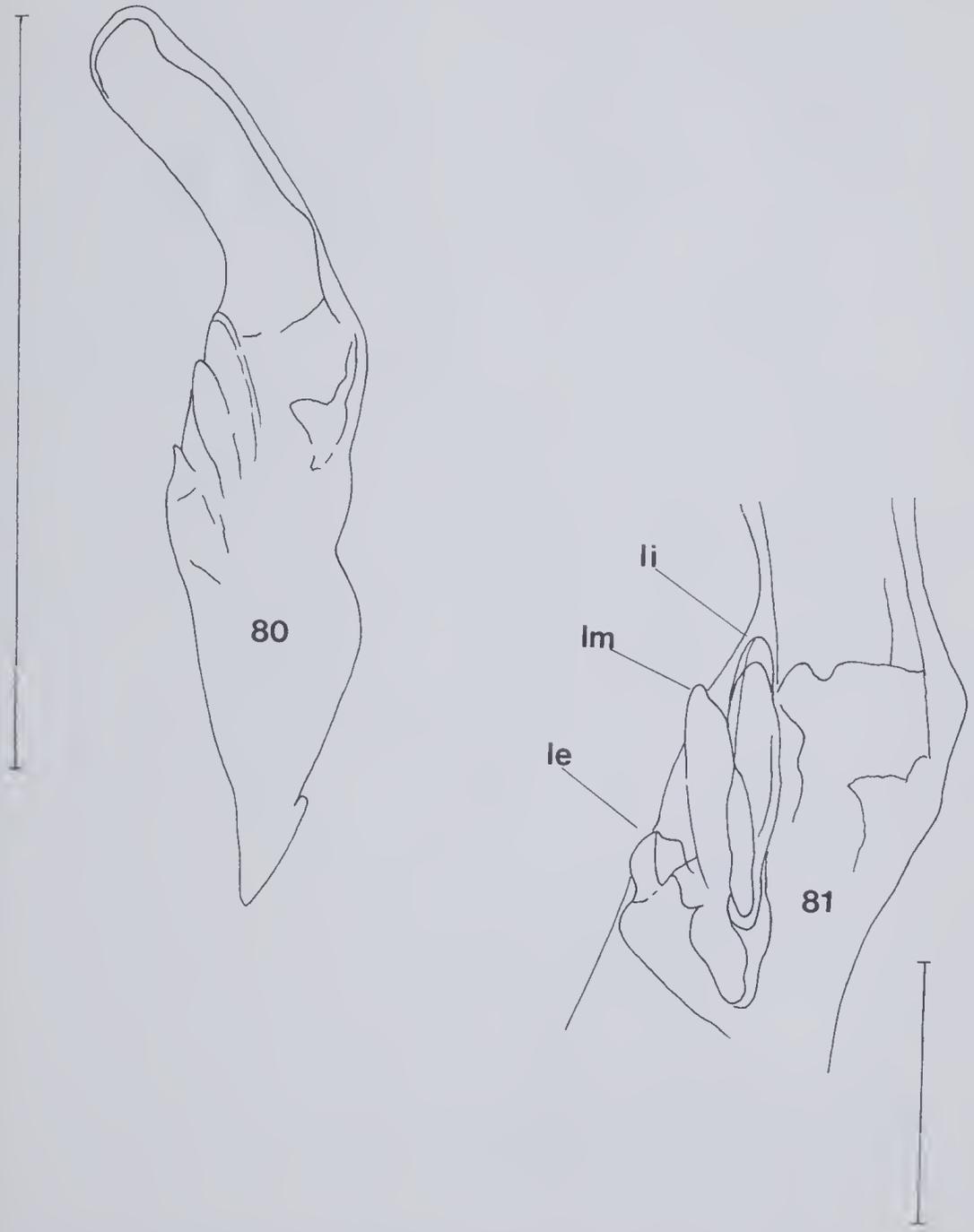
Figs 74, 75: *L. alexandrinus*. (Deniliquin, N.S.W.).

Figs 76, 77: *Isometroides vescus*. (Albion Downs, W.A.).

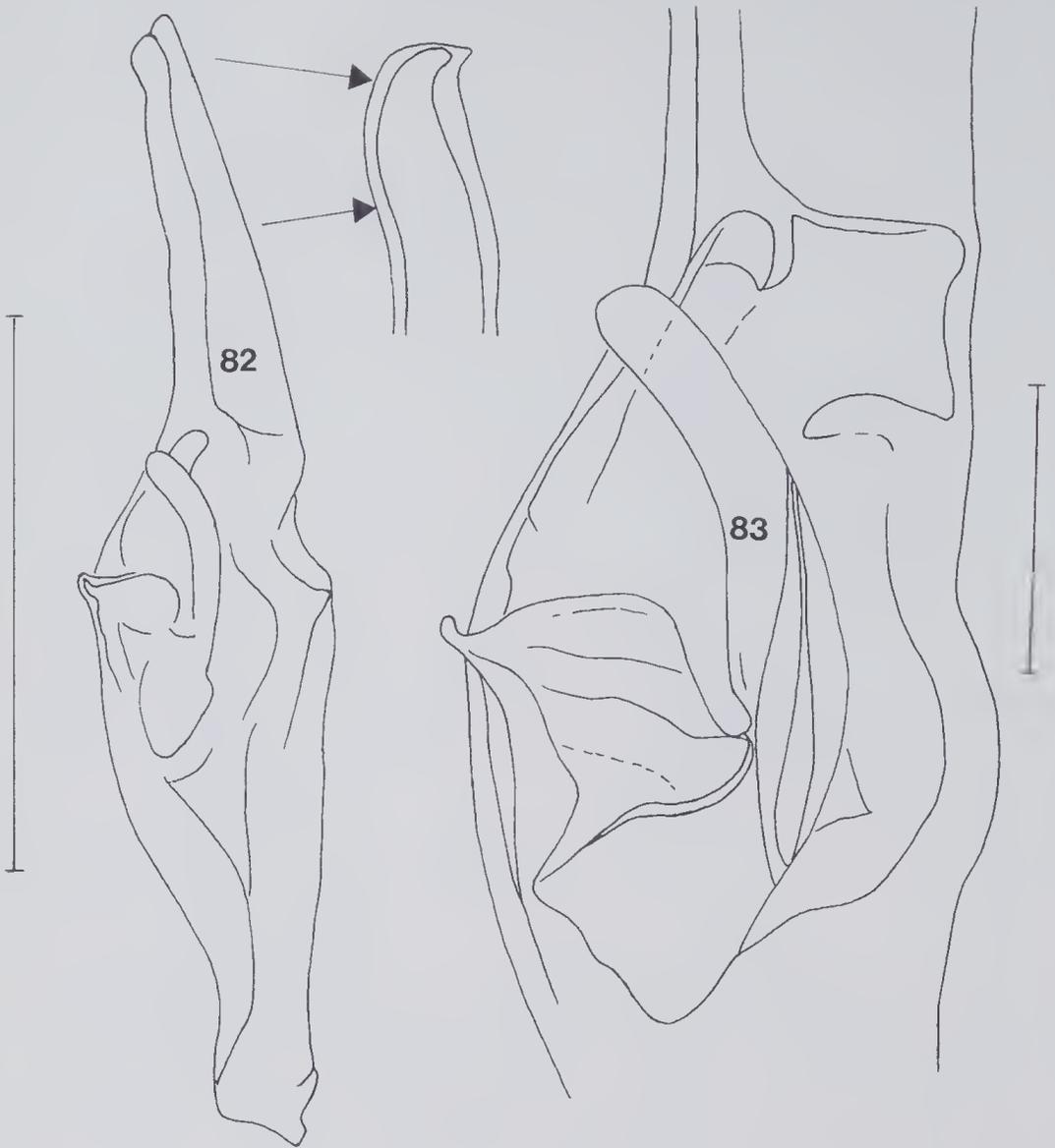


Figs 78, 79: *Isometrus melanodactylus*. (Brisbane, Qld).

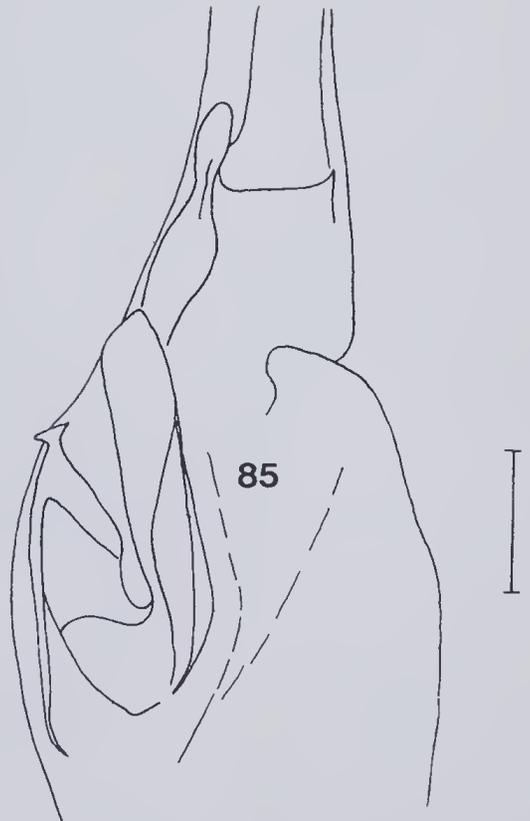
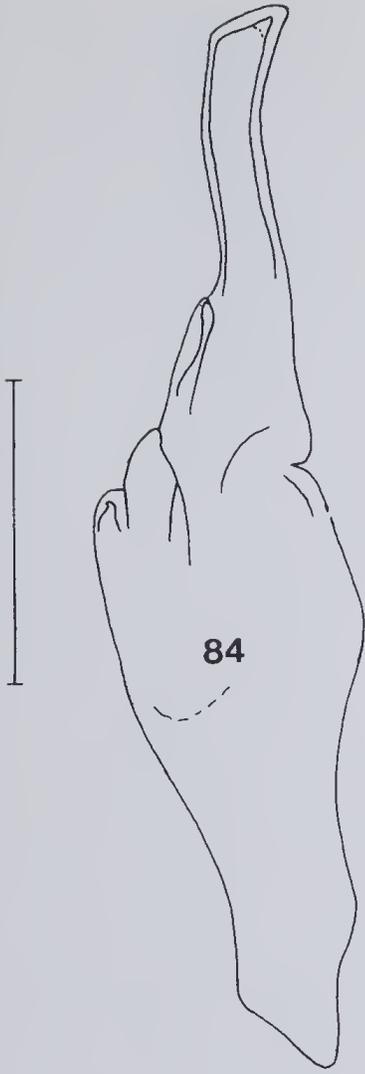
Paraxial organ (scale line 5 mm) and capsular area of paraxial organ (scale line 1mm) (lb, basal lobe; le, exterior lobe; li, inner lobe; lm median lobe).



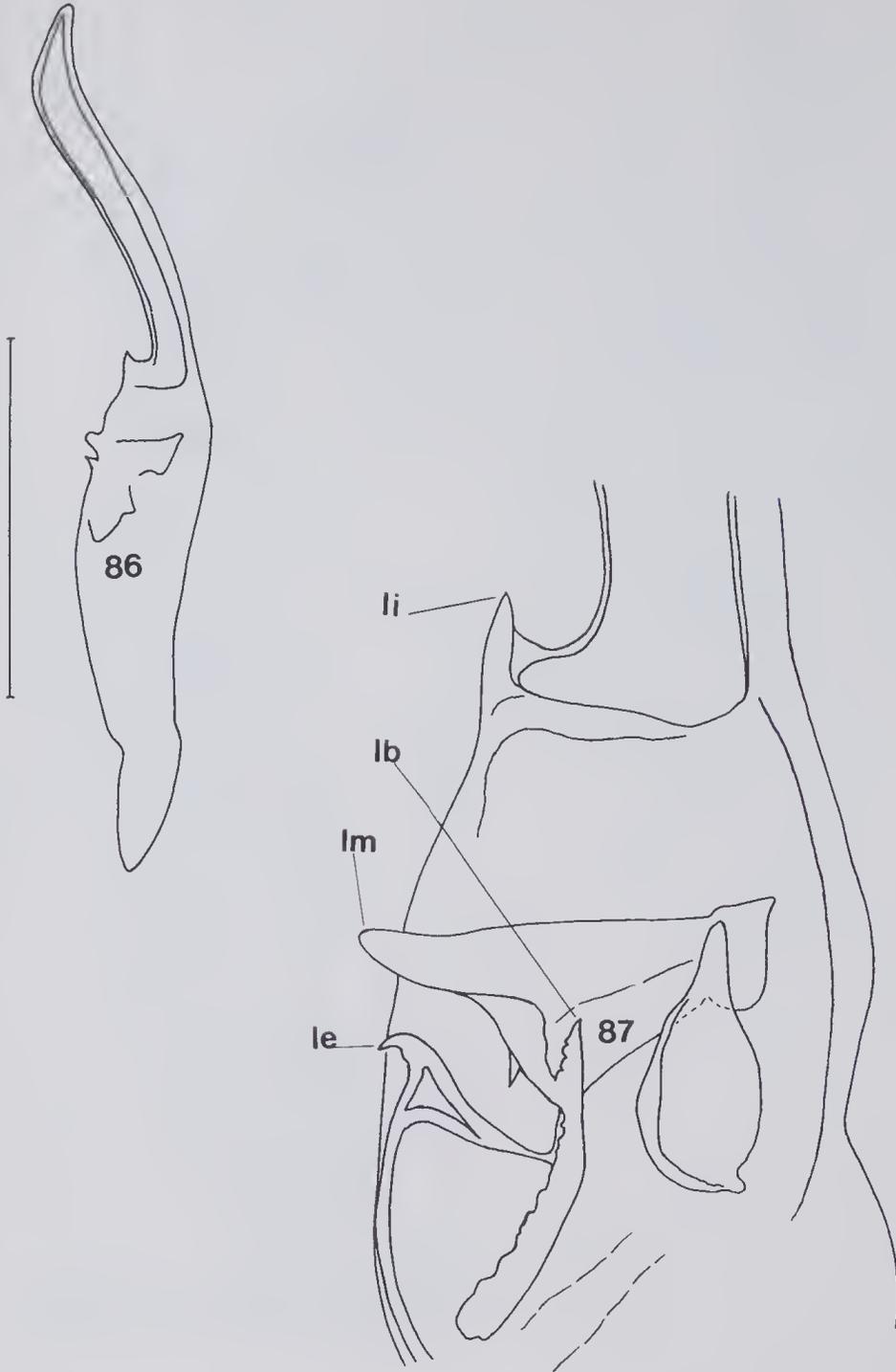
Figs 80, 81: *Liocheles australasiae*. (S.E. Papua).



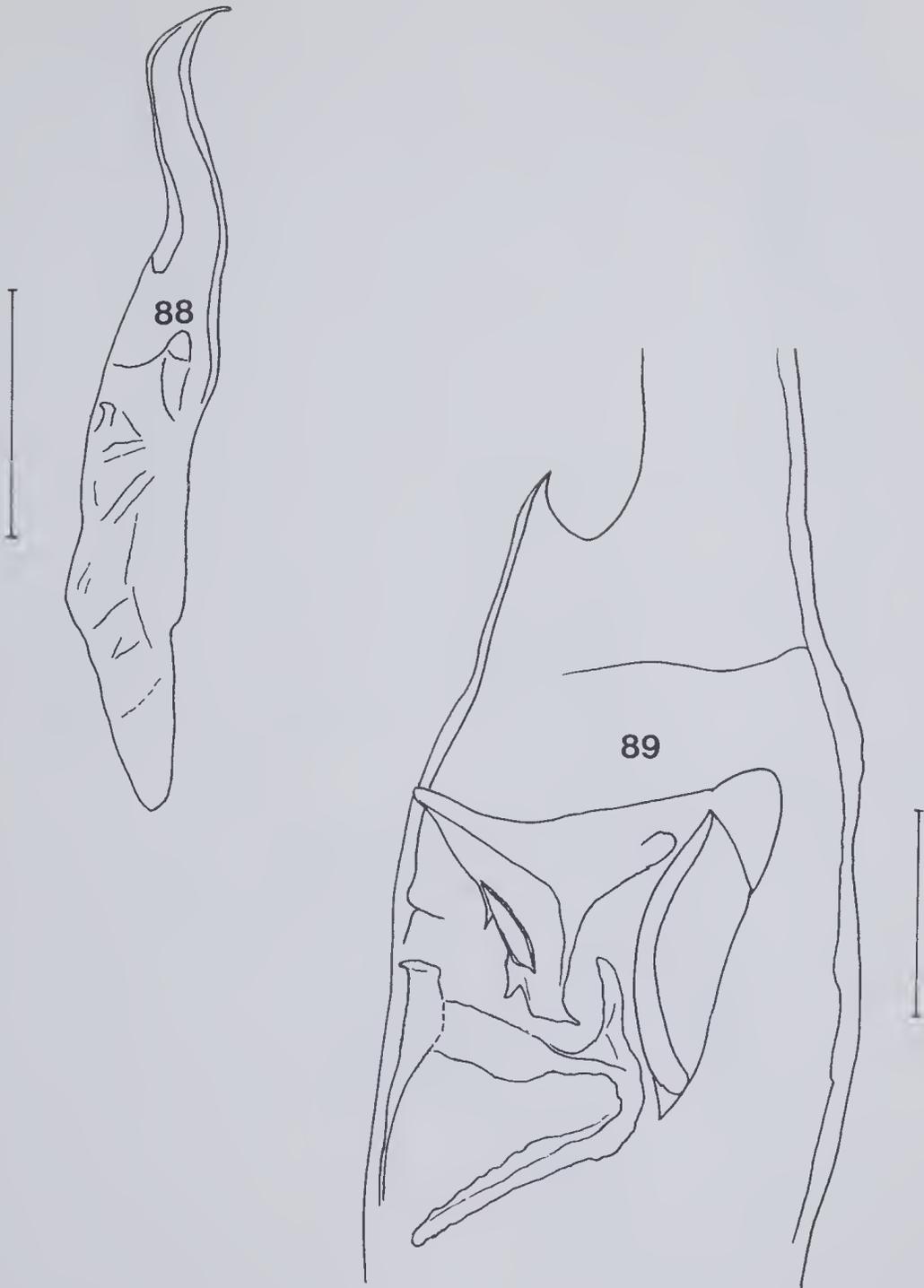
Figs 82, 83: *L. waigiensis*. (Pallarenda, Qld).



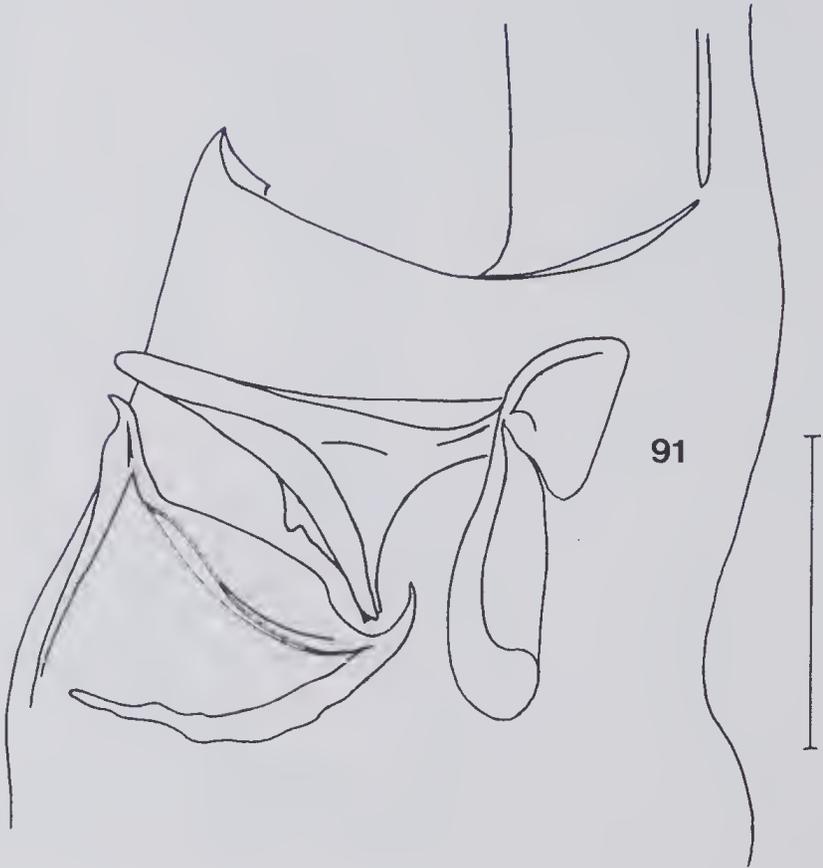
Figs 84, 85: *L. karschii*. (Kerema, Papua).



Figs 86, 87: *Urodacus manicatus*. (Kangaroo I., W.A.).



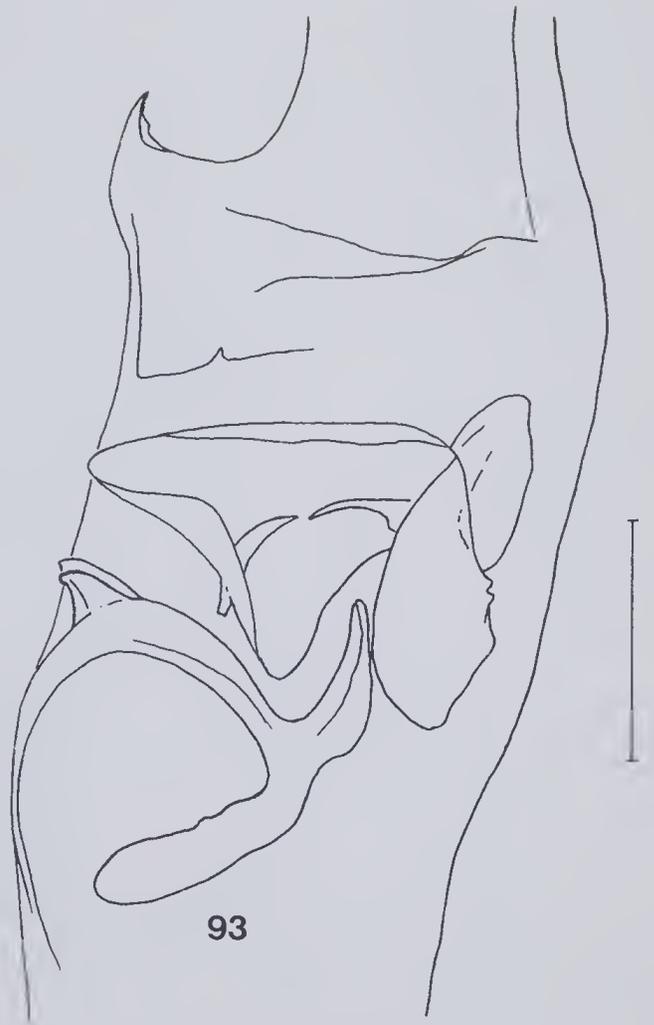
Figs 88, 89: *U. elongatus*. (Mt Remarkable, S.A.).



Figs 90, 91: *U. novaehollandiae*. (Dianella, W.A.).

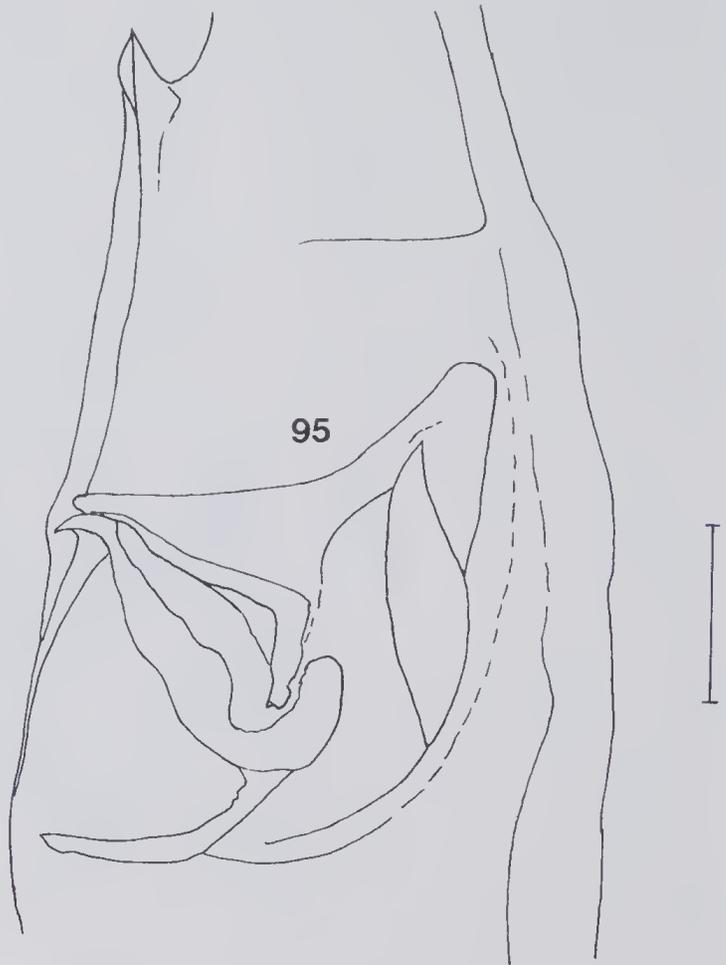
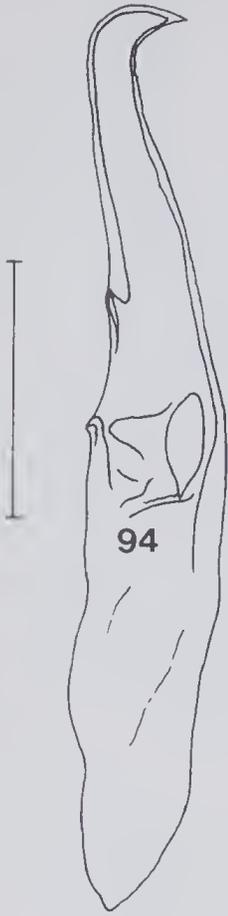


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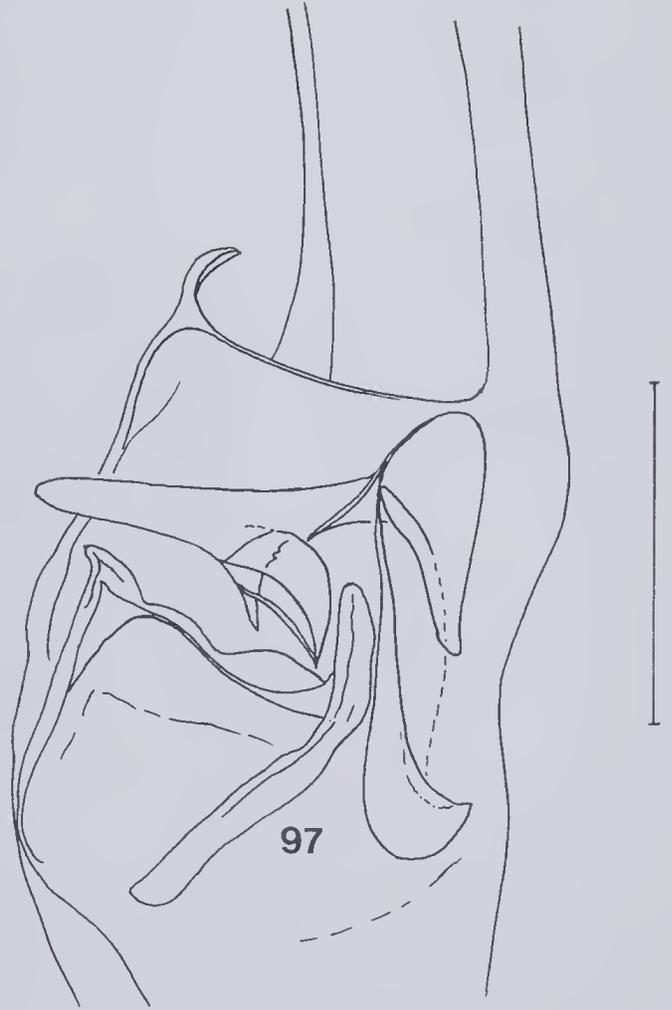


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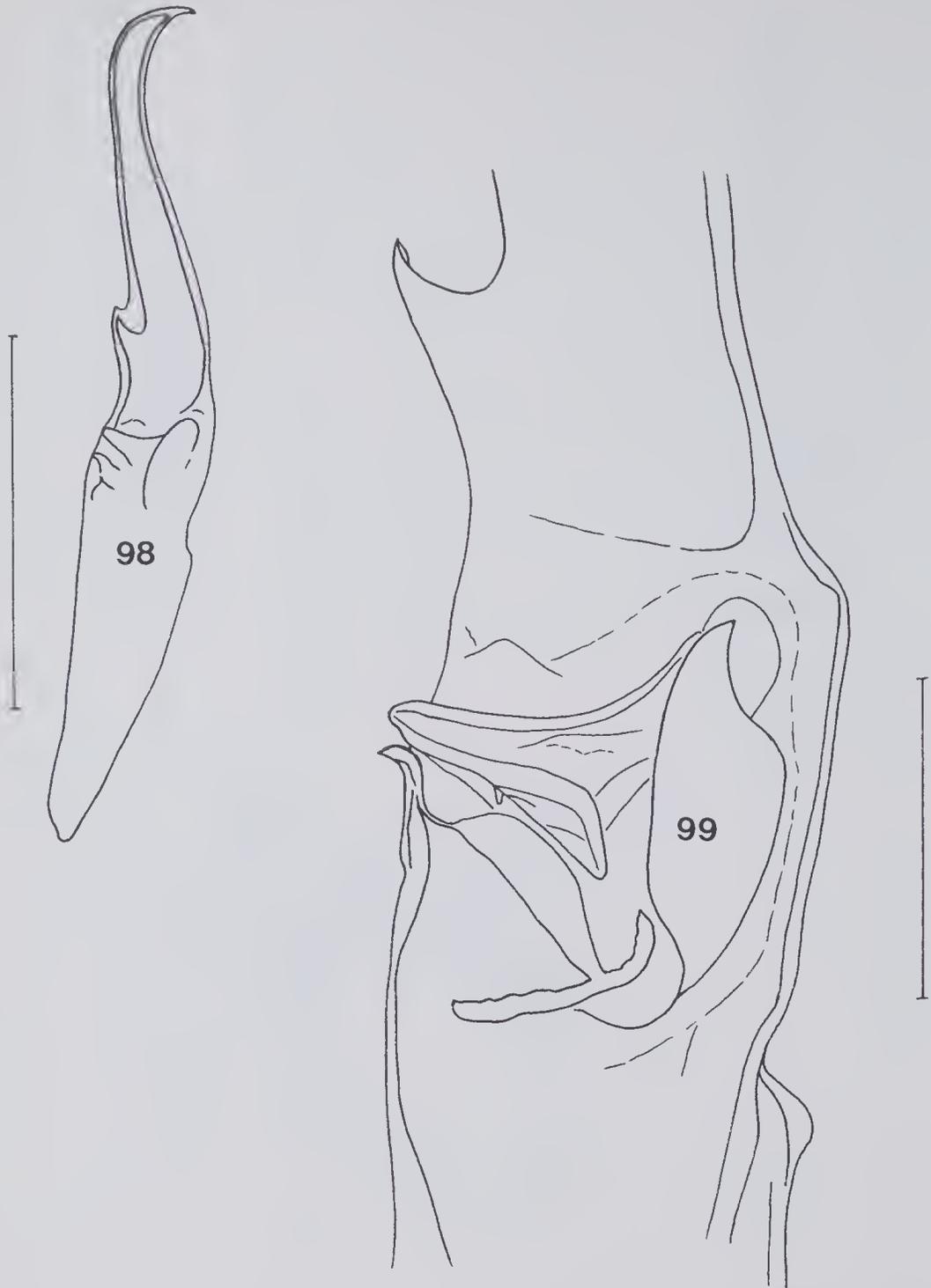
Figs 92, 93: *U. planimanus*. (Mundaring Weir, W.A.).



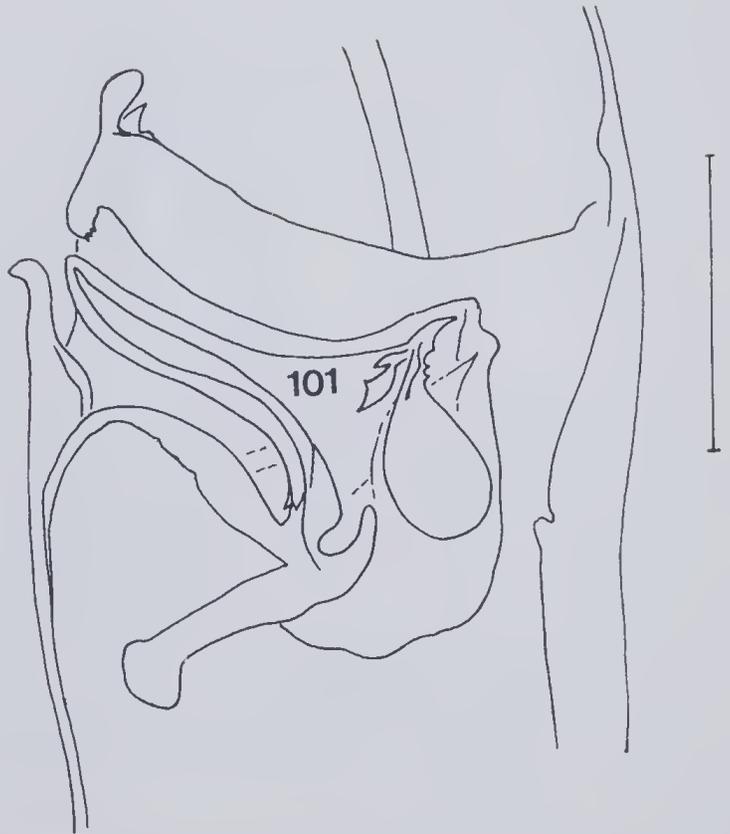
Figs 94, 95: *U. centralis*. (Palm Valley, N.T.).



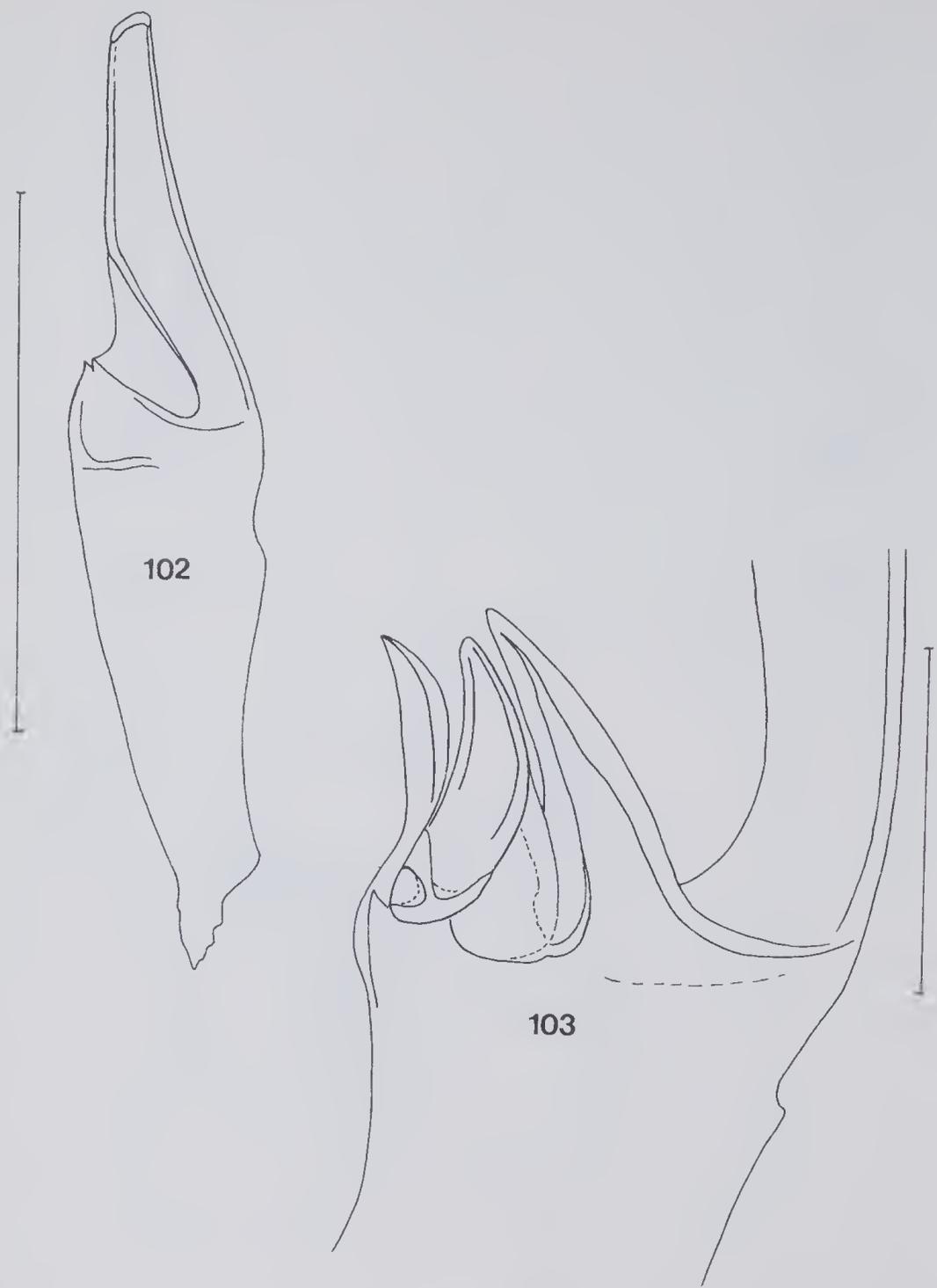
Figs 96, 97: *U. armatus*. (Kalgoorlie, W.A.).



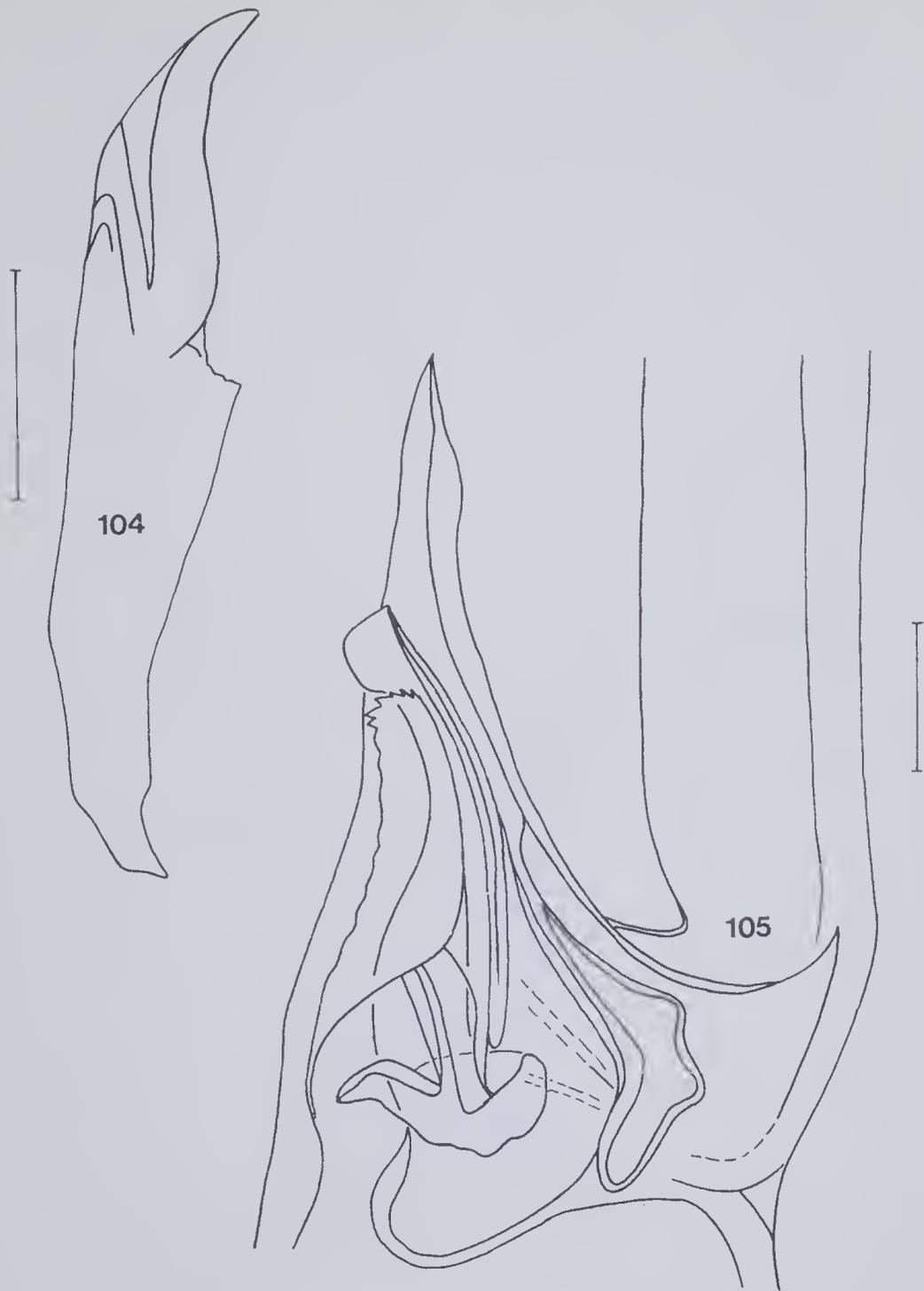
Figs 98, 99: *U. koolanensis*. (Koolan I., W.A.).



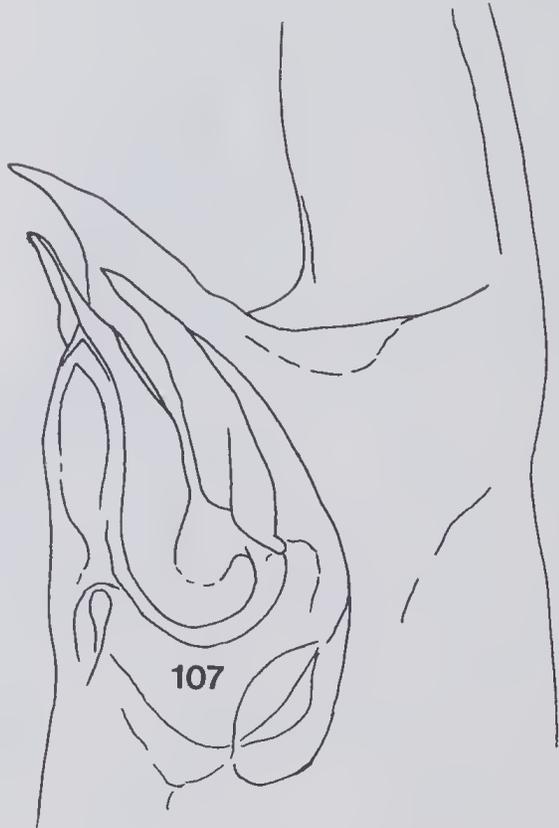
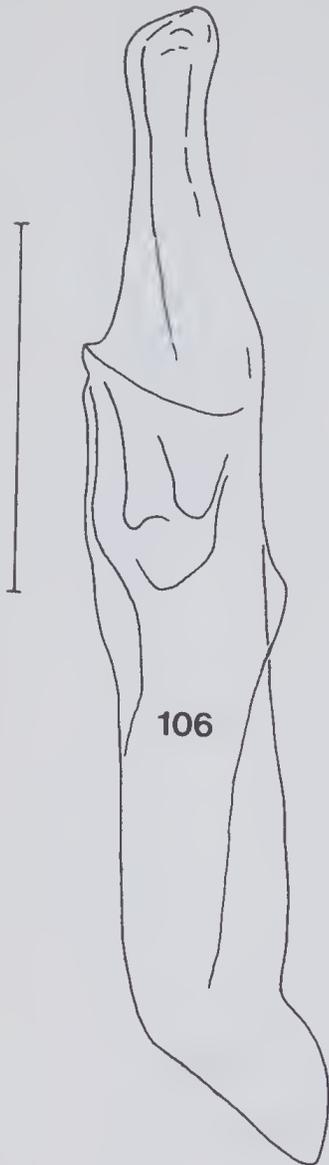
Figs 100, 101: *U. megamastigus*. (Mundiwindi, W.A.).



