The BEAGLE

Occasional Papers of The Northern Territory Museum of Arts and Sciences

Volume 3 **Number 1** **1986**

The BEAGLE, Occasional Papers of the Northern Territory Museum of Arts and Sciences

The Beagle is a journal of occasional papers published by the Northern Territory Museum of Arts and Sciences, Darwin, Australia. Whilst primarily intended to disseminate the results of research by Museum staff and their associates in the various fields of Museum activity, and concentrating on systematic and material research, the scope of *The Beagle* has been extended to cover broader but still associated fields.

Papers published will be concerned with:

- i) Systematic and other studies of the terrestrial, marine and freshwater flora and fauna of the Northern Territory, tropical Australia, South East Asia and Oceania;
- ii) Australian Aboriginal, South East Asian and Oceanic art, material culture and archaeology;
- iii) Northern Territory history, maritime history and marine archaeology;
- iv) Museum conservation, display techniques, taxidermy, publication, public relations, communication and education.

The Beagle will be published once, possibly twice a year, depending upon the material available and budgetary considerations.

Whilst papers for *The Beagle* will normally be 10-20 pages in length shorter communications and notes are welcomed, and book reviews and review articles will also be included. All submitted scientific manuscripts will be reviewed by at least two referees.

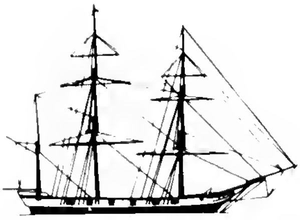
Papers which exceed the normal size may be considered for separate publication in the *Monograph Series of the Northern Territory Museum of Arts and Sciences*. Subscribers and exchange institutions will be informed of the publication and separate prices of the *Monograph Series*.

The Beagle may be obtained by subscription or by exchange. Subscription rates for one year are: Individuals $25.00. Institutions $35.00. Postal charges, etc. Australia only $5.00; overseas $10.00 (surface) $25.00 (airmail). Cheques should be made payable to 'Northern Territory Museum'.

All subscription and exchange enquiries should be addressed to the Business Manager, Northern Territory Museum, P.O. Box 4646, Darwin, NT 5794, Australia.

ISSN 0811-3653.

Cover: *Coranus aridellus* sp. nov. Drawn by D. Percival.



The BEAGLE

Occational Papers of The Northern Territory Museum of Arts and Sciences

Volume 3 Number 1 1986

CONTENTS

GENERAL COMMUNICATION

BOOK REVIEWS

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 1-5

TWO NEW ANOMURAN CRUSTACEA (DECAPODA: ANOMURA) FROM NORTH-WEST AUSTRALIA

KEIJI BABA
Biological Laboratory, Faculty of Education,
Kumamoto University, Kumamoto 860, Japan.

ABSTRACT

A new chirostylid, *Uroptychus brucei* sp. nov. and a new galatheid *Munida soelae* sp. nov. are described and illustrated from specimens collected from Northwest Australia. Their affinities to the closely related species are discussed.

KEYWORDS: Crustacea, Anomura, Chirostylidae, Galatheidae, *Uroptychus*, *Munida*, new species, North-West Australia.

INTRODUCTION

The new anomurans described below were found in the collection of the R.V. "Soela" (CSIRO) survey to the North West Shelf of Australia recently received for identification from Dr A.J. Bruce of the Northern Territory Museum, Darwin, Australia. One of the two new species belongs to the genus *Uroptychus* Henderson of Chirostylidae, and the other to the genus *Munida* Leach of Galatheidae. The types are deposited in the Northern Territory Museum (NTM).

SYSTEMATICS

Uroptychus brucei sp. nov.

(Figs. 1,2)

Type Material. HOLOTYPE - ♂, NTM Cr. 000604, Station NWS-33, 17°59.4′S 118°18.4′E, 406-416 m, deepsea lobster trawl, 28 January 1984. PARATYPES - 2 ♂, NTM Cr. 000598, Station NWS-38; 18°52.2′S, 116°11.1′E, 456-458 m, deepsea lobster trawl, 30 January 1984.

Description of holotype. Carapace (Figs. 1, 2a and b) excluding rostrum as long as wide, widest at 1/3 of length from posterior end. Dorsal surface glabrous, covered with very fine granules discernible only under high magnification; gastric, cardiac and branchial regions somewhat convex and delimited by shallow indistinct grooves; lateral margin convex, minutely denticulate, distinctly ridged along posterior 1/4 of length, anterolateral angle with strong spine. Outer orbital angle produced and spiniform.

Rostrum broadly triangular, 0.4 as long as remaining carapace, somewhat deflexed, and deeply concave dorsally.

Eyes relatively small, elongate, overreaching midlength of rostrum, cornea 1/3 as long as remaining eyestalk.