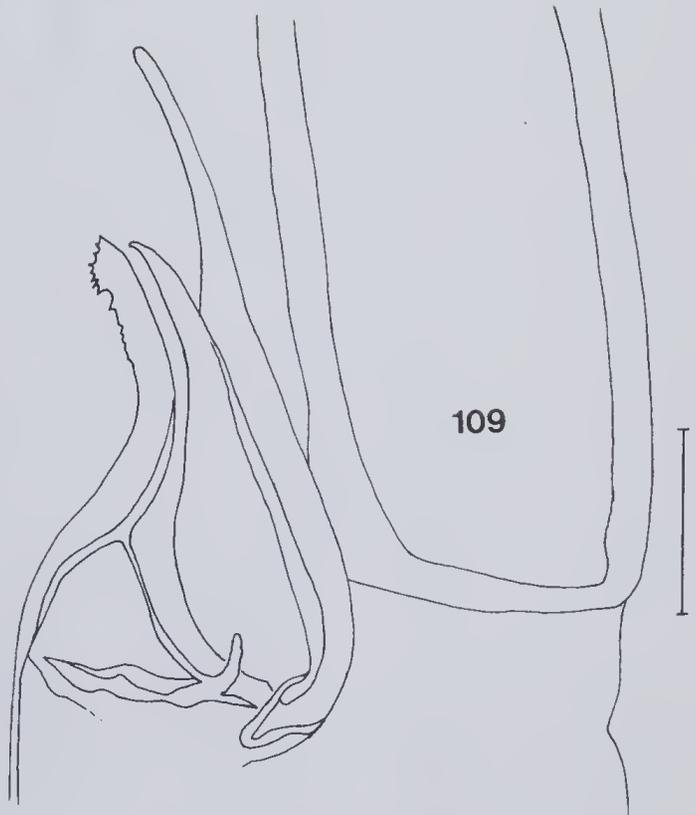
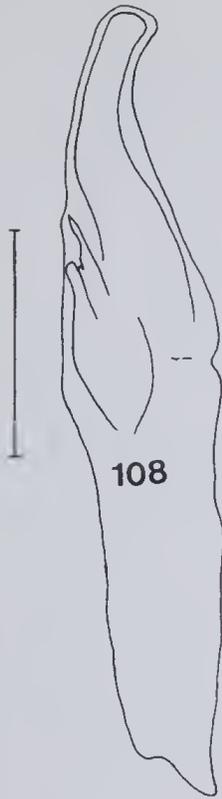
Figs 102, 103: *U. varians*. (Canning Stock Route, W.A.).



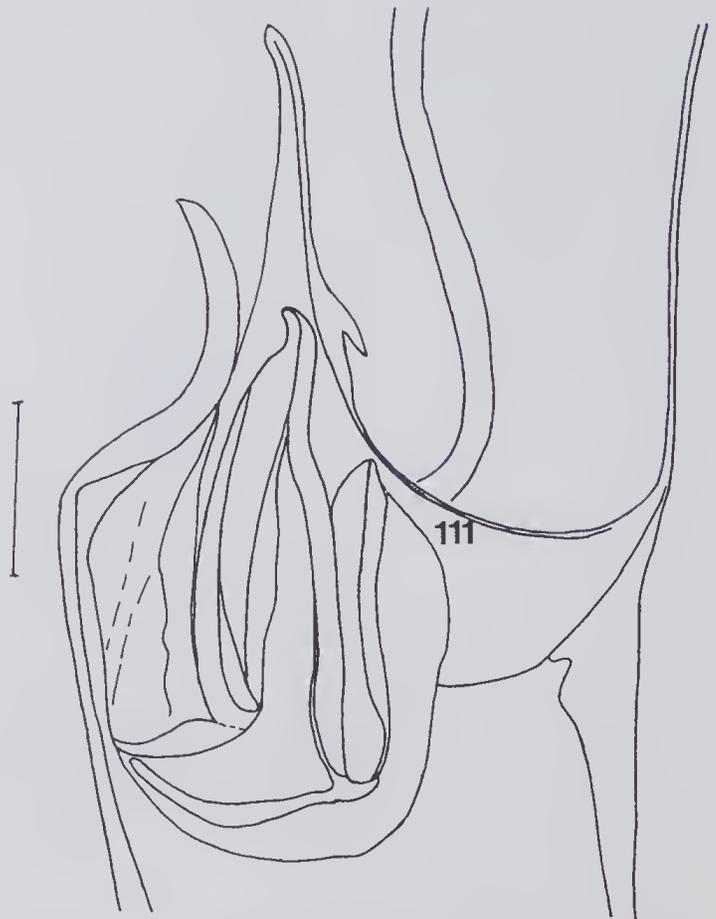
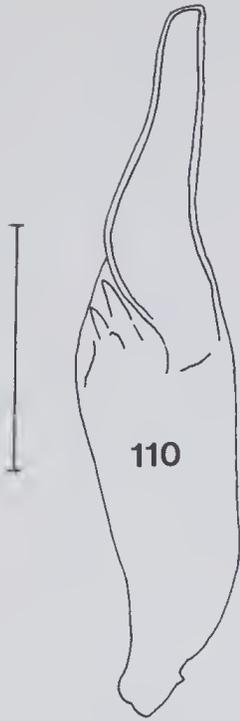
Figs 104, 105: *U. hoplurus*. (Landor Stn, W.A.).



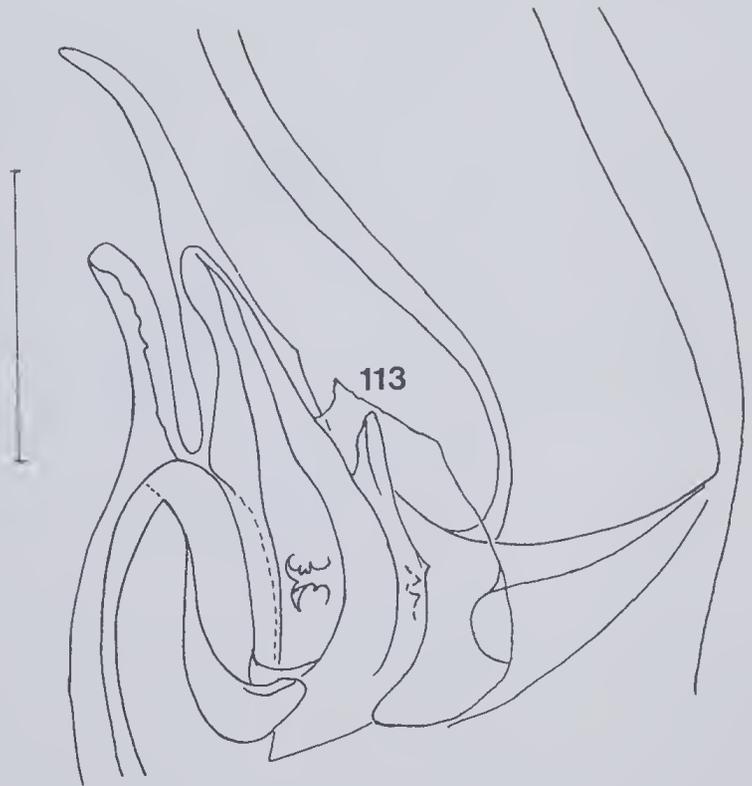
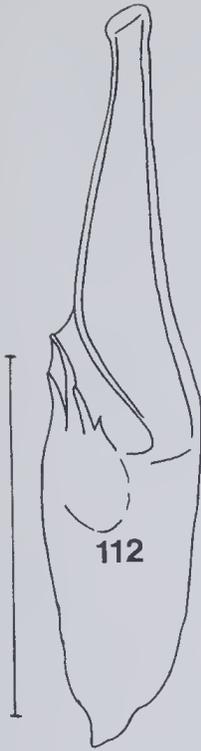
Figs. 106, 107: *U. carinatus*. (Haasts Bluff, N.T.).



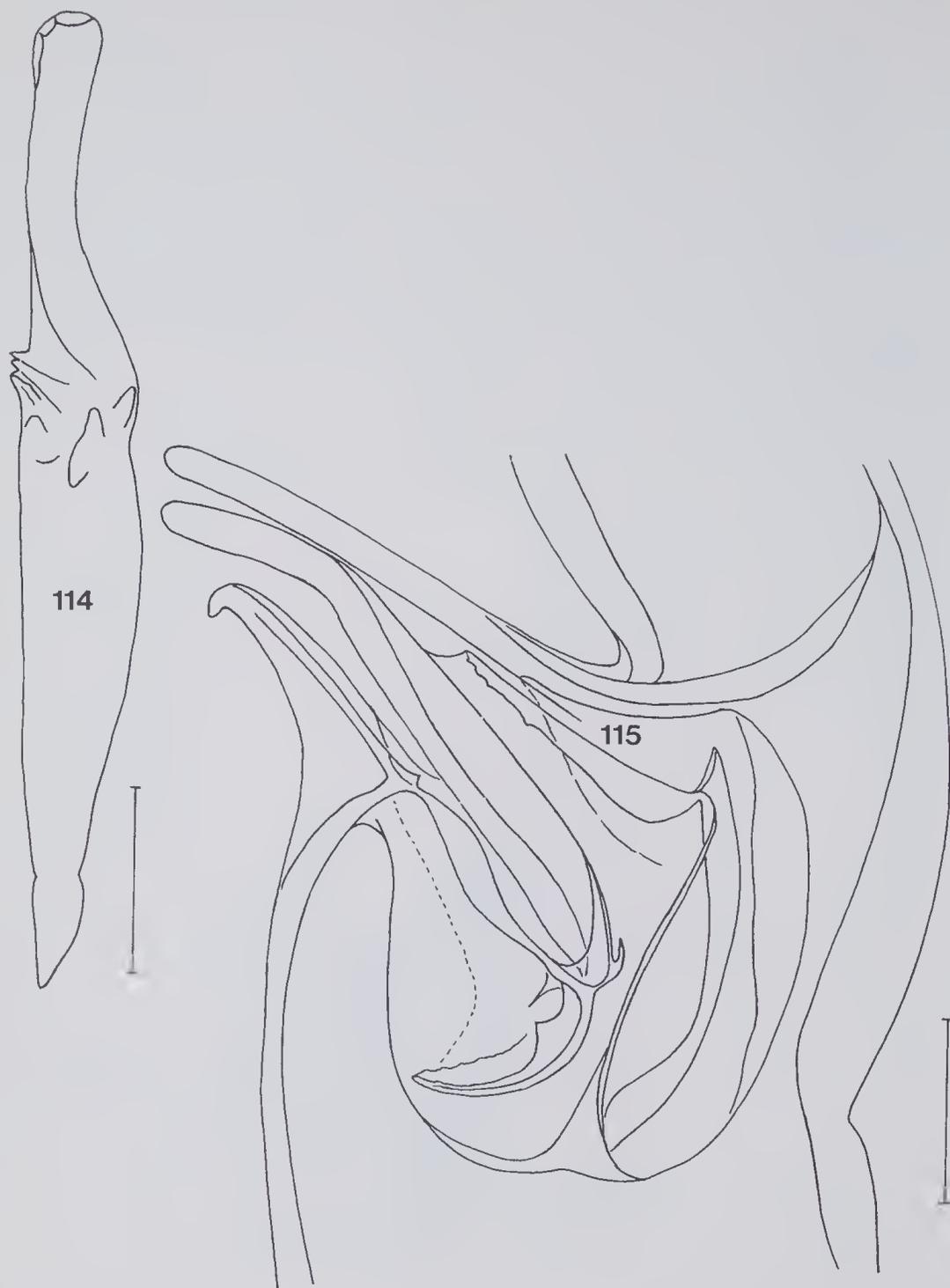
Figs 108, 109: *U. macrurus*. (Barcaldine, Qld).



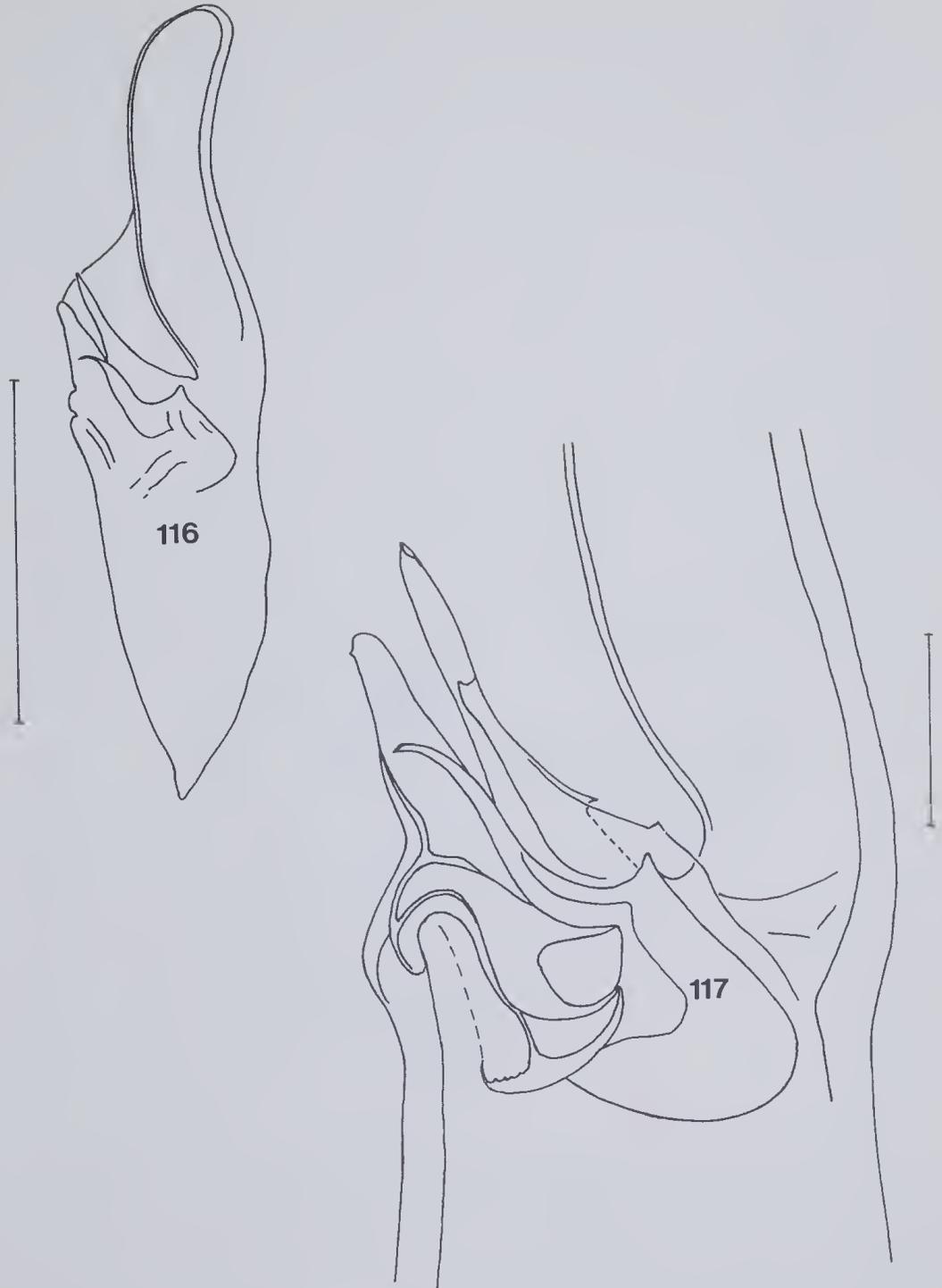
Figs 110, 111: *U. excellens*. (near Darwin, N.T.).



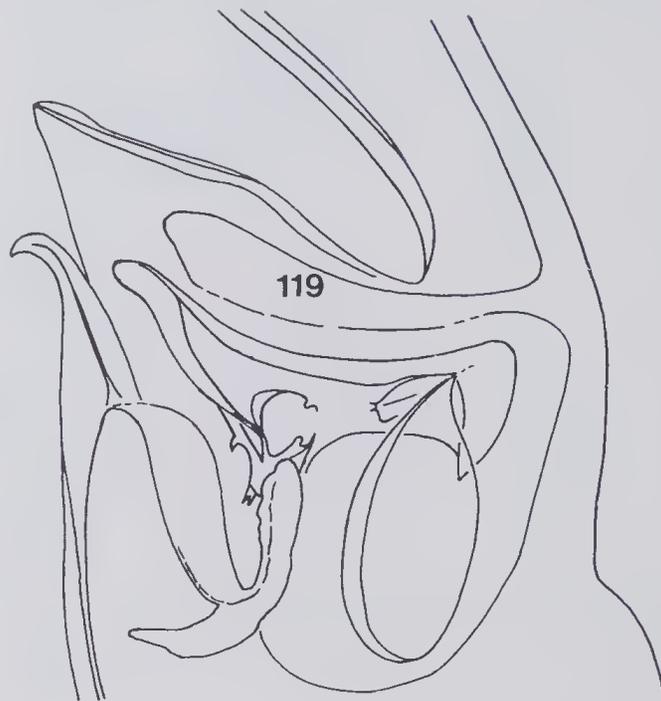
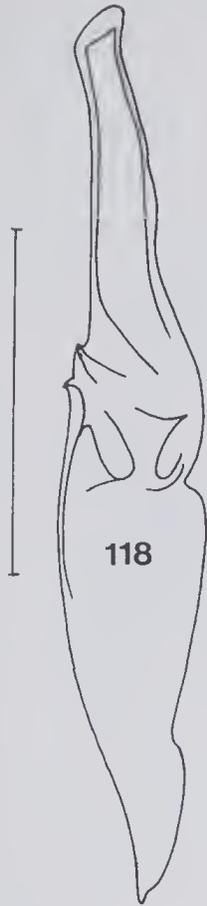
Figs 112, 113: *U. spinatus*. (Weipa, Qld).



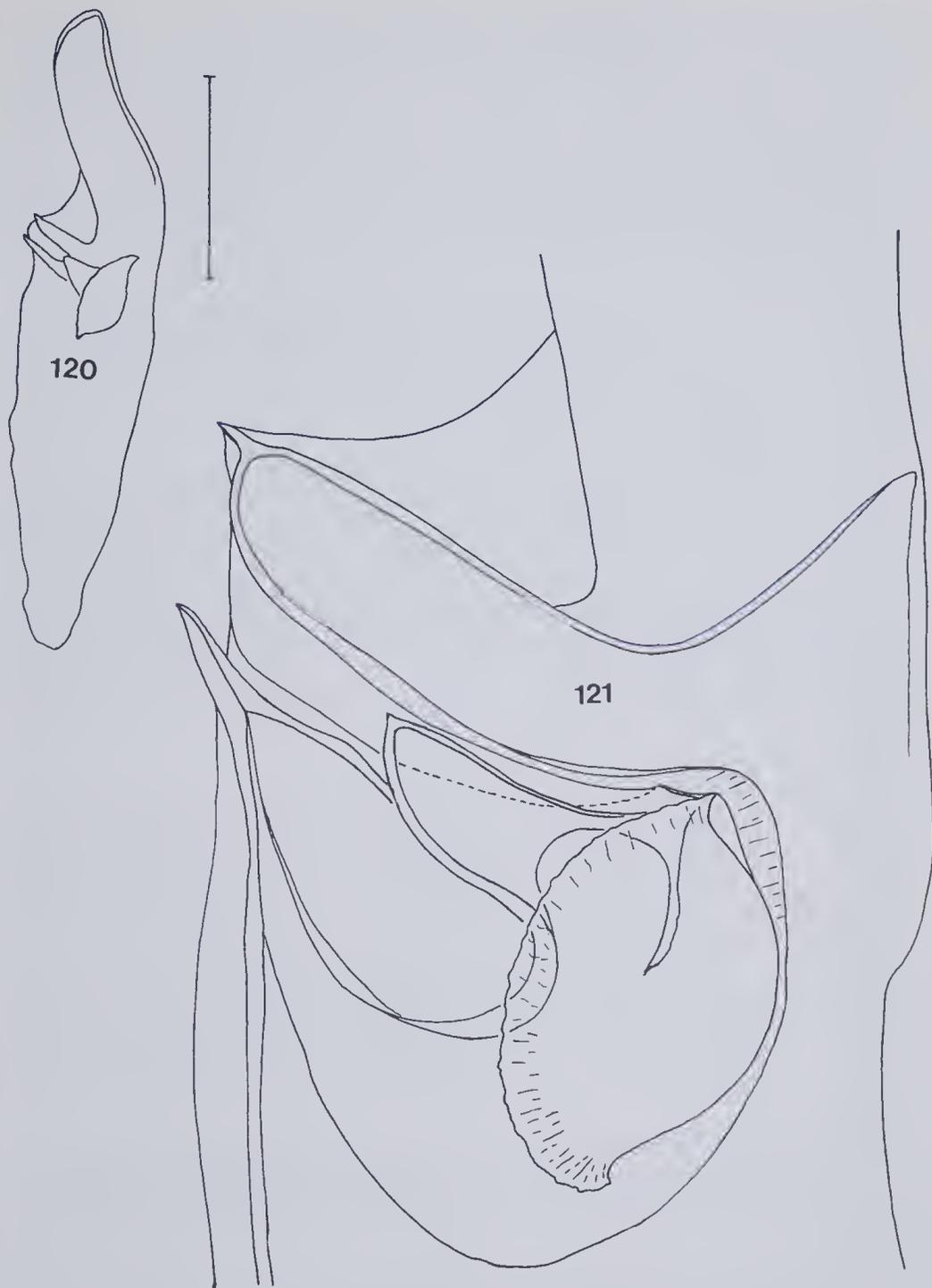
Figs 114, 115: *U. lowei*. (within 16 km of 14°58'S, 126°02'E, W.A.).



Figs 116, 117: *U. similis*. (Kathleen Valley, W.A.).



Figs 118, 119: *U. hartmeyeri*. (Shark Bay, W.A.).



Figs 120, 121: *U. yaschenkoi*. (Minnie Creek, W.A.).

*Urodacus hoplurus* Pocock  
(Figs 29, 58, 104, 105, 124, Map 20)

*Urodacus hoplurus* Pocock, 1898: 64; Kraepelin, 1899: 105; Kraepelin, 1908: 94; Hirst, 1911: 469; Kraepelin, 1916: 38; Takashima, 1945: 88. [Holotype examined.]

*Urodacus hillieri* Hirst, 1911: 469; Kraepelin, 1916: 38; Takashima, 1945: 89. [4 syntypes examined.] *Syn. n.*

**Range (Map 20)**

Western Australia, furthest north at Beverley Springs, furthest west at Carnarvon and Exmouth Gulf, furthest south at Bodallin. South Australia, furthest east at Wilpena Pound. Northern Territory, furthest north at Frewena Roadhouse.

**Measurements (mm)**

♂. Holotype. Total length 103, of tail 60; carapace, length 12.5, width 13.0; tail segments one to five (in that order), length 8.0, 9.2, 9.8, 10.0, 12.5, width 5.6, 5.1, 4.9, 4.2, 3.7, height 4.2, 4.2, 4.2, 4.0, 3.0; length of vesicle and aculeus 11.5; width of vesicle 4.7; length of humerus 8.5; brachium, length 9.5, width 4.0; hand, length 8.8, width of hand surface 8.0, height 6.3; length of hand and fixed finger 18.5; length of movable finger 11.2; length of pectine 8.1.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=25)									
Min.	9.0	8.1	7.6	6.3	4.3	14.8	8.6	6.4	3.1
Max.	13.2	14.0	10.7	9.6	6.6	21.2	13.0	11.7	4.3
Mean	11.2	10.9	9.0	7.9	5.7	18.2	10.8	9.1	3.7
SD	1.30	1.51	0.83	0.81	0.57	2.01	1.27	1.50	0.32
Female (n=15)									
Min.	9.2	9.2	8.3	5.5	3.8	15.8	8.9	5.1	2.8
Max.	14.7	15.0	11.7	11.5	8.5	24.6	15.7	8.3	4.4
Mean	12.4	12.5	10.0	8.9	6.6	20.3	12.1	6.9	3.7
SD	1.88	1.90	1.25	1.71	1.32	2.80	1.97	0.92	0.57

**Diagnosis**

Distinguished from *U. yaschenkoi* by equal or practically equal leg claws, from *U. armatus* by large size and dark coloration, and generally from other *Urodacus* species by large rounded hands and shape of terminal spine of tail segments.

**Description**

Colour reddish ochre-brown to ochraceous orange and clay-yellow (very rarely greenish yellow-brown, viz. Alice Springs, N.T.) legs and part of

ventral surface lighter (often yellowish); tergites and sternites (especially central parts of) sometimes greyish brown; finger blackish red, sometimes lighter.

Carapace with frontal notch moderate to very deep. Frontal lobes truncate. Interocular areas mainly smooth; slightly rugose anteriorly and sometimes granulate especially in male. Lateral and posterior two-thirds of carapace often mainly smooth, partly with coarse granules. Median sulcus uninterrupted to slightly interrupted. Triangular depression moderately deep sometimes rather shallow. Sides of triangular depression slightly retracted (rarely strongly retracted).

Chelicerae (Fig. 29) with secondary serrations distinct usually small. Teeth often badly worn. Fixed jaw with about four secondary serrations distal to the subdistal tooth and some secondary serrations between subdistal tooth and median tooth; all teeth large. Movable jaw with one or two secondary serrations at base of distal internal tooth; distal external tooth and subdistal tooth each with a secondary serration towards proximal base; median tooth large and wide with a few serrations at proximal base; basal tooth wide, with a notch at proximal base.

Tergites of first six abdominal segments posteriorly and laterally closely granulate, anteriorly finely granulate to smooth. Tergite of last abdominal segment closely granulate. Keels of coarse denticles; median keels about one-third length of segment, lateral keels about half to three-fourths length of segment.

Tail long in male, moderate in female. First four tail segments (Fig. 58) with intercarinal surfaces ranging from smooth to with fine scattered granules. Dorsal and dorsolateral keels weakly denticulate, the dorsal keels ending posteriorly in a large triangularly spiniform terminal tooth which sometimes tends to be back-curved (i.e. towards head) at tip. Ventrolateral and ventromedian keels smooth. Accessory keels granulate, usually well defined along first segment; evident only at posterior end of second segment; practically absent in other segments. Fifth tail segment moderate to long. Intercarinal surfaces smooth. Dorsolateral keels weakly denticulate or crenulate. Ventrolateral and ventromedian keels with large denticles. Ventromedian keel denticulate bifurcating distally at extremity.

Vesicle moderately large (especially in male), dorsally smooth, laterally and ventrally granulate.

Aculeus moderate to long, usually long; moderately curved, sometimes strongly curved.

Humerus dorsally with scattered, usually large granules. Dorsally bounded at anterior and posterior edges by coarse dark granules.

Brachium with dorsal surface finely granulate. Posteroventral keel smooth,

often strongly developed. Ventral group, *v*, with 10-16 (usually 12-14, rarely 16) trichobothria. Posterior group, *p*, with 30-43 trichobothria.

Hand tends to be large and rounded, especially in female, sometimes very squat, e.g. at Carnarvon and Nullagine, sometimes extremely wide. Keels tend to be smooth and not strongly ridged. Anterodorsal keel poorly defined by granules. Dorsal and anterior surface especially near anterodorsal keel with reticulation of fine, often close-set, granules. Ventral group, *V*, with 12-22 (usually 18-20; often 15, 16 near southern edge of its distribution, viz., Southern Cross, W.A., but also elsewhere, e.g. Beverley Springs, W.A.) trichobothria. Distal trichobothria of *V* group often arranged as a double row along hand, e.g. at Pender Bay (Broome), W.A., but not at e.g. Murchison River, and Laverton, W.A. Median group, *M*, of posterior surface with 7-15 (often 11-14) trichobothria.

Fingers moderately long. Along edge of movable finger 2-4 main rows of granules from base to middle, reducing to 1 row at apex; sometimes only 1 main row along entire length. Usually around 4 (sometimes up to 9) rows of transverse accessory teeth, all near distal end of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 6 or 7, rarely 5 (usually 6) prongs. Terminal claws of each leg of same length or nearly same length (rarely inner claw is as short as three-fourths outer). Ventral surface of tarsomere II of fourth pair of legs with 9-12 (rarely 8) inner, and 6-8, rarely 5 or 9 (usually 6 or 7) outer prongs (including a group of 4-6 on distal flap).

Pectinal teeth 13-27 (Mean 20.0, SD 2.70) in male; 8-23 (Mean 16.1, SD 3.18) in female.

Paraxial organ (Figs 104, 105) very variable with lamina moderate to small, weakly S-shaped, apex extremely pointed to rounded; inner lobe long, varying from gradually to abruptly tapering to sharp point at apex; median lobe noticeably shorter than inner lobe, usually about two-thirds its length, occasionally tapering and pointed at apex, usually moderately square, or rounded at apex; usually markedly composed of two plates at right angles to one another, the larger being in same plane as the width of the lamina, the other pointing ventral; external lobe usually somewhat shorter than median lobe, sometimes (e.g. in some specimens at Bencubbin, W.A.; and at James Range, N.T.) of about same length; apex of external lobe with toothed comb of serrations, which vary from 6-28 (e.g. 8 at Landor Station, W.A., 25 at Warburton Range, W.A.); rarely reducing to resemble the external lobe of *U. yaschenkoi* and especially that of *U. excellens*; toca large, open and thickly defined around boundary; ventral vinculum short, abruptly pointed; dorsal vinculum broad and wavy; juxtum with both arms about equal length and wavy along lower edge; basal lobe usually rounded at apex; proximal lobe usually pointed at apex; apotheca sclerotized; diaphragma strongly sclerotized.

## Material examined

161♂, 298♀ (Map 20).

### WESTERN AUSTRALIA

Annean Stn, iv.1925 (W.J. Butler) 1♀, 25/286, WAM. Balfour Downs, iii.1925 (C. Bluchmore) 1♂, 25/202, WAM. Bencubbin, 8.i.1929 (P.J. Barwise) 1♂, 29/31, WAM. Beverley Springs, new HS, 26 km S of old HS, 4.ix.1969 (D.D. Giuliani) 1♂, 1♀, 69/2039-40, WAM; 11.ix.1969 (D.D. Giuliani) 2♂, 8♀, 69/2046, 69/2048, 69/2042-5, 69/2047, 69/2049-51, WAM; 40 km NNE of, 8.ix.1969 (D.D. Giuliani) 1♀, 69/2041, WAM. Blackstone Mining Camp, v.1967 (C. Sneli) 1♂, 69/15, WAM, Bodallin, xii.1924 (H.H. Marshal) 2♂, 24/940-1, WAM. Booylgoo Springs, 4.x.1926 (E.L. Michel) 1♂, 26/643, WAM; 20.iii.1930 (E.L. Michel) 1♂, 30/282, WAM. Broome, 24.iii.1926 (H. Talboy) 1♀, 26/169, WAM; 19.ii.1971 (W.H. Butler) 1♂, 71/698, WAM. Burnerbinmah Stn, 21.i.1967 (D. Craven) 1♂, 68/874, WAM; 6.iii.1970 (D. Craven) 1♀, 70/304, WAM. Canning Stock Route, Well 18, vii.1972 (P.J. Waterfall) 1♂, 73/669, WAM. Carnarvon, 3.viii.1956 (Herz) 2♀, 56/1387-8, WAM; 25.vii.1967 (D.W. Thomas) 1♀, 68/877, WAM; 14.iii.1968 (D.W. Thomas) 1♀, 68/876, WAM; 29.xi.1972, 1♀, 73/666, WAM. Carnegie HS, 285 km E of, 6.ii.1967 (W.D.L. Ride, A.M. Douglas & A. Baynes) 1♂, 68/893, WAM. Cogla Downs (near Cue) ii.1925 (Mahood) 1♂, 25/75, WAM. Cue, 14.iii.1924 (H. Brown) 1♀, 24/186, WAM; 14.iii.1924 (Goeldner) 1♂, 24/190, WAM; 22.x.1932 (S.A. Mahood) 1♂, 32/2250, WAM; 24.iii.1933 (S.A. Mahood) 1♀, 33/1009, WAM. Dampier Downs, 80 km E of, 12.viii.1969 (D.D. Giuliani) 3♂, 3♀, 69/2033, 69/2028-32, WAM; 15.viii.1969 (D.D. Giuliani) 2♀, 69/2035-6, WAM. De Grey Stn, 19.v.1925, 1♂, 26/276, WAM. Derby, 8.viii.1967 (W.R. Lowe) 2♀, 69/614-5, WAM. East Mollerin, vii.1929 (Shilcock) 1♂, 69/930, WAM. Exmouth Gulf, 1967 (D.T. Richie) 1♂, 1♀, 68/884-5, WAM. Gabyon, 7.iv.1924 (S.D. Freeman) 1♂, 24/332, WAM; 30.i.1968 (J. Maley) 1♀, 68/887, WAM; 3.ii.1968 (J. Maley) 1♀, 68/688, WAM. Giles, 97 km S of, 8.vii.1969 (D.D. Giuliani) 1♀, 69/2014, WAM. Glenorn, near, 17.vi.1969 (L.E. Koch & D.D. Giuliani) 1♂, 69/1097, WAM. Kalgoorlie, 129 km NE of, vi.1968 (S.F. Tonkin) 1♀, 68/873, WAM. Kathleen Valley, iii-iv.1963, 1♂, 1♀, 68/786, 68/785, WAM. Kookynie, 8 km ESE of, 19.vi.1969, 1♀, 69/1098, WAM. Koorda, 25.vi.1925 (F. Bradshaw) 1♀, 25/432, WAM. Lake Seabrook, 28.iii.1970 (A.M. Douglas) 10♂, 70/305-14, WAM. Lake Violet Stn, v.1927 (P. Hopegood) 1♀, 27/659, WAM. Landor Stn, ii.1927 (C. Hughes-Hallett) 6♂, 12♀, 27/295, 27/297-301, 27/284-94, 27/296, WAM; iv.1927 (C. Hughes-Hallett) 14♂, 69♀, 27/609-22, 27/538-606, WAM. Laverton, 18.ii.1924 (B. Warren) 2♀, 24/53-4, WAM; 4.iii.1924 (B. Warren) 3♂, 13♀, 24/120, 24/130, 24/138, 24/121-9, 24/131-4, WAM; 4.iv.1924 (B. Warren) 1♀, 24/287, WAM; iv.1925 (P.C. Warren) 1♂, 1♀, 25/374, 25/376, WAM;

5.x.1926 (A.J. Warren) 4♀, 26/656-9, WAM; 10.x.1963 (M. Gillett) 1♀, 66/292, WAM; 124 km NE of, 28.vi.1969 (D.D. Giuliani) 1♀, 69/1996, WAM; 377 km NE of, 30.vi.1969 (D.D. Giuliani) 2♂, 1♀, 69/2003-5, WAM. Lawlers (W.O. Mansbridge) 98.4.18.1, 1♂, BMNH (holotype of *U. hoplurus*); 13.ii.1902 (G. Shipton) 1♂, K13239, AM; iv.1924 (H.L. Plant) 3♀, 24/244-5, 24/342, WAM. Learmonth, Wapet Creek, 13.iv.1969 (N. Cross) 2♂, 69/1963-4, WAM. Marloo, 30.i.1968 (L.E. Koch) 1♀, 68/900, WAM; 31.i.1968 (A.M. Douglas) 1♀, 68/894, WAM; 31.i.1968 (L.E. Koch) 1♀, 68/898, WAM; 1.ii.1968 (L.E. Koch) 1♂, 68/899, WAM; 1.ii.1968 (L.E. Koch & A.M. Douglas) 3♂, 68/895-7, WAM; 2.ii.1968 (L.E. Koch & A.M. Douglas) 21♂, 37♀, 68/903-5, 68/912-20, 68/935-8, 68/948-9, 68/956-8, 68/901-2, 68/906-11, 68/921-34, 68/939-47, 68/950-55, WAM. Meekatharra, iii.1968 (J. Sears) 5♂, 68/959-63, WAM. Menzies, vii.1925 (Wilsmore) 1♀, 25/500, WAM. Mileura, 25.ii.1936 (G.H. Walsh) 1♂, 36/669, WAM. Minilya, 108 km N of, 4.ii.1970 (R.B. Humphries, J.P. Ross & J.G. Gilbert) 1♀, 70/315, WAM. Minnie Creek, 3.iii.1972 (R. Prince) 2♂, 73/664-5, WAM. Moogooree, Mimabalya Well, viii.1969 (H.R. Thompson) 1♀, 69/1965, WAM. Morawa, iii.1970 (Burrows) 1♂, 70/303, WAM. Mundiwindi, ii.1971 (G. McGowan) 1♂, 71/699, WAM. Murchison River, i.1892 (R. Helms) 2♂, SAM. Mt James, 23.ii.1929 (A. McColl) 1♂, 1♀, 29/246, 29/245, WAM. Mt Magnet, 21.iv.1925 (J. Tippett) 2♂, 25/328-9, WAM; 64 km W of, 29.iv.1970 (L.E. Koch & A.M. Douglas) 1♀, 70/316, WAM; 80 km S of, 12.x.1969 (D.D. Giuliani) 1♀, 69/2058, WAM. Mt Newman, 8.xi.1968 (C. Snell) 1♀, 69/14, WAM. Mt Remarkable, 15-17.vi.1969 (L.E. Koch & D.D. Giuliani) 3♂, 11♀, 69/1083-96, WAM. Mt Weld, 25.ii.1947 (G.S. Macpherson) 1♀, 47/145, WAM. Noongaar, iii.1929 (W. Grundy) 1♀, 29/289, WAM. Nullagine, 22.iii.1963 (Angel) 1♂, 68/875, WAM. 'N.W. Australia', 1♀, NM; (W.D. Dodd) 1♂, SAM. Onslow, 80 km S of, 19.v.1967 (W. Allen & P. Lake) 1♀, 68/880, WAM. Paroo, 14.iv.1924 (R. Grant) 1♀, 24/339, WAM. Pender Bay, 24.v.1929 (J. Hamilton) 2♀, 29/442, 29/445, WAM; v.1929 (J. Hamilton) 3♂, 3♀, 29/446-8, 29/441, 39/443-4, WAM. (?) Perth, 14.iii.1902 (H.P. Richards) K13448, 1♂, AM. Point Coulomb, vi.1971 (W.H. Butler) 2♀, 73/667-8, WAM. Port Hedland, 3.iii.1968 (J.G.E. Schoneveld) 1♂, 68/883, WAM; 97 km S of, 2.x.1969 (D.D. Giuliani) 2♀, 69/2056-7, WAM. Sandstone, 9.ii.1969 (J. Kraus) 5♂, 68/305-9, WAM. Southern Cross, 12.v.1924 (W.E. Richards) 1♀, 24/434, WAM. Strathmore Parkers Road (?), 19.v.1926 (W. Henderson) 1♂, 26/275, WAM. Talawana (old Stn) 5.vi.1971 (J. Dell) 1♂, 73/673, WAM. Talawana, i.1971 (A.M. Douglas) 1♂, 1♀, 71/695-6, WAM. Tambrey, 22.vii.1929 (O. Cusack) 1♀, 29/1027, WAM; 16.i.1933, 1♂, 1♀, 33/44-5, WAM. Warburton Range, 16.x.1962 (M. de Graaf) 1♂, 68/882, WAM; vii.1963 (M. de Graaf) 1♀, 68/788, WAM; 20.x.1963 (M. de Graaf) 1♀, 68/787, WAM; 1963 (M. de Graaf) 1♀, 68/791, WAM; 1.iv.1967 (M. de Graaf) 2♀, 68/789-90, WAM; 1967 to 1968 (J.E. Carr) 1♂, 68/881, WAM. Warburton Mission, 161 km E of, 4.vii.1969 (D.D. Giuliani) 1♂, 69/2012,

WAM. 'Western Australia', 1898 (R.W. Hemlin) 1♀, K7855, AM. Westonia, 1.ii.1930 (M.L. Wilkins) 1♀, 30/102, WAM. Wiluna, 10.vii.1926 (C. Tothill) 1♀, 26/546, WAM; 18.v.1970 (S. Armstrong) 6♂, 14♀, 70/317-36, WAM. Wittenoom (head of Hancock Gorge) 12.viii.1971 (B. Pescod) 1♀, 73/670, WAM. Woogalong, 5.viii.1931 (L.C. McPherson) 1♂, 1♀, 31/785-6, WAM. Wooling Stn, 267 km N of Southern Cross, 14.i.1931, 1♂, K63103, AM. Yalgoo, 6 km S of, 30.i.1968 (L.E. Koch & A.M. Douglas) 2♂, 2♀, 68/889-92, WAM; 16 km S of, 22.vii.1964 (P.J. Fuller) 1♀, 66/256, WAM. Yallalong, 30.v.1924 (Sandie) 1♂, 24/400, WAM. Yamarna, new HS, 28.i.1967 (W.D.L. Ride & A. Baynes) 1♂, 1♀, 68/878-9, WAM. Yinnietharra Stn, ix.1971 (P. Bridge & M. Thomas) 1♀, 73/671, WAM.

#### SOUTH AUSTRALIA

Kychering Soak, 1♂, NM. Musgrave Ranges, 1♀, SAM. Oodnadatta, 1♀, SAM. Wilpena Pound, 22.viii.1970 (W.H. Butler & W.D.L. Ride) 1♂, 73/672, WAM.

#### NORTHERN TERRITORY

Aileron Dam area, about 129 km N of Alice Springs, 27.ii.1964 (D.R. Stephens) 1♂ (dry, carded) NTMB80, NT. Alice Springs, vi.1894 (R.W. Mack) 4♀, SAM; 1964 (A.D. Smith) 1♀, 69/555, WAM; 6.iv.1970 (M. Harpman) NTMB286, 1♂, NT; 1♂, 2♀, SAM. 6 km S of, ii.1969 (N. Harmer) 1♀, NTMB51, NT; 8 km S of, 1.v.1970 (D.J. Nelson) NTMB323, 1♀, NT; 10 km S of, 10.ii.1960 (J. Bergengren) 1♀, NTMB42, NT; 10 km S of, 18.ix.1962 (I. Mitchell) 1♀, NTMB44, NT; 10 km S of, i.1968 (D. Nelson) 1♂, NTMB45, NT; 29.xii.1970 (D.J. Nelson) 1♀, NTMB734, NT. Barrow Creek, v.1891 (McKay) 1♂, SAM; 1902 (Spencer & Gillen Expd.) 6♂, 21♀, NM; vi.1943 (W.A. McKenzie) 1♀, NM. 'Central Australia', 1♂, 1♀, SAM. Desert Block HS, 23°04'S, 133°01'E, 10.i.1965 (J. Hayes) NTMB38, NT. Frewena Roadhouse, i.1964 (A. Fitzgerald) 1♀, AM. George Gills Range, Reedy Creek, Tanami Desert Expd., 1965 (Cogger) 2♀, AM. Hermannsburg, around (H.J. Hillier) 1910.5.30.2-3, 3♂, 1 juvenile, BMNH (syntypes of *U. hillieri*). Honeymoon Gap, 2 km N of, near Alice Springs, 9.i.1964 (D.R. Stephens) 1♂ (dry, carded) NTMB81. James Range, Illumurta, vi.1897 (E.C. Cowle) (pres. W.B. Spencer) 23.vi.1916, 1♂, 4♀, NM. Kulgera (B. Greenwood) 1♀, 68/886, WAM. Mt Conway, 22.iv.1952, 2♀, 38, AM. Mt Olga, 80 km W of, 16.vii.1969 (D.D. Giuliani) 1♂, 69/2022, WAM. Palmer River (D. Borner) 1♂, AM. Simpson Desert, edge of, 23°49'S, 135°33'E, 26.iv.1965 (H.J. Disney) 1♀, AM. Todd River Stn (113 km S of Alice Springs) 16.iv.1969 (K. Slater) 1♀, 69/1100, WAM.

#### Remarks

Over its range of distribution, *U. hoplurus* is a highly variable species especially in trichobothrial numbers. *U. hoplurus* is closely allied to *U.*

*macrurus* including in paraxial characters. However, there are marked differences in the structure of the comb area of the external lobe of the paraxial organ in these two species. *U. hoplurus* also appears close to *U. yaschenkoii* especially when it occasionally tends towards having the terminal claws of its legs unequal and its movable finger with teeth in one row. The hands of the female specimens from Mt Conway, N.T., are atypical in shape characters.

The locality label of one specimen (collected in 1902, in Australian Museum, Sydney) is given as Perth, W.A., but *U. hoplurus* is not known to occur at or near Perth and the locality is not mapped.

*U. hoplurus* lives in deep spiral burrows under branches on the ground or in open ground. The scorpions rest under the first curve near the surface after rain. At Gabyon, W.A., in January 1968, burrows were as close as 1 m apart. (Descriptions of the burrows and their disposition in the field in relation to environmental features have been recorded—Koch 1978.)

Males have been found roaming on the ground at night in early February. The male from Aileron Dam area, N.T., was caught in the burrow of the lizard *Egernia*. The lizard, *Varanus gouldi* Gray, is a predator (Koch 1970).

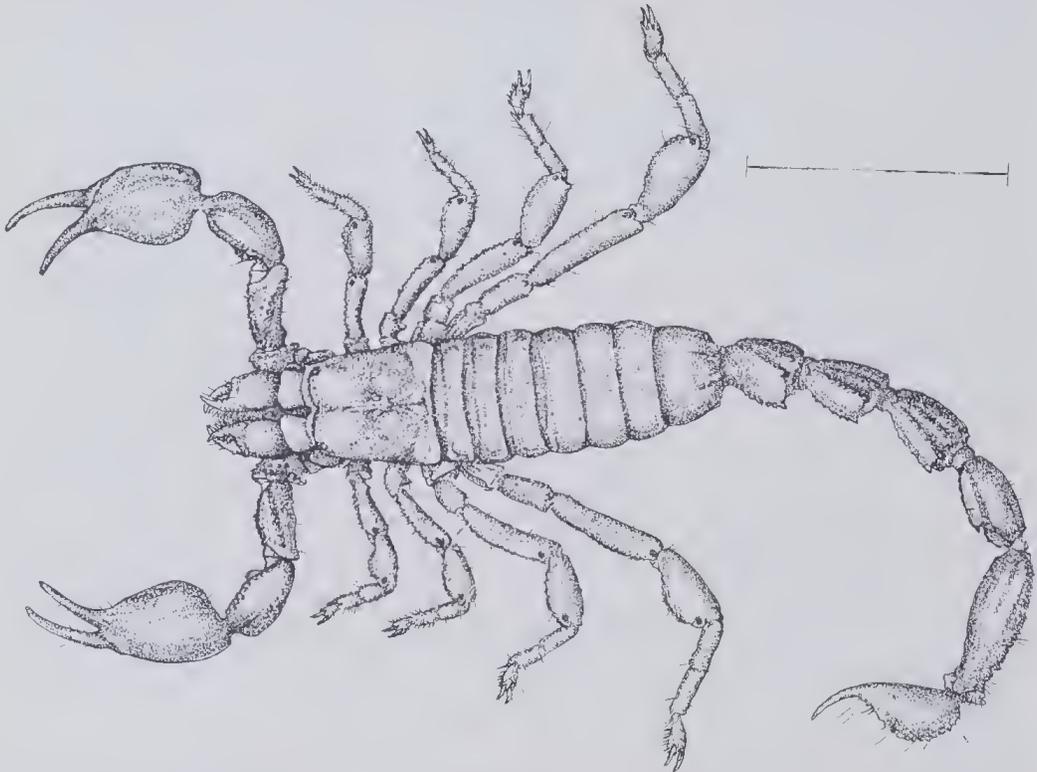


Fig. 122: Dorsal view of a representative male specimen of the *Urodacus armatus* species-group: *U. novaehollandiae* (68/530; Dianella, W.A.) (CL 9.0 mm). (Scale line 2 cm).

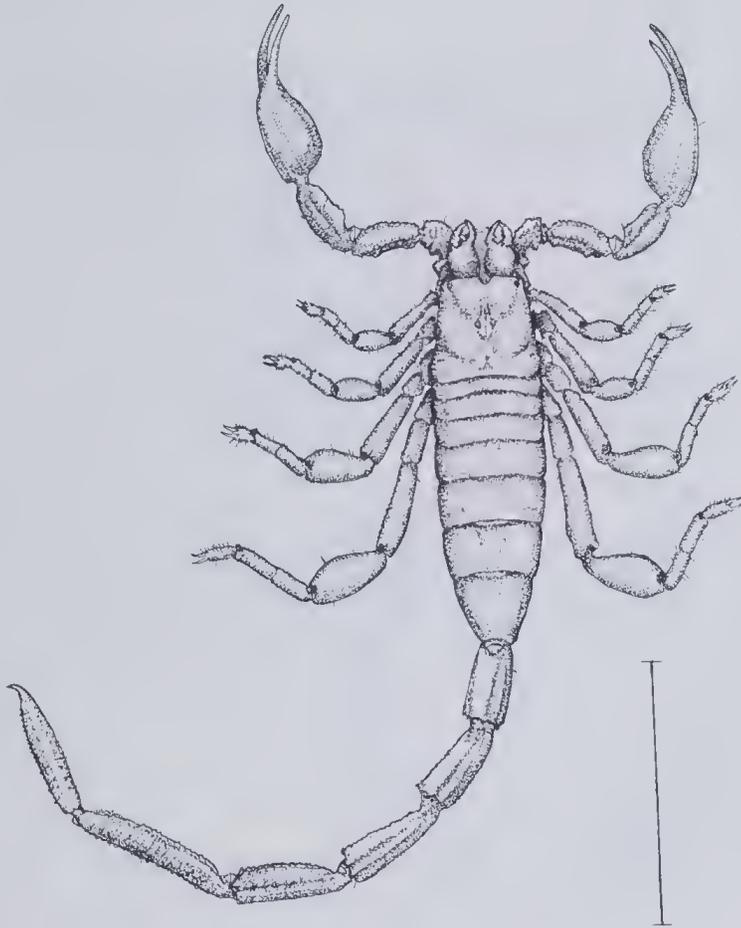


Fig. 123: Dorsal view of a representative male specimen of the *Urodacus megamastigus* species-group: *U. megamastigus* (66/368; holotype; Mundiwindi, W.A.) (CL 7.7 mm). (Scale line 2 cm).

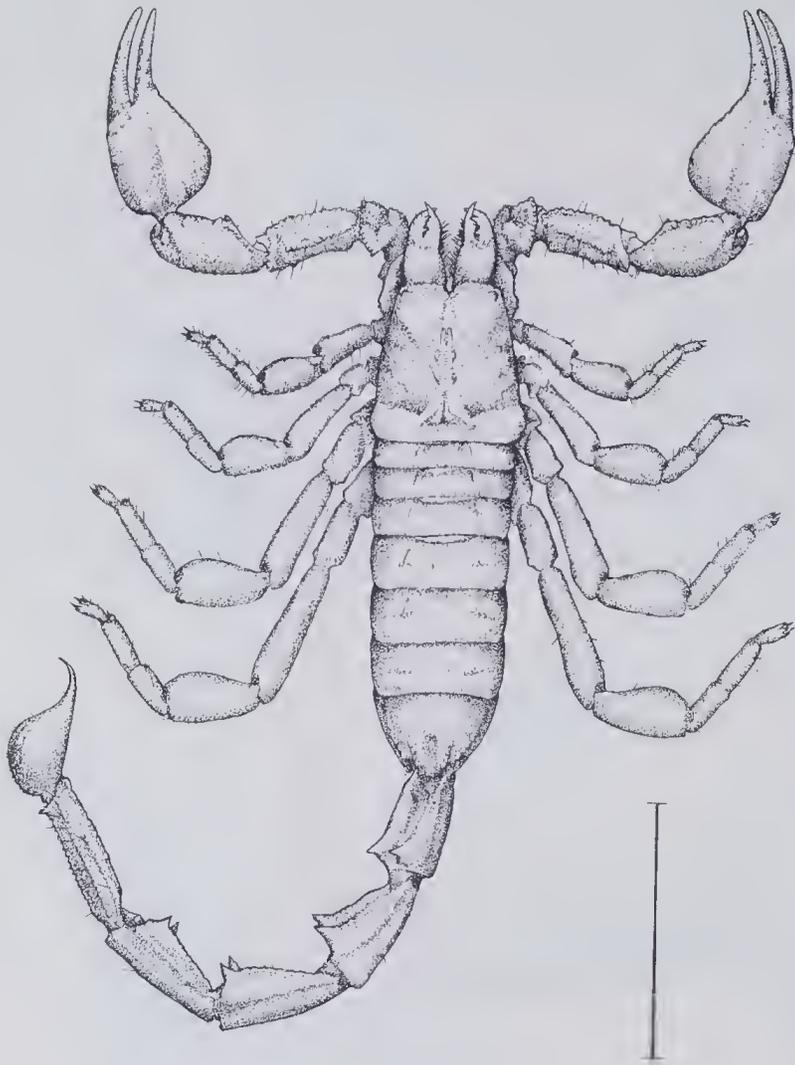


Fig. 124: Dorsal view of a representative male specimen of the *Urodacus hoplurus* species-group: *U. hoplurus* (27/609; Landor Stn, W.A.) (CL 11.3 mm). (Scale line 2 cm).

*Urodacus giulianii* sp. n.

(Figs 30, 59, Map 21)

**Holotype**

♀. South Australia: Mt Davies Camp, 26°11'S, 129°08'E, 8 km NW of, 7.vii.1969 (D.D. Giuliani) 69/2013, WAM.

**Paratypes**

3♂, 7♀. Western Australia: Laverton, 373 km NE of, 30.iv.1969 (D.D. Giuliani) 1♂, 1♀, 69/2000-1, WAM; 477 km NE of, 1.vii.1969 (D.D. Giuliani) 1♀, 69/2006, WAM. Warburton Mission, 98 km E of, 4.vii.1969 (D.D. Giuliani) 2♂, 69/2010-1, WAM. Northern Territory: Angas Downs, 3.ix.1947 (Bechervaise Expd.) 2♀, NM. Haasts Bluff, viii.1947 (C.W. Brazenor) 2♀, NM. Tanami, 4.viii.1969 (D.D. Giuliani) 1♀, 69/1612, WAM.

**Range (Map 21)**

Western Australia, furthest west at 373 km NE of Laverton. South Australia, at Mt Davies Camp. Northern Territory, furthest east at Angas Downs, furthest north at Tanami.

**Measurements (mm)**

♀. Holotype. Total length 55, of tail 24; carapace, length 6.6, width 6.0; tail segments one to five (in that order), length 2.8, 3.4, 3.3, 3.5, 4.8, width 2.5, 2.3, 2.1, 1.9, 2.0, height 2.0, 2.0, 2.0, 1.8, 1.6; length of vesicle and aculeus 5.7; width of vesicle 1.9; length of humerus 4.4; brachium, length 5.7, width 2.2; hand, length 5.3, width of hand surface 4.0, height 2.9; length of hand and fixed finger 10.9; length of movable finger 6.3; length of pectine 3.8.

Adult size: No adults available among material examined.

**Diagnosis**

Distinguished from other *Urodacus* species by the following combination of characters: small size, dark coloration and short, squat tail segments.

**Description**

Colour orangish brown to dark brown; cheliceral bases, terminal leg segments and ventral surface lighter.

Carapace with frontal notch wide and deep. Frontal lobes practically truncate. Interocular areas smooth. Lateral and posterior two-thirds of carapace partly with fine granules. Median sulcus uninterrupted. Triangular depression moderately deep. Sides of triangular depression moderately retracted.

Chelicerae (Fig. 30) with secondary serrations. Fixed jaw with secondary serrations at distal base and proximal base of subdistal tooth; median tooth

larger than basal tooth. Movable jaw with about six secondary serrations at base of distal internal tooth; subdistal tooth small; median tooth wide.

Tergites of first six abdominal segments finely granulate. Weak granulate line along posterior edge. Median keel weak. Tergite of last abdominal segment partly with fine granules. Median and lateral keels granulate; the median keel about half length of segment, the lateral keels about two-thirds length of segment.

Tail short, squat. First four tail segments (Fig. 59) with intercarinal surfaces practically smooth. Keels weakly denticulate. Terminal tooth slightly upraised in male, not upraised in female. Accessory keel present in first segment, absent in other segments. Fifth tail segment moderately long. Intercarinal surfaces granulate. Dorsolateral and accessory keels denticulate. Ventrolateral and ventromedian keels strongly denticulate. Ventromedian keel bifurcating in distal one-third of segment.

Vesicle small, smooth with coarse granules ventrally.

Aculeus moderately long, little curved.

Humerus dorsally with scattered granules. Dorsally bounded at anterior and posterior edges by an irregular row of spaced coarse denticles.

Brachium dorsally with granules in a reticulation. Posteroventral keel evident, moderately strong. Dorsal and ventral edges of anterior surface irregularly defined by granules. Ventral group, *v*, with 12-16 trichobothria. Posterior group, *p*, with 34-50 trichobothria.

Hand moderately round to moderately flat. Dorsal intercarinal surface with granules in a reticulation. Dorsal keels weakly granulate. Ventral keels smooth. Ventral group, *V*, with 15-22 trichobothria. Median group, *M*, of posterior surface with 11-17 trichobothria.

Fingers moderately long. Along edge of movable finger usually 1 row of granules, sometimes 2 rows along base, reducing to 1 row from about half finger length from base. Around 8-12 rows of transverse accessory teeth, mainly in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-6 prongs. Terminal claws of practically same length. Ventral surface of tarsomere II of fourth pair of legs with 10-11 inner, and 8 outer prongs.

Pectinal teeth 18-24 (Mean 20.8) in male; 17-27 (Mean 21.8) in female.

Paraxial organ. No adult males available.

## Remarks

All the available specimens are small; the holotype is the largest. There is very little variation among the material examined.

The burrows are deep, tortuously spiralling, and in open ground.

*Urodacus carinatus* Hirst, status n.

(Figs 31, 60, 106, 107, Map 22)

*Urodacus hoplurus carinatus* Hirst, 1911: 407; Takashima, 1945: 88 [Holotype examined.]

Range (Map 22)

Northern Territory, around Hermannsburg and at Haasts Bluff.

Measurements (mm)

♂. Holotype. Total length 77, of tail 43; carapace, length 9.0, width 9.4; tail segments one to five (in that order), length 4.9, 6.0, 6.5, 7.0, 9.2, width 4.0, 4.0, 4.0, 3.5, 3.6, height 3.5, 3.5, 3.5, 3.2, 3.0; length of vesicle and aculeus 10.0; width of vesicle 3.8; length of humerus 6.5; brachium, length 7.5, width 3.0; hand, length 6.2, width of hand surface 4.9, height 3.5; length of hand and fixed finger 13.8; length of movable finger 8.5; length of pectine 8.2.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=1)	10.2	10.9	7.6	5.6	4.2	15.3	9.7	7.6	4.1
Female (n=3)									
Min.	10.4	11.5	7.0	5.7	4.7	15.9	9.7	5.6	3.6
Max.	11.1	12.3	7.5	6.2	4.7	16.1	10.1	5.7	3.7
Mean	10.7	11.8	7.2	5.9	4.7	16.0	10.0	5.7	3.6

Diagnosis

Distinguished from *U. hoplurus* by the light reddish to light yellowish coloration, and shape of dorsal spines of tail segments.

Description

Colour light reddish brown to light yellowish orange; carapace, arms, hands, fingers, and tail light reddish orange; legs, chelicerae and sternites light yellow.

Carapace with frontal notch moderate to deep. Frontal lobes truncate and almost square. Interocular areas rugose and with large granules, sometimes smooth. Lateral and posterior two-thirds of carapace smooth to with some scattered granules mainly small. Median sulcus slightly interrupted to uninterrupted. Triangular depression moderately deep. Sides of triangular depression slightly retracted.

Chelicerae (Fig. 31) with some, generally few, secondary serrations; teeth sometimes badly worn. Fixed jaw usually with four well-defined secondary serrations at distal base of distal external tooth; sub-basal tooth with a large wide tooth at its proximal base; usually two secondary serrations at distal base of median tooth. Movable jaw with distal external tooth point-

ing towards tip of distal internal tooth; subdistal tooth small; median tooth with a tendency for some small secondary serrations along distal edge, and with an enlarged tooth at its proximal base.

Tergites of first six abdominal segments finely granulate, granules larger towards posterior edge and forming a faint posterior line; a faint median keel present. Tergite of last abdominal segment finely granulate with larger granules in posterior part. Both pairs of longitudinal keels granulate; the median keels about half length of segment, lateral keels about three-fourths length of segment.

Tail long in male, moderate in female. First four tail segments (Fig. 60) with intercarinal surfaces smooth, rarely with a few small granules mainly in female. Dorsal keels of denticles (which are large and rounded in male), the last few posterior denticles forming a large triangular tooth, which is wide and rather blunt at apex, in male, but not in female. Dorsolateral keels denticulate in male, less denticulate to smooth in female. Ventrolateral and ventromedian keels smooth in first three tail segments, mainly smooth in fourth. Accessory keel present in first tail segment, practically absent in other segments. Fifth tail segment with lateral intercarinal surfaces smooth, ventral intercarinal surfaces denticulate. Dorsal and dorsolateral keels denticulate, ventrolateral keel and ventromedian keel strongly denticulate. Ventromedian keel bifurcating distally from about three-fifths the length of segment.

Vesicle large (especially in male), dorsally mainly smooth, laterally and ventrally with large granules.

Aculeus short to moderately short, moderately curved.

Humerus dorsally with scattered granules and bounded at anterior and posterior edges by a row of large dark denticles.

Brachium dorsally with granules, of various sizes, especially towards anterior edge. Posteroventral keel evident, weak to strong. Ventral group, *v*, with 11-16 trichobothria. Posterior group, *p*, with 30-47 (usually 32 to 38) trichobothria.

Hand moderately small, moderately flat and narrow. Dorsal surface with a reticulation of fine granules. Anterodorsal keel made up of an irregular band of small to large dark denticles, much less evident in female. Anterior surface smooth with scattered granules. Ventral group, *V*, with 16-20 trichobothria. Median group, *M*, of posterior surface with 9 to 16 (usually 15, 16) trichobothria.

Fingers moderately long. Along edge of movable finger 1 or 2 row(s) of granules at base, and 1 row in middle and at apex. Usually about 8 rows of transverse accessory teeth, mainly in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 6 or 7, usually

6, prongs. Terminal claws of each leg slightly unequal in length. Ventral surface of tarsomere II of fourth pair of legs with 9-12 inner, and 4-7 outer prongs (with 4-6, usually 4, on outer flap).

Pectinal teeth 21-23 (Mean 22.0) in male; 16-18 (Mean 17.2) in female.

Paraxial organ (Figs 106, 107) with lamina broad, tending to be moderately round at apex; inner lobe moderately long, not very erect, tapering to form pointed apex; median lobe shorter than inner lobe and external lobe and tapering to sharp point; external lobe longer than median lobe but not as long as inner lobe, with small comb of about eight little serrations at apex; toquilla weakly defined; dorsal vinculum and ventral vinculum narrow and curved; basal lobe widening towards apex and strongly curved upwards towards the area at base of median lobe; proximal lobes seem to be absent.

Material examined

2♂, 8♀ (Map 22).

#### NORTHERN TERRITORY

Haasts Bluff, viii.1947 (C.W. Brazenor) 1♂, 7♀, NM, 1♀, 75/22, WAM. Hermannsburg (H.J. Hillier) 1910.5.30.1, 1♂, BMNH (Holotype of *U. hoplurus carinatus*).

#### Remarks

In its genitalia, *U. carinatus* is closest to *U. excellens*, but it has the external lobe of the paraxial organ with less well developed comb-structures. The chelicerae are as in *U. excellens* and *U. hoplurus*. Hirst (1911) says that ventral group, V, of hand of holotype has 11 trichobothria, but this is incorrect; perhaps his number is a misprint for 17. Hirst (1911) says that probably due to the immaturity of the specimen the hands of the holotype are narrower than in *U. hoplurus*; however, I have been able to examine adults and they all have narrow hands.

*Urodacus macrurus* Pocock  
(Figs 32, 61, 108, 109, Map 23)

*Urodacus macrurus* Pocock, 1899: 414; Kraepelin, 1908: 94; Kraepelin, 1916: 36; Takashima, 1945: 89. [Holotype examined.]

Range (Map 23)

Queensland, central; furthest south-west at Windorah, furthest north-east at Almaden, furthest west at Carnarvon Range, furthest south at 16 km W of Nebine Creek.

## Measurements (mm)

♂. Holotype. Total length 94, of tail 62; carapace, length 10.0, width 10.0; tail segments one to five (in that order), length 8.0, 8.5, 9.1, 10.0, 14.0, width 4.5, 4.4, 4.0, 3.8, 3.2, height 3.4, 3.2, 3.5, 3.5, 3.0; length of vesicle and aculeus 11.0; width of vesicle 4.0; length of humerus 8.0; brachium, length 9.0, width 3.4; hand, length 9.0, width of hand surface 8.5, height 5.9; length of hand and fixed finger 17.6; length of movable finger 10.8; length of pectine 9.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=12)									
Min.	8.7	9.1	7.4	6.2	4.8	15.3	9.0	6.2	3.3
Max.	12.4	12.3	10.4	7.9	6.0	20.9	12.3	11.1	4.4
Mean	10.4	10.7	8.9	7.1	5.4	17.8	10.6	8.6	3.8
SD	1.26	1.06	0.88	0.56	0.40	1.79	1.04	1.54	0.42
Female (n=2)									
Min.	10.7	12.1	8.4	7.7	5.9	17.6	11.2	5.8	3.5
Max.	12.8	12.3	10.0	8.2	6.2	20.8	12.6	7.5	3.7
Mean	11.1	11.6	9.0	7.7	5.8	18.7	11.5	7.1	3.7

## Diagnosis

Distinguished from *U. hoplurus* by lighter colour, and smaller, less rounded hand.

## Description

Colour bright clay-yellow to reddish brown; carapace deep reddish brown; tergites dark grey-brown; arms, hands, tail, and vesicle paler yellowish red; legs yellowish; fingers reddish dark brown.

Carapace with frontal notch moderate to deep. Frontal lobes truncate. Interocular areas smooth and shiny. Lateral and posterior two-thirds of carapace with scattered granules to finely granulate or sometimes smooth. Median sulcus uninterrupted. Triangular depression deep. Sides of triangular depression slightly retracted.

Chelicerae (Fig. 32) with many secondary serrations. Fixed jaw with weak secondary serrations at base of distal tooth; subdistal tooth large, notch at proximal base. Movable jaw with median tooth large and blunt, a secondary serration and notch at distal base of basal tooth and a secondary serration near proximal base of basal tooth.

Tergites of first six abdominal segments in females partly smooth, sometimes totally smooth; in males closely granulate with a faint suggestion of a granulate line along posterior edge. Tergite of last abdominal segment with coarse granules especially near posterior edge. Keels denticulate; lateral keels about two-thirds to three-fourths length of segment, median keels about half length of segment.

Tail segments moderately long. First four tail segments (Fig. 61) with intercarinal surfaces practically smooth. Dorsal and dorsolateral keels of widely spaced large denticles; dorsal keels gradually elevated posteriorly, the terminal tooth in males large and back-curved (i.e. towards carapace), in females less developed. Ventrolateral and ventromedian keels smooth. Fifth tail segment moderately long. Dorsal intercarinal surface smooth; lateral and ventral intercarinal surface mainly smooth with some scattered granules. Dorsolateral keels denticulate, ventrolateral and ventromedian keels strongly denticulate. Ventromedian keel bifurcating distally after about half to three-fourths length.

Vesicle large, smooth dorsally and laterally, and partly ventrally, with scattered granules especially near base.

Aculeus moderately long, usually little curved.

Humerus dorsally with sparsely scattered fine and coarse granules; anterodorsal and posterodorsal edges with coarse dark dense denticles.

Brachium dorsally with a reticulation of fine granules, sometimes smooth. Dorsal, posterior and ventral surfaces tend to be rounded. Posteroventral keel evident, sometimes weak. Ventral group, *v*, with 9-15 trichobothria. Posterior group, *p*, with 20-41 trichobothria.

Hand moderately rounded. Dorsal surface ranging from smooth to with a reticulation of fine granules. Anterodorsal keel poorly defined by a row of irregular dark granules which are sometimes absent. Ventral group, *V*, with 11-21 trichobothria. Median group, *M*, of posterior surface with 5-14 (usually 8-14, rarely 5) trichobothria.

Fingers moderately short. Along edge of movable finger 2-3 rows (rarely 1) of granules at base and middle, reducing to 1 row towards apex. 6-8, often 7, rows of transverse accessory teeth in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 (usually 7) prongs. Terminal claws of same length (sometimes slightly unequal). Ventral surface of tarsus of fourth pair of legs with 9-12 (rarely 13) inner, and 7-8 (rarely 9) outer prongs (sometimes with 5 on distal flap separated from the others).

Pectinal teeth 12-20 (Mean 17.5, SD 1.8) in male; 11-15 (Mean 13.5, SD 0.80) in female.

Paraxial organ (Figs 108, 109) with lamina wide, moderately large, weakly S-shaped, blunt and almost square at apex; inner lobe extremely elongate, narrow, gradually tapering to rounded apex (blunt point at Barcaldine); median lobe noticeably shorter than inner lobe, about two-thirds length of inner lobe, varying from abruptly tapering and with a sharply curved point at apex (e.g. at Barcaldine) to a wide blunt and flattened plate at apex (e.g. at Muckadilla); external lobe about same length as median lobe (longer at Bar-

caldine); apex of external lobe with broad toothed comb of serrations, which vary from 5-15 (e.g. 6-15 at Barcaldine) (hooked at apex at Milo); toca small, open and thickly defined around admesial edge; ventral vinculum short, abruptly pointed; dorsal vinculum long, very narrow; juxtum long, wide, wavy; basal lobe short narrow, somewhat pointed at apex; apotheca with base weakly sclerotized; diaphragma weakly sclerotized.

#### Material examined

33♂, 19♀ (Map 23).

#### QUEENSLAND

Almaden, Chillagoe Dist., x.1926 (W.D. Campbell) 1♀, K55311, AM; i.1928 (W.D. Campbell) 1♂, K57492, AM. Barcaldine, 14.iv.1916 (Moran) 11♂, QM, 1♂, 75/66, WAM; (Moran) 6♂, QM; 1.i.1945 (Moran) 1♂, 45/2, WAM; (Moran) 1♂, 66/318, WAM; 11.i.1954 (R. Scott) 5♀, QM, 1♀, 75/67, WAM. Carnarvon Range, iii.1944 (W.Geary) 2♂, AM. Clermont, 3.vii.1937 (C. Barnard) 1♂, 3♀, W737, QM. Darriveen HS, 8.i.1954 (D.H. Johnson) 2♀, QM. Delta Stn (near Blackall) (K. Niall) 1♂, SAM. Einasleigh, 1945 (M. Shaw) 1♂, W1629, QM. Hughenden, 1♂, K35315, AM. Injune, 12.v.1942 (N.L. Reilly) 1♂, W1492, QM. Isisford, 5.iv.1937 (R. Robertson) 1♂, W714, QM. Jericho, 26.iv.1935 (R.B. Tucker) 1♀, W556, QM. Milo HS, 24.iii.1952 (R.N. Randall) 1♂, QM. Muckadilla, 27.iii.1939 (B.E. Rayner) 1♂, W922, QM. Muldiva, 7.ii.1898 (pres. Broom) 1898.11.7.1, 1♂, BMNH (holotype of *U. macrurus*). Nebine Creek, 16 km W of (145 km S of Moreven) viii.1940 (C.H.J. Schmidt) 1♀, AM. Telemon Stn, 26.v.1935 (J.E. Young) 4♀, W567, QM. Windorah, 3 km W of, 10.iv.1971 (G.B. Monteith) 1♀, UQ. Winton (T.W. Roberts) 1♂, W300, QM.

#### Remarks

In some specimens, e.g. those from Milo, the comb area of the external lobe of the paraxial organ tends towards the hook-shaped structure of *U. excellens*. *U. macrurus* is closely similar to *U. hoplurus*. *U. macrurus* resembles *U. spinatus* in the length of the fifth tail segment.

I question the authenticity of the locality record, Cairns, given by Kraepelin (1916); it does not fit in the distribution pattern of any *Urodacus* species.

*Urodacus excellens* Pocock  
(Figs 33, 62, 110, 111, Map 24)

*Urodacus excellens* Pocock, 1888: 170; Pocock, 1898: 62; Kraepelin, 1899: 104; Kraepelin, 1908: 91, 95; Kraepelin, 1916: 39; Takashima, 1945: 88. [Holotype examined.]

*Iodacus darwinii* Pocock, 1891: 245. [Holotype examined.] *Syn. n.*

*Urodacus darwinii* (Pocock) Kraepelin, 1894: 23; Pocock, 1898: 61; Kraepelin, 1899: 105; Kraepelin, 1908: 92; Takashima, 1945: 89.

Range (Map 24)

Northern Territory, far northern; south to Katherine; also Groote Eylandt.

#### Measurements (mm)

♀. Holotype. Total length 116, of tail 63; carapace, length 17.0, width 15.9; tail segments one to five (in that order), length 7.5, 8.4, 9.2, 9.2, 14.5, width 6.0, 5.7, 5.4, 5.0, 4.6, height 4.5, 4.5, 4.5, 4.2, 4.0; length of vesicle and aculeus 14.0; width of vesicle 4.9; length of humerus 12.0; brachium, length 14.0, width 5.5; hand, length 14.5, width of hand surface 11.5, height 9.3; length of hand and fixed finger 30.9; length of movable finger 19.0; length of pectine 9.5.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=4)									
Min.	9.3	9.4	8.2	6.1	4.6	16.9	9.9	8.2	3.1
Max.	12.8	12.3	10.6	8.0	6.6	22.3	14.0	11.8	4.1
Mean	11.7	11.4	9.8	7.4	5.9	20.7	12.6	10.7	3.7
Female (n=5)									
Min.	12.8	13.8	10.8	8.2	6.4	22.2	13.6	6.8	3.8
Max.	14.6	15.4	12.7	9.6	7.8	25.8	15.2	8.4	4.4
Mean	13.7	14.4	11.7	9.2	7.3	24.2	14.7	7.7	4.1
SD	0.77	0.62	0.76	0.58	0.57	1.37	0.63	0.61	0.22

#### Diagnosis

Distinguished from *U. spinatus* and *U. lowei* by the following combination of characters: small terminal spines of dorsal keels of tail segments; round hands; large vesicle. Some females are hard to distinguish from those of *U. hoplurus*. The frontal lobes of *U. excellens* are never narrow like those of *U. spinatus* in some localities.

#### Description

Colour clay-yellow to reddish brown; carapace deep reddish brown; tergites greyish brown to dark grey-brown; arms, hands, tail and vesicle paler yellowish red; legs yellowish, ventral surface yellowish to brown; aculeus, fingers and cheliceral jaws reddish brown to reddish dark brown; legs (mainly the patella) occasionally with a greyish tinge.

Carapace with frontal notch moderate to deep. Frontal lobes slightly rounded to truncate. Interocular areas smooth and shiny. Lateral and posterior two-thirds of carapace granulate, sometimes smooth. Median sulcus uninterrupted. Triangular depression deep. Sides of triangular depression slightly retracted to straight.

Chelicerae (Fig. 33) with many secondary serrations. Fixed jaw with large secondary serrations along distal external tooth near sub-basal tooth. Sub-basal tooth with serrations near proximal base, median tooth tending to be bilobed; usually with a serration along distal edge. Basal tooth bilobed. Movable jaw often with secondary serrations along edge near external distal tooth. Subdistal, median and basal teeth also usually with secondary serrations especially at proximal and distal bases of median tooth.

Tergites of first six abdominal segments in female largely smooth especially centrally, in male closely to finely granulate. Median keel weakly present, better defined in female. Tergite of last abdominal segment with scattered coarse granules, finely granulate anteriorly. Median and lateral pairs of keels of spaced denticles, extending about half length of segment, often weakly defined; the lateral keels sometimes about three-fourths to nearly whole length of segment.

Tail very long in male, moderately short in female. First four tail segments (Fig. 62) with intercarinal surfaces smooth. Keels of widely spaced moderate to large denticles; dorsal keels gradually elevated posteriorly, terminal spine small in both sexes, i.e. in male broadly triangular and short, in female undeveloped. Dorsolateral keels notched to denticulate. Ventrolateral and ventromedian keels smooth. Accessory keel in first segment present; in other segments if present weak and only apparent posteriorly. Fifth tail segment long, usually very long in male. Dorsal intercarinal surface smooth; lateral and ventral intercarinal surfaces mainly smooth. Dorsolateral keels denticulate. Ventrolateral and ventromedian keel strongly denticulate; ventromedian keel bifurcating distally at about half length of segment.

Vesicle usually large to very large, smooth dorsally and laterally, and partly smooth and shiny ventrally with scattered granules mainly confined to ventral surfaces especially near base.

Aculeus short to moderately short, usually little curved.

Humerus dorsally with scattered, fine and coarse granules, and bounded at anterior and posterior edges by an irregular row of large dark denticles.

Brachium with dorsal surface smooth. Dorsal, posterior and ventral surfaces tending to be rounded. Posteroventral keel evident, sometimes weak. Ventral group, *v*, with 10-15 trichobothria. Posterior group, *p*, with 28-36 trichobothria.

Hand moderately round. Dorsal intercarinal surface ranging from smooth to with fine granules in a reticulation. Keels evident, smooth, weak. Finger keel evident, dark, smooth. Anterodorsal keel poorly defined by an irregular row of dark denticles. Ventral group *V*, with 13-18 trichobothria. Median group, *M*, of posterior surface with 8-12 trichobothria.

Fingers long. Along edge of movable finger 2-3 rows (rarely 1) of granules

along base and middle, reducing to 1 row towards apex. Around 7 rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 prongs. Terminal claws of each leg often thin and long, of same length, sometimes practically of same length, i.e. slightly unequal. Ventral surface of tarsomere II of fourth pair of legs with 9-14 (rarely 14) inner, and 7-9 outer prongs (sometimes with 4-5 on distal flap separated from the others).

Pectinal teeth 15-21 (Mean 16.0) in male; 10-16 (Mean 12.9) in female.

Paraxial organ (Figs 110, 111) with lamina long, increasing in width from base to very wide at about one-third its length, thereafter narrowing abruptly then gradually to blunt apex; inner lobe extremely long, tapering to point; spiniform protuberance of inner lobe large and pointed away from apex of inner lobe; median lobe about half length of inner lobe; inner lobe abruptly narrowing into curved blunt apex; prong, fulcrum and fissure not evident; carina wide narrowing abruptly to apex; toca large, long and tending to be pointed at both ends; external lobe intermediate in length between that of inner lobe and median lobe; external lobe moderately wide curving to pointed apex; ventral vinculum elongate; dorsal vinculum poorly defined; juxtum narrow, long; basal lobe short; proximal lobe long (about five times as long as basal lobe) slightly curved.

#### Material examined

26♂, 26♀ (Map 24).

#### NORTHERN TERRITORY

Batchelor, 13.i.1960 (C.P. Miller) 1♂, UQ. Darwin, (Lords of the Admiralty, p.) (J.J. Walker) 1♀, 1891.6.23.2, BMNH (holotype of *I. darwinii*); i.1925 (O. Herbert) 13♂, 14♀, 69/556-79, 69/582-4, WAM; i.-ii.1944 (K. Nightingale) 2♂, 2♀, NM; 5.x.1951, 1♂, NM; (N. Ward) 1♀, AM; area, 1♂, NTMB158, NT; near, xii.1916 (G.F. Hill) 4♂, 1♀, MM; 1.vii.1917 (G.F. Hill) 1♂, NM; 35 km S of (along Stuart Highway) early xi.1968 (A.D. Smith) 1♂, 69/580, WAM. Douglas River Stn, x.1968, 1♂, NTMB50, NT. Groote Eylandt (D. Levitt) 2♀ and 28 young, AM. Katherine, 2.iii.1963 (T. Ronan) 1♂, 69/581, WAM. Koolpinyah, 1933 (C. Barrett) 1♀, NM. Noonamah, near Darwin, 1943 (R.J. Ramsden) 1♀, NM. Port Essington, 1♀ (dry, pinned) 44.57, BMNH (holotype of *U. excellens*). Rum Jungle, 19.ix.1953 (C.J. Bickerton) 1♀, QM. Yirrkala, 1966 (A.D. Smith) 1♀, 69/618, WAM.

#### Remarks

*U. excellens* is rather variable in paraxial organ features.

*Urodacus spinatus* Pocock  
(Figs 34, 63, 112, 113, Map 25)

*Urodacus spinatus* Pocock, 1902: 370; Kraepelin, 1908: 94; Kraepelin, 1916: 38; Hirst, 1911: 469; Takashima, 1945: 89. [Holotype examined.]

*Urodacus subarmatus* Pocock, 1902: 371; Kraepelin, 1908: 91, 94; Takashima, 1945: 89. [Holotype examined.] *Syn. n.*

*Urodacus simplex* Pocock, 1902: 372; Kraepelin, 1908: 93; Kraepelin, 1916: 35; Takashima, 1945: 89. [Holotype examined.] *Syn. n.*

#### Range (Map 25)

Queensland, far northern; furthest north at Cape York Peninsula, from Cape York south to Chester River.

#### Measurements (mm)

♂. Holotype. Total length 93, of tail 63 (not 68 as in Pocock); carapace, length 10.0, width 10.0; tail segments one to five (in that order), length 8.1, 9.0, 10.0, 10.1, 13.5, width 4.0, 3.3, 3.0, 3.0, 2.7, height 3.5, 4.0, 3.9, 3.5, 2.9; length of vesicle and aculeus 8.5; width of vesicle 3.5; length of humerus 9.0; brachium, length 9.0, width 4.0; hand, length 9.0, width of hand surface 6.5, height 4.4; length of hand and fixed finger 17.5; length of movable finger 10.9; length of pectine 8.0.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=1)	9.9	9.3	8.0	6.0	4.5	17.7	10.4	8.2	3.2
Female (n=4)									
Min.	10.2	10.2	8.5	6.8	5.3	17.5	10.3	5.3	3.2
Max.	12.0	12.0	9.8	7.7	6.3	20.5	12.7	6.7	3.7
Mean	11.3	11.1	9.2	7.4	6.0	19.1	11.6	6.0	3.4

#### Diagnosis

Distinguished from *U. macrurus* by the reddish light brown granulate finger keel.

#### Description

Colour light yellow-brown to reddish brown; tergites reddish light brown; hands, arms, and legs usually lighter and yellowish; keels of arms and hands, and fingers reddish light brown.

Carapace with frontal notch wide, moderately deep to deep. Frontal lobes truncate. Interocular areas smooth, rugose towards frontal edge. Lateral and posterior two-thirds of carapace with granules ranging from fine to coarse. Median sulcus slightly interrupted to uninterrupted. Triangular depression deep. Sides of triangular depression unretracted but sometimes slightly swollen inwards towards depression.

Chelicerae (Fig. 34) with secondary serrations. Fixed jaw with distal base of sub-basal tooth forming a right angle or obtuse angle. Movable jaw with subdistal tooth moderately large.

Tergites of first six abdominal segments finely granulate. Tergite of last abdominal segment granulate. Both pairs of longitudinal keels denticulate, about half to three-fourths length of segment.

Tail moderately long in male, short in female. First four tail segments (Fig. 63) with intercarinal surfaces smooth. Dorsal and dorsolateral keels of denticles; terminal tooth of dorsal keel in male greatly enlarged, upright and triangularly pointed, in female less developed. Accessory keel in first segment faint to strong; in second segment scarcely indicated and only towards posterior edge; in third and fourth segments not evident. Fifth tail segment in male long, in female moderately long. Intercarinal surfaces mainly smooth. Keels denticulate. Ventromedian and ventrolateral keels strongly denticulate. Ventromedian keel usually single and bifurcating distally from about two-thirds the length of segment, rarely double.

Vesicle small to moderate, rugose especially ventrally and towards base, mainly smooth dorsally.

Aculeus moderately short, moderately weakly curved.

Humerus with dorsal surface finely granulate, and bounded at anterior and posterior edges by large dark denticles.

Brachium with dorsal surface finely granulate. Posteroventral keel evident. Posterior surface smooth. Ventral group, *v*, with 10-13 trichobothria. Posterior group, *p*, with 22-27 trichobothria.

Hand rounded and narrow. Dorsal surface with a reticulation of fine granules. Anterodorsal edge with dark scattered denticles; posterodorsal edge mainly smooth. Finger keel finely granulate. Anterior surface with fine scattered granules to smooth; with a faint central keel. Ventral group, *V*, with 12-15 trichobothria. Median group, *M*, of posterior surface with 6-9 trichobothria.

Fingers long. Along edge of movable finger 3-4 rows of granules at base, reducing to 1 or 2 row(s) at apex. Around 6-8 rows of transverse accessory teeth, all positioned in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 (usually 6) prongs. Terminal claws of each leg of same length. Ventral surface of tarsomere II of fourth pair of legs with 9-12 (usually 12) inner, and 7-10 outer prongs.

Pectinal teeth 16-20 (Mean 17.9) in male; 11-17 (Mean 12.8) in female.

Paraxial organ (Figs 112, 113) with lamina long, increasing in width from base to very wide at about one-third its length, thereafter gradually tapering

to apex where it slightly widens and is blunt; inner lobe extremely long tapering to blunt point; spiniform protuberance of inner lobe weakly developed; median lobe about half length of inner lobe; median lobe wide, narrowing towards rounded apex; prong, fulcrum and fissure area small but sclerotized and complex; carina practically rounded at apex; toca usually moderately long, sometimes with small warty projections on outer side; external lobe about same length or slightly longer than median lobe; external lobe rounded at apex; ventral vinculum elongate; dorsal vinculum wide; juxtum wide; basal lobe short, rounded; proximal lobe moderate to large, curved, tapering to a point.

#### Material examined

7♂, 9♀ (Map 25).

#### QUEENSLAND

Blue Mountains, Cape York Peninsula, 14.xi.1945 (Wassell) 2♂, 3♀, UQ, 1♂, 1♀, 75/68-9, WAM. Cape York, 1♀ (dry, pinned) BMNH (holotype of *U. subarmatus*); 1♂ (dry, pinned) BMNH (holotype of *U. simplex*). 'Cape York Promontory', Old cat. 3D (H-10), 1♂, BMNH (holotype of *U. spinatus*). Chester River, Silver Plains, east coast of Cape York Pen., 4.xii.1961 (J.L. Wessell) 1♀ and 14 young, AM. Jardine River, Telegraph Line crossing, 16.vi.1969 (G.B. Monteith) 2♀, UQ. 'Queensland', 1961, 1♂, UQ; 1♀, UQ. Weipa, x.-xi.1961 (E. Gamberg) 1♂, 66/328, WAM.

#### Remarks

The immature specimens from Blue Mountains have tail segments that are relatively shorter than average and have smaller terminal spines. The specimen from Weipa has an atypical inner lobe of the paraxial organ in which the spiniform protuberance is only developed as a slight bulge.

Kraepelin (1916) records that the species (as *U. simplex*) has tortuous holes 46 cm deep in hard sandy soil. The Cape York (Telegraph Line crossing) specimens are from spiral burrows about 92 cm deep. The Blue Mountains specimens are from a sand and gravel ridge.

*Urodacus lowei* sp. n.

(Figs 35, 64, 114, 115, Map 26)

#### Holotype

♂. Western Australia: Lawley River and Mitchell River area, within 16 km of, 14° 58'S, 126° 02'E, 2.ix.1967 (W.R. Lowe) 69/620, WAM.

#### Paratypes

6♂, 9♀. Western Australia: Broome, 161 km ENE of, 11.viii.1969 (D.D. Giuliani) 1♂, 1♀, 69/2026-7, WAM. Dampier Downs, 3 km S of, 16.viii.1969

(D.D. Giuliani) 2♀, 69/2037-8, WAM; 64 km E of, 13.viii.1969 (D.D. Giuliani) 1♀, 69/2034, WAM. Kalumburu, 14.xii.1965 (W.H. Butler) 1♂, 69/616, WAM; 29.i.1966 (W.H. Butler) 1♂, 66/265, WAM. Lawley River (near Mitchell River, 48 (?) km from sea) x.1967 (W.R. Lowe) 1♂, 69/617, WAM. Lawley River and Mitchell River area (within 16 km of 14°58'S, 126°02'E) viii.1967 (W.R. Lowe) 1♂, 2♀, 69/621-3, WAM. Mitchell River flats, 48 km from sea, ix.1967 (W.R. Lowe) 1♀, 69/619, WAM. Mitchell River Stn, 1972 (L.A. Smith & R.E. Johnstone) 1♂, 73/774, WAM. Napier Broome Bay, 29.viii.1910 (G.F. Hill) 2♀, 10/3982-3, WAM.

### Range (Map 26)

Western Australia, north-western; furthest north at Napier Broome Bay, furthest south at Dampier Downs.

### Measurements (mm)

♂. Holotype. Total length 120, of tail 67; carapace, length 12.0, width 12.0; tail segments one to five (in that order), length 8.3, 9.4, 10.4, 10.7, 13.7, width 5.5, 4.5, 4.4, 4.3, 3.8, height, 4.1, 4.4, 4.1, 3.9, 3.2; length of vesicle and aculeus 12.4; width of vesicle 5.5; length of humerus 9.5; brachium, length 10.0, width 4.2; hand, length 9.8, width of hand surface 8.2, height 6.4; length of hand and fixed finger 21.9; length of movable finger 13.6; length of pectine 11.2.

Adult size:	CL	CW	LW	WHS	HH	HFF	MF	FTL	FTH
Male (n=4)									
Min.	9.4	9.1	7.2	5.6	4.4	16.1	10.1	8.5	2.4
Max.	12.1	12.5	10.3	8.4	6.7	21.8	13.5	12.0	3.9
Mean	11.0	10.9	9.0	7.0	5.6	19.2	11.2	10.6	3.2
Female (n=4)									
Min.	12.1	12.4	10.6	9.0	6.9	22.2	13.5	6.3	3.7
Max.	15.1	15.7	12.2	9.8	7.4	24.0	14.9	7.1	4.9
Mean	13.8	14.2	11.5	9.4	7.2	23.0	14.0	6.6	4.4

### Diagnosis

Distinguished from *U. excellens* by the size and shape of the terminal tooth of the dorsal keel of the tail segments.

### Description

Colour light yellowish brown to reddish brown; carapace brownish yellow to deep reddish brown; tergites brown to greyish brown; arms, hands, tail and vesicle yellowish red-brown; legs greyish brown to yellowish, ventral surface yellowish to brown, aculeus, fingers, and cheliceral jaws reddish brown to reddish dark brown.

Carapace with frontal notch moderate to deep, occasionally very deep or shallow. Frontal lobes truncate. (In some specimens, anterolateral edges of

carapace tend to converge sharply towards frontal lobes in region of lateral eyes.) Interocular areas smooth and shiny but rugose towards and along anterior edge. Lateral and posterior two-thirds of carapace with scattered granules of various sizes, or partly to totally smooth. Median sulcus uninterrupted (sometimes slightly uninterrupted). Triangular depression extremely deep. Sides of triangular depression slightly retracted, sometimes retracted.

Chelicerae (Fig. 35) with numerous secondary serrations. Sometimes teeth are worn smooth. Fixed jaw with basal tooth bilobed, median tooth moderately large. Movable jaw with subdistal tooth small.