Abdominal segments glabrous and spineless.

Outer terminal process of basal antennular segment simple but well developed. Ultimate segment of antennal peduncle (Fig. 2c) twice as long as penultimate when measured at midline, with indistinct process at outer distal margin; penultimate segment with blunt but distinct outer distal marginal spine; antennal scale fully twice as wide as, and overreaching, midlength of ultimate peduncular segment.

Third maxilliped unarmed on merus and carpus, ischium with about 30 closely placed denticles on inner toothed ridge.

Third thoracic sternum (Fig. 2d) strongly depressed below level of following sternal segments, anterior margin concave, sharply V-shaped medially, with 2 strong median spines, anterolateral angle distinctly produced inward. Following sternum mesially grooved, anterolateral angle roundly produced, anterolateral margin distinctly convex.

Chelipeds (Fig. 1) dissimilar, right one larger and longer. Right cheliped about 4 times as long as carapace including rostrum, relatively massive, glabrous except for fingers; basis with small but distinct distodorsal spine; ischium with strong distodorsal and moderate-sized distoventral spines. Merus and carpus subcylindrical, somewhat tuberculate ventrally; merus with several more pronounced tubercles near inner margin, distoventral margin with distinct spine; palm as long as carpus, fully 2.5 times as long as wide;

Fig. 1. *Uroptychus brucei* holotype ♂.

massive but depressed; lateral margins somewhat convex, distinctly ridged; fingers (Fig. 2e) barely half as long as palm, setose especially distally, opposable margins with low processes and tubercles, as figured, distally curving inward and crossing. Left cheliped shorter and slenderer, possibly because of regeneration; about 3 times as long as carapace; opposable margins of fingers bearing fewer processes (Fig. 2f).

Walking legs slender, spineless on anterior margin, distal 2 segments setose. Propodus of first walking leg (Fig. 2g) 6 times as long as wide, posterior margin with 19 spinelets in whole length, bearing long coarse setae on distal half; dactylus curving, with 12 spinelets, proximal 3 somewhat smaller, others subequal, outer margin very thickly setose. Second and third walking legs similar to first, prododus of second walking leg with 17 posterior marginal spinelets on distal ⅔ of length, that of third leg with 12 spinelets on distal half.

Variation. In two males from Station NWS-38, the ultimate segment of the antennal peduncle bears a distinct terminal spine; and propodi of the first walking legs bear 10-12 spinelets on distal ⅔ of the posterior margin; on the second and third legs the propodal spinelets are 8-11 in numer, restricted to distal half.

Measurements of holotype. Length of carapace 21.8 mm; width of carapace 15.7 mm; length of cheliped 69.2 mm (left), 86.8 mm (right); length of palm 17.8 mm (left), 25.3 mm (right); length of movable finger 11.0 mm (left), 13.3 mm (right).

Measurements of paratypes. Carapace lengths of males, 18.0-19.5 mm.

Remarks. The carapace, having finely denticulate lateral margins, the chelipeds being glabrous, smooth and relatively massive, and the dactyli of walking legs bearing subequal-sized spinelets on the posterior margins, suggest a relationship with *U. nitidus occidentalis* Faxon, previously known from both the eastern and western Pacific (Faxon 1895; Baba 1973). However, they differ in the following: 1) the dorsal surface of the rostrum is flattish in *U. n. occidentalis*, while it is deeply excavated in *U. brucei*; the dorsal surface of the carapace is entirely smooth in *U. n. occidentalis*, while in *U. brucei* it is covered with very fine granules that are discernible only under high magnification; and 3) the distal two segments of the antennal peduncle are unarmed in *U. n. occidentalis*, whereas in *U. brucei* the penultimate segment bears a distinct inner terminal spine.

It is a pleasure to dedicate this species to A.J. Bruce, who collected these specimens.

Munida soelae sp. nov.

(Fig. 3)

Type Material. HOLOTYPE - ♀, NTM Cr. 000655, Station NWS-37, 18°52.2'S 116°09.4'E, 501-502 m, deepsea lobster trawl, 30 January 1984. PARATYPES - 1 ♂, 1 ovig. ♀, Station NWS-91, 16°07.2'S 120°20.0'E, 544-550 m, lobster trawl.

Description of holotype. Carapace (Fig. 3a) as long as wide when measured between front margin behind eye and posterior margin. Gastric region weakly convex, cervical groove shallow; pair of epigastric spines well developed; another pair directly behind it smaller. Hepatic region squamate. Anterior branchial region with 2 oblique ridges. Posterior half of carapace with interrupted transverse ridges. Postcervical spines strong. Cardiac region with 2 spines on elevated anterior ridge. Small but distinct spine on branchiocardiac boundary directly laterad of cardiac spines. Posterior transverse ridge with 6 spines, median 2 stouter. Lateral margin convex, widest at midlength, bearing 6 spines on anterior half, 2 of them in front of cervical groove and remaining 4 behind it.