Tergites of first six abdominal segments with a faint suggestion of a granulate line along posterior edge; in male closely granulate, in female partly to mainly smooth. Median keel weak in male, well developed in female especially the posterior tergites. Tergite of last abdominal segment mainly with granules of various sizes. Both pairs of longitudinal keels mainly of coarse granules, weakly defined; median keels about half or more than half length of segment, lateral keels about three-fourths to nearly whole length of segment.

Tail moderately long in male, short in female (rarely, e.g. Kalumburu, No. 66-265, extremely long in male). First four tail segments (Fig. 64) with intercarinal surfaces smooth to with scattered granules. Dorsal and dorsolateral keels of widely spaced moderately large denticles or crenulations, sometimes small in female; dorsal keel gradually elevated posteriorly; in male rising to a large terminal tooth (in male terminal tooth is curved backward or forward or is erect); terminal tooth moderately large in female. Dorsolateral keels notched to denticulate, in female usually smooth. Ventrolateral and ventromedian keels practically smooth. Accessory keels, if present, weak and only at posterior end of segment. Fifth tail segment long, intercarinal surfaces smooth, sometimes granulate; ventral intercarinal surfaces usually with large granules. Keels strongly denticulate. Ventromedian keel denticulate, bifurcating distally from about three-fourths length of segment.

Vesicle extremely large in male, much smaller in female, smooth dorsally, usually smooth laterally but sometimes granulate; large scattered granules ventrally especially towards base.

Aculeus moderately long, moderately curved.

Humerus dorsally with some scattered granules, especially centrally, and bounded at anterior and posterior edges by irregular rows of large dark denticles.

Brachium with dorsal surface smooth to granulate. Posteroventral keel evident, sometimes weak. Ventral group, *v*, with 9-21 trichobothria. Posterior group, *p*, with 27-60 trichobothria.

Hand rounded. Dorsal surface smooth to with a distinct reticulation of granules. Keels of hand evident, sometimes weak. Anterodorsal keel weakly defined, often by an irregular row of dark granules. Finger keel smooth and sometimes dark. Ventral group, V, with 11-32 trichobothria. Median group, M, of posterior surface with 8-26 trichobothria.

Fingers moderate to long. Along edge of movable finger 1-3 row(s) of granules along base and middle, reducing to 1 row towards apex. 3 to 7 (usually 6 or 7) rows of transverse accessory teeth, all in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5 or 6 prongs. Terminal claws of each leg (not very thin and long) slightly unequal in length. Ventral surface of tarsomere II of fourth pair of legs with 8-12 inner, and 3-9 outer prongs (with tendency for the 3-6 distal prongs to be separated from the others).

Pectinal teeth 16-22 (Mean 18.5) in male; 12-20 (Mean 15.2) in female.

Paraxial organ (Figs 114, 115) with lamina moderately short to long; curved, uniformly wide, rounded at apex; inner lobe thin, long, uniformly wide, rounded at apex; close to thin median lobe and about same length or longer than it, and inner lobe of same width as median lobe for about the last third of its length; toquilla long, narrowing and tending to be dorsally pointed, ventrally rounded, and with a large outward usually well-defined bulging central portion and thick along ventral edge where it meets diaphragma; external lobe somewhat like in *U. yaschenkoi*; large, wide at base, narrowing towards curved to bulbous blunt apex; ventral vinculum long and tending to be wide; dorsal vinculum long and wavy; basal lobe curved, pointed and with a small prong at base; proximal lobe longer than basal lobe, curved and pointed; apotheca weakly sclerotized; diaphragma strongly sclerotized.

### Remarks

The collector of the holotype, W.H. Lowe, appended a note to the locality label indicating that the holotype and paratypes bearing the same data were collected 'over the last few weeks before 2.ix.1967' on the Mitchell Plateau at about 270 m above sea level.

In cheliceral characters, *U. lowei* is close to *U. varians*, *U. hoplurus* and *U. yaschenkoi*. The male tail segments and paraxial organs are like those of *U. hoplurus* and *U. yaschenkoi*. The male from 161 km ENE of Broome, W.A., has its vesicle and aculeus tending towards the form in *U. megamastigus*. One of the males from Kalumburu, W.A., has extremely long tail segments.

The specimens from 161 km ENE of Broome, and 3 km S of and 64 km E of Dampier Downs, W.A., were in loosely spiralling burrows 38-58 cm deep in open ground.

*Urodacus similis* sp. n.  
(Figs 36, 65, 116, 117, Map 27)

**Holotype**

♂. Western Australia: Kathleen Valley, 27°23'S, 120°38'E, iii.-iv.1963 (T. Moriarty) 69/467, WAM.

**Paratypes**

2♂, 1♀. Western Australia: Kathleen Valley, iii.-iv.1963 (T. Moriarty) 1♂, 69/498, WAM. Minnie Creek, 103 km E of Cosmo Newbery, 30.i.1967 (W.D.L. Ride & A. Baynes) 1♂, 1♀, 69/499-500, WAM.

**Range (Map 27)**

Western Australia, known only from Kathleen Valley and Minnie Creek.

**Measurements (mm)**

♂. Holotype. Total length 72, of tail 32; carapace, length 9.5, width 10.5; tail segments one to five (in that order), length 4.3, 5.6, 5.8, 6.0, 9.0, width 5.4, 5.3, 5.1, 4.7, 4.7, height 4.0, 4.3, 4.4, 4.1, 3.7; length of vesicle and aculeus 11.4; width of vesicle 5.0; length of humerus 6.1; brachium, length 7.3, width 3.6; hand, length 6.4, width of hand surface 5.3, height 4.6; length of hand and fixed finger 14.2; length of movable finger 9.1; length of pectine 8.1.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=3)									
Min.	9.5	10.5	6.4	5.3	4.3	14.2	9.1	6.0	3.8
Max.	11.5	12.4	8.9	7.2	5.5	18.0	11.1	6.7	4.2
Mean	10.4	11.3	7.4	6.1	4.8	15.9	10.0	6.3	4.0
Female (n=1)	12.7	13.6	9.5	7.5	5.6	19.6	12.2	6.4	4.0

**Diagnosis**

Distinguishable from all other *Urodacus* species by the extreme shortness of the first four tail segments which are each not much longer than high.

**Description**

Colour light yellow to reddish yellow-brown; tergites darker usually with greyish tinge, fingers tending towards reddish brown; legs and ventral surface light yellow to brownish yellow; patellas sometimes faintly greyish.

Carapace with frontal notch slight to moderately deep. Frontal lobes truncate (sometimes sloping towards middle). Interocular areas strongly rugose but not granulate. Lateral and posterior two-thirds of carapace mainly smooth but with some scattered fine granules. Median sulcus uninterrupted. Triangular depression extremely deep. Sides of triangular depression retracted.

Chelicerae (Fig. 36) with some secondary serrations. Fixed jaw with large sub-basal tooth. Movable jaw with long external distal tooth and small subdistal tooth.

Tergites of first six abdominal segments smooth towards middle but with fine scattered granules laterally, and with a row of larger granules along posterior edges. Tergite of last abdominal segment mainly smooth but with some granules; keels composed of pointed granules, or smooth notches, extending one-fourth to three-fourths length of segment, usually weakly defined towards anterior.

Tail moderately short in male, short in female. First four tail segments (Fig. 65) short and squat (i.e. not much longer than high). Intercarinal surfaces smooth. Dorsal keels slightly notched but mainly smooth, rising in a curve to terminal tooth which is backward pointing, and rounded at apex. Dorsolateral keels notched to smooth, ventrolateral and ventromedian keels smooth. Accessory keel present in first segment and usually indicated at posterior third of second segment, but practically absent in third and fourth segments. Fifth tail segment with dorsal intercarinal surface smooth, dorsolateral intercarinal surfaces usually smooth, sometimes with scattered granules; ventral intercarinal surfaces with scattered denticles smaller than those of ventral keels. Dorsal and dorsolateral keels granulate, the latter extending more than half length of segment; ventrolateral and ventromedian keels denticulate. Ventromedian keel bifurcating in distal one-third of segment, if at all.

Vesicle moderate, to very large, usually large, smooth towards aculeus and dorsally, granulate laterally, covered ventrally with dense granules.

Aculeus moderately short, moderately to strongly curved.

Humerus dorsally with some scattered granules of various sizes, and bounded at anterior and posterior edges by large dark irregularly spaced denticles.

Brachium dorsally with fine scattered granules and faint pigment spots towards anterior edge. Posteroventral keel evident but usually weak. Ventral group, *v*, with 12-15 trichobothria. Posterior group, *p*, with 27-38 trichobothria.

Hand moderately round, especially in female. Dorsal surface with granules in a reticulation especially towards anterodorsal keel which has large, coarse, pigmented granules. Anterior surface with some scattered granules, especially centrally and near anterodorsal edge. Ventral group, *V*, with 17-21 trichobothria. Median group, *M*, of posterior surface with 8-17 trichobothria.

Fingers long. Along edge of movable finger 1 row of granules from base to apex (sometimes showing a tendency towards 2 rows). Around 7 rows of transverse accessory teeth, mainly in distal half of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5-7 prongs (usually 6 or 7). Inner claw of each leg ranging from a small claw to one equal in length to the outer. Ventral surface of tarsomere II of fourth pair of legs with 9-11 inner, and 7-9 outer prongs.

Pectinal teeth 18-22 (Mean 20.2) in male; 16-17 (Mean 16.5) in female.

Paraxial organ (Figs 116, 117) with lamina large, very wide and curved, rounded at broad apex; inner lobe long, narrow and pointed; inner lobe-tooth present, closer to base of inner lobe; median lobe very thin, shorter than inner lobe and external lobe, tapering to apex at which it forms an abrupt point; toquilla large; external lobe moderately wide, gradually tapering to rounded apex, one notch (of a comb) present just below apex; complex of thin sclerotized tapering bands near junction of external lobe and vinculum; ventral vinculum wide; dorsal vinculum long, thin and wavy, varying in thickness but usually clearly defined; juxtum usually clearly defined with a long, curved, tapering basal lobe, ending in a point, and about twice as long as proximal lobe which tapers to a fine point and has several serrations along its inner edge; a distinct flap present near apex of basal lobe.

#### Remarks

*U. similis* is larger than *U. armatus* and has higher trichobothrial numbers. *U. similis* is very close to *U. yaschenkoi*, but differs in genitalia and has shorter tail segments and the terminal claws of legs sometimes equal. The paraxial organ features of *U. similis* are similar to those of *U. excellens* (e.g. there is a thorn on the inner lobe) but the lamina is as in *U. yaschenkoi*. *U. similis* has higher trichobothrial numbers than *U. excellens*, but it has one row of teeth along the movable finger as in *U. yaschenkoi*. Owing largely to the varying lengths of the terminal claws of its legs, *U. similis* is ranked between *U. excellens* and *U. yaschenkoi*.

A few of the examined individuals of *U. similis* (and of *U. hoplurus*) had their bodies and tails loaded with the larvae of mermithid nematodes; nevertheless, some of the scorpions were alive when collected. Mermithid larvae are known to use various arthropods, including scorpions, as hosts (W.G. Inglis, personal communication); but they have not been previously recorded from Australian scorpions. (Mermithid adults are free-living in soil or water.)

Ectoparasitic mites were found on some individuals of every genus of scorpion throughout its range in Australia. These mites belong to the families Acaridae and Erythraeidae whose members occur on various terrestrial arthropods. The mites were usually attached around the sternites and near the base of the pectines, but were never numerous on any individual and are thought to be of little significance in affecting the survival of the scorpions.

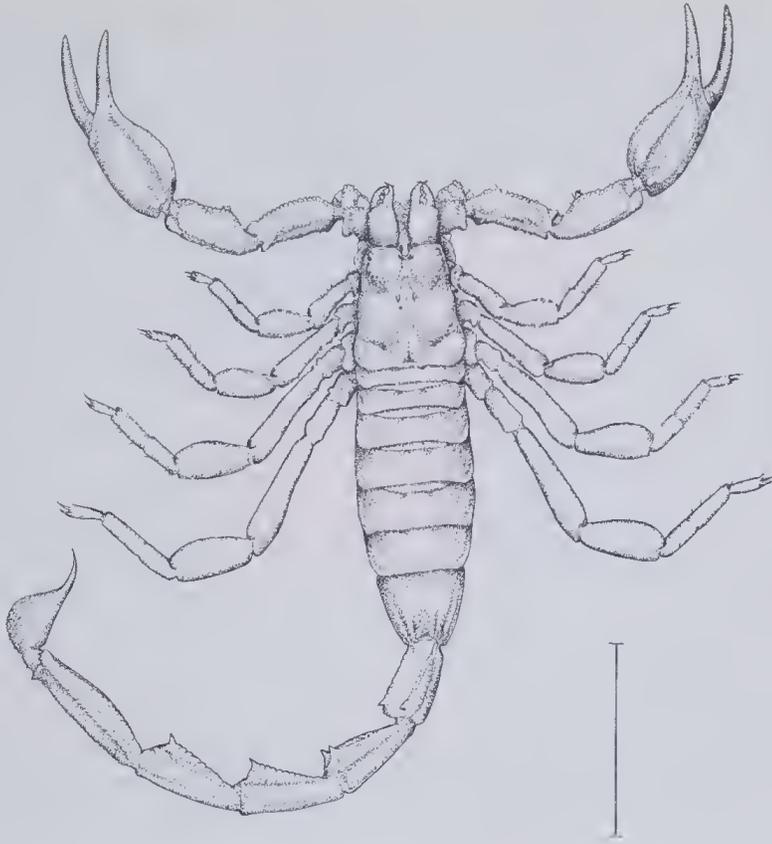


Fig. 125: Dorsal view of a representative male specimen of the *Urodacus hartmeyeri* species-group: *U. hartmeyeri* (68/389; Hamel, W.A.) (CL 11.9 mm). (Scale line 2 cm).

Species-group *hartmeyeri*  
*Urodacus hartmeyeri* Kraepelin  
(Figs 37, 66, 118, 119, 125, Map 28)

*Urodacus hartmeyeri* Kraepelin, 1908: 94, 99; Kraepelin, 1916: 39; Takashima 1945: 89. [2 syntypes examined.]

Range (Map 28)

Western Australia, west coast and coastal plain, from North West Cape to Hamel.

Measurements (mm)

♂. 35 km NE of Yuna, W.A., 68/1059, WAM. Total length 103, of tail 62; carapace, length 11.5, width 10.9; tail segments one to five (in that order),

length 8.4, 10.2, 10.7, 10.5, 13.5, width 4.3, 4.2, 3.9, 3.8, 3.8, height 3.5, 3.9, 3.6, 3.4, 3.2; length of vesicle and aculeus 11.7; width of vesicle 3.7; length of humerus 8.8; brachium, length 10.2, width 4.1; hand, length 8.9, width of hand surface 6.5, height 5.0; length of hand and fixed finger 19.7; length of movable finger 11.9; length of pectine 9.5.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=10)								n=8	n=8
Min.	9.1	8.7	7.0	5.6	4.0	15.0	9.2	7.0	2.9
Max.	11.9	11.5	9.5	7.3	5.4	20.4	12.9	10.5	4.1
Mean (n=8)	10.5	9.9	8.3	6.2	4.7	17.4	10.3	8.8	3.4
SD (n=8)	0.95	0.89	0.71	0.45	0.42	1.75	1.02	1.08	0.38
Female (n=7)								n=6	n=6
Min.	10.7	10.7	9.0	7.0	5.2	18.4	10.4	5.9	3.4
Max.	14.3	13.8	11.0	9.1	7.3	22.6	13.3	8.6	4.5
Mean (n=6)	12.3	12.2	9.8	7.9	6.1	20.3	11.7	7.0	3.9
SD (n=6)	1.24	1.25	0.91	0.76	0.73	1.88	1.05	0.99	0.41

### Diagnosis

Distinguished from the *hoplurus* species-group by the movable finger having one row of central teeth and the legs having the terminal claws markedly unequal. Distinguished from *U. yaschenkoi* by the tail segments being moderately long to long, vesicle being smaller, aculeus being longer, hand being somewhat flat in male and moderately round in female.

### Description

Colour mainly uniform clay-yellow; with tergites darker, patellas sometimes dark; fingers, and keels on arms, and usually also on hands, reddish brown.

Carapace with frontal notch wide and shallow. Frontal lobes truncate. Interocular area rugose, mainly smooth, partly with coarse granules. Lateral and posterior two-thirds of carapace usually smooth except for a sparse scattering of minute to coarse granules, sometimes with numerous granules. Median sulcus uninterrupted. Triangular depression deep. Sides of triangular depression usually only slightly retracted (i.e. practically straight, somewhat swollen inwards to depression).

Chelicerae (Fig. 37) usually with many secondary serrations. Fixed jaw with many secondary serrations along edge of distal external tooth, between sub-basal tooth and median tooth and at distal bases of sub-basal tooth and median tooth; sub-basal tooth often sharply downcurved in proximal direction from half its distance from point. Movable jaw with serrations along edge of distal internal tooth near base of distal external tooth. Proximal base of external distal tooth sometimes notched. Notch present at proximal base of subdistal tooth. Proximal edge of median tooth with secondary serrations,

sharply notched at base. Basal tooth with secondary serrations, especially along proximal edge.

Tergites of first six abdominal segments granulate or with minute close-set granules; often smooth centrally and with coarse granules posterolaterally; much smoother in female. Tergite of last abdominal segment with median keels reaching about half length of segment; lateral keels granulate and up to about three-fourths length of segment.

Tail long in male, moderately long in female. First four tail segments (Fig. 66) with intercarinal surfaces smooth. Dorsal keels notched to denticulate, ending in moderately large backwardly pointing tooth which dorsally is a continuation of the (notched or denticulate) keel (these keels are much less developed in female). Dorsolateral keels notched, ventrolateral and ventromedian keels smooth. Accessory keels smooth; in first segment usually extending about three-fourths or more of distance from posterior edge, if present in next three segments faintly defined and only in posterior part. Fifth tail segment with dorsal and lateral intercarinal surfaces practically smooth, with few granules; ventral intercarinal surfaces with coarse granules. Dorsolateral keels denticulate. Ventrolateral and ventromedian keels strongly denticulate. Ventromedian keel bifurcating distally at extremity.

Vesicle large, dorsally smooth, laterally slightly granulate, ventrally and ventrolaterally coarsely granulate especially towards base.

Aculeus long, moderately curved.

Humerus dorsally smooth with some granules, and bounded at anterior and posterior edges by keels of coarse dark denticles.

Brachium dorsally with a faint reticulation of granules, practically smooth. Posteroventral keel present, moderately weak. Ventral group, *v*, with 11-15 trichobothria. Posterior surface sharply convex along its length. Posterior group, *p*, with 25-38 trichobothria.

Hand somewhat flat in male, moderately round in female. Dorsal intercarinal surface granulate. Anterodorsal keel with scattered dark denticles, finger keel sometimes faint, posterodorsal keel smooth. Ventral group, *V*, with 11-22 (rarely 11,12) trichobothria. Median group, *M*, of posterior surface with 6-15 (usually 8-13) trichobothria.

Fingers long. Along edge of movable finger 1 row of granules from base to apex. In a few specimens there is a tendency for more than 1 row at base. Around 10 rows of transverse accessory teeth, mostly towards distal end of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 6-7 (rarely 8) prongs. Terminal claws of each leg unequal in length; inner claw usually ranging from a short claw to a claw of length up to four-fifths that of outer, usually half to two-thirds the length of outer. Ventral surface of tarsomere II

of fourth pair of legs with 8-13 (usually 10, 11) inner, and 6-11 (usually 7-10, rarely 6, 11) outer prongs.

Pectinal teeth 17-32 (Mean 25.5, SD 3.98) in male; 12-24 (Mean 18.4, SD 3.15) in female.

Paraxial organ (Figs 118, 119) with lamina moderately long, of somewhat uniform but irregular width, apex square, blunt; inner lobe large, wide, not upcurved, sometimes very pointed, sometimes has back-plate with a point which is about halfway between apex of inner lobe and the base of lamina; inner lobe close to moderately long median lobe which sometimes has thick walls; prong area complex and variable, prong pointed; sclerotized plate variable sometimes weak, sometimes small and narrow but clearly defined; fulcrum variable, broad to narrow usually pointed at apex; fissure well developed; caulis evident, sometimes well defined and terminating usually in five or six points; caulis sometimes poorly developed (e.g. at Hamel, W.A.); carina varies from small to large, rounded at apex, sometimes with a thickened rim along curved outer edge; toca large, rounded at base; external lobe long and prominent, wide at base, usually narrowing gradually, curved towards blunt apex; ventral vinculum narrowing and long; dorsal vinculum long, of variable shape, usually bulbous just before midpoint from its junction with ventral vinculum, sometimes appears broadly joined to basal lobe which varies from narrow to broad and is moderately long and about the same length as or sometimes longer than proximal lobe; basal lobe rounded at apex sometimes with inner edge wavy; proximal lobe tapers to apex or enlarges to rounded apex.

#### Material examined

15♂, 17♀ (Map 28).

#### WESTERN AUSTRALIA

Ajana, 29 km N of, 16-18.i.1969 (Kalbarri Survey) 1♂, 2♀, 69/545-7, WAM; 18.i.1969 (Kalbarri Survey) 1♀, 69/548, WAM. Bidgemia Stn, 6.vii.1926 (W. Cream) 4♂, 26/457-60, WAM. Caladenia Cave, Gingin, 17.iii.1971 (R. Roe) 1♂, 71/1287, WAM. Carnarvon, 3.viii.1956 (E. Herz) 1♂, 56/1385, WAM. Coburn Stn (near Hamelin Bay) vi.1967, 1♂, 68/1058, WAM. Dandaragan, x.1942, 2♀, 42/599-600, WAM. Dartmoor (via Yuna) 22.iii.1927 (S.L. Parker) 1♂, 27/364, WAM. Hamel, 7.i.1958 (K. Volprecht) 1♂, 1♀, 68/389-90, WAM. Irwin, 19.vi.1926 (Brady) 1♀, 26/274, WAM. Kalbarri, 31 km E of, 12-17.i.1969 (Kalbarri Survey) 1♀, 69/549, WAM. Meanarra Hill, 6 km E of Kalbarri, 11.i.1969 (Kalbarri Survey) 2♀, 69/544, 69/550, WAM. Mullewa, vi.1925 (R.L. Shannon) 1♀, 25/486, WAM. North West Cape, 3 km S of Mauds Landing, 23.ix.1968 (D. Stebbing) 1♀, 68/1057, WAM. Ogilvie, iii.1967 (R. Goldsmith) 1♀, 68/387, WAM. Point Cloates, pres. vii.1967 (L.A. Finlay) 1♀, 68/388, WAM; pier of, 15.v.1960 (A.M. Douglas & G.F. Mees) 1♂, 68/386, WAM. Shark Bay, Useless Loop,

iii.1966 (B.R. Wilson & G.W. Kendrick) 1♂, 68/385, WAM; 6 km S of Useless Bay, 25.viii.1970 (A. Baynes) 2♂, 1♀, 73/700-2, WAM. Tamala (Hamburg S.W. Austral. Expd.) 1905.70.7.18.ix, vi.08, 2♀, Zoologisches Museum, Hamburg (syntypes of *U. hartmeyeri*). Yuna, 35 km NE of, iii.1965 (G.E.J. Hitchin) 1♂, 68/1059, WAM.

#### Remarks

*U. hartmeyeri* is morphologically close to *U. yaschenkoi* and not as close to *U. armatus*.

A specimen at Point Cloates, W.A., was caught dragging a lizard *Tympanocryptis parviceps* Storr. Scorpion burrows at Point Cloates were numerous in sandhills, near the roots of spinifex, and not deep (A.M. Douglas, personal communication). A large female from near Kalbarri, W.A., was dug from a spiralling burrow 15 cm deep with entrance dimensions 25.4 mm by 19.0 mm (N. Allen, personal communication).

Hardly any geographic variation in size or colour is exhibited by the specimens examined.

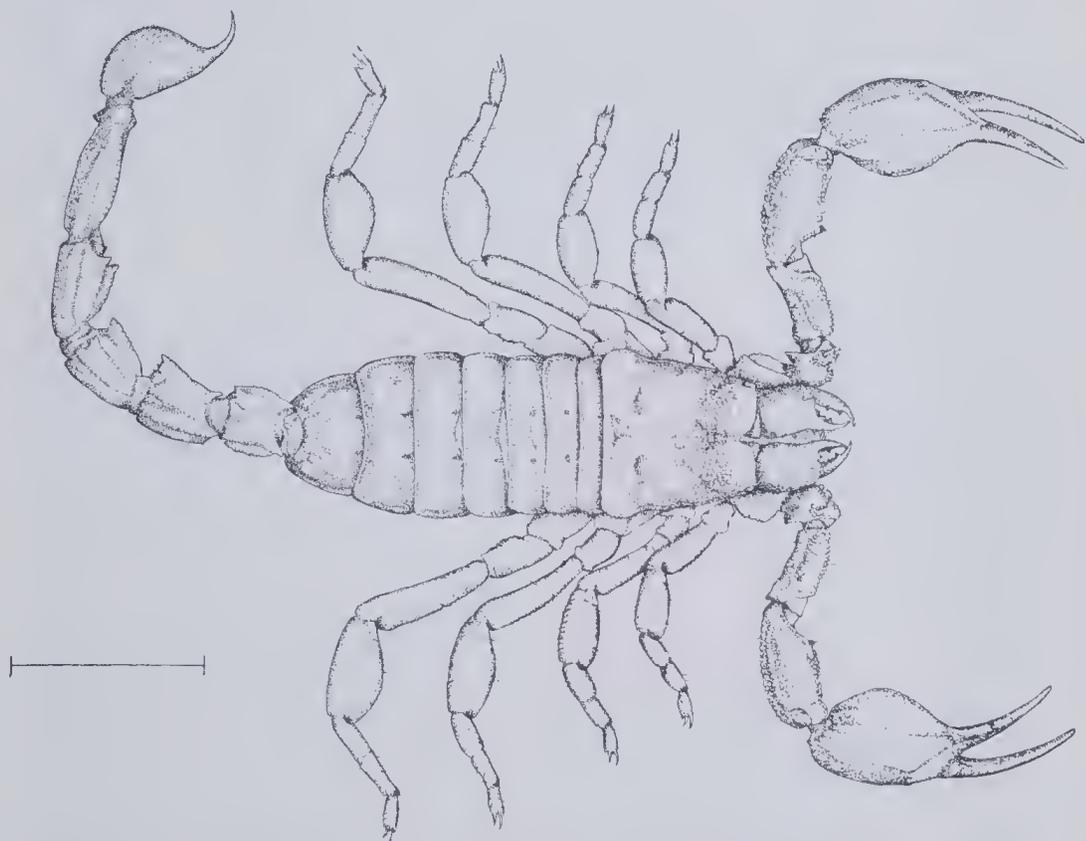


Fig. 126: Dorsal view of a representative male specimen of the *Urodacus yaschenkoi* species-group: *U. yaschenkoi* (66/327; Broome, W.A.) (CL 15.7 mm) (Scale line 2 cm).

Species-group *yaschenkoi*  
*Urodacus yaschenkoi* (Birula)  
(Figs 5, 38, 67, 120, 121, 126, Map 29)

*Hemihoplopus yaschenkoi* Birula, 1903: 33.

*Urodacus granifrons* Kraepelin, 1916: 39. *Syn. n.*

*Urodacus kraepelini* Glauert, 1963a: 134. *Syn. n.*

*Urodacus fossor* Kraepelin, 1916: 36; Takashima, 1945: 89. [1 syntype examined.] *Syn. n.*

*Urodacus kraepelini* Takashima, 1945: 87; Koch, 1963: 22 (replacement name). *Syn. n.*

*Urodacus yaschenkoi* (Birula); Kraepelin, 1908: 95; Kraepelin, 1916: 39; Glauert, 1925a: 85; Hickman, 1944: 19; Takashima, 1945: 87.

**Range (Map 29)**

Western Australia, north-western and central; furthest north at Broome, furthest west at Eginbar, furthest south at 29 km NE of Laverton. South Australia, furthest north-west at Mann Range, furthest south-east at Renmark. Victoria, north-western; at Irymple and Mildura. New South Wales, western; furthest north-west at Broken Hill, furthest south-east at South Ita Sand Hills. Queensland, south-western; at Birdsville and Coongoola. Northern Territory, south-central; furthest north at Barrow Creek.

**Measurements (mm)**

♀. Broome, W.A., 26/69, WAM. Total length 102, of tail 47; carapace, length 15.0, width 15.0; tail segments one to five (in that order), length 5.0, 6.0, 6.7, 7.5, 10.5, width 6.0, 5.9, 5.5, 5.0, 5.0, height 4.5, 5.0, 5.0, 4.8, 3.9; length of vesicle and aculeus 13.0; width of vesicle 4.7; length of humerus 8.5; brachium, length 11.0, width 5.5; hand, length 9.9, width of hand surface 8.0, height 6.0; length of hand and fixed finger 23.4; length of movable finger 15.0; length of pectine 6.5.

Adult size:	CL	CW	LH	WHS	HH	HFF	MF	FTL	FTH
Male (n=9)									
Min.	10.6	10.8	8.2	6.7	5.3	16.5	10.3	6.0	3.5
Max.	15.7	16.1	10.8	9.6	7.8	24.8	16.6	9.3	5.4
Mean	12.9	13.4	9.5	8.0	6.3	20.6	13.2	7.3	4.4
SD	1.64	1.85	0.90	0.99	0.89	2.61	2.11	1.03	0.54
Female (n=14)									
Min.	9.4	9.6	7.0	5.2	4.1	15.6	9.8	4.8	2.9
Max.	16.9	18.0	11.3	9.6	7.0	26.5	17.3	8.5	5.6
Mean	11.9	12.2	8.8	6.9	5.2	18.9	11.9	6.0	3.7
SD	2.3	2.4	1.2	1.3	0.9	3.4	2.6	1.1	0.8

## Diagnosis

Distinguished from *U. hartmeyeri* by the short squat tail segments, larger vesicle, shorter aculeus, and less flat hands. The females of the two species are sometimes hard to distinguish. Distinguished from all other *Urodacus* species by the greatly reduced length of the terminal inner claw of legs.

## Description

Colour of carapace reddish yellow-brown; tergites, tail, arms and hands darker; fingers even darker and sometimes tending towards reddish black; legs and ventral surface brownish yellow; leg segments (mainly the patella), fifth tail segment, vesicle, carapace, and tergites sometimes with a light to dark greyish tinge.

Carapace with frontal notch slight to very deep. Frontal lobes truncate, usually slightly sloping inwards towards middle. Interocular areas often densely covered with very coarse, pigmented, hump-shaped granules. Lateral and posterior two-thirds of carapace mainly smooth, sometimes with granules posteriorly and laterally. Median sulcus interrupted, sometimes practically uninterrupted. Triangular depression deep. Sides of triangular depression slightly retracted or unretracted, sometimes retracted.

Chelicerae (Fig. 38) with many fine secondary serrations, especially along edges of distal external tooth of fixed jaw and distal internal tooth of movable jaw. Fixed jaw with several secondary serrations between sub-basal and median teeth. Movable jaw with secondary serrations at proximal base of external distal tooth, at distal edge of median tooth between median and basal teeth, and on each edge of basal tooth.

Tergites of first six abdominal segments usually densely covered with fine to coarse granules mainly in posterior half of each segment, especially in the more posterior segments, and with a row of larger granules along posterior edges. Tergite of last abdominal segment smooth to with scattered granules. Lateral keels composed of pointed granules or denticles reaching half length of segment. These granules or denticles and those along the middle of the posterior edge are backward-pointing. Median keels short and ill-defined; lateral keels about half length of segment.

Tail moderately long in male, short in female. First four tail segments (Fig. 67) moderately short, i.e. not much longer than high; sometimes tail segments in male very pronounced (e.g. at 290 km SE of Derby, W.A.). Intercarinal surfaces mainly smooth. Dorsal keels of denticles pointing backward and rising gradually to terminal tooth which is also backward-pointing, and usually sharp. Accessory keel present in first segment and usually indicated at posterior third of second segment, but usually absent in third and fourth segments. Fifth tail segment with dorsal and lateral intercarinal surfaces practically smooth; ventral intercarinal surface with numerous scattered denticles smaller than those of ventral keels. Dorsal keels faintly

granulate, dorsolateral keel granulate, present only in first half of each side; ventrolateral keels denticulate; ventromedian keel formed by a wide irregular row of scattered denticles. Ventromedian keels bifurcating distally from about half to two-thirds length of segment.

Vesicle large to very large, rarely moderate in size, i.e. at Jiggalong, W.A.; covered ventrally with dense granules especially towards base; smooth dorsally and almost smooth laterally and towards aculeus.

Aculeus moderately short, moderately to strongly curved.

Humerus dorsally with scattered granules, mainly coarse, and bounded at anterior and posterior edges by irregularly placed large denticles.

Brachium (Fig. 5) with dorsal surface granulate, especially towards anterodorsal edge and often with a reticulation of pigment spots. Posteroventral keel weak. Ventral group, *v*, with 12-19 (usually 14-16, rarely 12) trichobothria. Posterior group, *p*, with 29-54 (usually 32-45, rarely 48-54) trichobothria.

Hand wide to narrow, tending to be moderately flat, sometimes rounded. Dorsal surface with coarse granules in a reticulation especially towards anterodorsal keel which has large, coarse pigmented granules. Keels of hand somewhat weakly defined, except for posteroventral. Anterior surface with a few scattered granules, especially centrally and near anterodorsal edge. Ventral group, *V*, with 18-31 trichobothria. Median group, *M*, of posterior surface with 6-26 trichobothria.

Fingers often very long. Along edge of movable finger 1 row of granules from base to apex, sometimes showing a tendency towards 2 rows at base. Often about 12 rows of transverse accessory teeth along length of movable finger.

Legs with tarsomere I of first pair dorsally with a row of 5 or 6, less often 7, rarely 8, prongs. Terminal claws of each leg unequal in length; inner claw ranging from a minute papilla to a claw of length half to two-thirds that of outer, especially in third and fourth pairs of legs. Ventral surface of tarsomere II of fourth pair of legs with 9-12 (usually 11, but rarely 12) inner prongs, and 7-9 (usually 7 or 8) outer prongs (with 4 or 5 on distal flap).

Pectinal teeth 15-29 (Mean 21.3, SD 2.87) in male; 8-20 (Mean 14.3, SD 6.9) in female.

Paraxial organ (Figs 120, 121) with lamina moderately short, wide, of about uniform width but with a tendency to taper towards apex which is mainly rounded, sometimes, e.g. at Strzelecki Creek, S.A., wavy towards apex; inner lobe with sclerotized edges, wide and of uniform width for most of its length, tapering very abruptly at apex to a pronounced and sharp point; median lobe short and wide at base and for most of length, then taper-

ing to a sharp point; median lobe much shorter than inner lobe; external lobe large, pointed; toquilla large, well developed, and shaped like a shell with numerous fine wrinkles along edges.

#### Material examined

85♂, 127♀ (Map 29).

#### WESTERN AUSTRALIA

Blackstone Mining Camp, v.1967 (C. Snell) 1♀, 68/1060, WAM. Broome, 23.i.1911 (Withers) 1♂, 4075, WAM; 10.ix.1924 (H. Talboy) 1♀, 24/830, WAM; 24.iii.1926 (H. Talboy) 5♂, 4♀, 26/160-4, 26/166, 26/168, 26/170, 26/172, WAM; iii.1926 (Douglas) 3♂, 6♀, 26/62-5, 26/67-71, WAM; v.1926 (E. & G. & B.B. Bardwell) 2♀, 26/260, 26/262, WAM; 24.viii.1929, 1♂, 2♀, 29/1036, 29/1035, 29/1037, WAM. i.1962 (M. McDonald) 2♂, 66/261, 66/327, WAM. Canning Stock Route, Well 8 (43-42) 1♀, 69/427, WAM. Carnegie, 145 km N of, 31.viii.1971 (D. Williams) 1♂, 2♀, 73/707-9, WAM. Derby, 290 km SE of, 1960 (J.P. Calleran) 1♂, 1♀, 69/33-4, WAM. Eginbah Stn, 9.ix.1938 (A. Snell) 1♂, 38/2483, WAM. Giles, iv.1962 (G.M. Raymond) 1♂, NM; 32 km E of, 10.vii.1969 (D.D. Giuliani) 1♀, 69/2016, WAM; 64 km E of, 13.vii.1969 (D.D. Giuliani) 1♂, 69/2019, WAM; 80 km S of, 8.vii.1969 (D.D. Giuliani) 1♀, 69/2015, WAM; 113 km W of, xii.1961 (G.M. Raymond) 1♀, NM. Jiggalong Mission, 30.x.1922, 1♀, 22/609, WAM. Laverton, 29 km NE of, 26.vi.1969 (D.D. Giuliani) 3♂, 2♀, 69/1990, 69/1993-4, 69/1991-2, WAM; 106 km NE of, 28.vi.1969 (D.D. Giuliani) 2♀, 69/1989, 69/1995, WAM; 124 km NE of, 28.vi.1969 (D.D. Giuliani) 1♂, 69/1997, WAM; 222 km NE of, 29.vi.1969 (D.D. Giuliani) 1♀, 69/1998, WAM; 304 km NE of, 29.vi.1969 (D.D. Giuliani) 1♀, 69/1999, WAM; 373 km NE of, 30.vi.1969 (D.D. Giuliani) 1♂, 69/2002, WAM; 477 km NE of, 1.vii.1969 (D.D. Giuliani) 1♀, 69/2007, WAM. Minnie Creek, 30.i.1967 (W.D.L. Ride & A. Baynes) 5♂, 69/249, 69/253-6, WAM. Mt Ant, 13.vii.1969 (D.D. Giuliani) 2♀, 69/2017-8, WAM. Pardoo Outcamp, 8 km SW of, 28.ix.1969 (D.D. Giuliani) 3♂, 69/2053-5, WAM. Pierre Springs, 27.i.1969 (M. de Graaf) 1♂, 69/552, WAM. Poole Range (80 km SE of Fitzroy Crossing) v.1927 (H.W. Talboy) 2♂, 27/657-8, WAM. Queen Victoria Stn (?), 8.v.1971 (K. Thies) 1♀, 73/703, WAM. Streeters Stn (?), near Broome, ix.1912 (Mjoberg) 1♀, Zoologisches Museum, Hamburg (syntype of *U. fossor*). Talawana, i.1971 (A.M. Douglas) 1♂, 71/697, WAM. Warburton Mission, 80 km E of, 3.vii.1969 (D.D. Giuliani) 1♀, 69/2008, WAM; 97 km E of, 4.vii.1969 (D.D. Giuliani) 1♀, 69/2009, WAM. Warburton Range, 12.v.1963 (M. de Graaf) 1♂, 1♀, 69/251-2, WAM; 1963 (M. de Graaf) 1♂, 1♀, 69/250, 69/257, WAM; 80 km E of, 23.viii.1962 (W.H. Butler) 1♂, 62/6, WAM.

#### SOUTH AUSTRALIA

Alton Downs, viii.1958 (I.G. Filmer) 2♂, QM. Birdsville (Qld) 161 km S of, 12.viii.1969 (G.B. Monteith) 1♀, UQ. Canniwaukaninna Bore, 14 km W

of (Etadunna Stn) ix.-xi.1972 (M. Archer) 2♀, 73/711-2, WAM. Emu, 64 NW of, 1.ix.1968 (P.J. Fuller) 1♀, 69/407, WAM. Fowlers Bay (A. Zietz) 1♀, SAM. Kychering Soak, overland Railway West, in area 24 km, 26.v.1909 (Chandler) 2♂, NM. Lake Eyre, district east of, vii.1922 (B. Nicholls) 1♀, NM. Lake Kanuka, 22.vii.1971 (A. Waren) 1♂, 73/710, WAM. Lake Kittakitooloo, 27.vii.1971 (M. Archer) 1♀, 73/713, WAM; vii.-viii.1971 (M. Archer) 1♂, 1♀, 73/715-6, WAM. Lake Ngapakaldi, 21.viii.1970 (W.H. Butler & W.D.L. Ride) 1♂, 73/706, WAM; vii.1971 (M. Archer) 1♀, 73/714, WAM. 'lower Coopers Creek', 17.viii.1903 (Melb. Univ. Expd. Lake Eyre, J.W. Gregory) 1♀, NM. 'Millers Creek and Coopers Creek', 4.ii.1925 (F. Wood Jones) 1♀, 25/148, WAM; ii.1925 (F. Wood Jones) 1♀, 25/78, WAM. 'Murray', 1897 (Shaw) 1♀, SAM. Musgrave and Petermann Ranges, vi.1926 (H. Basedow) 2♂, 3♀, SAM. Oodnadatta, 23.iii.1916 (Spencer Coll.) 5♂, 17♀, NM. Ooldea (A.O. Jones) 1♂, 1♀, SAM. Piltardi (Mann Ranges), 22 km E of, 12.vi.1961 (H.G. Cogger) 1♂, AM. Piltardi Rockhole, Mann Ranges, vii.1961 (H.G. Cogger) 1♂, AM. Port Augusta, 1891 (Besler) 2♀, SAM; (K. Prince) 2♂, 3♀, SAM; 2♂, 3♀, SAM. Renmark, 10.viii.1894 (E. Crambrook) 1♂, SAM. Strzelecki Creek, 3.ix.1916 (E.R. Waite) 1♂, 5♀, SAM. Wynbring (L. Watson) 1♂, 2♀, SAM.

#### VICTORIA

Irymple, x.1953 (H.F. Thomas) 1♀, NM. Mildura, 23.x.1955 (N. Gryst) 1♀, NM.

#### NEW SOUTH WALES

Bindara Stn, section of Lake Tandou, Menindee Dist., 19.v.1967 (P. Lawson) 1♀, 69/248, WAM. Broken Hill, 64 km S of, 3.iv.1969 (G.B. Monteith) 2♀, UQ. Cal Lal, 129 km W of Mildura (Victoria) Kulcurna Cliffs, Murray River, 26.i.1968 (K. Simpson) 1♀, NM. Coombah (D.J. Shorthouse) 6♂, 71/1071-6, WAM. Coombah Stn, 113 km S of Broken Hill, 15.i.1969 (D.J. Shorthouse) 1♀, 69/553, WAM; 21.iv.1969 (D.J. Shorthouse) 1♀, 69/1101, WAM. Menindee, 32 km E of, 2.iv.1969 (G.B. Monteith) 2♂, 3♀, UQ. South Ita Sand Hills, 6.iii.1967 (E. Brough) 2♂, UQ. Talgarry Stn, Lake Victoria, 23.iii.1969 (R. Blackwood) 1♀, NM.

#### QUEENSLAND

Birdsville, 1.ix.1958 (I.G. Filmer) 1♂, 5♀, QM. Coongoola (W.B. Wilson) 1♀, QM.

#### NORTHERN TERRITORY

Andado Stn, 27 km N of (Simpson Desert Expd.) 519, 1♂, AM. Alice Springs, 24 km E of, 14.vi.1968 (B.M. Doube) 1♀, 69/1968, WAM; 240 km NW of, 30.vii.1969 (D.D. Giuliani) 1♀, 69/2025, WAM. Ayers Rock, vi.1969 (C. Le Souef) 1♀, NM; 32 km W of, 15.i.1969 (D. Howe) 2♂, NTMB48-9, NT. Barrow Creek, 1902 (Spencer & Gillen Expd.) 4♀, NM. 'Central Australia', 1♂, SAM. Curtin Springs, 108 km NE of, 21.vii.1969 (D.D.

Giuliani) 2♀, 69/2023-4, WAM. Docker River Settlement, 25.ix.1970 (C. Dunlop) 1♀, NTMB738, NT. 3.x.1970 (D. Howe & C. Dunlop) 1♀, NTMB735, NT, 7.x.1970 (D. Howe & C. Dunlop) 1♀, NTMB736, NT; Macdonnell Ranges (White) 2♀, SAM. Mt Burrell, vi.1891, 2♀, SAM. Mt Conner (H.H. Finlayson) 1♂, AM. Mt Olga, Lasseters cave, 16 km E of, 18.v.1969 (P.J. Fuller) 1♀, 69/958, WAM; 113 km W of, 16.vii.1969 (D.D. Giuliani) 1♂, 69/2021, WAM; 129 km W of, 15.vii.1969 (D.D. Giuliani) 1♀, 69/2020, WAM. 'North Australia', viii.1886 (Magarey) 1♂, SAM. 'Northern Territory', 1885, 1♂, SAM. Papunya, Western Macdonnell Ranges, xi.1970 (L. Lumsden) 4♂, NTMB730-33, NT. 'Petermann Ranges, between Barrow Ranges and', 10.vi.1968 (B.M. Doube) 1♀, 69/1967, WAM. Plenty River (C.A.N.S.W.) i.1931 (R. Barton) K64042, 1♂, AM.

#### Remarks

In most specimens of *U. yaschenkoi* from the north-western part of the distribution (viz. at Broome, 290 km SE of Derby, Eginbar Station, Poole Range, and Pierre Springs, W.A.), the granules of the carapace are coarser and darker and cover more of the interocular triangle than in specimens from elsewhere.

On the taxonomic evidence, I have retained *U. yaschenkoi* in the genus *Urodacus*, but not in a separate subgenus (i.e. *Hemihoplopus* Birula, 1903) from all the other species. These conclusions are supported by the burrow form of *U. yaschenkoi* which is closely similar to that of other species of the genus, especially *U. hoplurus*. *U. yaschenkoi* makes deep spiral burrows in open ground. The species lives in sand dunes at Bindara Station and 64 km S of Broken Hill, N.S.W. Burrows were recorded by D.J. Shorthouse (personal communication) in sandy hills and sandy soil, but some were seen on intervening riverine soils at Coombah, N.S.W. The specimen from Mt Olga, N.T., came from the top of a red sand dune. The Northern Territory specimens collected by B.M. Doube were in sand dunes in spinifex country. Lea (in Anon 1917: 490) measured the burrows of specimens (here identified as *U. yaschenkoi*) from Strzelecki Creek, S.A., as follows: entrance 51.0 mm by 6.4 mm, terminal chamber 6.4 cm by 2.5 cm, and depth 76 cm. (Details of the burrows of *U. yaschenkoi* have been included in a separate paper on a comparative study of the burrows in the genus *Urodacus*—Koch 1978.)

## KEYS TO THE AUSTRALO-PAPUAN TAXA OF SCORPIONS

### Keys to Higher Taxa

#### Key to the Australian Families of Scorpions

1. Sternum of two small narrow transverse sclerites positioned end to end ... .. Bothriuridae  
(One subfamily in Australia: Bothriurinae)

- Sternum not as above ... .. 2
- 2 (1). Sternum triangular ... .. Buthidae  
 (One subfamily in Australia: Buthinae)
- Sternum pentagonal ... .. Scorpionidae  
 (Two subfamilies in Australia: Ischnurinae and Urodacinae)

Key to the Australian Subfamilies of the Family Scorpionidae

1. Three lateral eyes on each side of carapace;  
 first four tail segments with two ventro-  
 median keels ... .. Ischnurinae  
 (One genus in Australia: *Liocheles*)
- Two lateral eyes on each side of carapace;  
 first four tail segments with one ventro-  
 median keel ... .. Urodacinae  
 (only genus *Urodacus*)

Key to the Australian Genera of the Subfamily Buthinae

1. Tibial spur present on third and fourth legs ... .. 2  
 Tibial spur absent on third and fourth legs ... .. *Isometrus*
- 2(1). Subaculear prong distinctly present (varies  
 from small to large, triangular; pointed or  
 blunt at end) ... .. *Lychas*
- Subaculear prong absent (occasionally a  
 slight indication of a prong) ... .. *Isometroides*

Keys to Species

The Australian genera *Cercophonius* and *Isometroides* are recognized in the present study as monotypic. Keys to species of the other genera are given below.

Key to Australo-Papuan Species of the Genus *Lychas*

1. Subaculear prong laterally narrow (i.e. not  
 high), size moderate to minute; subaculear  
 prong rounded, blunt, or truncate; dorsal  
 thorn on subaculear prong present or absent ... .. 2
- Subaculear prong laterally broad and  
 flattened (i.e. high), size large; subaculear  
 prong pointed sharply or bluntly; dorsal  
 thorn on subaculear prong present ... .. *variatus* (Thorell)

- 2 (1). Subaculear prong size moderate; subaculear prong rounded or blunt; dorsal thorn on subaculear prong present along prong, sub-terminal, or absent; tail segments usually long, sometimes moderately long; dorsal keels of tail segments one to four finely denticulate; carapace with frontal notch ranging from slight to absent ... .. *marmoreus* (Koch)
- Subaculear prong size ranging from moderate to minute; subaculear prong truncate; dorsal thorn on subaculear prong sub-terminal or absent; tail segments ranging from moderately long to short; dorsal keels of tail segments one to four ranging from finely denticulate to strongly crenulate; carapace with frontal notch ranging from moderate to deep ... .. *alexandrinus* Hirst

Key to Australo-Papuan Species of the Genus *Isometrus*

1. Fourth and fifth tail segments not, or only slightly, darker than tergites; second and third tail segments with dorsal terminal tooth not enlarged; aculeus long, gradually curved; subaculear prong sharp, conical, pointing towards point of aculeus; curve formed by aculeus base and subaculear prong wide and large; second to fifth tail segments, humerus, and brachium excessively long (length >4 times height); pectinal tooth count 15-19 ... .. *maculatus* (De Geer)
- Fourth and fifth tail segments darker than tergites; second and third tail segments with dorsal terminal tooth enlarged, especially in male; aculeus short, abruptly curved; subaculear prong blunt, laterally compressed, pointing towards middle of curve of aculeus; curve formed by aculeus base and subaculear prong narrow and small; second to fifth tail segments, humerus, and brachium extremely long but not excessively long (length 3-4 times height); pectinal tooth count 10-17 ... .. *melanodactylus* (Koch)

Key to Australo-Papuan Species of the Genus *Liocheles*

1. Dorsolateral keel of third tail segment with a terminal spine; anterior (inner) surface of humerus with a median granule and seta; posterior (outer) surface of hand basally with five trichobothria (*Esb*, *Db*, *Eb<sub>1</sub>*, *Eb<sub>2</sub>*, and *Eb<sub>3</sub>*); anterior (inner) surface of brachium with tip of prominence bifid; carapace and tergites minutely pitted throughout, granules absent in both sexes; small species (adult CL <5.9 mm) ... .. *australasiae* (Fabricius)
- Dorsolateral keel of third tail segment without a terminal spine; anterior surface of humerus without a median granule and seta; posterior surface of hand basally with four trichobothria (*Db*, *Eb<sub>1</sub>*, *Eb<sub>2</sub>*, and *Eb<sub>3</sub>*); anterior surface of brachium with tip of prominence trifold, with central tip larger than the two lateral tips; carapace and tergites not minutely pitted throughout, granules present in male; medium to large species (adult CL >6.5 mm) ... .. 2
- 2 (1). Carapace granulate, but not pitted; tergites rugose, usually granulate in male but not in female; hand with numerous large granules; the three trichobothria (*dst*, *dsb*, and *db*) at base of fixed finger in a smooth shining continuous sulcus; pectinal tooth count 7-12 (usually 9-12); very large species (adult CL > 13.6 mm) ... .. *karschii* (Keyserling)
- Carapace finely granulate, with frontal lobes and interocular area pitted (only slightly so in male); tergites minutely pitted, in male granulate along distal edge of more posterior segments; hand with some small granules; the three trichobothria (*dst*, *dsb*, and *db*) at base of fixed finger separated by granules or rugosities, hence not in a smooth and shining continuous sulcus; pectinal tooth count 5-10 (usually 6-9, often 6-8); medium to large species (adult CL = 6.6-11.8 mm) ... .. *waijensis* (Gervais)

Key to Species of the Genus *Urodacus*

1. Chelicerae with few or no secondary serrations ... .. 2  
 Chelicerae with prominently developed secondary serrations ... .. 10
- 2 (1). Hands with dorsal and ventral surfaces flat and parallel ... .. 3  
 Hands rounded ... .. 7
- 3 (2). Vesicle length less than four times vesicle height ... .. 4  
 Vesicle length more than four times vesicle height ... .. *megamastigus* sp. n.
- 4 (3). Hand width about or less than half hand length; vesicle laterally flattened ... .. *varians* Glauert  
 Hand width more than half hand length; vesicle rounded ... .. 5
- 5 (4). Trichobothrial numbers high (e.g.  $v = 13$  or more;  $p = 38$  or more) ... .. 6  
 Trichobothrial numbers low (e.g.  $v = 6-9$ ,  $p = 19-25$ ) ... .. *planimanus* Pocock
- 6 (5). Frontal lobes of carapace rounded; interocular areas of carapace rugose anteriorly; medium to small species (adult CL 6.7-9.5 mm) ... .. *koolanensis* sp. n.  
 Frontal lobes of carapace truncate; interocular areas of carapace smooth throughout; large species (adult CL 10.8-13.5 mm) ... .. *centralis* sp. n.
- 7 (2). Frontal lobes of carapace truncate ... .. 8  
 Frontal lobes of carapace rounded ... .. *manicatus* (Thorell)
- 8 (7). Length of each of second to fourth tail segments more than three times height of segment ... .. *elongatus* sp. n.  
 Length of each of second to fourth tail segments less than three times height of segment ... .. 9
- 9 (8). Arms and hands light ochre-yellow; conspicuous red spots on leg joints; tail slender (carapace mostly 2.7-3.6 times the width of fourth tail segment) ... .. *armatus* Pocock

	Arms and hands dark to very dark reddish brown; inconspicuous dull spots on leg joints; tail robust (carapace mostly 2.1-2.7 times the width of fourth tail segment) ...	<i>novaeollandiae</i> Peters	
10(1).	Length of each of first three tail segments slightly more than height of segment (length = 1.1-1.3 times height) ... ..	<i>similis</i> sp. n.	
	Length of each of first three tail segments considerably more than height of segment (length = 1.4 or more times height) ... ..		11
11(10).	Length of terminal claws of tarsus of each leg distinctly unequal, i.e. the inner claw varies from a minute papilla to a claw up to two-thirds length of outer claw ... ..		12
	Length of terminal claws of tarsus of each leg equal or practically equal ... ..		13
12(11).	Most or all of interocular areas of carapace with large pigmented granules ... ..	<i>yaschenkoi</i> (Birula)	
	Most or all of interocular areas of carapace smooth, not densely covered with large pigmented granules ... ..	<i>hartmeyeri</i> Kraepelin	
13(11).	Vesicle narrower than fifth tail segment ... ..	<i>giulianii</i> sp. n.	
	Vesicle wider than fifth tail segment ... ..		14
14(13).	Hands with dorsal and ventral surfaces moderately flat and parallel ... ..	<i>carinatus</i> Hirst	
	Hands rounded ... ..		15
15(14).	Terminal dorsal spine of tail segments weakly developed ... ..	<i>excellens</i> Pocock	
	Terminal dorsal spine of tail segments strongly developed ... ..		16
16(15).	Vesicle moderately large to very large (mostly 1.3-1.6 times as high as fifth tail segment) ... ..		17
	Vesicle small to moderately large (mostly 1.0-1.2 times as high as fifth tail segment) ... ..		18
17(16).	Bright clay-yellow; interocular areas of carapace smooth and shiny throughout ... ..	<i>macrurus</i> Pocock	
	Light yellowish brown to reddish brown; interocular areas of carapace rugose towards and along anterior edge ... ..	<i>lowei</i> sp. n.	

- 18(16). Finger keel strong, granulate, and reddish light brown to reddish brown; fifth tail segment considerably longer than carapace; hands small and narrow ... .. *spinatus* Pocock
- Finger keel not strong, granulate, or reddish; fifth tail segment about as long as carapace; hands large and wide ... .. *hoplurus* Pocock

## EXTRALIMITAL DISTRIBUTION OF THE FAMILIES AND SUBFAMILIES REPRESENTED IN AUSTRALIA

The Bothriuridae (10 genera) has three subfamilies: Brachistosterninae in South America (arid and semi-arid parts); Vachonianinae in South America (Argentina); Bothriurinae in South America (from south of the Amazon to Tierra del Fuego) and Australia.

The Bothriurinae has six genera in South America and one genus in Australia.

The Buthidae (42 genera) has four subfamilies: Tityinae, Centurinae, and Ananterinae in South America; and Buthinae in South America, the Mediterranean, Africa, Madagascar, part of Asia to Australia and Fiji.

The Buthinae is the largest of the subfamilies and one of the most widespread. Although most of its genera occur in Africa, India, and Asia, one genus (*Ananteris*) is found in South America. In Australia, one genus (*Isometroides*) is endemic. The other genera represented in Australia are widespread in countries to the north.

The Scorpionidae (19 genera) has five subfamilies: Lipsominae in South Africa; Hemiscorpioninae in Arabia and Madagascar; Scorpioninae in Africa and Indo-Malaysia; Ischnurinae in South America, Africa, Madagascar, India through Australia to Tahiti; Urodacinae in Australia.

The species of the ischnurine genus *Liocheles* that are present in Australia are widespread in countries to the north.

The ischnurine genus *Opisthacanthus* occurs in South America, Africa, Madagascar, and India. Giltay (1931) says that *O. davydovi* Birula, 1904, is now present only on the Aru Islands. But Birula (1917a) points out that, because of its rarity, it must have been introduced. A unique location for a species of this genus seems highly improbable. This point is particularly cogent because the Aru Islands fall within the 200 metre bathymetric contour surrounding the Australia-New Guinea land mass and hence the species would have to be a recent member of an ancient genus. I have not examined

this specimen but suspect that it may have been misidentified or that its locality record is incorrect.

The monotypic subfamily Urodacinae appears morphologically closest to the Scorpioninae and to have evolved from it by reduction in certain morphological features. The Scorpioninae are distributed in Africa and Indo-Malaysia, the Urodacinae being morphologically closest to the Indo-Malaysian forms.

## VARIATION OF CHARACTERS

The kind of variation exhibited by the characters of the Australo-Papuan scorpions studied during the taxonomic investigations are classified below.

### Sexual Dimorphism

In scorpions, males (even juveniles) are recognized by the possession of a pair of minute pointed genital papillae under the genital opercula; the females lack papillae. (The genital operculum of the male is always divided.) The sexual dimorphism in external morphology of the species as revealed by the present study is classified as follows:

1. Shape. As a result of multivariate analyses of nine measurements characters (details in Campbell & Koch, in preparation) the following extents of sexual dimorphism in shape are recognized:

Marked in	<i>U. elongatus</i> , <i>U. planimanus</i> , <i>U. hoplurus</i> , <i>U. hartmeyeri</i>
Less marked in	<i>U. novaehollandiae</i> , <i>Isometrus melanodactylus</i> , and in <i>Liocheles</i> (especially in <i>L. waigiensis</i> for which adequate data for both sexes are available)
Less evident in	<i>U. manicatus</i> , <i>U. yaschenkoi</i>
Variable	<i>U. armatus</i> —from less marked to little evident
Not marked in	Bothriuridae and Buthidae (except for <i>Isometrus melanodactylus</i> )

2. Presence of a feature in male but not female:

Prong on hand (near fingers)—*C. squama*

Large tooth on movable finger, near base (with corresponding notch on fixed finger)—*Liocheles*

3. Males have the following features larger or more strongly developed:

(i) Size and shape

Body size (as indicated by carapace length)—*Liocheles australasiae*

Tail length—all species of all genera; extreme contrast is shown in *Isometrus*, also marked in *Urodacus*, especially *U. varians*, least evident in *Cercophonius* and *Liocheles*

Tail keels—all species of all genera; especially *Lychas*, *Isometrus*, and *Urodacus*

Terminal tooth or denticle or dorsal keel of tail segments—all species of all genera; least dimorphism in *Cercophonius* and *Liocheles*

Humerus and brachium length—*Isometrus maculatus*

Hand length—*Isometrus maculatus*, *Liocheles karschii*

Keels of hand—especially in *Urodacus*

Vesicle size—all species of all genera

Pectinal size (especially length)—all species of all genera

Genital opercula more pointed posteriorly—all species of all genera

(ii) **Texture**

Coarser and more plentiful granulation, in male than female, especially on carapace and tergites—all species of all genera

4. Larger size in female than male:

Body size (as indicated by carapace length)—as a rule, in *C. squama*, *U. excellens*, *U. lowei*, *U. spinatus*, *U. similis*

Hand width—as a rule, in *U. elongatus*, *U. planimanus*, *U. excellens*, *U. spinatus*, *U. lowei*

5. Meristics higher in male than female:

Pectinal tooth count—all species of all genera

**Geographic Variation**

Characters found to vary geographically are:

(i) **Size and shape**

Overall size—*Lychas variatus*, largest in northern parts of range.  
*Liocheles waigiensis*, largest at Mt Fox, Pallarenda, Palm I. (Queensland)

Tail length—*U. novaehollandiae*, longer in northern part of range.  
*U. lowei*, longer at Kalumburu, W.A.

Hand length—*Liocheles waigiensis*

(ii) **Colour**

Dark tinge, e.g. on patellas—*U. yaschenkoi*

Light colour—*C. squama* lighter in the more northern (=the central arid) area of its distribution. *U. manicatus* lighter in N.S.W.

Variations, extent of—*C. squama*

Dorsal tergal stripe, width of—*C. squama*

(iii) Texture (granulations)

Overall—all genera, more granulate in specimens from arid areas

### Individual Variation

The characters of intraspecific variation that remain after exclusion of sexual dimorphism and geographic variation are regarded as those that exhibit individual variation. Details of the extent of individual variation have been included in the descriptions of and remarks on the individual species.

The salient characters exhibiting individual variation are:

(i) Size and shape

Overall size—all genera, markedly in *Liocheles waigiensis*, *U. novaehollandiae*, *U. hoplurus*

Chelicerae—*Urodacus*

Carapace—frontal notch: *U. manicatus*, *Lychas alexandrinus*

Carapace—frontal lobes: *Lychas alexandrinus*, *Liocheles waigiensis*, *Liocheles karschii*, *U. elongatus*, *U. armatus*, *U. koolanensis*, *U. excellens*, *U. spinatus*

Tail length—*Lychas variatus*, *Lychas alexandrinus*

Terminal spine of dorsal keel of tail segments—*Urodacus*, *Lychas*

Hand size—*Liocheles waigiensis*

Legs—terminal claw lengths: *U. hoplurus*, *U. yaschenkoi*, *U. hartmeyeri*

Legs—ventral spines: *Urodacus*, especially *U. armatus*

Vesicle—*U. excellens*, *U. lowei*, *U. hoplurus*, *U. yaschenkoi*

Subaculear prong—*Lychas*, and sometimes in *Isometroides*

Subaculear thorn (presence or absence)—*Lychas marmoreus*

(ii) Colour

Overall—all species of all genera, but to least extent in *Liocheles*

Hand keel—*Urodacus*

Variegations—*Lychas*

(iii) Texture (especially granulations)

Carapace—interocular triangle: *U. yaschenkoi*

Tergites—*Lychas*

Last sternite—*Cercophonius*

First tail segment ventrally—*Cercophonius*

Tail surfaces—*Lychas*, especially *Lychas alexandrinus*

Hand keels (pronounced or not)—*Urodacus*

(iv) Meristics

Trichobothria—mainly in *Urodacus* (some trichobothrial groups, i.e. *M*, *V*, *v*, *p*)

Pectinal teeth—all species of all genera

(v) Paraxial organ

Much variation especially in *C. squama* (particularly width of lamina), *U. hoplurus* (teeth of apex of external lobe), *U. macrurus*, *U. hartmeyeri*

### ECOLOGICAL TRENDS

In many characters there are differences between the species that are adapted respectively to the arid central areas and the wetter areas. The ecological trends shown by the characters are classified below at three operative levels (intergeneric, interspecific and intraspecific). The taxa are listed below as examples showing the stated trends in arid areas; e.g. larger overall size is displayed by *Isometroides* which lives in more arid places than *Lychas*.

(1) Greater development of:

Size—

Intergeneric: *Isometroides* compared to *Lychas*

Interspecific: *Liocheles* and *Urodacus* species, e.g. *U. yaschenkoi* compared to *U. novaehollandiae*

Intraspecific: *U. novaehollandiae*, *U. armatus*

Tail size—

Intergeneric: *Isometroides* compared to *Lychas*

Tail length (and length of terminal dorsal and other dorsal tail spines)—

Intraspecific: *U. novaehollandiae*, *U. hoplurus*

Lighter colour—

Interspecific: *Lychas*

Intraspecific: *C. squama*, *Lychas alexandrinus*

Granulations—

Intraspecific: *C. squama*, *Lychas marmoreus*, *U. yaschenkoi*

Paraxial capsule complexity—

Interspecific: all species of *Urodacus*

Intraspecific: *C. squama*, *U. hoplurus*, *U. macrurus*, *U. hartmeyeri*

(2) Lesser development of:

Variations (dark patches)—

Interspecific: *Lychas* species

Intraspecific: *C. squama*, *L. alexandrinus*

Subaculear prong—

Intergeneric: *Isometroides* compared to *Lychas*

Interspecific: *Lychas* species

Intraspecific: *Lychas alexandrinus*

Terminal inner claw of leg—

Interspecific: *U. hartmeyeri*, *U. yaschenkoi*

Intraspecific: *U. hoplurus*, *U. hartmeyeri*, *U. yaschenkoi*

(3) Increase in numbers of:

Secondary serrations of chelicerae—

Intraspecific: all species of *Urodacus*

Trichobothria—

Intraspecific: all species of *Urodacus*

Pectinal teeth—

Intergeneric: *Isometroides* compared to *Lychas*

Intraspecific: *C. squama*, and all species of *Lychas* and *Urodacus*

(4) More complex behaviour:

Burrow construction (burrows are deeper, more spiralling, less under cover)—

Interspecific: *Urodacus* species

Intraspecific: *U. hoplurus*

Feeding specialization (on trapdoor spiders caught within their burrows)—

Intergeneric: *Isometroides* compared to *Lychas*

## ZOOGEOGRAPHY AND EVOLUTIONARY RADIATION OF AUSTRALO-PAPUAN SCORPIONS

### Introduction—Factors Affecting Scorpion Evolution

From the maps\* (1-29) of distribution of the extant species it is possible to infer some features of the evolution of Australian scorpions. The maps

naturally vary in their degree of completeness, but for most species there are sufficient recorded localities for indicating current distributions.

In the present publication an attempt is made to understand these distribution patterns on the grounds that the distribution of any animal represents two interacting sets of circumstances:

- (1) the distribution of climatic and other environmental factors, the ecological tolerance of the species, and the biotic factors of species interaction,
- (2) historical factors, viz., past events that have determined the occurrence of the species in a particular locality, e.g. evolution, land connections, dispersal routes

In addition, a wider consideration of the distribution and affinities of higher taxa leads to some conclusions on the origins of components of the scorpion fauna.

Present distributions of the Australo-Papuan scorpions can be related to features such as temperature and rainfall, and to some extent to places of origin of the species.

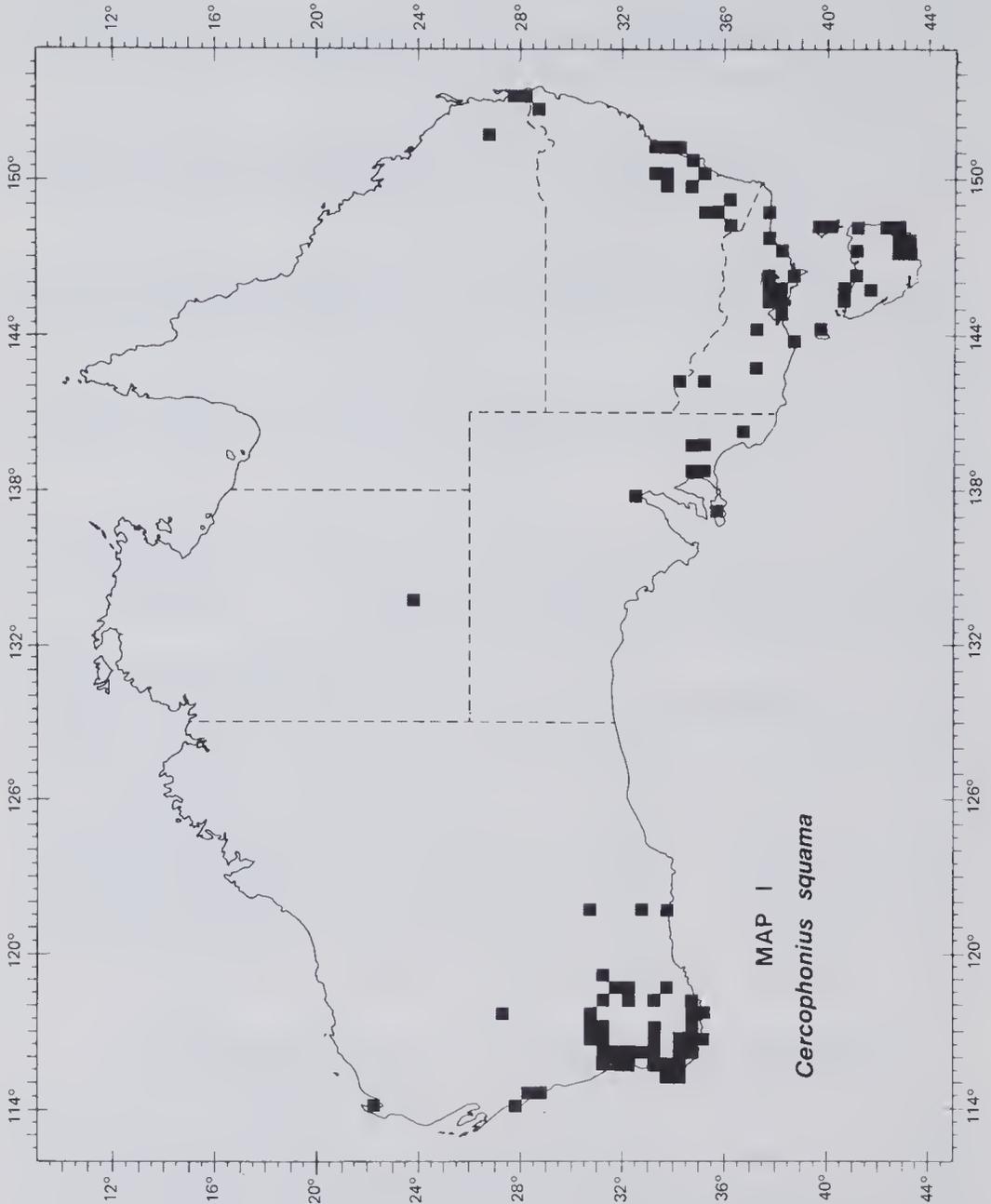
The main features of the Australian continent that require consideration for understanding the ecological factors controlling scorpion distributions are the physiography, the average annual temperature and rainfall, the main barriers and climatic zones, and the refuge areas.

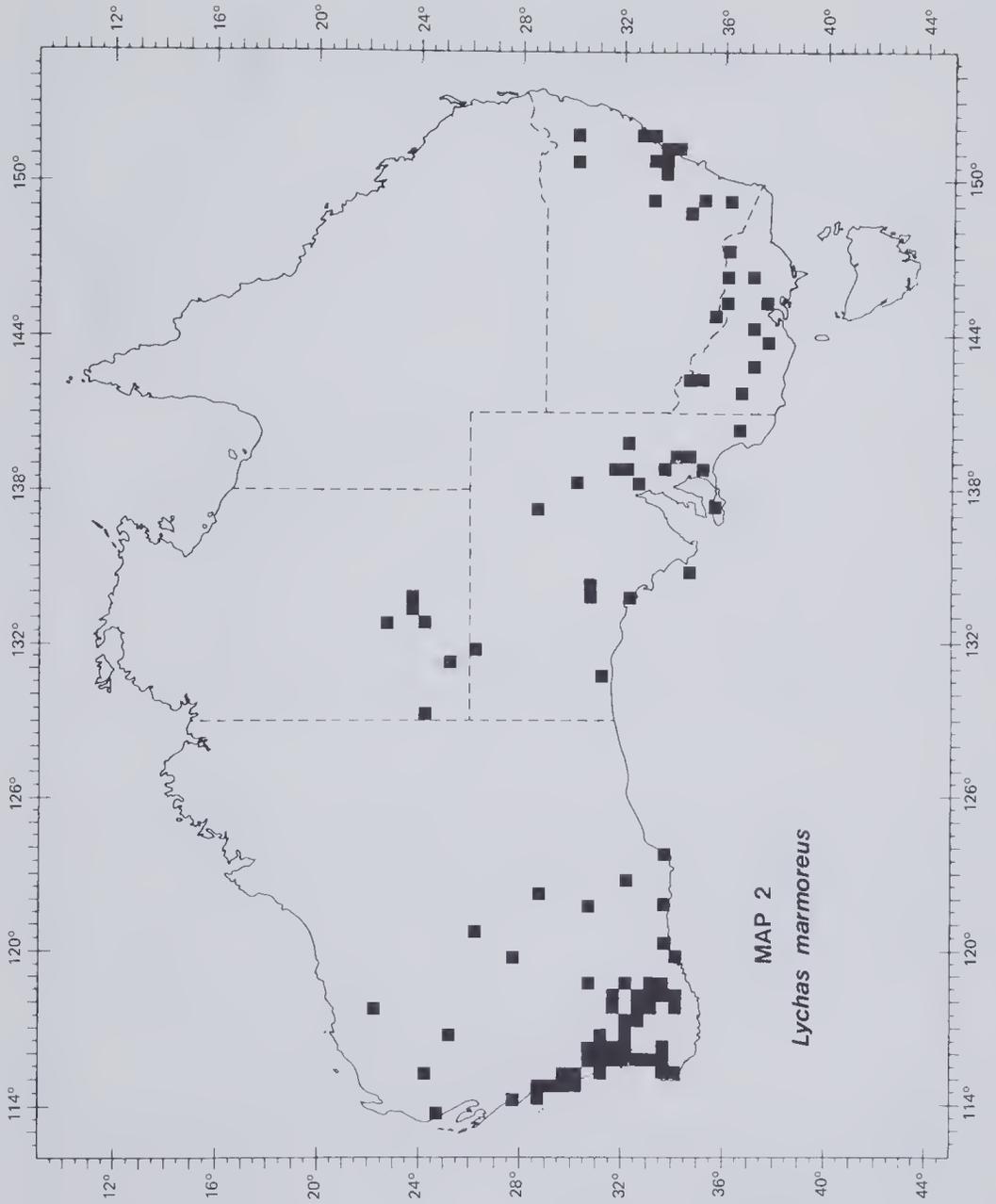
Some of the more important mountain barriers to distribution in Australia are the Great Dividing Range in the east, the Mount Lofty and Flinders Ranges in the south, the Macdonnell and other ranges in central Australia, the Darling and Stirling Ranges in the south-west, and the Hamersley and Kimberley Ranges in the north-west. Although most are only 600-1400 m high, these mountain systems have a significant influence on rainfall and vegetation. The highest peak in Australia is Mt Kosciusko in the Great Dividing Range. It is a mere 2225 m high. Few other Australian mountains exceed 1200 m. In much of Australia rainfall is unreliable and evaporation is high. Maximum summer temperatures above 38°C are common in the interior.

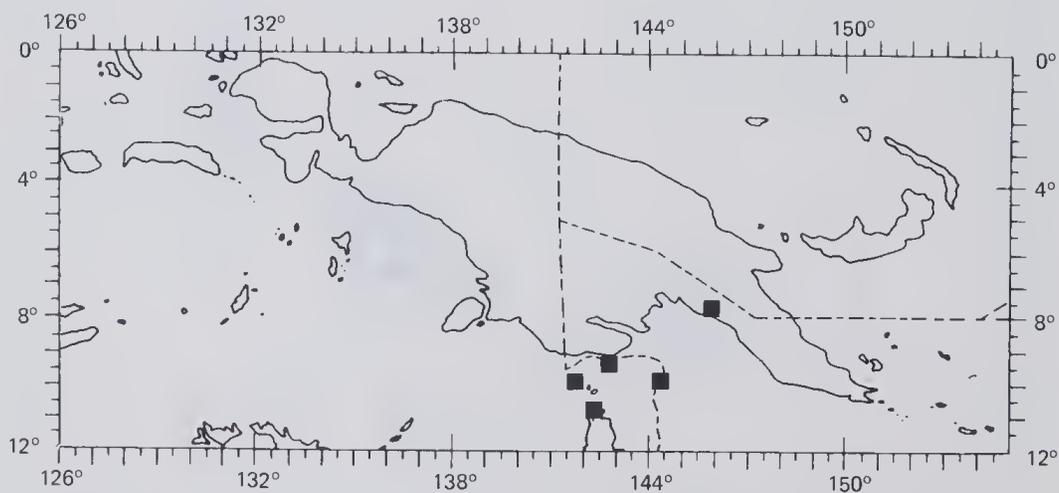
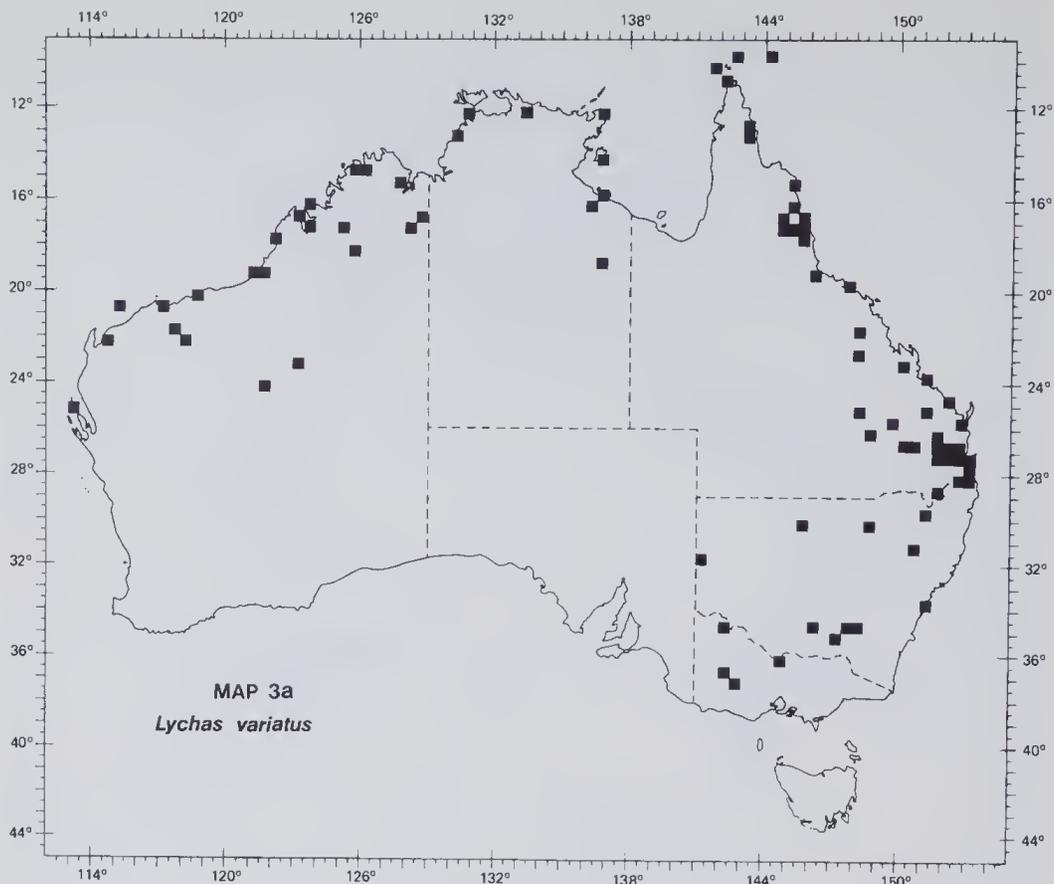
In New Guinea, most of the ranges in the Central Cordillera have peaks over 3000 m. The highest peak (4450 m) is Mt Wilhelm in the Bismarck Ranges. As there has been scant collecting of scorpions in New Guinea particularly in high inland areas, little can be concluded regarding the influence of mountains as barriers to distribution. Most of New Guinea has rainfall over 2,500 mm and the maximum probably exceeds 7,500 mm. Average maximum temperature rarely exceeds 32°C for any lowland station.

Map 1-29: Distributions of the scorpion species in Australo-Papua.

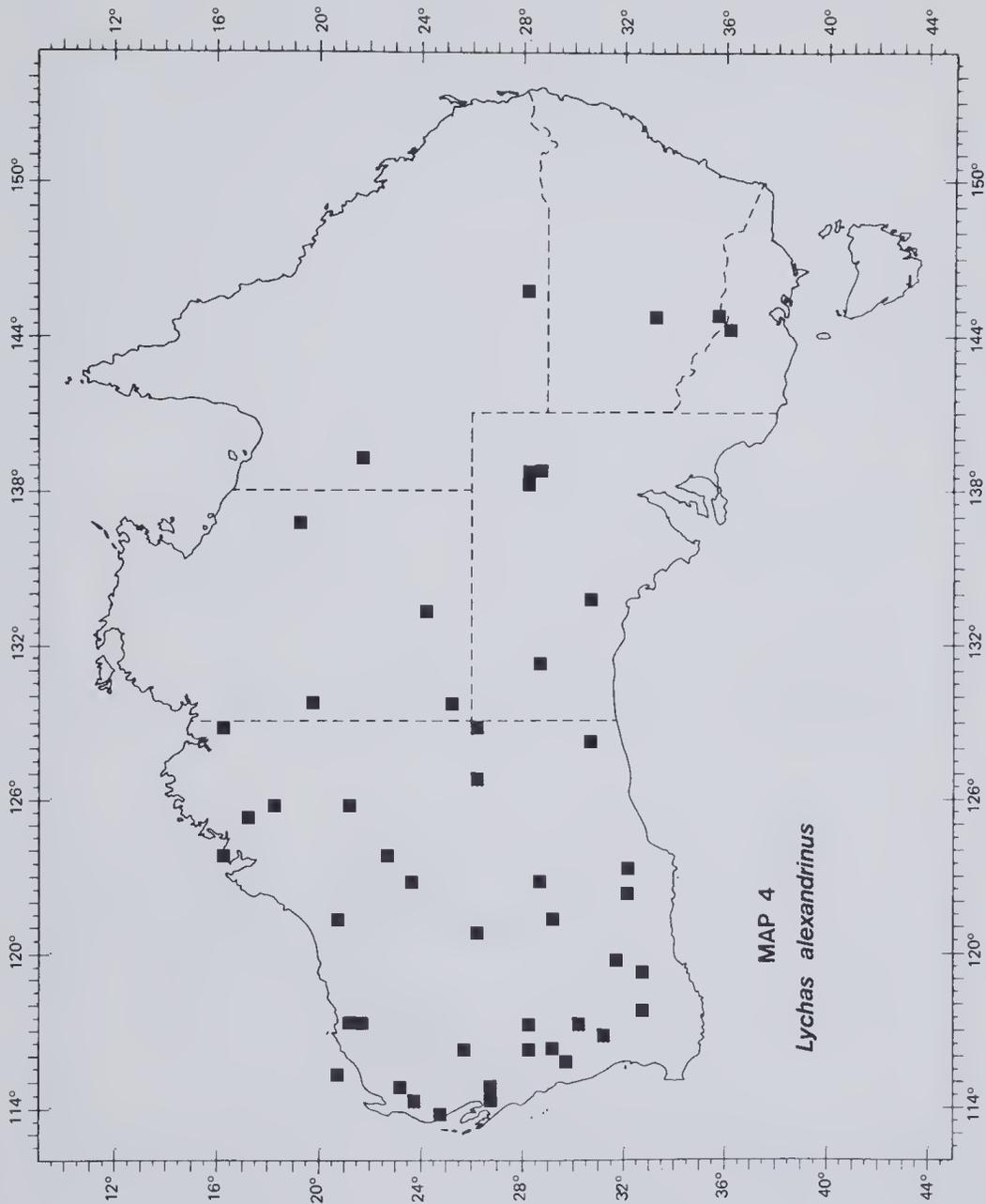
\*The maps have been brought up to date (of acceptance for publication) with locality data from recently collected material and further material located in some museums.