Rostrum spiniform, straight, but directed slightly upward, about 1/3 as long as remaining carapace. Supraocular spines subparallel, considerably remote from rostrum, overreaching midlength of rostral spine.

Second through fourth abdominal segments with 4 acute spines on anterior ridge; posterior ridge of fourth segment with strong median spine. Pleura of second abdominal segment rounded, those of third and fourth segments tapering.

Eyes dilated, not strongly depressed, eyelashes short.

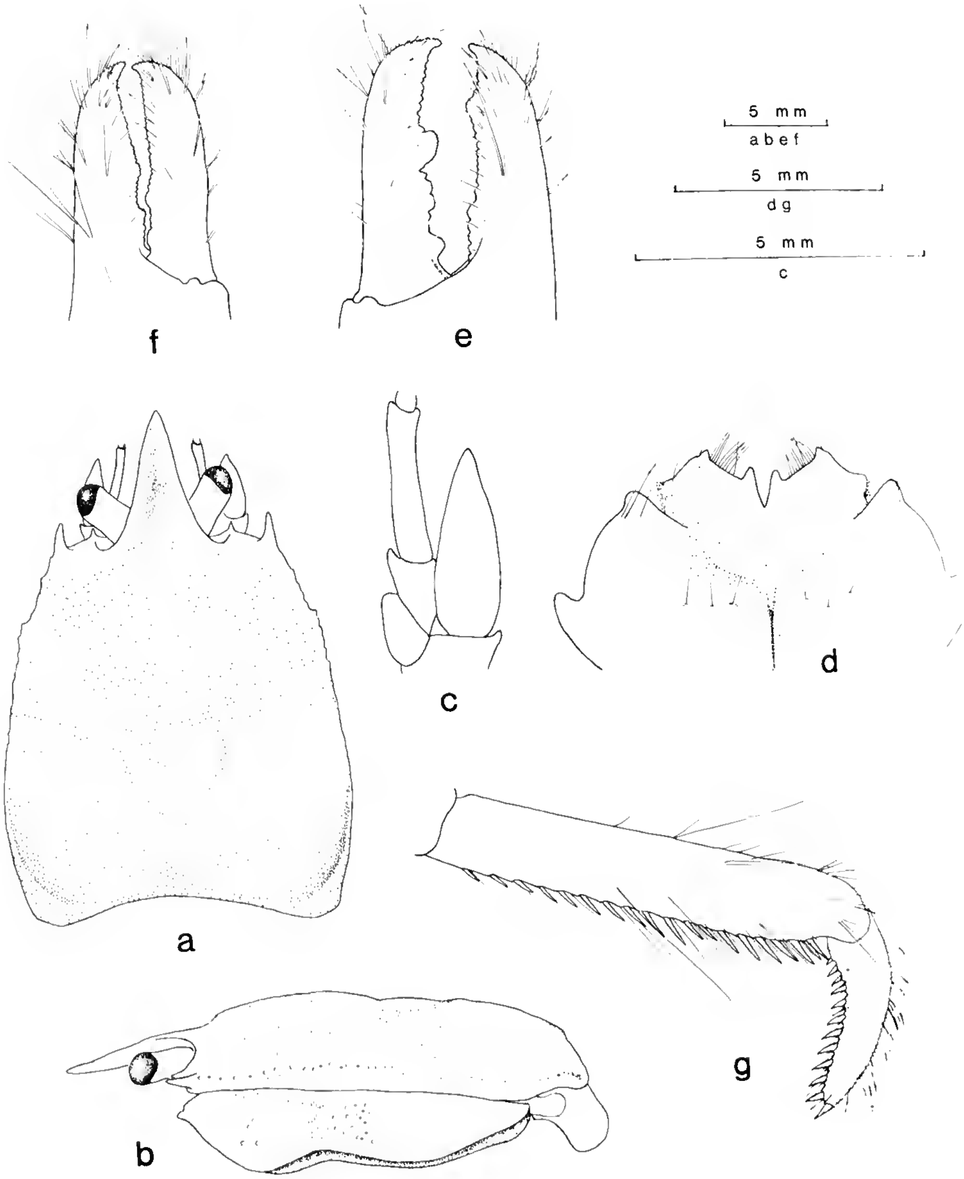


Fig. 2. *Uroptychus brucei* holotype ♂: **a**, carapace, in dorsal view; **b**, same, in lateral view; **c**, left antennal peduncle; **d**, anterior part of sternal segments: **e**, fingers of right chela; **f**, same of left chela; **g**, distal two segments of right first walking leg.

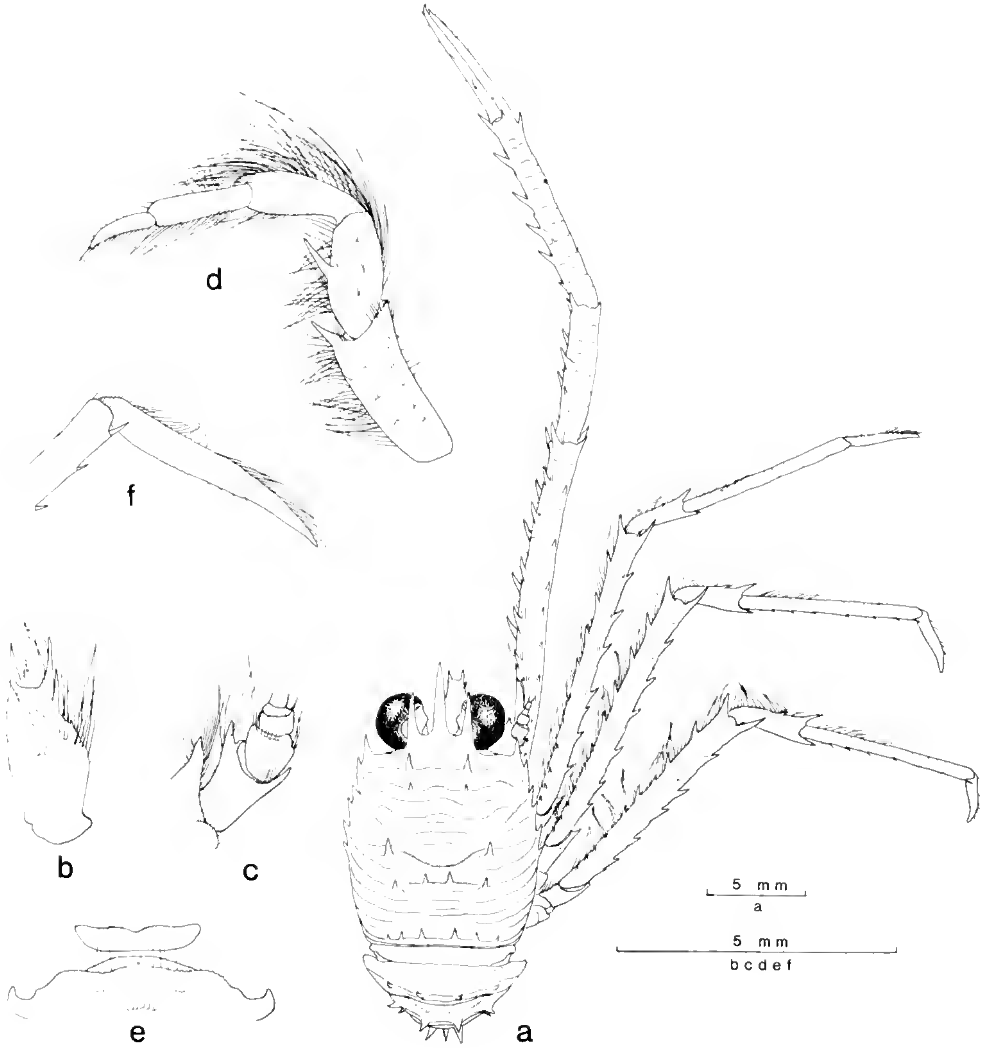


Fig. 3. *Munida soelae* holotype ♀: **a**, animal in dorsal view, left appendages omitted; **b**, basal segment of left antennule; **c**, left antennal peduncle; **d**, endopod of left third maxilliped; **e**, anterior part of sternal segments; **f**, distal part of right second walking leg.

Basal segment of antennule (Fig. 3b) elongate, setose in distal half; 2 terminal spines subequal; outer margin strongly convex at midlength, with 2 spines, proximal tiny, distal ending opposite midlength of outer terminal. First segment of antennal peduncle (Fig. 3c) with moderate-sized inner process not reaching beyond second segment; second segment produced on both distal margins, third segment unarmed.

Third maxilliped (Fig. 3d) setose, especially thick and long on lateral margins of merus and carpus. Ischium slightly longer than merus, relatively thin, distomesial margin with strong spine, inner toothed ridge with 10 minute, vestigial denticles. Merus with only one mesial marginal spine at midlength. Carpus unarmed. Distal two segments slender.

Anterior sternal segments as figured (Fig. 3e); comparatively short and wide. Third thoracic sternum 5.6 times as wide as long; barely half as wide as, and not contiguous to, following sternum; anterior margin minutely dentate, weakly undulating.