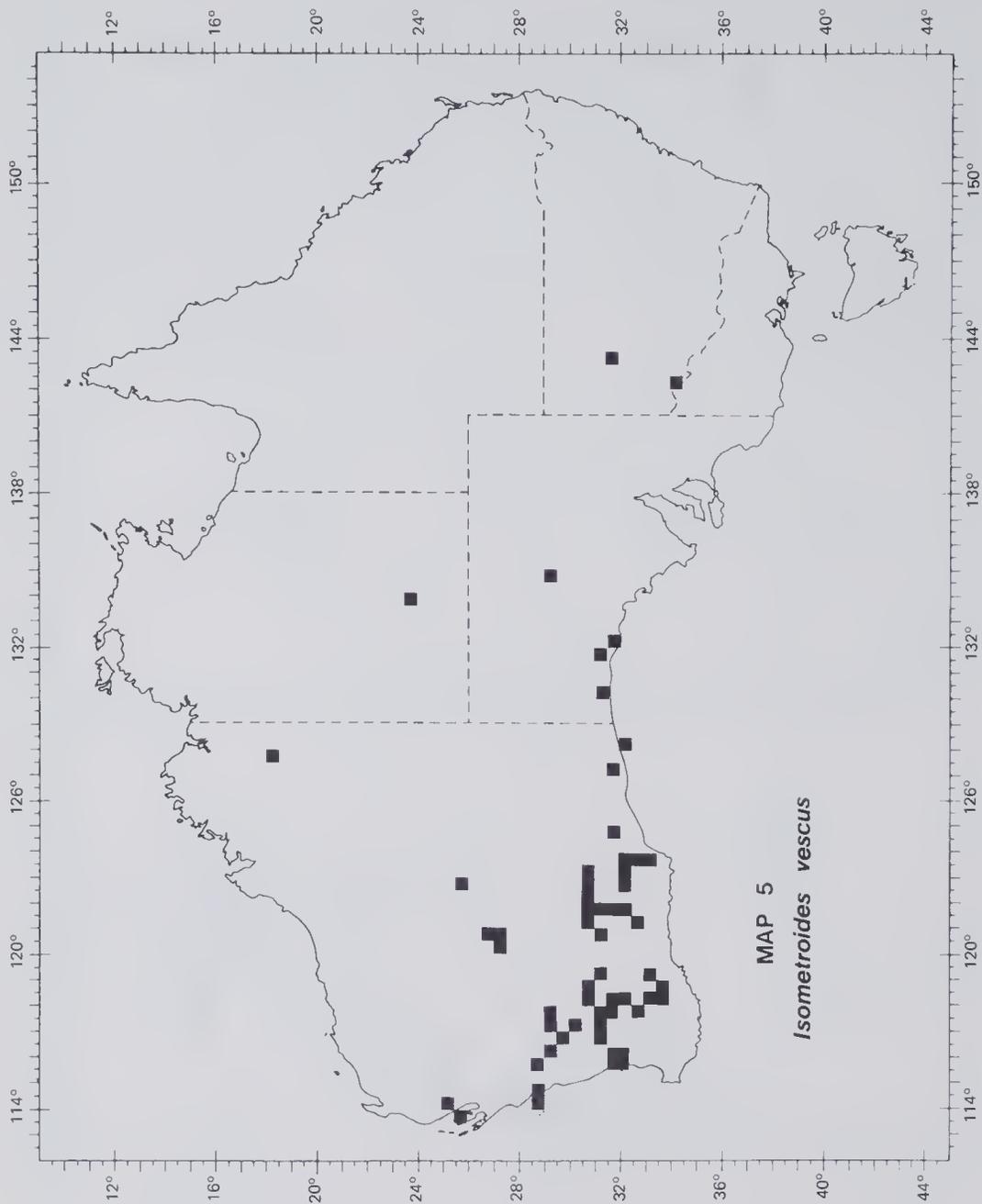


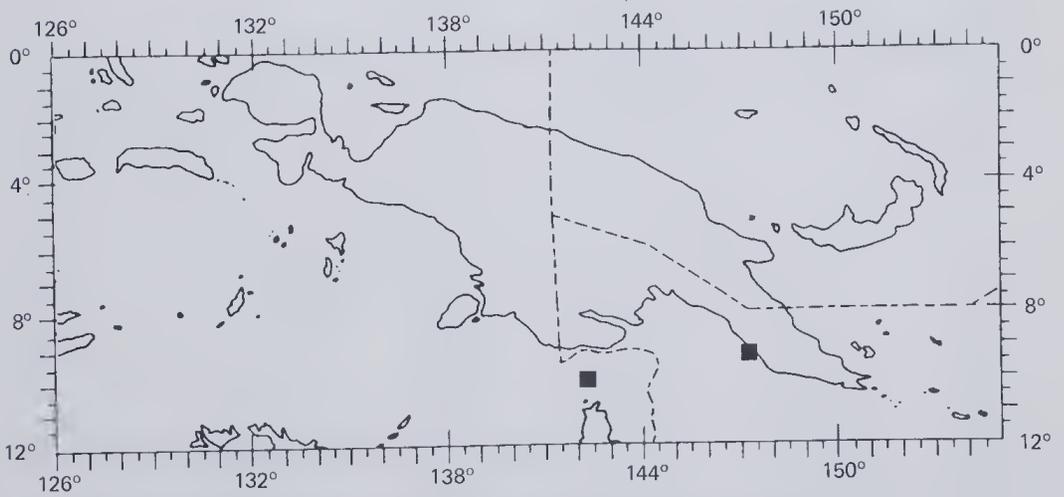
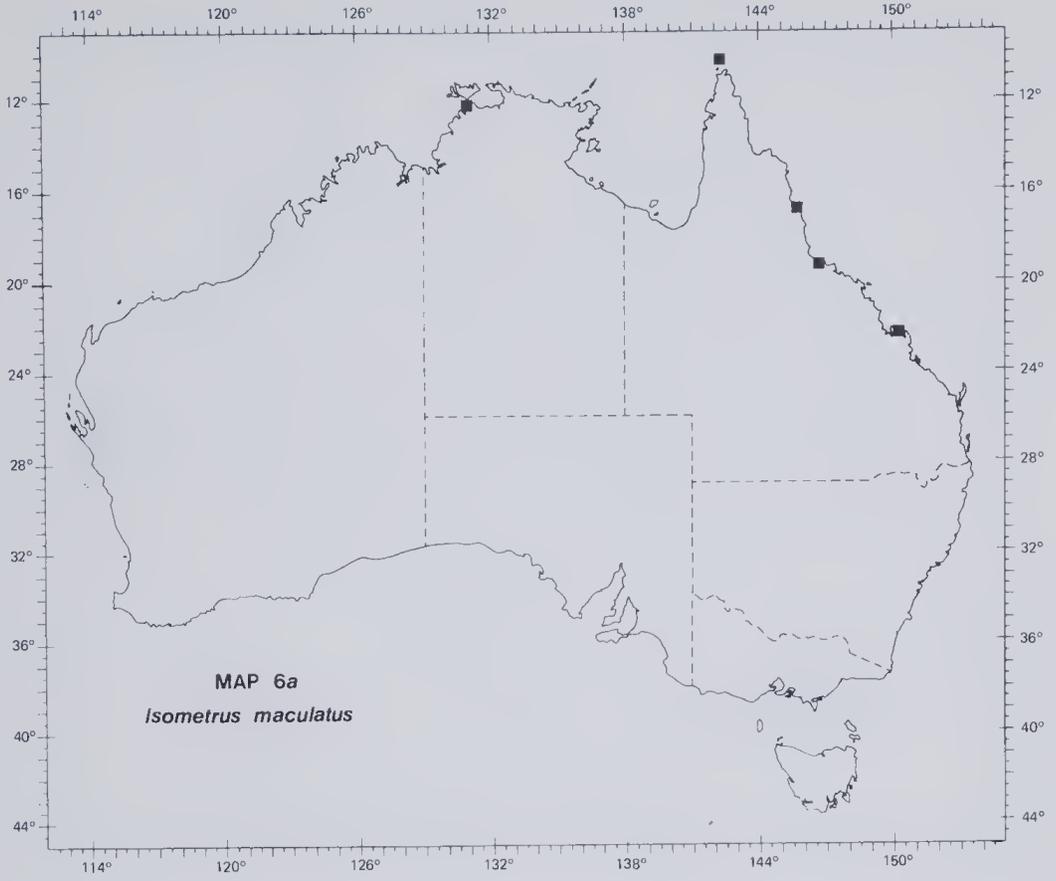


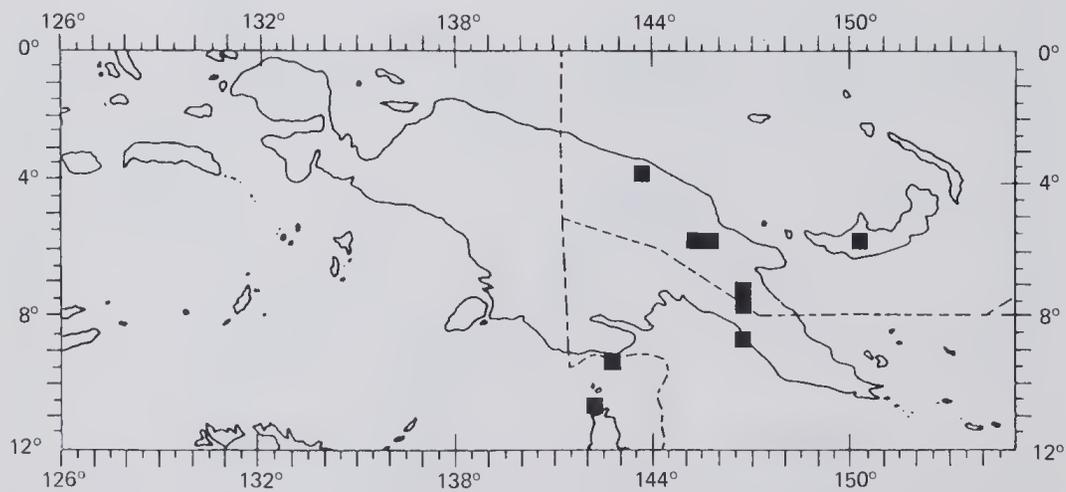
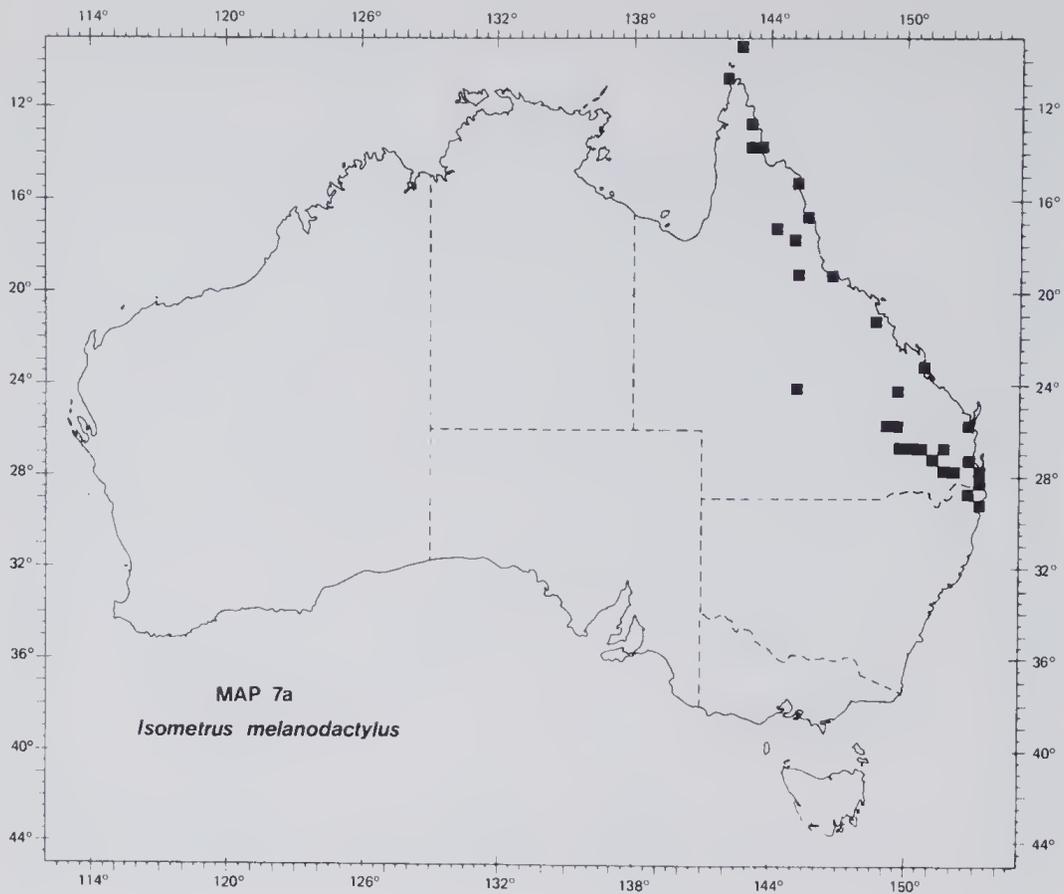


MAP 3b: *Lychas variatus*

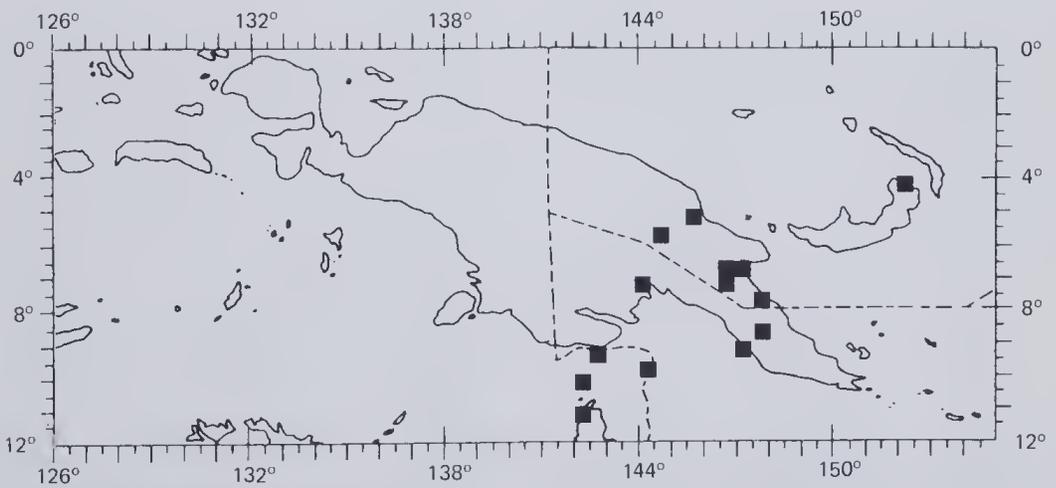
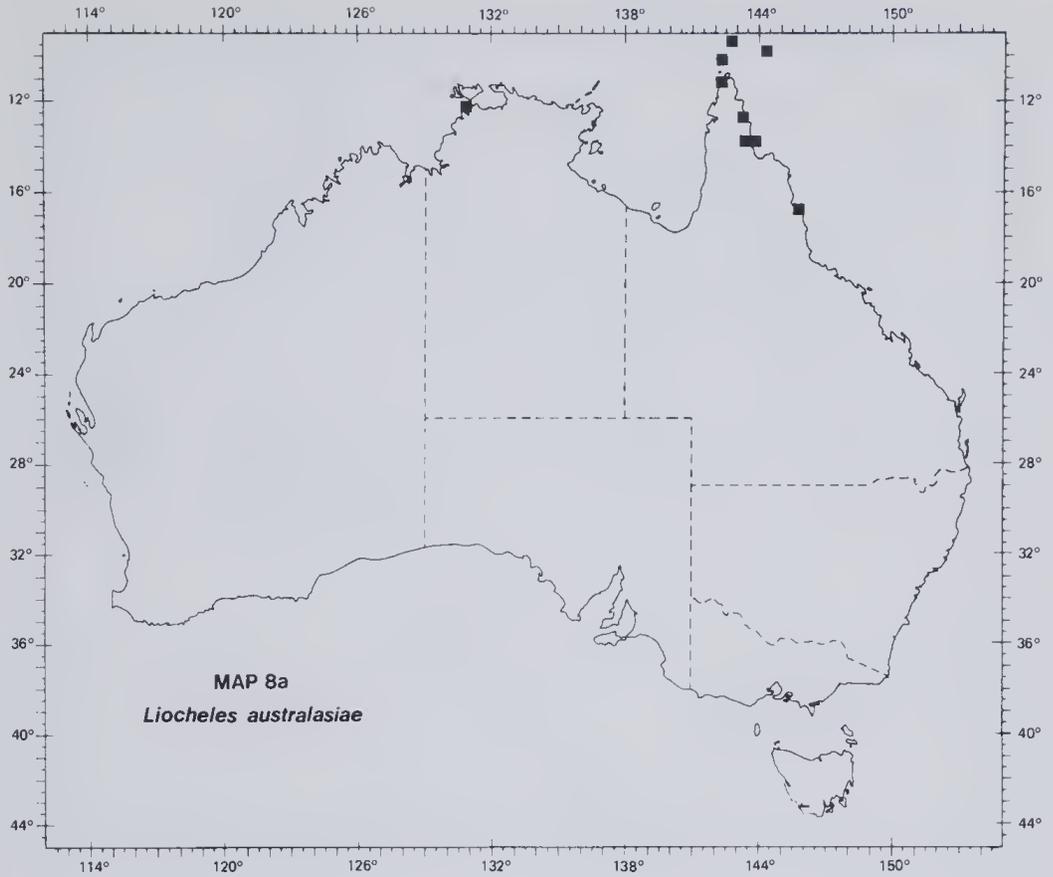




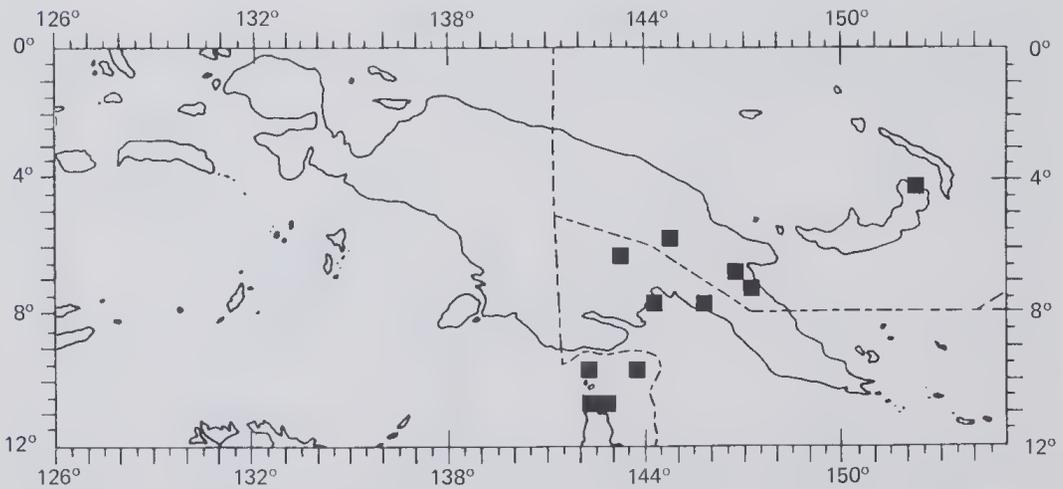
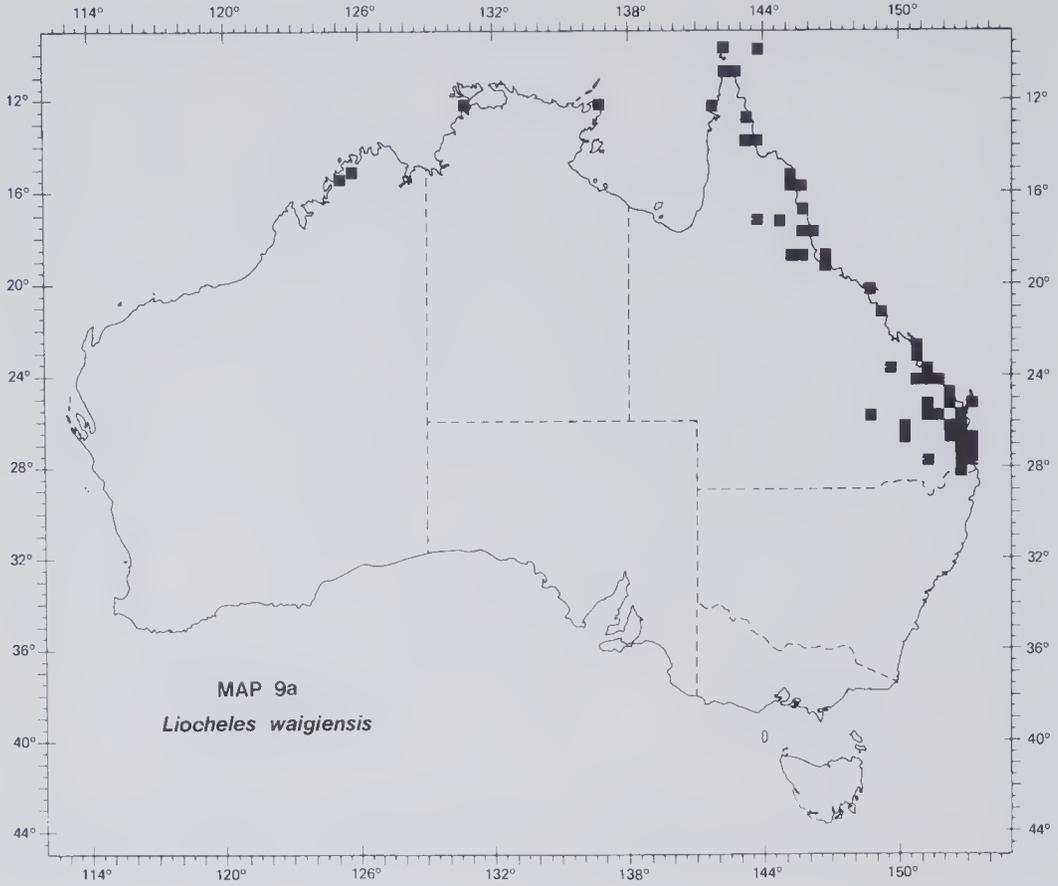