Left cheliped missing. Right cheliped (Fig. 3a) weakly squamate dorsally, slender, subcylindrical, 3 times as long as carapace including rostrum, moderately setose on inner margin. Merus with 4 rows of spines, ventral row consisting of tiny spines. Carpus as long as movable finger, with 2 rows of spines and 1 short outer distal marginal spine. Palm 8.9 times as long as wide, 1.6 times as long as movable finger, spination as figured; inner marginal spines pronounced. Fingers not gaping, curving inward and crossing, opposable margins minutely tuberculate, with equidistant, somewhat pronounced tubercles on movable finger; immovable finger bifid distally.

Walking legs (Fig. 3a) slender, depressed, dorsally flattish and indistinctly squamate, and setose on anterior margins of merus, carpus and proximal part of propodus. First walking leg overreaching carpus of cheliped when extended forward; merus as long as total of distal 3 segments, armed with 11 anterior marginal and 7 or 8 posterior marginal spines, distalmost of both marginals strongest; carpus produced on both distal margins, bearing small anterior marginal spine at ⅓ from distal end; propodus fully 12 times as long as wide, barely twice as long as dactylus, posterior margin with 6 or 7 spinelets; dactylus (Fig. 3f) gently curving, depressed, proportionately wide, anterior margin setose, especially on distal half, indistinctly crenulate, posterior margin finely denticulate on median ⅓ of length.

Measurements of holotype. Length of carapace 14.1 mm; width of carapace 10.4 mm; length of right cheliped 43.2 mm; length of carpus 6.8 mm; length of palm 10.5 mm; length of movable finger 6.6 mm.

Measurements of paratypes. Carapace lengths: male 28.2 mm, ovigerous female 28.0 mm.

Remarks. This species seems to be closely related to *Munida normani* Henderson, only originally known from the Fiji Islands (Henderson 1885; 1888), from which it differs in the following respects: 1) the carapace bears additional two spines behind the epigastric pair, only two spines on the branchiocardiac boundary, two well developed spines on the cardiac transverse ridge, and more numerous spines, 6 in number, on the posterior transverse ridge; 2) the palm of the cheliped is relatively long and bears a well developed outer distal marginal spine and an additional spine that is located near the junction with the movable finger.

ACKNOWLEDGEMENTS

I thank Dr A.J. Bruce for making these intersting specimens available for study. Thanks are also due to the cruise leaders Drs T. Davis and T. Ward.

REFERENCES

Baba, K. 1973 Remarkable species of the Chirostylidae (Crustacea, Anomura) of Japanese waters. *Memoirs of the Faculty of Education Kumamoto University, Natural Science* **22**: 117-124.

Faxon, W. 1895 Reports on an exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands, etc. XV. The stalk-eyed Crustacea. *Memoirs of the Museum of Comparative Zoology at Harvard College* **18**: 1-292.

Henderson, J.R. 1885 Diagnoses of the new species of Galatheidea collected during the "Challenger" Expedition. *Annals and Magazine of Natural History* (5) **16**: 407-421.

——— 1888 Report on the Anomura Collected by H.M.S. Challenger During the Years 1873-76. *Report on the Scientific Results of the Voyage of H.M.S. Challenger, Zoology* **27**: 1-221.

Accepted 16 September 1985

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 7-9

A NOTE ON SOME SIPUNCULANS (SIPUNCULA) FROM THE NORTHERN TERRITORY, AUSTRALIA

S.J. EDMONDS
Honorary Research Associate
South Australian Museum, Adelaide, SA 5000, Australia.

ABSTRACT

Six species of sipunculans are reported from the Northern Territory, Australia; the records of *Sipunculus titubans* Selenka, de Man and Bülow, *Themiste variospinosa* Edmonds, *Aspidosiphon steenstrupii* Diesing and *Phascolosoma arcuatum* Gray are new for the Northern Territory.

KEYWORDS: Sipuncula, marine worms, Northern Territory, Australia.

INTRODUCTION

Most of the sipunculans listed in this paper were collected, preserved and sent to me for identification by Mr Russell Hanley of the Northern Territory Museum. None of the species are new; all were described in Edmonds (1980) or Stephen and Edmonds (1972).

Very little is known about the Northern Territory species of this phylum of marine invertebrates. There are two previous records; they are of *Themiste lageniformis* Baird and *Phascolosoma pacificum* Keferstein (Edmonds 1980: 42, 63). The last general paper on Australian sipunculans was that of Edmonds (1980). More recent articles on the systematics of the phylum are those of Cutler, Cutler and Nishikawa (1984), Cutler and Cutler (1985a and 1985b), Cutler and Gibbs (1985) and Gibbs (1985).

LIST OF SPECIES

Sipunculus titubans Selenka, de Man and Bülow, 1883
Themiste lageniformis Baird, 1863
Themiste variospinosa Edmonds, 1980
Aspidosiphon steenstrupii Diesing, 1859
Phascolosoma arcuatum (Gray, 1828)
Phascolosoma pacificum Keferstein, 1866

DETAILS OF SPECIES

Sipunculus titubans Selenka, de Man and Bülow

Sipunculus titubans — Edmonds 1980: 10-12, Figs 22-23.

Material. Off Tasman Point, Gulf of Carpentaria, one specimen, coll. J. Elder, July 1976.

Notes. Specimen long and cylindrical. Trunk, length 110 mm, maximum width 12 mm. Longitudinal musculature of trunk wall grouped in bands, 23 in mid-trunk and 22 at level of anus. Well-developed, finger-like processes attached to anterior dorsal rim of brain.

This large and well-preserved specimen corresponds very closely with two specimens collected from Weipa, Gulf of Carpentaria, Queensland and another from the mouth of Embly River, Queensland which were identified as *S. titubans* by Edmonds (1980:11). Cutler (1985:236) has recently synonymised *S. titubans* and *S. nudus* Linnaeus, the latter name having priority. I am inclined to the view that the specimens with 22 to 26 muscle bands from the Gulf of Carpentaria possess fewer bands than *S. nudus* which has 28 to 32 and consequently are different. Until more specimens are available for study I am leaving the designation of the specimens from the Gulf of Carpentaria for the time being as *S. titubans*.

Distribution. Gulf of Carpentaria and Moreton Bay, Queensland; Zanzibar; Madagascar; Gulf of Siam; Thailand.

Habitat. Burrows in sand or sandy mud below level of low tide.

Themiste lageniformis Baird

Themiste lageniformis — Edmonds 1980: 41-42, Fig. 61.

Material. Lee Point, Darwin, from rock and coral, coll. A.J. Dartnall, 13 June 1976, NTM (Northern Territory Museum, Darwin) WS 17, SAM (South Australian Museum, Adelaide) E1208; East Point, Darwin, from rock and coral, coll. A.J. Dartnall, 11 June 1976, NTM WS1, WS2; Escape

Cliffs, Cape Hotham, coll. R. Hanley, 25 May 1985, NTM WS27.

Distribution. Queensland and north-west Western Australia; Indo-Pacific.

Habitat. Burrows in coral and calcareous reefs. Sometimes found under stones and rocks.

Themiste variospinosa Edmonds

Themiste variospinosa — Edmonds, 1980:42-43, Figs 62, 69.

Material. Sandy I., no. 2, Northern Territory, from muddy bottom at 14 m, coll. R. Hanley, 25 May 1982; Trepang Bay, Cobourg Peninsula, at edge of rock platform, coll. R. Hanley, 15 October 1981, NTM WS39.

Notes. The specimens from both localities are small and the tentacular region of the introvert retracted. Although the arrangement of the tentacles could not be determined with certainty, the arrangement of the introvert hooks and the internal anatomy are like those of *T. variospinosa*. The species is allied to *T. huttoni* Benham.

Distribution. Queensland.

Habitat. Collected from burrows in rocks and from under rocks.

Aspidosiphon steenstrupii Diesing

Aspidosiphon steenstrupii — Stephen and Edmonds 1972: 254-5, Fig. 28A; Cutler, Cutler and Nishikawa 1985: 308, Figs 13B, 13G.

Material. Orontes Reef, Cobourg Peninsula, in sand at 6m, coll. R. Hanley, 5 August 1982, NTM WS38.

Distribution. Queensland; Indo-Pacific.

Habitat. Rock-boring species.

Phascolosoma arcuatum (Gray)

Phascolosoma arcuatum — Edmonds 1980 : 58-59, Figs 104, 109-111.

Material. From mud-flats associated with mangroves at Rapid Creek, Darwin, 16 March 1982, NTM WS10; mouth of Ludmilla Creek, Darwin, 26 March 1982, NTM WS9 and at various dates NTM WS10, WS22-26, WS28-35; mouth of Adelaide River, 26 May 1985, WS6, WS20-21, WS37; Creek "H", Darwin, WS4, WS8, WS11-16, WS19; all coll. by R. Hanley.

Distribution. In Queensland and north-west Western Australia where there are extensive growths of mangroves; Malaysia; Philippines.

Habitat. Forms burrows in mud and soil associated with mangrove flats.

Phascolosoma pacificum Keferstein

Phascolosoma pacificum — Edmonds 1980: 62-63.

Material. Fannie Bay rocks, Darwin, specimen, coll. E. Pope, 11 October 1965, in Australian Museum, Sydney.

Distribution. Queensland to north-west Western Australia; Indo-Pacific.

Habitat. Under rocks; whether it is a rock-boring species is not known for sure.