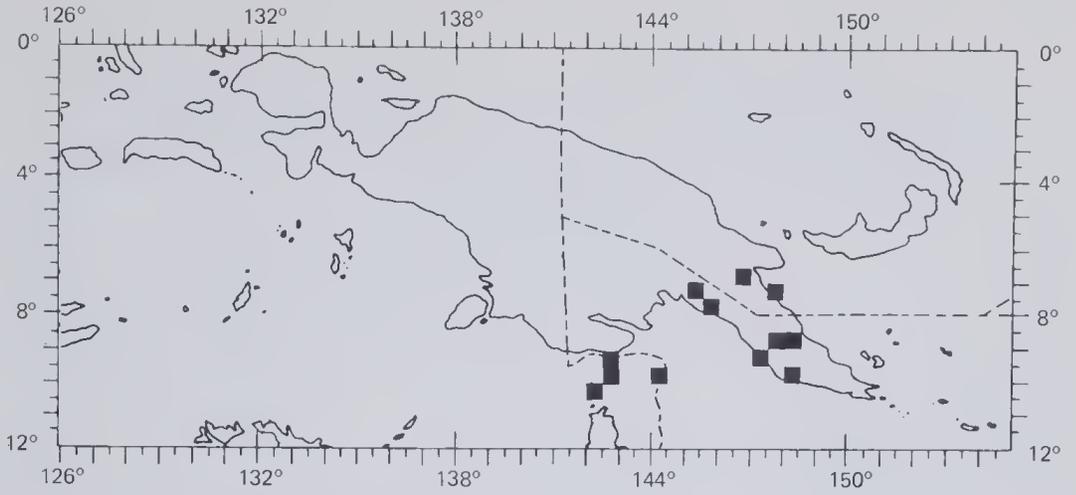
MAP 7b: *Isometrus melanodactylus*



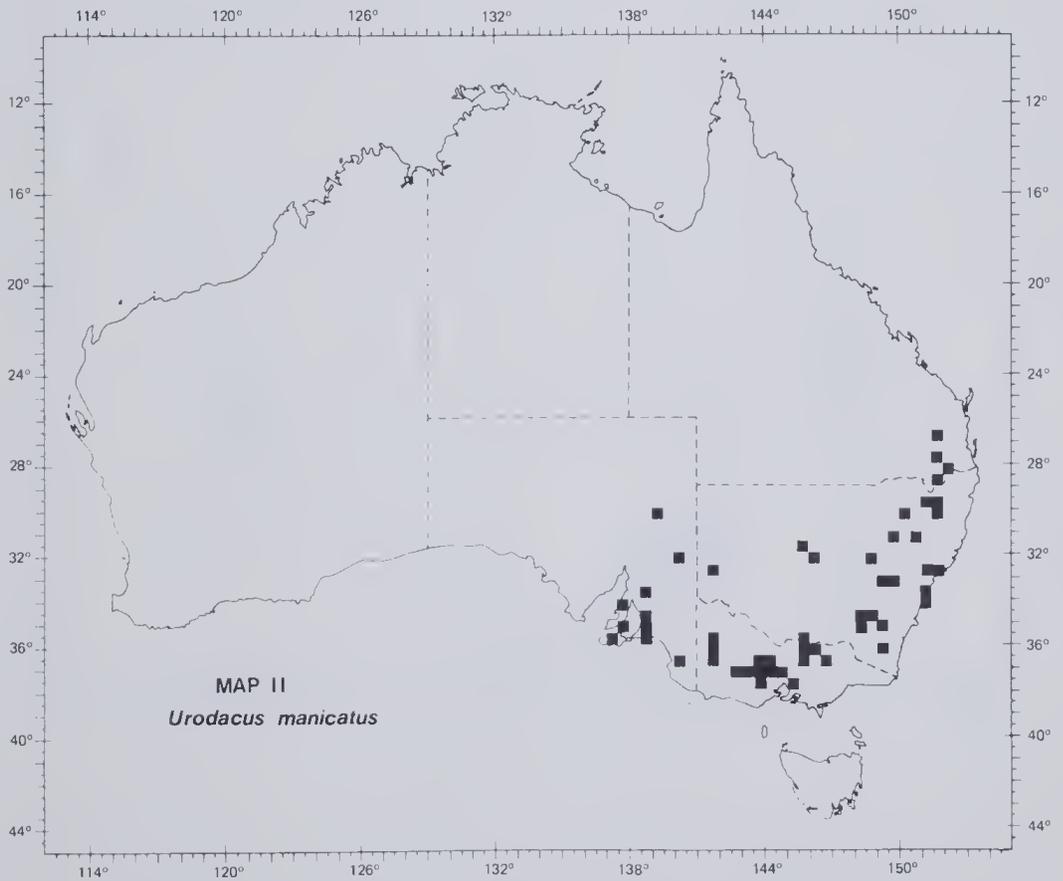
Map 8b: *Liocheles australasiae*



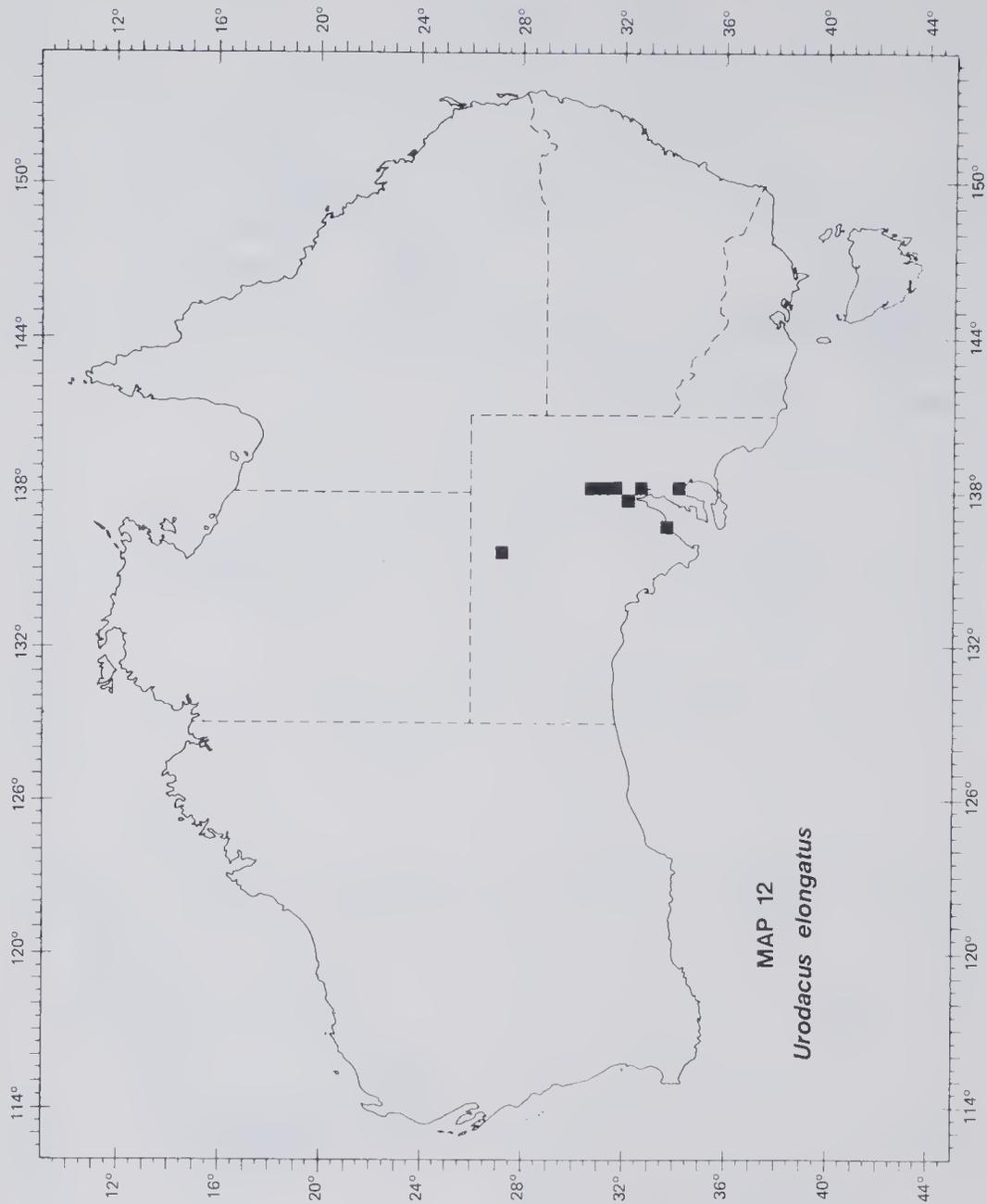
Map 9b: *Liocheles waigiensis*

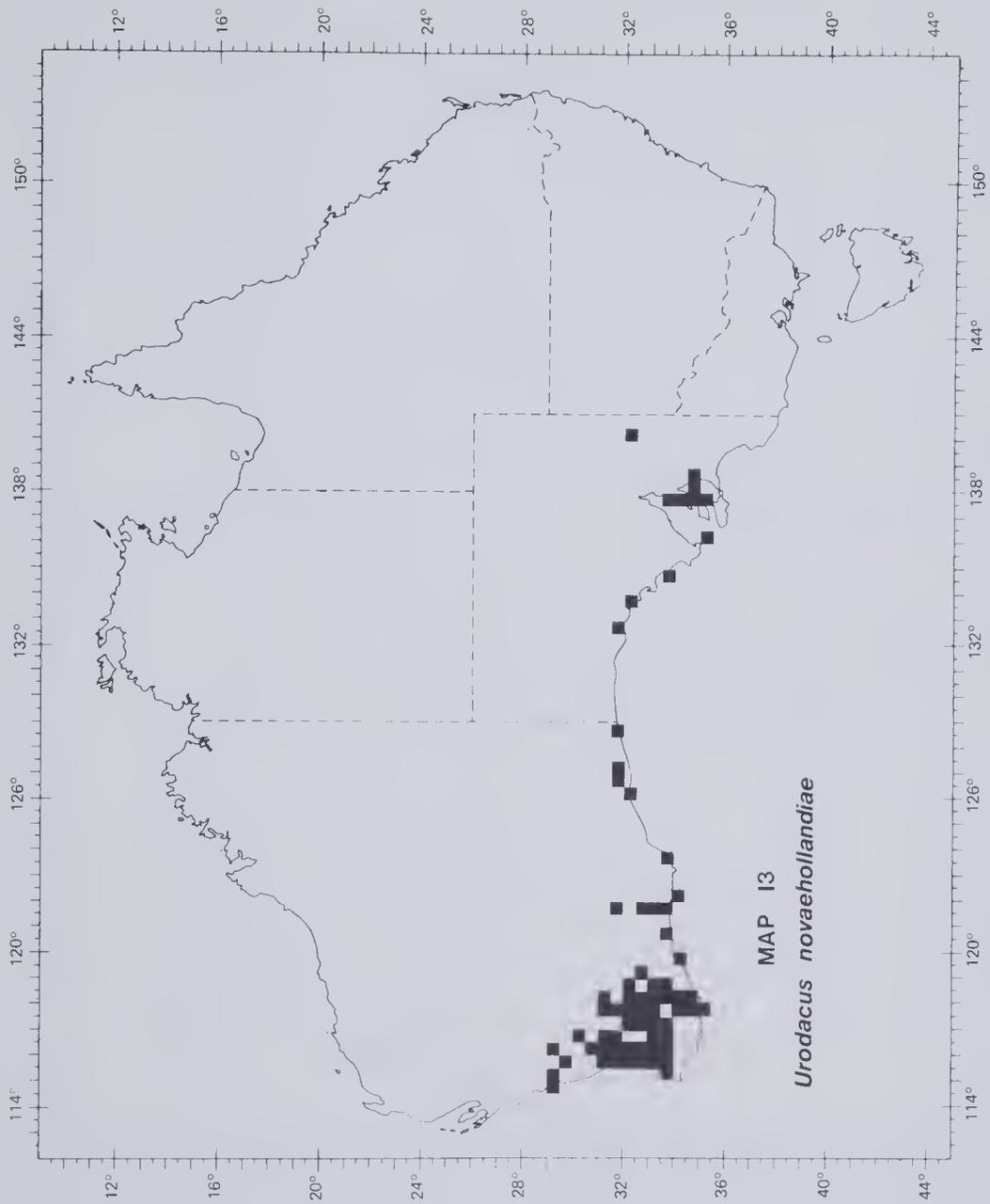


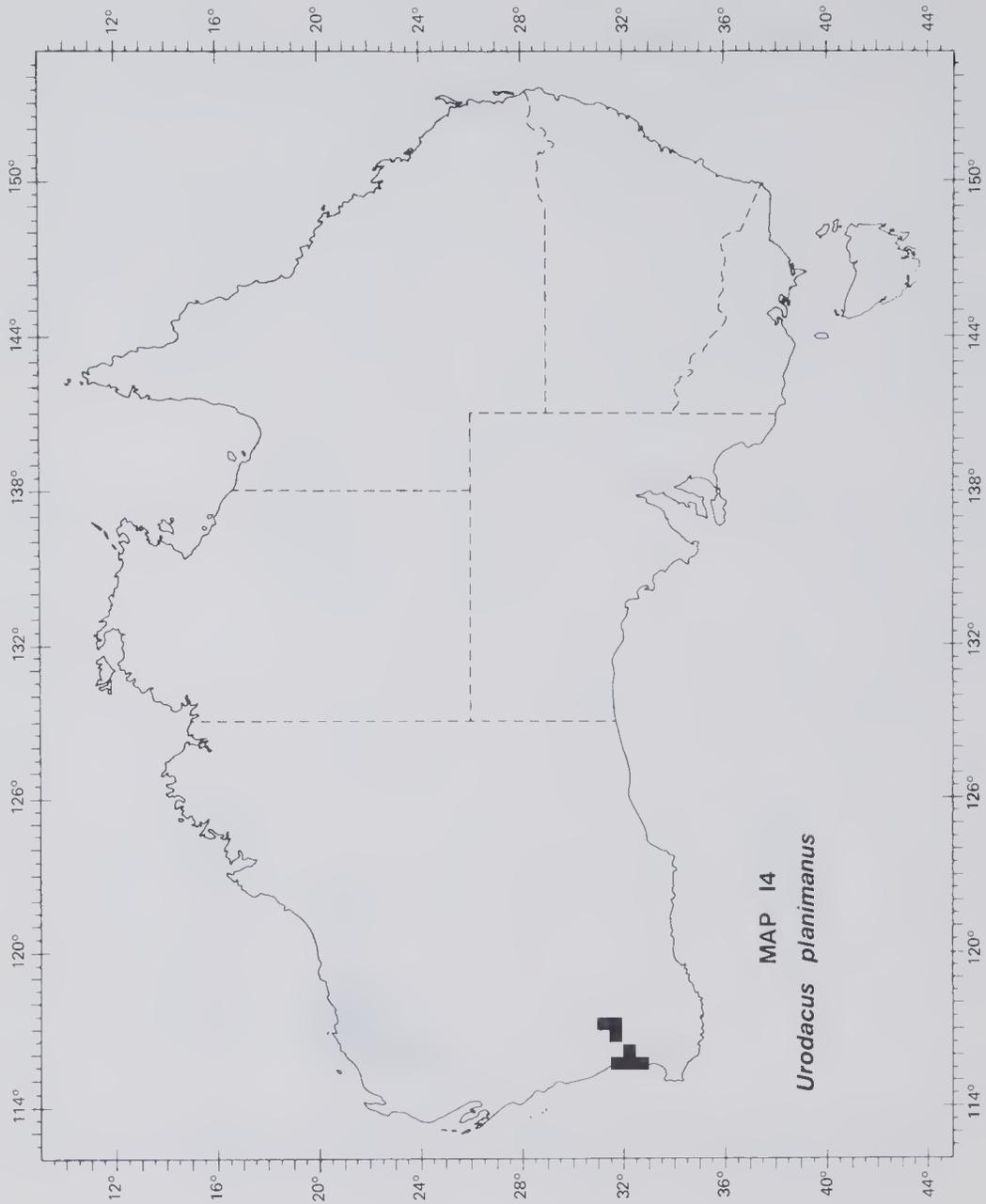
MAP 10: *Liocheles karschii*

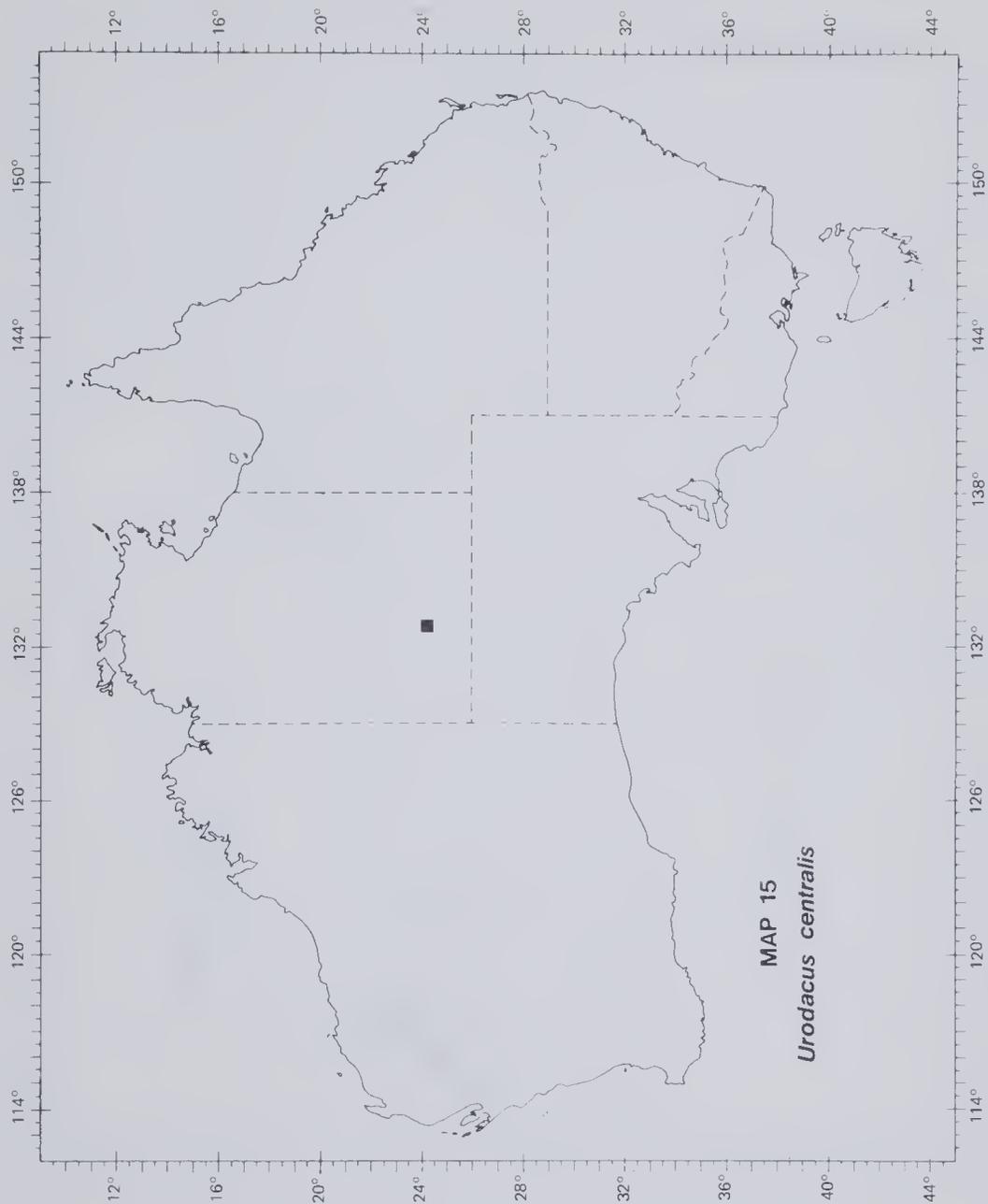


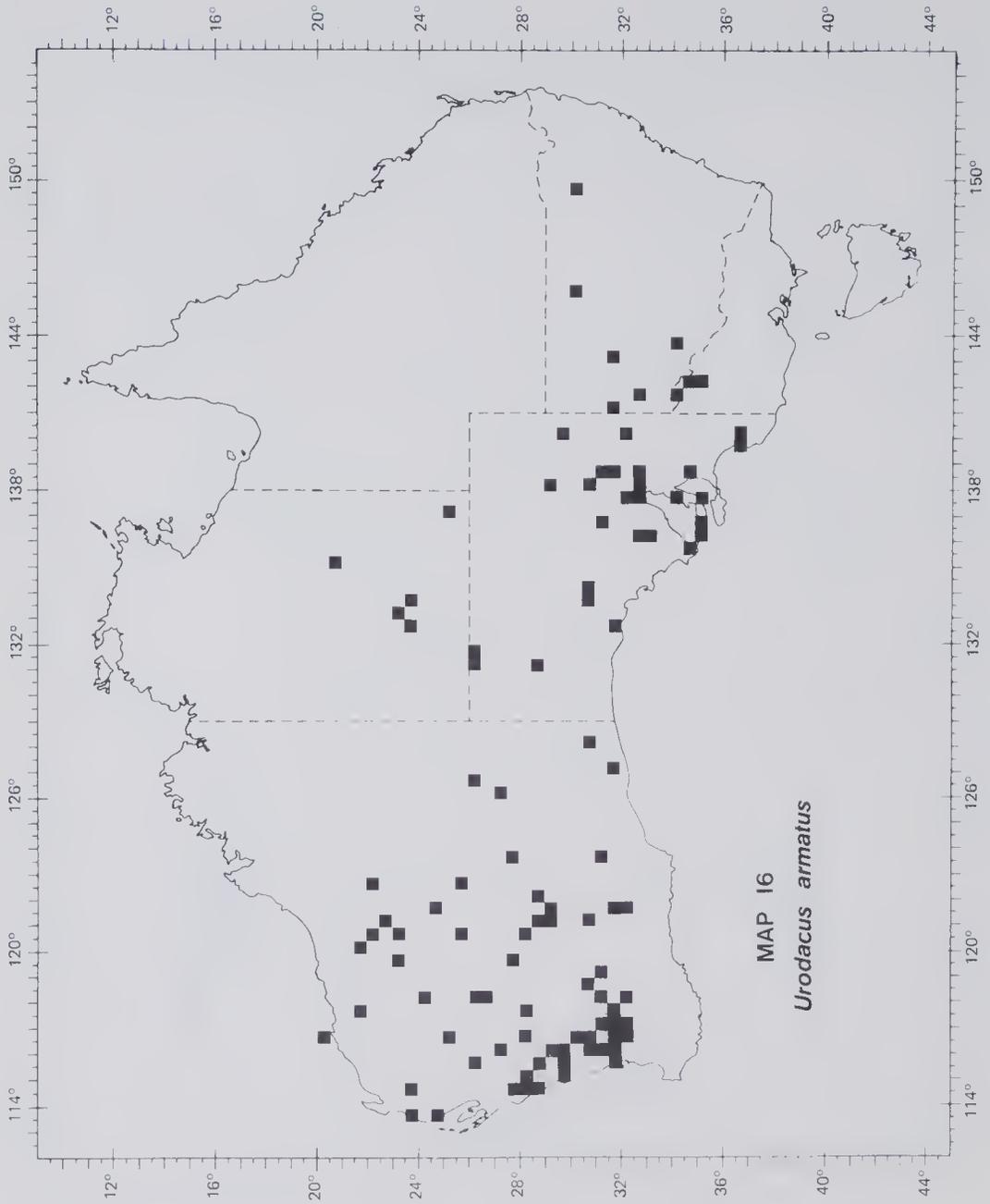
MAP II  
*Urodacus manicatus*

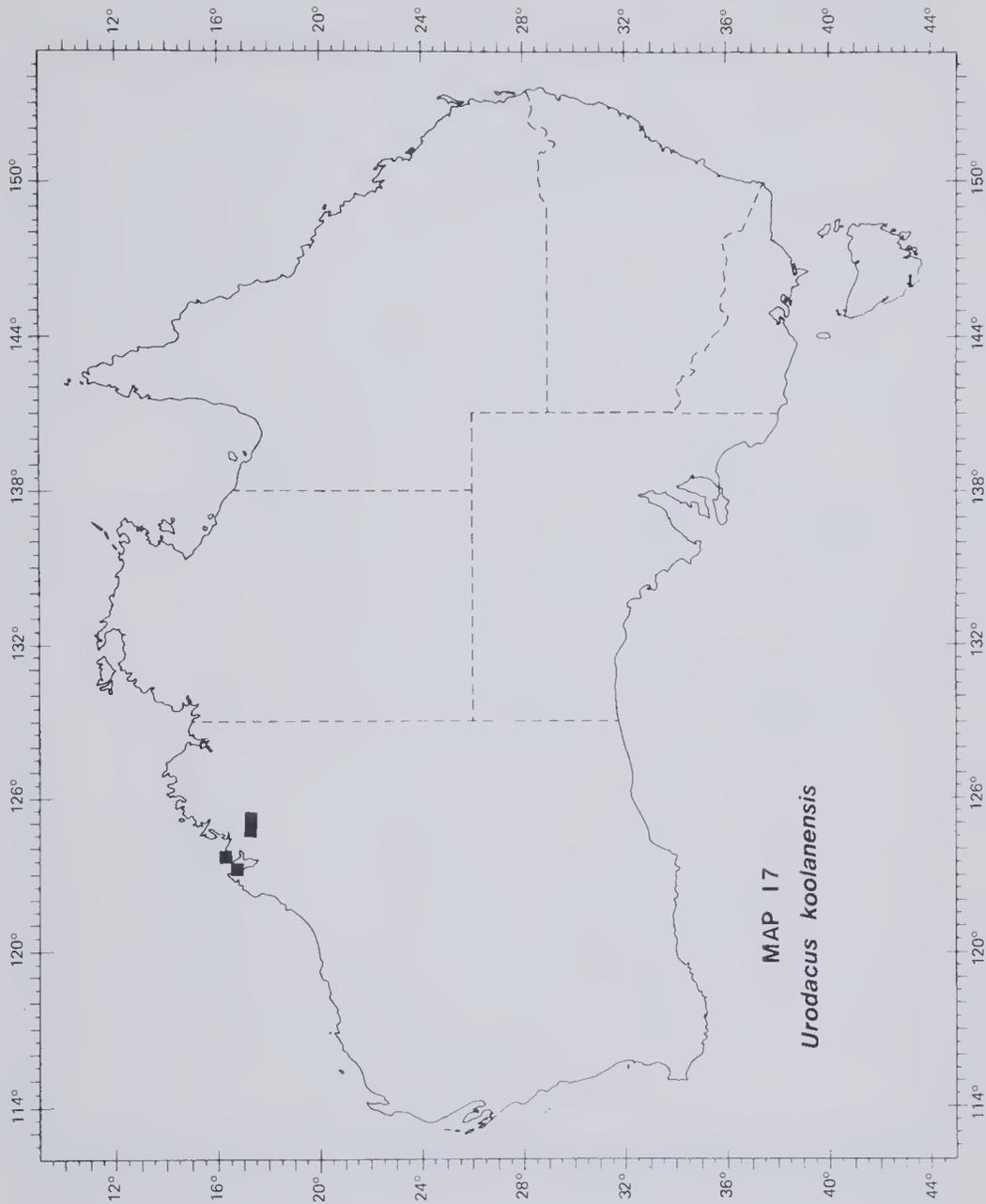


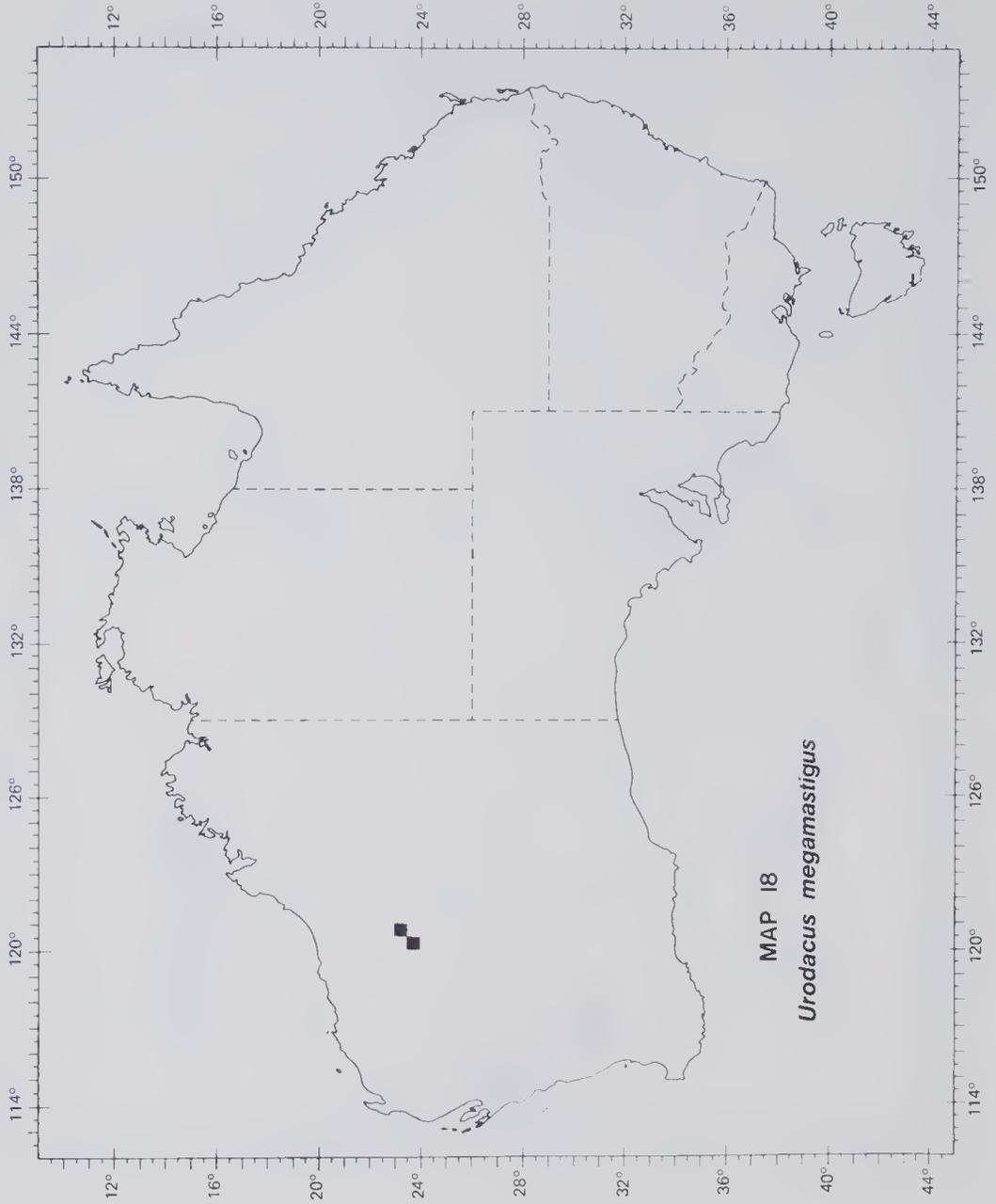


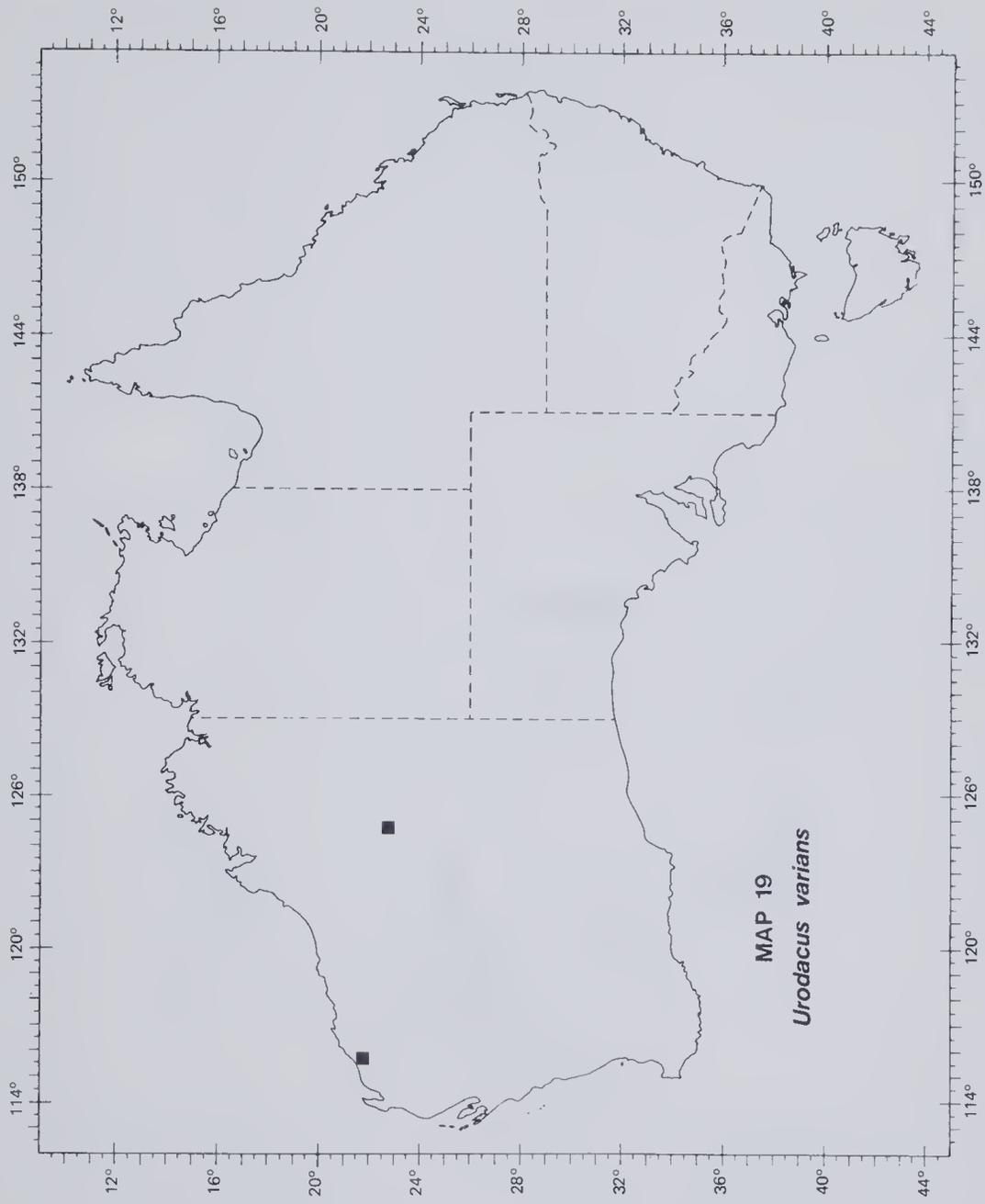


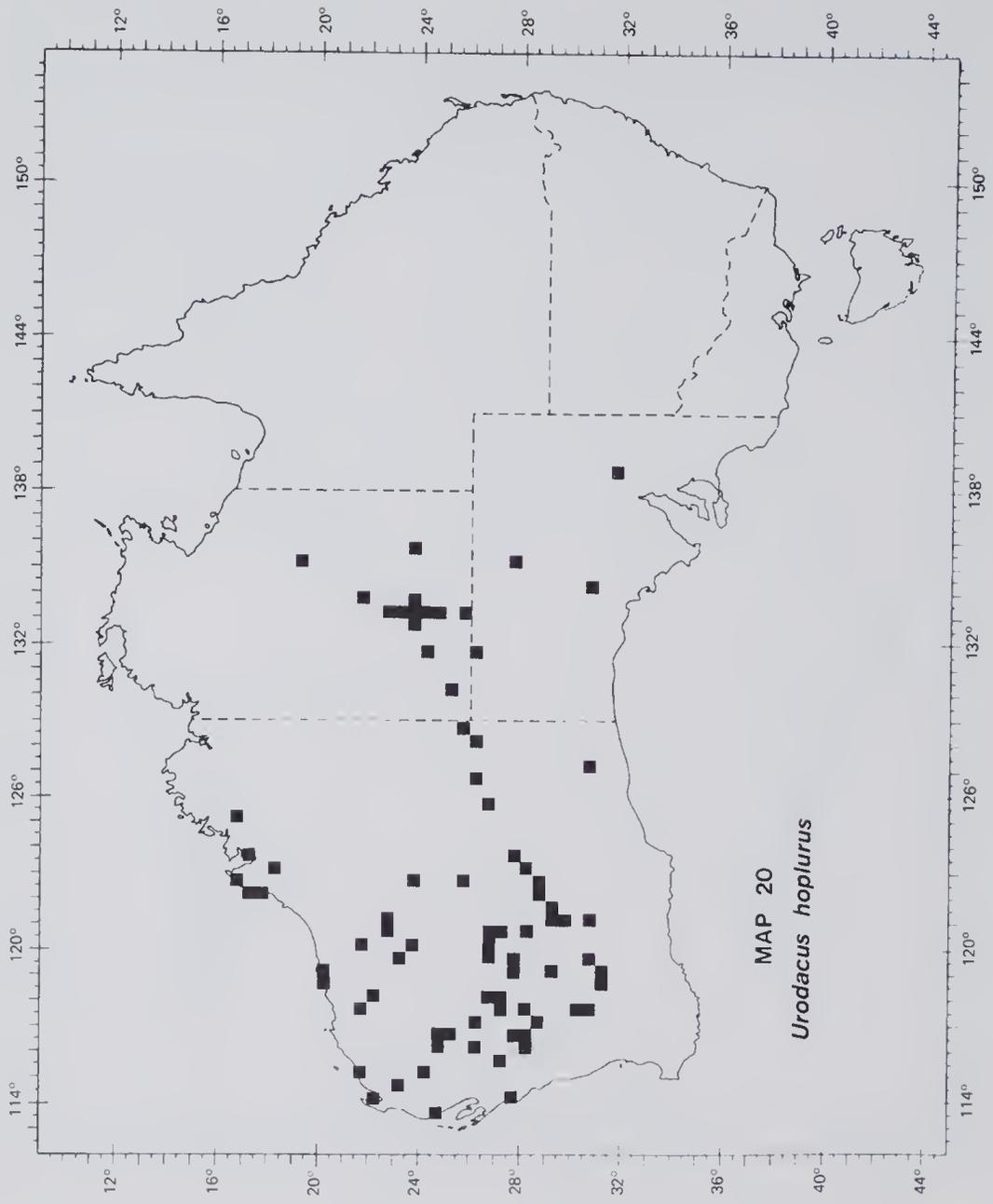




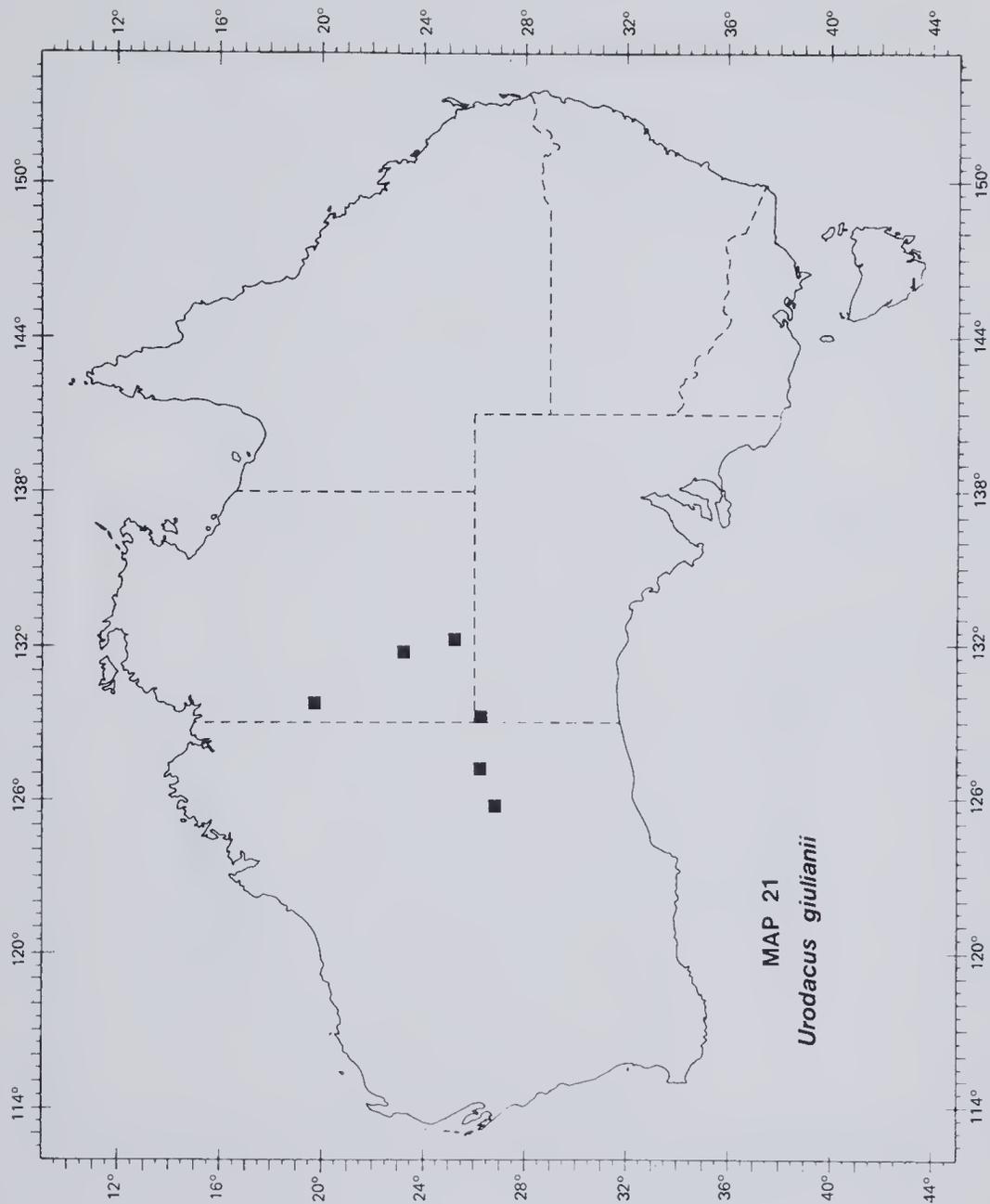


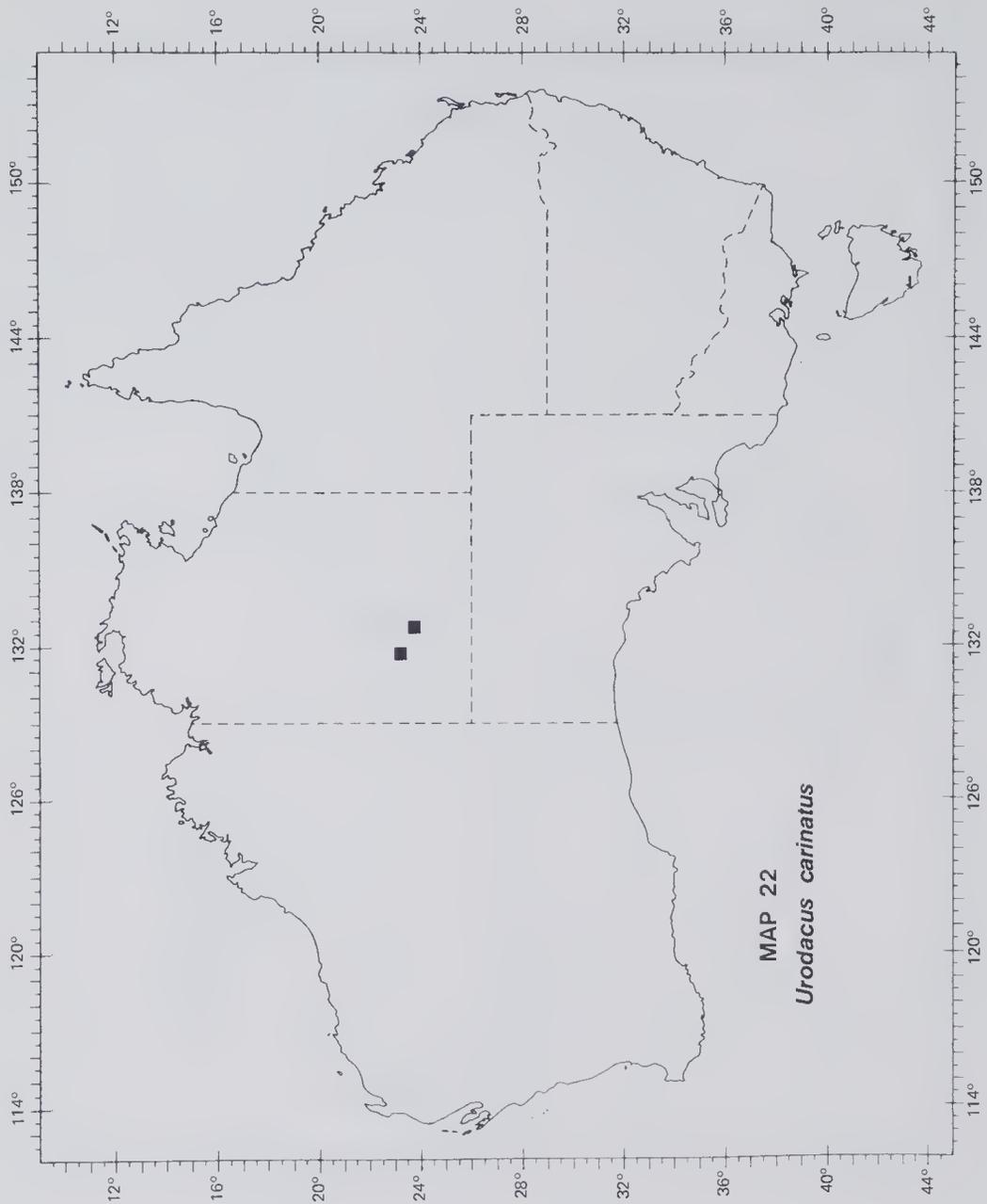


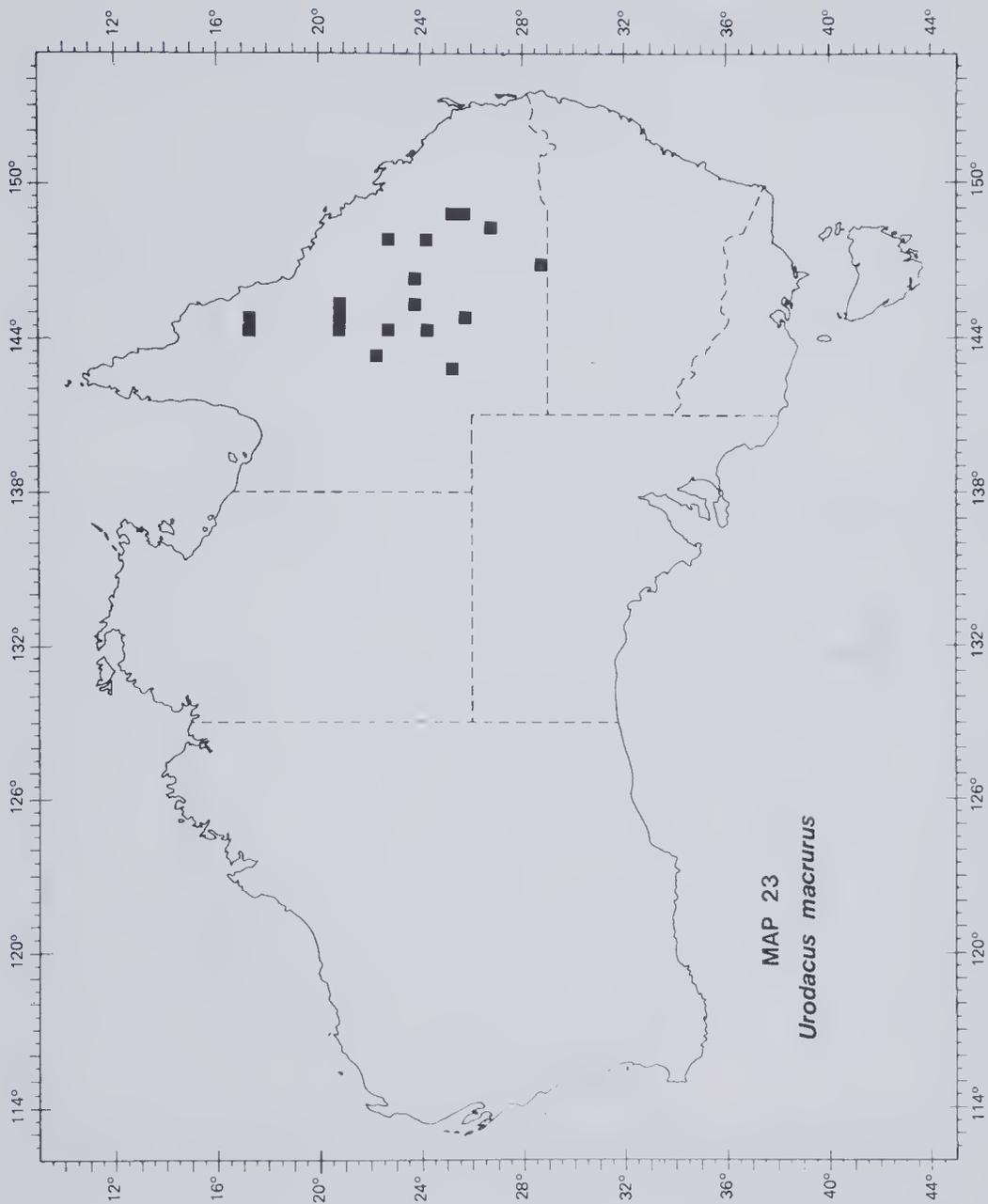


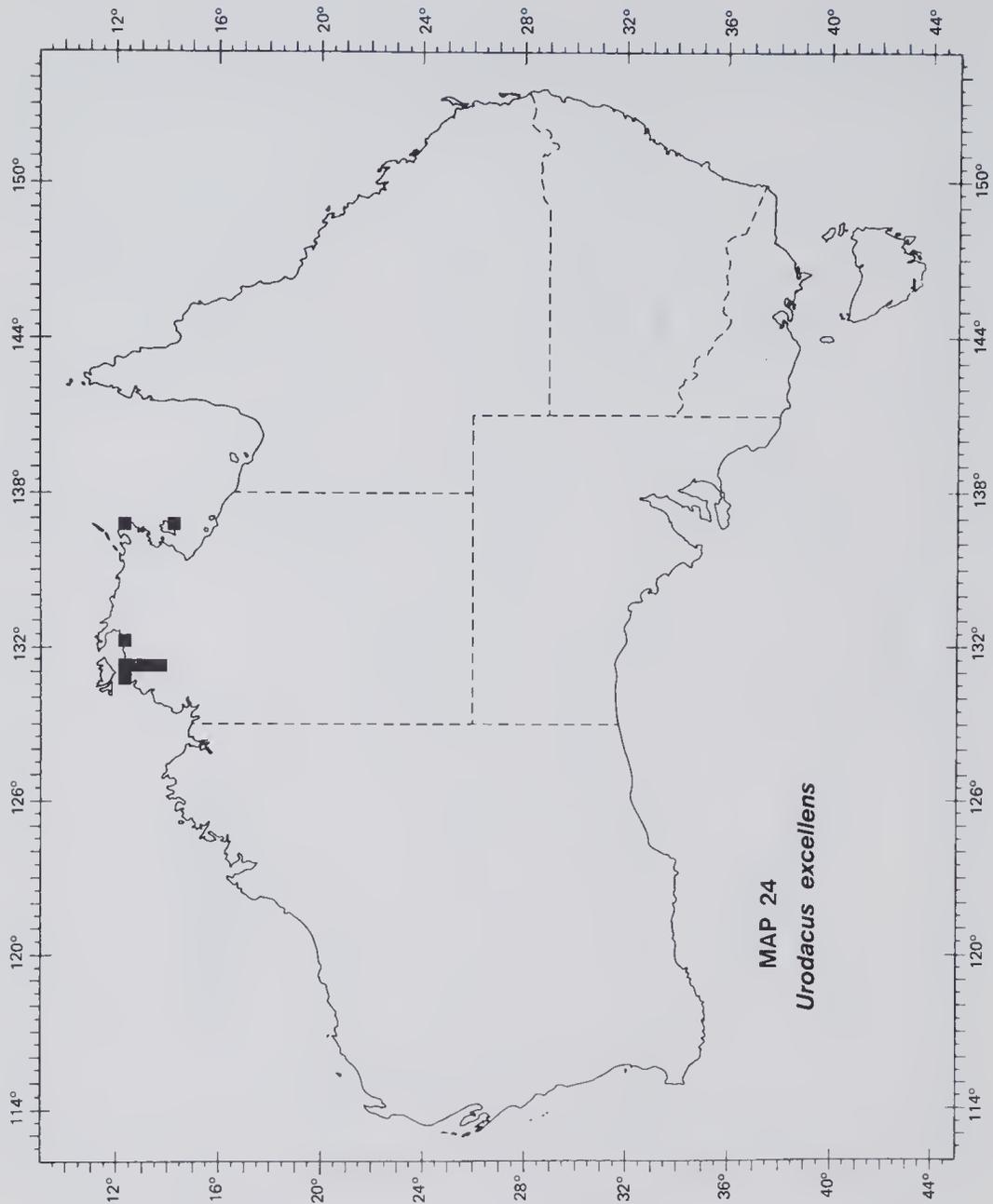


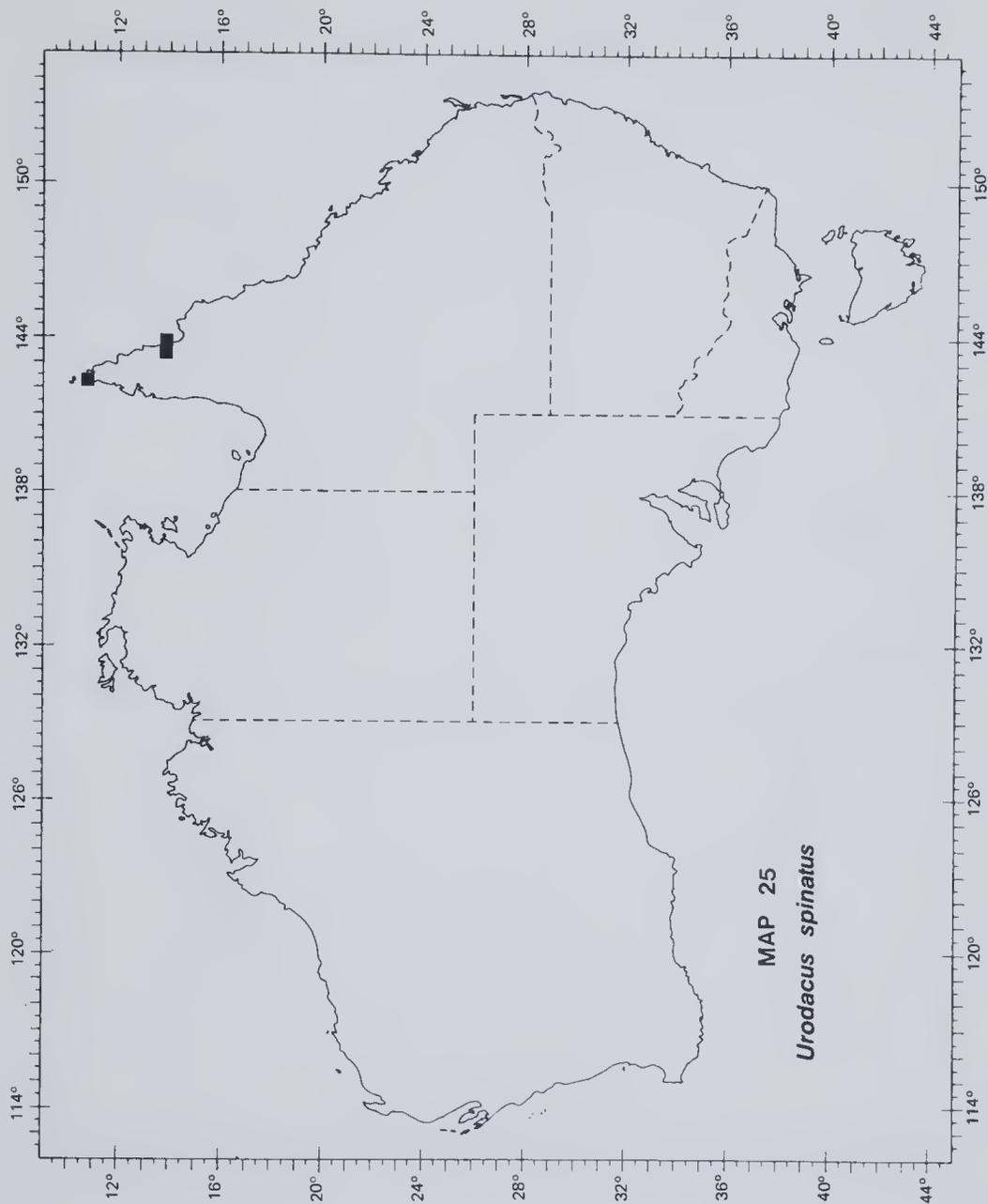
MAP 20  
*Urodacus hoplurus*

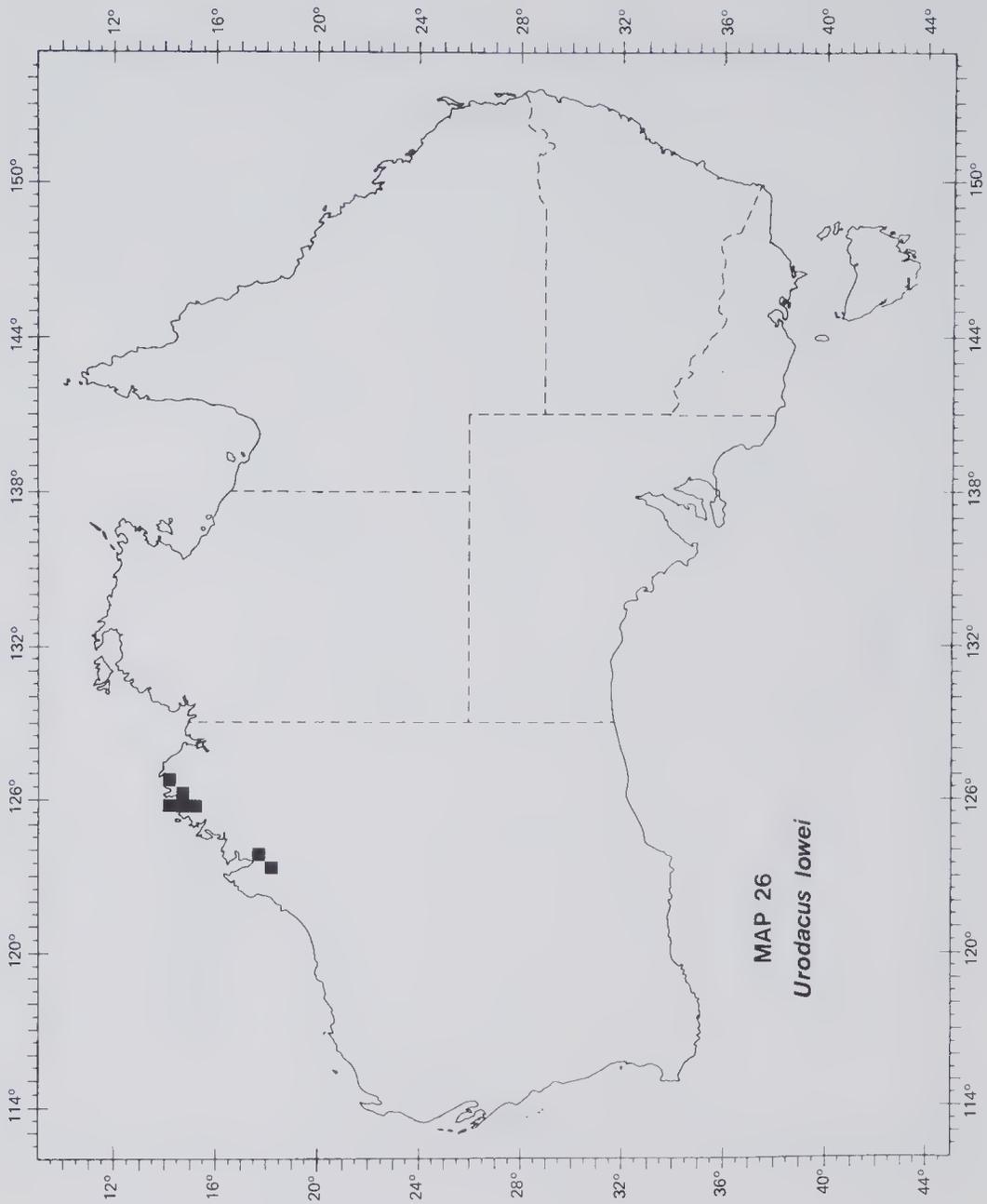


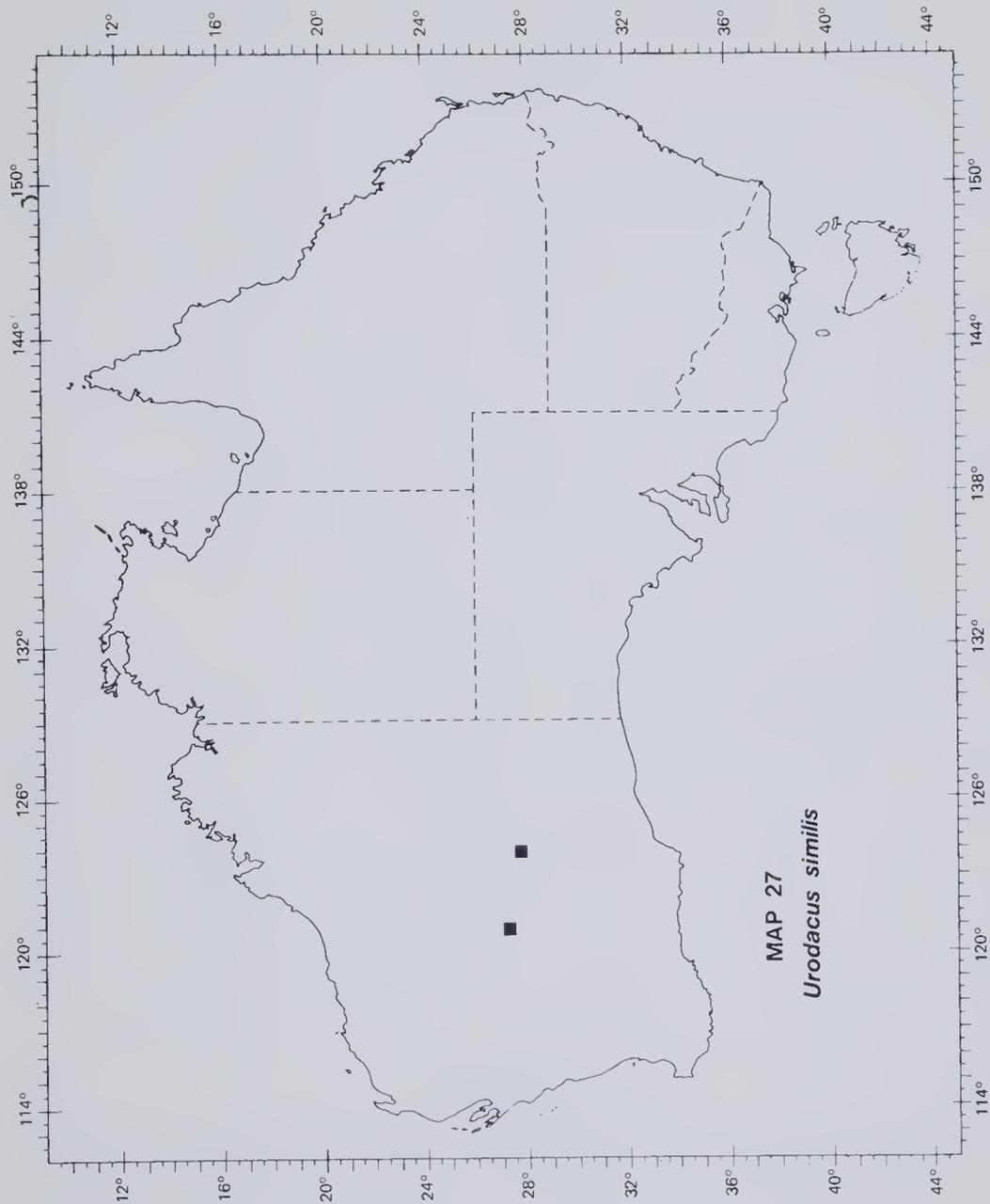


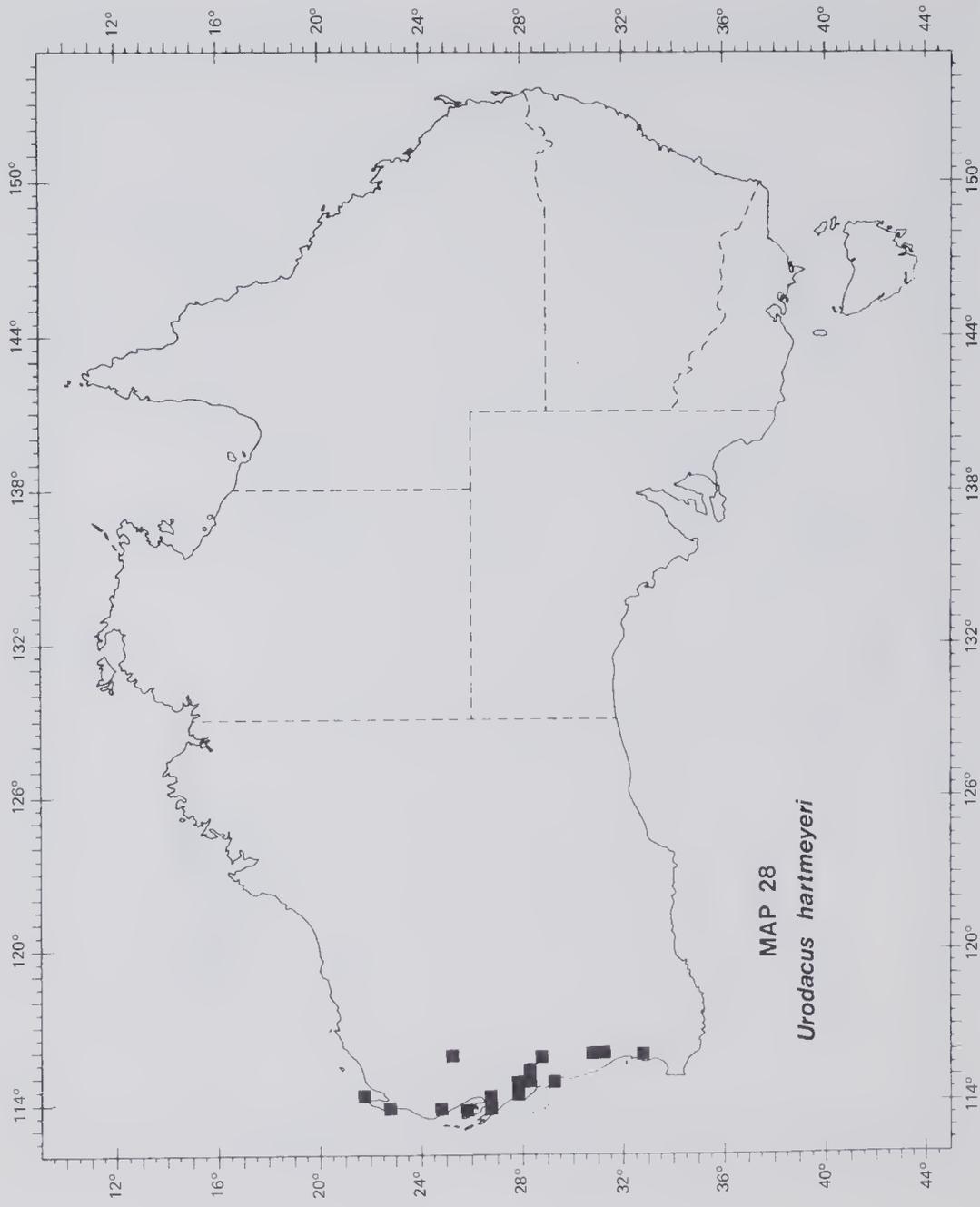


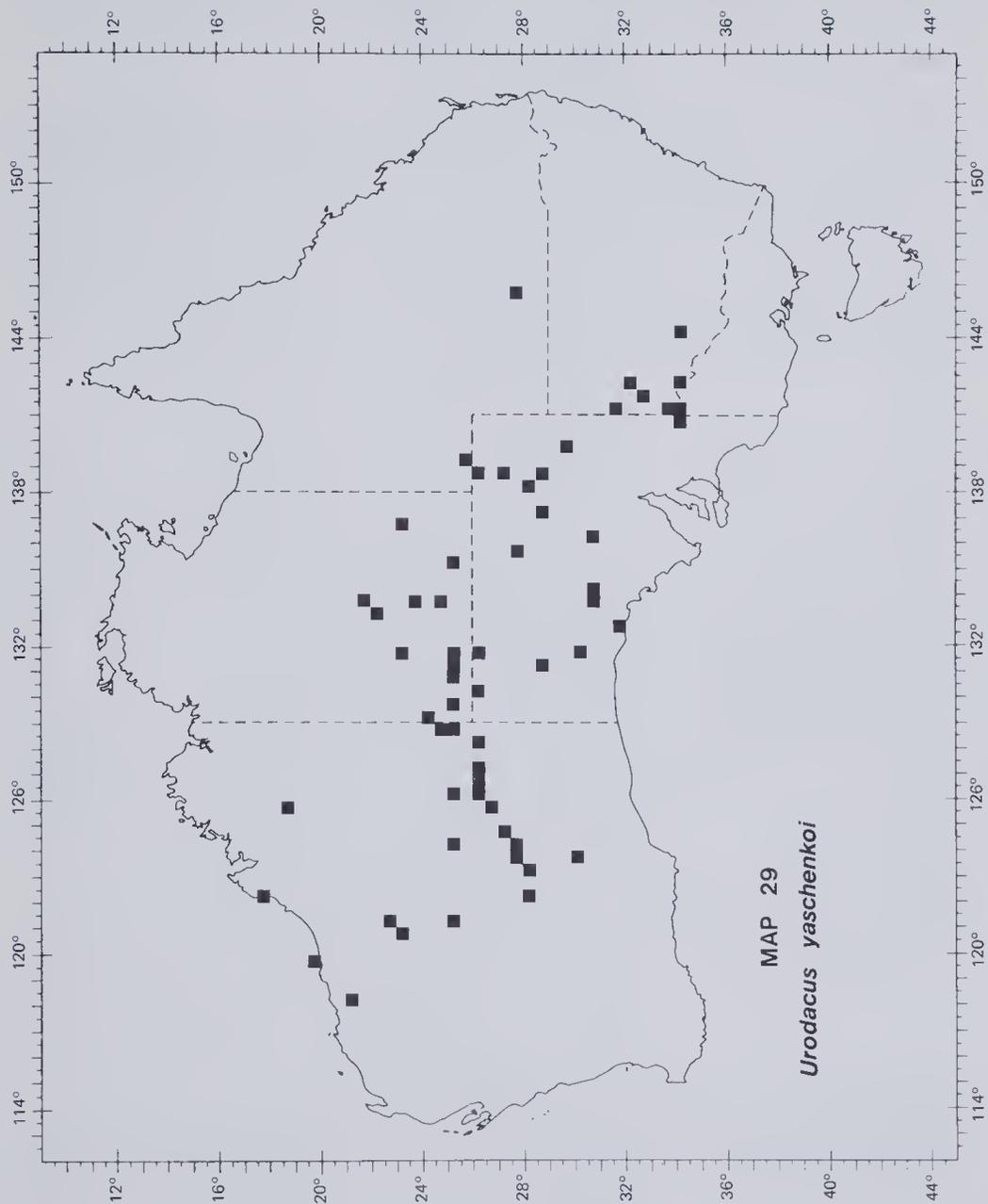












The lowest average annual rainfall (1,170 mm) is around Port Moresby where the climate and open eucalypt savanna are similar to those of northern and north-eastern Australia. It is not surprising therefore that this part of New Guinea shares scorpion species with similar parts of tropical Australia.

### Ecological Requirements of Species

Although mountain barriers have been responsible for speciation, the limits of current distributions of scorpion species in Australia are largely due to climatic and biotic factors. In the present study, the distributions of species have been delineated. An attempt has then been made to list the chief environmental factors that limit the range of each species. Of these factors, rainfall and temperature emerge as the two most important. The information listed below has been obtained by comparing the species distribution maps with those of rainfall (mm) and temperature ( $^{\circ}\text{C}$ ).