DISCUSSION

Sipunculans are a well-known component of the marine fauna of tropical, temperate and polar waters. Because they are burrowers in sand, mud, limestone and coral and live in protected places, they are not always easy to find. All the species in the present collection are known from other parts of Australia, especially from Queensland and Western Australia. The commonest species in the collection was *P. arcuatum* which is always associated with mangroves.

Collecting sipunculans usually requires slow and patient work. It involves digging in sand and mud, turning over rocks, and searching in limestone and coral reefs and in solitary corals, in pulling apart the roots of marine angiosperms, examining the discarded shells of small molluscs and the encrusting masses of serpulid worms, and in dredging. So far no specimens of *Cloeosiphon* Grübe or of *Lithacrosiphon* Shipley, both inhabitants of coral reefs, have been found in the Northern Territory.

REFERENCES

Cutler, E.B. and Cutler, N.J. 1985a A revision of the genera *Sipunculus* and *Xenosiphon* (Sipuncula). *Zoological Journal of the Linnean Society, London* **85**: 219-246.

Cutler, E.B. and Cutler, N.J. 1985b A revision of the genera *Phascolion* Theel and *Onchnesoma* Koren and Danielssen (Sipuncula). *Proceedings of the Biological Society of Washington* **98** (4) :809-850.

Cutler, E.B., Cutler, N.J. and Nishikawa, T. 1984 The Sipuncula of Japan; their systematics and distribution. *Publications of the Seto Marine Biological Laboratory* **29**: 249-322.

Cutler, E.B. and Gibbs, P.E. 1985 A phylogenetic analysis of the higher taxa in the phylum Sipuncula. *Systematic Zoology* **34**: 162-173.

Edmonds, S.J. 1980 A revision of the systematics of Australian sipunculans (Sipuncula). *Records of the South Australian Museum* **18**: 1-74.

Gibbs, P.E. 1985 On the genus *Phascolion* (Sipuncula) with particular reference to the north-east Atlantic species. *Journal of the Marine Biological Association of the United Kingdom* **65**: 311-323.

Stephen, A.C. and Edmonds, S.J. 1972 *The Phyla Sipuncula and Echiura*. Trustees of the British Museum (Natural History): London.

Accepted 19 February 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 11-20

AXIOPSIS BRUCEI SP.NOV., A NEW SPONGE-INHABITING AXIID (CRUSTACEA: DECAPODA: THALASSINIDEA), FROM NORTH-WEST AUSTRALIA

K. SAKAI
Laboratory of Crustacea, Shikoku Women's University,
771-11, Tokushima, Ohjineho-Furukawa, Japan.

ABSTRACT

A new axiid, *Axiopsis brucei* sp.nov. of the family Axiidae is described and illustrated from specimens obtained from a hexactinellid sponge host, from North-west Australia at 296-456 m depth.

KEYWORDS: Crustacea, Decapoda, Thalassinidea, Axiidae, Axiopsis, new species, hexactinellid sponge, North-west Australia.

INTRODUCTION

In January and February 1984, the R.V. "Soela" (CSIRO) undertook a survey of the benthic fauna of the Australian North-west Shelf. Amongst the material collected were specimens of an axiid that shows similarities to *Axius (Axius) novaezealandiae* Borradaile from New Zealand and *Axius (Eiconaxius) caribbaeus* (Faxon) from the West Indies, but is distinct from them. This animal, which lives as a commensal in a hexactinellid sponge, is defined as a new species of the genus *Axiopsis* Borradaile. This association with a hexactinellid sponge is the first record for a member of the genus *Axiopsis*, though four species of *Eiconaxius s. str.*, viz. *acutifrons* (Bate) and *weberi* (De Man) from Indonesian Waters, *farreae* (Ortmann) from Japan, and *caribbaeus* (Faxon) from the West Indies are known to be commensal in hexactinellid sponges (De Man 1925:10). This new species is the eleventh species of the family Axiidae recorded from Australian Waters (Poore and Griffin 1979).

The following abbreviations are used: AM Australian Museum, Sydney; BM (NH) British Museum (Natural History), London; MP Museum national d'Histoire naturelle, Paris; NTM Northern Territory Museum, Darwin; RML Rijksmuseum van Natuurlijke Historie, Leiden; USNM U.S. National Museum, Washington, D.C.; ZLKU Zoological Laboratory, Kyushu University, Fukuoka, Japan. E epipod; TL total body length.

SYSTEMATICS

Genus *Axiopsis* Borradaile

Axiopsis Borradaile, 1903: 538 (type species *A. serratifrons* A. Milne-Edwards, 1837, designated by De Man 1925:72).