<i>Cercophonius squama</i> :	mainly above 250 mm; and below $24^{\circ}\text{C}$
<i>Lychas marmoreus</i> :	250-1000 mm; below $24^{\circ}\text{C}$ and mostly above $15^{\circ}\text{C}$
<i>L. variatus</i> :	mainly above 200 mm; above $12^{\circ}\text{C}$
<i>L. alexandrinus</i> :	below 350 mm, but as high as 550 mm in parts of north-west; above $15^{\circ}\text{C}$
<i>Isometroides vescus</i> :	below 550 mm; $17-27^{\circ}\text{C}$
<i>Isometrus maculatus</i> :	above 1000 mm; above $21^{\circ}\text{C}$
<i>I. melanodactylus</i> :	above 550 mm; above $18^{\circ}\text{C}$
<i>Liocheles australasiae</i> :	above 1000 mm (and below 3550 mm in New Guinea); above $24^{\circ}\text{C}$
<i>L. waigiensis</i> :	above 550 mm, above $15^{\circ}\text{C}$
<i>L. karschii</i> :	above 1525 mm; above $27^{\circ}\text{C}$
<i>Urodacus manicatus</i> :	350-1000 mm; $12-18^{\circ}\text{C}$
<i>U. elongatus</i> :	above 125 mm; below $22^{\circ}\text{C}$
<i>U. novaehollandiae</i> :	mostly above 250 mm and not above 1200 mm; mostly below $18^{\circ}\text{C}$
<i>U. planimanus</i> :	above 750 mm; $15-18^{\circ}\text{C}$
<i>U. centralis</i> :	about 250 mm; above $21^{\circ}\text{C}$
<i>U. armatus</i> :	from very dry up to 750 mm; $17-27^{\circ}\text{C}$ (mostly up to $24^{\circ}\text{C}$ )
<i>U. koolanensis</i> :	550-750 mm; above $27^{\circ}\text{C}$
<i>U. megamastigus</i> :	200-250 mm; $21-24^{\circ}\text{C}$
<i>U. varians</i> :	probably below 200 mm; $21-27^{\circ}\text{C}$

<i>U. hoplurus</i> :	mostly below 250 mm, but below 750 mm in the north-west; above 18°C
<i>U. giulianii</i> :	200-254 mm; 21-24°C
<i>U. carinatus</i> :	200-250 mm; 21-24°C
<i>U. macrurus</i> :	250-750 mm; 18-21°C
<i>U. excellens</i> :	above 1000 mm; above 24°C
<i>U. spinatus</i> :	above 1000 mm; above 24°C
<i>U. lowei</i> :	mostly above 550 mm; above 27°C
<i>U. similis</i> :	200-250 mm; 18-21°C
<i>U. hartmeyeri</i> :	up to 1000 mm; 18-27°C
<i>U. yaschenkoi</i> :	below 550 mm, mostly below 350 mm; mostly above 18°C

Although they are concomitants of climate, vegetation zones seldom approximate scorpion distributions. Therefore it is concluded that vegetation is not primarily responsible for the distribution patterns of scorpion species.

Comparison of Australian soil and scorpion distributions are seldom similar. Field observations confirm that usually there is little correlation between them. For example, *U. armatus* ranges from flat stony ground to red soil and yellow sandy soil; *U. novaehollandiae* occurs in soils ranging from hard rocky soil to sandy soil and coastal sand; *U. hoplurus*, although abundant in areas of earthy loam with red-brown hardpan, also occurs in sandy soil. Burrow entrances of species like *U. novaehollandiae* and *U. hoplurus* may be constructed in situations that range from open ground to beneath rocks, logs and twigs. *U. yaschenkoi*, a widespread species, occurs in areas covering a variety of soil types, but appears to have a preference for sandy soil. Similarly, while *U. planimanus* has been recorded from low-lying sandy soil, it is most abundant in the hills east of Perth. A notable exception to the lack of soil preference is *U. hartmeyeri*, which appears to be confined to sandy soil.

#### Endemicity and Faunal Categories

Australo-Papuan taxa have been discussed in relation to their affinities with outside taxa and their times of arrival in the region, e.g. birds by Mayr (1944), mammals by Simpson (1961a). Differences in endemicity are interpreted in an evolutionary and zoogeographic sense to mean that ancestral members of the groups reached Australo-Papua at different times and in different ways, and have evolved at different rates.

Thus faunal groups in Australo-Papua may be classified in a hierarchy of categories. For example, mammals have high ranking taxa (viz., subclasses) restricted to Australo-Papua, like the Protheria (monotremes). Then there

are less high ranking taxa (viz., orders) that are particularly Australo-Papuan but have related taxa of the same rank elsewhere (W.D.L. Ride, personal communication). Obviously, these categories of high ranking taxa cannot apply to scorpions. However, the following lower ranking categories do apply.

- A. Lower ranking taxa (families, subfamilies, genera) that are peculiar to Australo-Papua but have related taxa of the same rank elsewhere; e.g. within the rodent family Muridae, an ancient stock radiated in New Guinea into genera such as *Hydromys*, and in Australia there has been a major radiation of the genus *Pseudomys*; whereas numerous genera such as *Hapalomys* occur outside Australo-Papua. Some endemic scorpion groups that are monotypic belong to this category, viz., the scorpionid subfamily Urodacinae (*Urodacus*, 19 spp.) and the genera *Cercophonius* (1 sp.) (Bothriuridae) and *Isometroides* (1 sp.) (Buthidae). (The three *Lychas* species in Australo-Papua are also endemic.)
- B. Genera that have species confined to Australo-Papua but have other species elsewhere; e.g. *Rattus* (Muridae). (There are six species of *Rattus* in Australia, five in New Guinea, three in both, and over 500 forms recognized outside Australo-Papua.) To this category there belong the scorpion genera *Isometrus* and *Lychas*. There are 11 species of *Isometrus* outside Australo-Papua. Of the two species in Australo-Papua, *I. melanodactylus* is confined there, whereas *I. maculatus* is cosmopolitan. *Lychas* has about 27 species outside Australo-Papua. *L. variatus* is found mainly in Australo-Papua, and *L. marmoreus* and *L. alexandrinus* are confined to Australia.
- C. Species that occur both in Australo-Papua and outside; e.g. species of 14 genera among the bats (*Pteropus*, *Macroglossus*, etc.: Simpson 1961a). The scorpions in this category are the three *Liocheles* species and *Isometrus maculatus*.

Hence there are three grades of endemism in Australo-Papuan scorpions.

1. Species present in Australo-Papua that have not arisen there:

<i>Liocheles</i>	3 spp.
<i>Isometrus</i>	1 sp.

2. Species that have arisen in Australo-Papua from genera of other areas:

<i>Lychas</i>	3 spp. (2 of these are confined to Australia)
<i>Isometrus</i>	1 sp.

3. Genera that have arisen in Australo-Papua:

<i>Cercophonius</i>	1 sp. (confined to Australia and Tasmania)
<i>Isometroides</i>	1 sp. (confined to Australia)
<i>Urodacus</i>	19 spp. (all species confined to Australia)

It has been shown (Taxonomy Part) that *Cercophonius* is related to the South American forms, and that all other genera are related to forms which, by the Miocene, were already widespread in Asian lands to the north of Australia. In agreement with the geophysical data, the six genera are classifiable in four main categories:

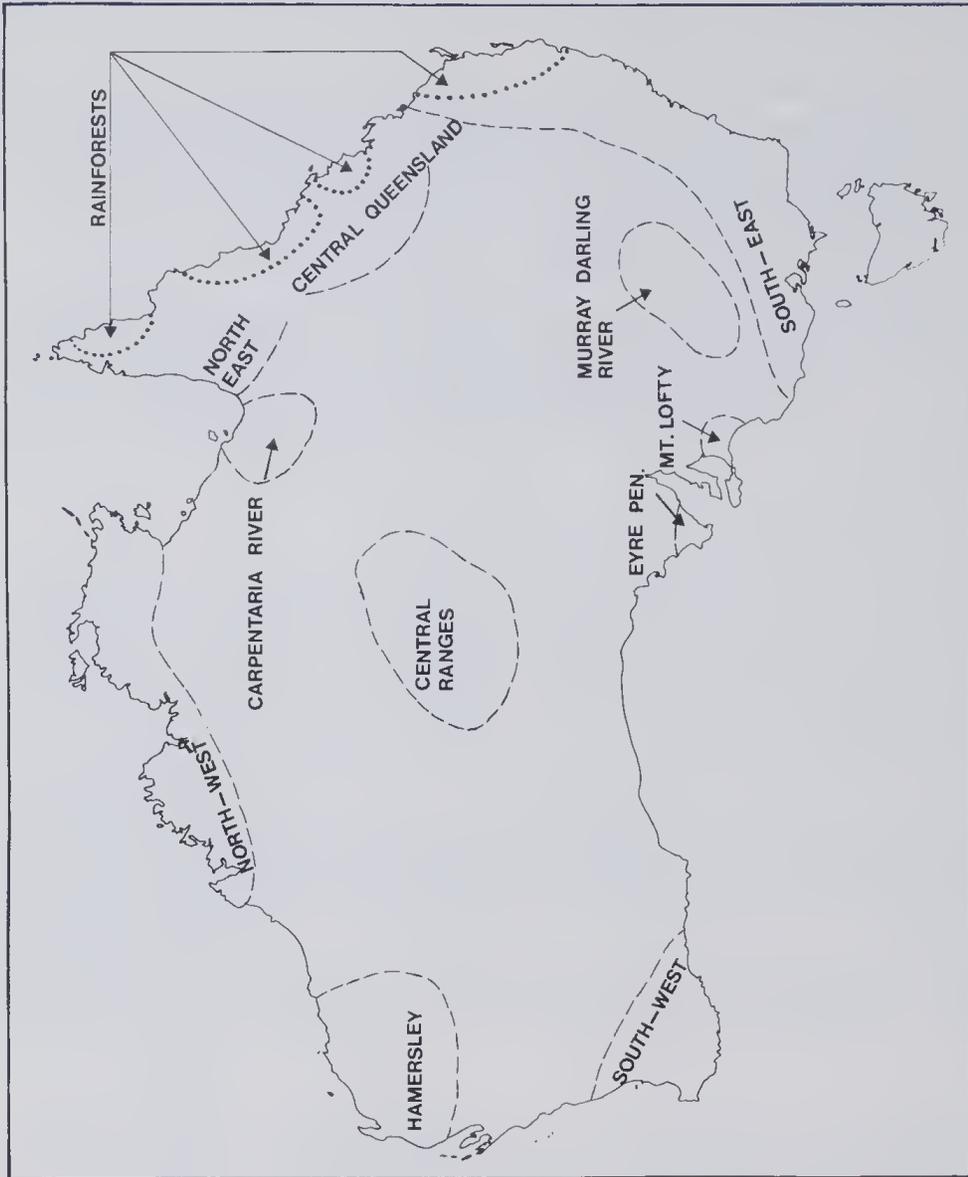
1. Ancient stock with forms in Australia and S. America—*Cercophonius*
2. Australian stock with less certain relationships and probably ultimately from Asia—*Urodacus*
3. Forms clearly derived from Asia—*Lychas*, *Isometrus*, *Liocheles*
4. Forms clearly derived from these—*Isometroides*

Different rates of evolution have been expressed in these different groups. The time that has elapsed since the entry of ancestral stocks to Australo-Papua has been adequate to enable evolution of new species, new species-groups, new genera (e.g. *Isometroides*, *Urodacus*) and a new subfamily (Urodacinae).

#### Modes of Speciation of Scorpions in Australia

The general view of allopatric speciation has emerged from the work of numerous evolutionists (as discussed by Mayr 1942, 1957, 1963); cf. alternative and supplementary modes of speciation, e.g. for certain insect groups, see White (1974). Speciation involves the development of intrinsic reproductive isolation between one or more spatially separated populations and a 'parental' species. Various levels of gene flow between two species have been regarded as acceptable provided that the integrity of the two gene pools is maintained, i.e. reproductive isolation is effective when one integrated and harmoniously coadapted gene pool is protected from swamping by another (Simpson 1961b, Bigelow 1965). Speciation of the Australo-Papuan scorpions can be explained in accordance with the concept of allopatric speciation. Species have evolved from components of animal populations isolated in refuge areas (Map 30). The refuge concept has been successfully applied to other groups in Australia, e.g. birds by Keast (1959, 1961).

Speciation of a scorpion genus or species-group in Australia may be explained as follows. The Australian ancestral (parental or proto-) species was originally widely and uniformly distributed. Then owing to a number of environmental changes a series of localized climatic and habitat zones arose. Isolation of components of the proto-species in these zones for prolonged periods has enabled speciation to occur. Further environmental changes allowed zones to merge. Consequently, the present patterns of distribution of the extant scorpion species have arisen by various combinations of contracting, spreading and overlapping.



Map 30: Main refuge areas in Australia.

## Present Geographic Distribution and Derivation

The general distribution and derivation of the Australo-Papuan species of the six genera present in the region are discussed below.

Bothriuridae: Bothriurinae

### *Cercophonius*

From a cursory glance at the distribution (Maps 1, 31) it is tempting to regard *Cercophonius* as a form that, having entered Australia when the climatic regime was much colder and wetter, persisted in southern environments and in the relict population at Alice Springs. But closer inspection shows that the genus also occurs in moderately hot dry places, e.g. north-western Victoria, central New South Wales, and the Eastern and Murchison Goldfields of Western Australia. In other words, the genus has a typical southern desert distribution analogous with that of many desert mammals. Rainfall and temperature are recognized as limiting its distribution. But its distribution in south-western Australia, in which area most specimens have been collected, indicates that it has been eliminated from places that have been cleared for wheat and sheep farming. This supports the view that *Cercophonius* favours trees such as *Casuarina* for its dwelling place; *Cercophonius* occurs not only in dry sclerophyll but also in karri forest.

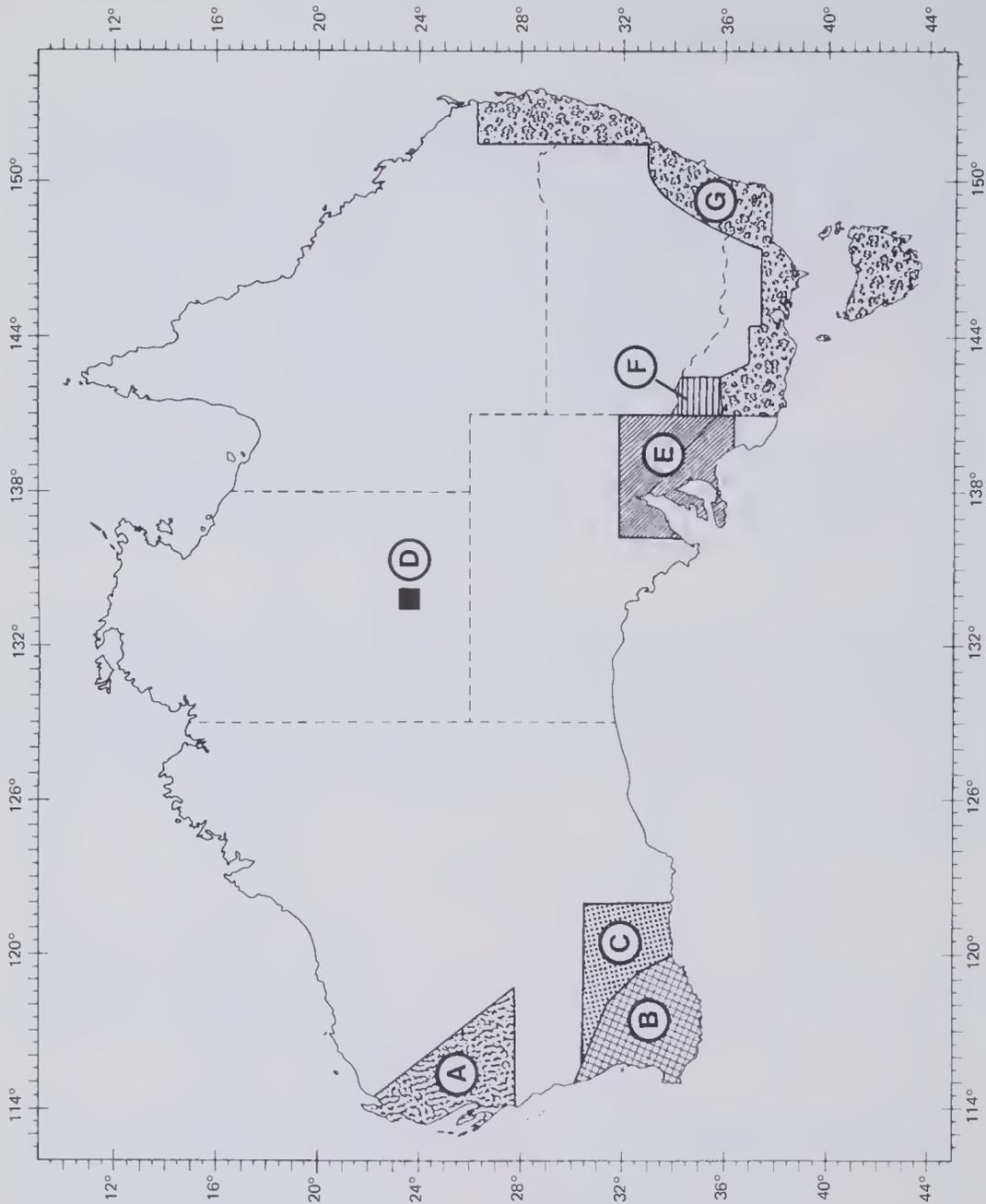
In external features as well as the structure of the paraxial organ, *Cercophonius* cannot be separated as a distinct subfamily from the other six genera of Bothriurinae. These other six genera are confined to South America. Because of the close morphological similarity of numerous features in all seven genera, it is concluded that there has been a single stock of Bothriurid proto-species in South America and Australia. Two explanations are possible:

- (1) a widespread connection across northern areas followed by northern extinction, or
- (2) a connection across a previously continuous southern land mass.

The latter explanation is supported by the current opinions of the history of land masses based on the available physiographic evidence (e.g. that presented by Raven & Axelrod 1972, Jardine & McKenzie 1972).

In spite of the long period of time that has elapsed since the separation of these southern land masses in early Tertiary, there is a remarkable morphological similarity between *Cercophonius* and the South American bothriurine genera, e.g. *Urophonius* and *Timogenes* (as discussed in the Taxonomy Part).

An early record of *Timogenes sumatranus* Simon, 1880, in Sumatra caused some concern to Pocock (1894) in his discussion of geographic distribution. He therefore concluded that the bothriurids entered Australia from northern areas in which they were widely distributed. However, the



Map 31 : Seven population segments (A to G) of *Cercophonius squama*.

identification of the Sumatran species proved to be incorrect and Kopstein (1921: 143) included this species within the synonymy of the Sumatran chaetid *Chaerilus cavernicola* Pocock.

There is a locality record of *Cercophonius squama* from the Solomon Islands (Kraepelin 1901), and there are three female specimens in the Australian Museum labelled from the New Hebrides. The Solomon Islands record is accepted by Maury (1971) but is not mentioned by Millot & Vachon (1949) or Vachon (1952). If these locality records are correct it means that *C. squama* and perhaps other bothriurid species were widespread in and around Australo-Papua. These records, however, are inconsistent with the known distribution of the species in Australia and with its absence from New Guinea. I therefore confine *C. squama* to Australia and Tasmania.

#### Buthidae: Buthinae

The genera of the subfamily Buthinae that occur in Australia clearly show connections with genera in northern areas. The hypothesis of a connection with southern land masses is not required to explain their introduction into Australia.

#### *Lychas*

*Lychas* has offshoots with a long history in Australia. It is a large, ancient, and widespread genus also occurring in Eastern Africa and Asia, especially in the Oriental region. It is closely related to the ancient genus *Isometrus*, which is widespread and has many species especially in eastern Asia, and in which genus many *Lychas* species were at one time included (e.g. by Simon 1882, 1884; Keyserling 1885; Pocock 1890b, 1891).

*Lychas* species in Australia normally live under the bark of trees and under rocks, stones and litter. With regard to feeding on spiders:

*L. variatus* has not been found in spider burrows

*L. marmoreus* is rarely found in spider burrows

*L. alexandrinus* is sometimes found in spider burrows

Arranged in this order, the three species display a progressive trend in feeding behaviour towards that of *I. vescus*. The trends shown by these species with regard to morphological features and paraxial organ structure have been discussed under *I. vescus* (in the Taxonomy Part).

*L. variatus* occurs over a large area of north-western, northern and eastern Australia. It is present at moderate altitudes in the Great Dividing Range. It is mainly a wet-adapted warmth-loving species (a few localities—e.g. Central Western Australia, are drier). *L. variatus* is the only one of the three Australian *Lychas* species that also occurs in New Guinea and other countries, e.g. Fiji Is (Kraepelin 1899, Birula 1917a). *L. variatus* is morphologically closest to *L. mucronatus* (Fabricius, 1798), which has a wide distribution that includes China, Japan, Philippines, and Indonesia.

*L. marmoreus* is the southern Australian representative of *Lychas*. The species occurs mainly in the cooler wetter parts of Australia, but is absent from Tasmania. It exhibits conspicuous variation in certain features, e.g. subaculear prong (Taxonomy Part).

*L. alexandrinus* is the central, eyrean, dry-adapted representative of *Lychas* in Australia. The species displays many morphological features that parallel those of other scorpions adapted to aridity in Australia, e.g. some *Urodacus* species.

#### *Isometroides*

The prey of *Isometroides* consists solely of burrowing spiders. On the basis of the trends exhibited by the species of *Lychas* towards feeding on burrowing spiders, as well as morphological grounds, it is clear that *Isometroides* has been derived from *Lychas* within Australia.

#### *Isometrus*

*Isometrus* is another genus with representatives outside Australia and New Guinea. *I. melanodactylus* of eastern and north-eastern Australia and New Guinea is closest to *I. maculatus* originally from the Oriental region. *I. melanodactylus* is not known from high altitudes and is absent from the cold wet south-eastern highlands; many of its localities are relatively low-lying. *I. maculatus*, which has been found in Northern Queensland, Darwin, and New Guinea, is a well-known synanthropic cosmopolitan species distributed around the world in ships and not surprisingly appears sporadically in sea-ports around Australia, e.g. Broome (Kraepelin 1916) and Adelaide (Anon 1966).

#### Scorpionidae: Ischnurinae

##### *Liocheles*

*Liocheles* has species both inside and outside Australo-Papua, e.g. India (*L. nigripes* Pocock, 1897), Malaysia and Australia. *Liocheles* is very close in appearance to the Indian and African *Iomachus*, less close to the African *Hadogenes*, and also somewhat close to the more widely distributed *Opisthacanthus*.

Distributions of the species of *Liocheles* have been given (Taxonomy Part). *L. australasiae* is the most widespread, and occurs from India through Australia to Tahiti. It is a small species compared to *L. waigiensis* and especially *L. karschii* and hence would be more easily dispersed. The distribution of *L. waigiensis* in Australia exemplifies a tropical species that thrives in a warm climate with high summer rainfall. The species was not necessarily introduced recently. The intraspecific variation, especially in size, that it exhibits in pockets of rainforest in Queensland would tend to support this view. *L. karschii* has a small range compared to the above two species.

## Scorpionidae: Urodacinae

### *Urodacus*

*Urodacus* is clearly an autochthonous element in the Australian scorpion fauna which within Australia has produced several distinct evolutionary radiations. These are now represented by species-groups, five of which are established in the present study on external morphology and male genitalia.

*Urodacus* appears closest to Indomalayan species of the scorpionine genera *Heterometrus* and *Palamnaeus*, and it seems likely on morphological grounds that *Urodacus* and these genera had a common ancestor. Although Kopstein (1923: 185) records *Heterometrus cyaneus* (Koch, 1836) from Eastern New Guinea (Hollandia in the north, and Merauke in the south), Giltay (1931) excludes the species from Australo-Papua. This species was not among the material I examined from Australo-Papua. Another scorpionine, the African *Pandinus*, sometimes has unequal terminal leg-claws similar to those exhibited in some *Urodacus* species. The Urodacinae appear to have evolved from the Scorpioninae by reductive evolution in some features, examples of characters of major taxonomic importance being the lateral eyes reduced from three to two and the ventromedian tail keel from two to one.

It is clear in *Urodacus* that species-group status was achieved during geographic isolation. This was followed by various extents of overlap. Speciation within species-groups occurred independently of one another, and was possible during their overlap. Speciation within the five species-groups may be explained in three categories in order of increasing complexity.

(a) The simplest to explain are the *hartmeyeri* and *yaschenkoi* species-groups. *U. hartmeyeri* and *U. yaschenkoi*, each representing one of these groups, are closely related species which are now allopatric. Their speciation may be explained as follows. Their common ancestor was widespread and mainly arid-adapted and burrowed in sandy soil. Speciation followed fragmentation which resulted in the isolation of a *hartmeyeri* component (in western coastal Western Australia) and a *yaschenkoi* component (widely distributed in the central and some other parts of the continent). Much of the intermediate country between the distribution of these species is occupied by the Precambrian Shield, especially the Hamersley Plateau. Factors responsible for the fragmentation of the proto-species may have been the presence of this Plateau, the marine intrusion in the region during the Tertiary, and the formation of the tongue of very arid country extending from the interior to the coast in the region of Shark Bay.

(b) It can clearly be seen that the northern species of the *hoplurus* species-group (*U. lowei*, *U. excellens* and *U. spinatus*) and the eastern species (*U. macrurus*, which is in central Queensland) have arisen by geographic separation and that no subsequent overlap has persisted.

Of the species in the central and western parts of the continent, *U. hoplurus* is now widespread, unlike *U. varians*, *U. giulianii*, *U. carinatus* and *U. similis*. These latter species may be regarded as arising from isolated populations, and subsequently being overlapped by *U. hoplurus*. Alternatively, if sympatric speciation is possible in scorpions, these species have arisen by ecological isolation within the distribution of *U. hoplurus*.

(c) The *armatus* species-group includes a typical Bassian pair, *U. novaehollandiae* and *U. manicatus*. These occur along the southern coast in areas of winter rainfall. They have related species that are mostly confined to the Flinders Ranges (*U. elongatus*) in the east, and the Darling Range (*U. planimanus*) in the west. *U. elongatus* is sympatric with *U. manicatus*: *U. planimanus* is sympatric with *U. novaehollandiae*. Speciation is thus more difficult to explain in this than in other species-groups.

Evolution of the above-mentioned four species of the *armatus* group may be explained as follows. The species in the Darling and Flinders Ranges were derived from populations that fragmented from southern populations. Subsequently *U. manicatus* has overlapped the distribution of *U. elongatus*, and *U. novaehollandiae* of *U. planimanus*. Amelioration of the climate would have enabled such overlapping. Minimal competition between the species would have helped them to overlap. *U. centralis* has arisen from an isolated population in central Australia. *U. armatus* could have survived without further speciation as small populations in gorge country in the ranges, e.g. Hamersley, Barlee and Ophthalmia in the 'Hamersley' and Petermann and Macdonnell in the 'central ranges' (Map 30). From these, *U. armatus* has spread to overlap the distributions of other species. *U. armatus* partly overlaps *U. novaehollandiae* and *U. manicatus*, and completely overlaps *U. centralis*, but whether it is syntopic with these species is not known. *U. koolanensis* would have speciated after isolation of a far northern part of the proto-species of this species-group.

Allopatric speciation of an isolate of an *armatus*-like proto-species would have given rise to the closely related *megamastigus* species-group.

It is considered likely that the proto-species or their immediate descendants arising within Australia were morphologically closest to the less specialized extant species of the genus, viz. *U. novaehollandiae* and *U. manicatus*.

### *Urodacus* Burrows

A comparative study of the structure, function and adaptation to different habitats of *Urodacus* burrows has been prepared as a separate paper (Koch 1978). The direction of evolutionary adaptation to aridity is from shallow to deeper burrows, and from burrow entrances sited under rocks, stones and logs to those emerging in open ground. Members of the *armatus* species-group have the least arid-adapted burrowing behaviour and

*yaschenkoi* is the most arid-adapted. The morphological trends exhibited by the species in arid areas have been classified in the section on ecological trends.

### *Urodacus* Chromosomes

The chromosomes of *U. novaehollandiae* and *U. planimanus* have been investigated because of the similarity of these two species in external morphology. The entire distribution of *U. planimanus* occurs within a small part of the range of *U. novaehollandiae*. The chromosomes were studied in male cells of a few specimens of each species from Mundaring, W.A. The anterior regions of the testes of living, recently moulted final instar males were dissected in saline, treated in Carnoy's fluid for over 10 minutes and squashed and stained in 2% aceto-orcein. The observations were made during the first week in April when, in relation to the known information on mating habits, the cells were expected to be undergoing meiosis.

From an examination of first metaphases of male meiosis (Fig. 127a and b) and spermatogonial metaphase plates, both species are found to have the same chromosome number,  $2n = 68$ . The two species, however, exhibit distinct differences in chromosome morphology. *U. novaehollandiae* has smaller chromosomes, all of which are approximately equal in size; *U. planimanus* has chromosomes of varying sizes, seven of them being considerably larger than the others.

In scorpions, the question of whether or not chiasmatic meiosis occurs during spermatogenesis has been discussed (Brieger & Graner 1943; Piza 1947; White 1954; Sharma, Parshad & Joneja 1959; Guénin 1961; Srivastava & Agrawal 1961; Sharma, Parshad & Handa 1962; Venkatanarasimhiah & Rajasekarasetty 1964). In *Urodacus* there is no evidence for chiasmata, and although the chromosomes (Fig. 127) are in metaphase, it is most unlikely that chiasmata, if present, should have terminalized in all bivalents. Neither is there evidence for any translocation heterozygosity in *Urodacus*. It has been pointed out in the buthid scorpion *Buthus tamulus* (Gupta & Sarker 1965), in which no chiasmata or translocations have been observed, that the question remains as to how recombinations take place. The same applies to *Urodacus*.

Scorpion males are not visibly heterogametic (Sharma & Joneja 1959, Sokolow 1913, Sato 1936). However, Srivastava & Agrawal (1961) suspect the presence of an X-Y bivalent in males of the scorpionid *Palamnaeus longimanus*. No X-Y bivalent could be distinguished in the *Urodacus* males.

It is concluded from the present investigation that the difference in chromosome morphology is another criterion for distinguishing the two similar (sympatric) species, *U. novaehollandiae* and *U. planimanus*.



Fig. 127: Meiotic (Metaphase 1) chromosomes in male *Urodacus*: (a) *U. novae-hollandiae*, (b) *U. planimanus* (Scale line = 10  $\mu$ ).

## Patterns of Distribution and Colonization in Relation to Past and Present Climatic Zones

The ancestor species of *Cercophonius* may have been widespread and even uniformly distributed throughout the continent. If so, it would have been eliminated early from the northern zone of moist tropical habitats when most of these were destroyed by the continuing drying trend from late Miocene. Later, *C. squama* was eliminated from most of the central zone, although a relict population survives at Alice Springs, N.T.

When the New Guinea land mass emerged in the Miocene (Raven 1972, Raven & Axelrod 1972), *Lychas* and other genera (*Liocheles* and *Isometrus*) colonized Australia from New Guinea principally across the Torres Strait region. The *Lychas* offshoot could have entered Australia earlier than *Liocheles* and *Isometrus* because, unlike these two genera, *Lychas* has (1) given rise to a genus (*Isometroides*), (2) spread throughout the continent, and (3) speciated in central and southern Australia. But the ancestral species of the Australian *Lychas* is thought to have entered later than *Urodacus* because an Australian *Lychas* species (*L. variatus*, which is closely related to overseas species, e.g. *L. mucronatus*) (a) has not been eliminated from northern Australia but occurs throughout it, (b) has spread southwards in the eastern corridor, and (c) also occurs in and around New Guinea.

*Lychas* is at present known from all parts of Australia (Maps 2 to 4) except the southernmost parts of the south-west and the south-east and Tasmania. Its apparent absence or rarity in central Queensland and central north Australia might be due to insufficient collecting there. It is considered that *Isometroides* arose from the *Lychas* offshoot as an early response to aridity. *Isometroides* is adapted to arid conditions and has specialized as a predator on the burrowing trapdoor spider fauna of Australia and although highly specialized has become widespread. The forerunners of these spiders were already well established in Australia (Main 1957). Each of the three Australian *Lychas* species may be interpreted as clearly evolving in response to a different one of the three broad climatic zones (which are recognized by Savage 1973).

*Liocheles* and *Isometrus* after entering from the north, spread southwards in eastern Queensland. *I. melanodactylus* arose in the New Guinea-north Queensland region; and it has subsequently extended its range further south along eastern Queensland.

Of all the genera, *Urodacus* has had the greatest radiation in Australia. *Urodacus* fits in broadly with the concept of three main trans-continental climatic zones. The deep burrowing habit enabled *Urodacus* species to disperse northwards in the central arid area which increased from the late Cainozoic. The basic temperate remnant stock of the *Urodacus* ancestor species diversified in southern Australia into the *armatus* species-group and is the southern component of the genus. This species-group speciated ex-

tensively and later expanded northwards, leaving an isolate species (*U. koolanensis*) at Koolan I., W.A., and on the nearby mainland. The *megamastigus* species-group would have resulted from the isolation of a small part of this northward expansion. Drying of the north would have eliminated any *Urodacus* ancestors in this area, and colonizations by species of the *hoplurus* group would have been relatively recent.

In late Cainozoic, semi-arid to desert conditions developed in south-central Australia; these drying trends fragmented the temperate forests and woodlands (Savage 1973). As a result, the widely distributed southern counterpart of the *armatus* species-group was likewise fragmented. From the isolates in each of the southern corners there have arisen the south-western species, *U. novaehollandiae*, and the south-eastern species, *U. manicatus*.

The segments of the original *Urodacus* ancestors that had been adapted to subtropical humid conditions remained in central Australia and differentiated into the *hoplurus*, *hartmeyeri*, and *yaschenkoi* species-groups. In this diverse environment, the *hoplurus* species-group has undergone extensive speciation.

The view that the *hoplurus* species-group is originally and essentially an occupant of the central zone is supported by the extensive distribution and speciation of the group in the centre rather than the north and by its absence from the wet south-west.

The *yaschenkoi* and *hartmeyeri* species-groups are coextensive with the central intermediate semi-arid to desert zone. The close morphological relationship between these species-groups and the presence of the *hartmeyeri* group along the western coast supports the view that the central arid zone extended far to the west as a belt across the continent and was not a limited area in the centre of the continent.

Summarizing, *Liocheles* and *Isometrus* live only in humid northern and eastern areas, but the species of the scorpion genera that occur in central, southern and south-western parts of Australia show similar adaptations to aridity at both intraspecific and interspecific levels. *Cercophonius* exhibits adaptation to the arid central conditions at only the intraspecific level. The distributions of the *Urodacus* species-groups conform remarkably well with the three broad zones of climate recognized for Cainozoic times. Thus there is (1) a southern group that has penetrated into the centre and the west, (2) a central group that has undergone much speciation and recently colonized far northern parts of the continent, and (3) a group confined to the central zone. *Isometroides* is mainly an arid-adapted genus. Each of the three *Lychas* species evolved in a different zone.

The patterns of species distributions (Maps 1-29) are as follows:

1. Species confined to Australia.

(a) Southern species:

<i>C. squama</i>	(southern and lower central, both east and west, and Tasmania)
<i>L. marmoreus</i>	(southern and lower central, both east and west)
<i>U. manicatus</i>	(southern eastern)
<i>U. elongatus</i>	(eastern hills, essentially Flinders Ranges, S.A.)
<i>U. novaehollandiae</i>	(southern western)
<i>U. planimanus</i>	(south-western hills—Darling Range, W.A.)

*C. squama* occurs in most of the southern Australian mainland as well as Tasmania. *L. marmoreus* is southern, but absent in Tasmania and the coldest parts of south-eastern Australia. The ancestor species of the Bassian pair, *U. novaehollandiae* and *U. manicatus*, would have had a southern distribution. The climatic effects of the Nullarbor Region (Johnstone *et al* 1973) and the Lake Dieri-Torrens barrier (David 1950) would have strongly influenced the splitting of ancestor species.

Main, Lee & Littlejohn (1958), Littlejohn (1961), and Lee (1967) for frogs, and Main (1962) for spiders, have interpreted their findings by postulating repeated invasions of Western Australia from Eastern Australia along the southern coastal fringe during periods of higher rainfall in Pleistocene glacials. Similar east to west invasions do not appear to have occurred in scorpions, and some species (*viz.* *C. squama*, *L. marmoreus* and *U. novaehollandiae*) are at present distributed across the southern part of the continent.

If the absence of *Urodacus* from Tasmania is not owing to extinction, it is either because the species (*e.g.* *U. manicatus*) have only reached their southern limits since the last land connection (12,000 years ago: Ridpath & Moreau 1966) or because of cold.

(b) Northern species:

<i>U. excellens</i>	(coastal N.T.)
<i>U. spinatus</i>	(far north-eastern Qld)
<i>U. lowei</i>	(north-western)
<i>U. koolanensis</i>	(north-western coastal)

*U. excellens* occurs to the west and *U. spinatus* to the east of the Gulf of Carpentaria. These two northern species are not known even from the woodlands of the Trans-Fly plains and Port Moresby areas of New Guinea. The morphological closeness of these two species indicates their having a common ancestor. If extinction is not considered, the two species or their ancestor must be regarded as having been absent from northern Australia and New Guinea prior to the latest formation of the Gulf of Carpentaria\*, and as having reached the far north since this time. This view is in keeping with the simplest explanation of the distribution of the frog, *Hyla latopal mata* (Tyler 1970), and the lizard genus *Diplodactylus* (Kluge 1967).

(c) Central species:

The Eyrean, of all subregions, correlates best with scorpion distributions and has more scorpion species than any other subregion:

- L. alexandrinus*,
- I. vescus*, *U. armatus* (central and western)
- U. yaschenkoi* (central)
- U. hoplurus* (mid-central and western)
- U. macrurus* (central Queensland, west of Great Divide)
- U. centralis*, *U. giulianii*, *U. carinatus* (central ranges)
- U. megamastigus*, *U. varians*, *U. similis* (central W.A.)
- U. hartmeyeri* (western W.A.)

Speciation in the arid centre of Australia is generally regarded as being due to isolation in mesic refuge areas (Gentilli 1949, Keast 1961, Kluge 1967) (Map 30). The view holds well for *Urodacus*, especially for some central species, e.g. *U. carinatus*, *U. giulianii* and *U. centralis*. The other genera of scorpions have no such species confined to relatively small areas and which can thus be recognized as having speciated in, survived in, and spread from refuge areas of limited size. Like *U. yaschenkoi* and *U. armatus*, some species of other genera (e.g. *Isometroides vescus* and *L. alexandrinus*) have widespread Eyrean distributions. *C. squama* with its relict population at Alice Springs is another species that was originally widespread.

2. Species that occur in an area that includes New Guinea and extends southwards mainly east of the Great Dividing Range.

The southward extension of some of the species reaches the significant area of vegetational transition, viz, the Macpherson-Macleay overlap

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\*5,000 to 11,000 years ago, probably between 6,500 and 8,000 years ago; Jennings, in Walker (1972).

recognized by Burbidge (1960), but the main limiting factor appears to be temperature. These species are as follows:

A. Australia and New Guinea, mainly

*L. variatus* (in Australia: northern coastal, north-western, and eastern to southern)

*I. melanodactylus* (in Australia: east of Great Divide)

B. New Guinea, Australia, and widespread elsewhere

*I. maculatus* (in Australia: east of Great Divide)

*I. waigiensis* (in Australia: coastal north-western, northern and north-eastern)

*L. australasiae* (in Australia: coastal northern and north-eastern)

*L. karschii* (in Australia: islands of Torres Strait)

The differing modes of speciation in various groups of animals in the eastern parts of Australia have been discussed by Keast (1961), Mackerras (1962), and Littlejohn & Martin (1964). Straughan & Main (1966) suggest that the semi-arid country surrounding the north-east has prevented New Guinean frog species from moving into the rest of Australia during the whole of the Pleistocene. However, this barrier has been intermittent and has not prevented invasion by scorpions (or birds or reptiles, Horton 1973). The main factor limiting the southward expansion of the east coastal species (*Isometrus melanodactylus* and *Liocheles waigiensis*) appears to be temperature: it becomes too cold for them in July.

### Some Zoogeographic Implications

The concept of a New Guinean origin for a part of the mammal fauna is now suspect because fossils of genera previously regarded as of New Guinean origin have now been discovered in the Pliocene of Victoria (Lundelius & Turnbull 1967). Ride (1968) provides evidence to suggest that it is equally sensible to regard Tasmania and New Guinea as refuges for forms originating from central Australia under a more humid climatic regime. Hence, the scorpions *Lychas variatus* and *Isometrus melanodactylus*, or their ancestor species, could have originated in Australia and spread to New Guinea or vice versa. An Australian origin is considered most unlikely for those species (viz. *Liocheles* spp.) that occur in Australia and New Guinea and are widespread in other countries.

The development of the central aridity in Australia has strongly influenced the distribution of *Cercophonius*; and the Miocene marine embayment and the Pleistocene Lake Dieri-Torrens water barrier have produced the Bassian pairs of *Urodacus*. The Australian scorpions of Gondwanaland origin are not related to those of Africa and India but are related to those of South

America. The fact that the scorpion family Bothriuridae occurs only in South America and Australia supports the evidence presented by Keast (1973) for the earlier date of separation of Africa than South America or Australia from Gondwanaland.

Whereas *Isometroides*, a predator on burrowing spiders, has evolved from *Lychas* in Australia, the other genera (*Cercophonius*, *Lychas*, *Isometrus* and *Liocheles*) have continued to live in the same fashion, e.g. under stones or the bark of trees, as they do outside Australia. On the other hand, *Urodacus* has evolved the deep and spiral burrowing habit which has enabled it to take advantage of the widespread arid and semiarid conditions in Australia; this radiation has produced the five species-groups.

Individuals of *C. squama* and *L. marmoreus* occurring under stones and small rocks have survived bushfires. Merrilees (1968) concludes that bushfires, especially those caused by man, have had profound effects on the mammalian fauna of Australia. All tree and litter dwelling Australian scorpions occasionally occur under stones and small rocks. This may be important for their survival during fires. The deep burrow living species (*Urodacus*) would escape such destruction particularly as their burrows occur in open environments with little undergrowth.

Scorpions interact among themselves, and competitive exclusion may account for certain distributions. *Cercophonius squama* is absent from eastern Queensland, except in the southern-most part, and this may be due to the presence of *Lychas variatus* and *Isometrus melanodactylus*; these three species have similar home sites. Also possibly because of competition, the overall distributions of *C. squama* and *L. variatus* show little overlap, and *Urodacus* species are absent where *Liocheles waigiensis* occurs in Queensland.

There are no Australian scorpion species with a similar distribution pattern to that of the Antarctic Beech, *Nothofagus* (Brundin 1966). *N. cunninghami*, for example, is common in Tasmania, but restricted in Australia to a few small patches in Victoria and New South Wales. It has a near relative in the mountains of south-eastern Queensland and coastal New South Wales; and close allies dominate parts of New Zealand and Tierra del Fuego. The only extant bothriurid scorpion species inherited from Gondwanaland (*Cercophonius squama*) has some rather dry areas included in its present widespread southern distribution in Australia, indicating a degree of adaptation to aridity. Hence, unlike the response to the development of the central aridity by *Lychas* (Buthidae) and *Urodacus* (Scorpionidae), the Bothriuridae in Australia has responded by contraction of the wide range of *C. squama* to southern areas. Although speciation has not occurred there is some marked geographic variation.

The distribution of *C. squama* includes Flinders I. and King I. At first Tasmania formed a single island with these, but King I. was separated within

1,000 years; Flinders I. was united to Tasmania longer, for some 3,000 years, i.e. until well after 10,000 years ago (Ridpath & Moreau 1966). Three species of scorpions, *C. squama*, *L. marmoreus* and *U. manicatus*, occur on Kangaroo I., S.A. The last separation of this island is thought to have occurred about 10,000-12,000 years ago (Godwin, Suggate & Willis 1958; Littlejohn & Martin 1964).

Scorpions that occur on other islands along the western and southern coasts of Australia are as follows:

Western Australia:

Koolan I.	<i>L. alexandrinus</i> , <i>U. koolanensis</i>
Dolphin I.	<i>U. armatus</i>
Barrow I.	<i>L. variatus</i> , <i>L. alexandrinus</i>
Dorre I.	<i>L. variatus</i>
Rottneest I.	<i>C. squama</i> , <i>L. marmoreus</i>
Garden I.	<i>L. marmoreus</i>
Mondrain I.	<i>U. novaehollandiae</i>

South Australia:

South Neptune I.	<i>U. armatus</i>
Wedge I.	<i>U. novaehollandiae</i>
Althorpe I.	<i>U. armatus</i>

The dates of last isolation of these islands from the mainland are also relatively recent, e.g. 7,000 years ago for Garden I. and Rottneest I. (Main 1961).

All the scorpion species on the offshore islands within the area of study also occur over considerably larger areas on the mainland. Further, none of these islands has been separated from the mainland for more than about 12,000 years. Therefore, the conclusion that no specific differentiation of scorpions has originated on any of these islands seems inescapable.

The fact that a scorpion species occurs in Australia as well as New Guinea or Tasmania enables estimation of a minimum age for the species based upon the estimated time of last separation of these land masses. Thus the Australian representatives of the Bothriuridae (*Cercophonius squama*), the Buthidae (e.g. *Lychas variatus*, *Isometrus melanodactylus*) and the ischnurine Scorpionidae (e.g. *Liocheles waigiensis* and *Liocheles australasiae*) have existed for at least 5,000 to 12,000 years (the time of the last major transgression, the Flandrian). The highly speciated urodacine scorpionid genus *Urodacus* is widespread in Australia but absent from both New Guinea and Tasmania. Because of the time required for the evolution of a genus, there are two possibilities: either the genus *Urodacus* has always been con-

fined to inland Australia, or there have been species outside Australia and these became extinct. The exclusion from Tasmania of the genera *Urodacus* and *Lychas* (which have been derived from or are related to forms in areas north of Australo-Papua) could be due to cold. There is however an absence of factors (e.g. climatic and vegetational) which might exclude *Urodacus* from New Guinea. I consider therefore that either its species in the more peripheral northern areas of the Australian mainland have reached there relatively recently (since the last major transgression of the sea) or that species in New Guinea have been eliminated.

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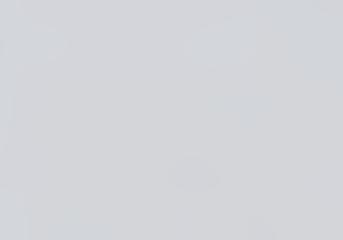
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