Definition. Suture on uropod exopod. Antennal acicle of segment 3 large or medium in size. Maxilliped 2 with podobranch, but without arthrobranch. Pereiopod 4 without podobranch. No pleurobranchs. Pleopods 2-5 similar.

Discussion. Confusion exists over the precise definition of the genus *Axiopsis* (Miyake and Sakai 1967; Boesch and Smalley 1972; Saint-Laurent 1972; Williams 1974; Poore and Griffin 1979; Kensley and Gore 1981). However, a provisional definition of *Axiopsis sensu* Borradaile is given above for description of the present new species.

In the family Axiidae four genera, *Axiopsis, Calocaris* Bell, *Calastacus* Faxon and *Oxyrhynchaxius* Parisi are defined by the presence of a suture on the uropod exopod.

Axiopsis differs from *Calocaris* and *Calastacus* in the arrangement of its gill-formula (see Kensley and Gore 1981). In the type species of *Axiopsis, A. serratifrons*, the 2nd maxilliped bears an epipod with a podobranch, but no arthrobranch (Kensley 1981), while in the type species of *Calocaris, C. macandreae* Bell, the 2nd maxilliped has an epipod with a podobranch and an arthrobranch (Saint-Laurent 1972), and in the type species of *Calastacus, C. stilirostris* Faxon, the 2nd maxilliped has only an epipod without a podobranch and no arthrobranch (Faxon 1893). The genus *Oxyrhynchaxius*, represented by the type species, *O. japonica* Parisi, is different from *Axiopsis*. That is, the specimens (ZLKU 7367-8, 8237) from Kii, Japan, show almost the same gill-formula as that of *Calocaris* except that there is a rudimentary arthrobranch on the 5th pereiopod.

The genus *Axiopsis* is defined by characters including the absence of a keel on the carapace behind the cervical groove. However since Boesch and Smalley (1972) considered that "the presence or absence of a mid-dorsal keel is not a character at the generic level", this feature is considered not to be available as a defining character. De Man (1925) considered *Axiopsis habereri* (Balss), as an exceptional species of the present genus, though it bears a middorsal carina throughout the cardiac region. However, the present new species is not always defined by this generic character of *Axiopsis*, because a middorsal carina was present on only the anterior half of the cardiac region of even the smallest specimen examined, TL 38mm.

It seems that the status of the first pleopod of males and females has some importance at the generic level. However this character is also not associated with the present axiid taxon as summarized for the Australian axiid species described by Poore and Griffin (1979): in *Axiopsis (Paraxiopsis) appendiculis* Poore and Griffin, *Axiopsis (Axiopsis) australiensis* De Man, *Axiopsis (Axiopsis) werribee* Poore and Griffin, and *Axius (Neaxius) glyptocerus* von Martens the first pleopod of males is absent; in *Axiopsis (Paraxiopsis) brocki* (De Man) and *Axiopsis (Axiopsis) consobrina* De Man the first pleopod is a single small ovate segment; in *Axius (Neaxius) waroona* Poore and Griffin, *Axius (Neaxius) plectrorhynchus* Strahl, and *Scytoleptus serripes* Gerstaecker it is a single narrow curved segment; while in *A. brucei* the first pleopod is two-segmented, the distal segment being spatulate. On the other hand, in *Axiopsis (Paraxiopsis) appendiculis*, *Axiopsis (Axiopsis) australiensis*, *Axiopsis (Paraxiopsis) brocki*, *Axius (Neaxius) waroona*, *Axius (Neaxius) plectrorhynchus*, *Scytoleptus serripes*, and the present species, *Axiopsis brucei*, the first pleopod of females is two-segmented, the distal segment being a multiarticulate flagellum; in *Axiopsis (Axiopsis) consobrina* and *Axius (Neaxius) glyptocerus*, it is two-segmented, the distal segment being lanceolate; and in *Axiopsis (Axiopsis) werribee* it is two-segmented, the distal segment being medially lobed.

Axiopsis brucei sp. nov.

(Figs 1-6)

Type material. HOLOTYPE - ♂, NTM Cr. 000610A, TL 77 mm, RV "Soela", Station NWS-43, T/18, 18°43.7′S 117°02.2′E, trawl, 454 m, 31 January 1984, A.J. Bruce. ALLOTYPE - ♀, NTM Cr. 00610B, TL 83 mm, data as for holotype. PARATYPES - 1 ovig. ♀, NTM Cr. 000605, TL 71 mm, 3 ♀, TL 56 mm, 65 mm, 77 mm, RV "Soela", Station NWS-29, T/3, 17°55.5′S 118°19.5′E, trawl, 450-454 m, 27 January 1984, A.J. Bruce; 1 ovig. ♀, NTM Cr. 000606, TL 72 mm, RV "Soela", Station NWS-30, T/4, 17°59.7′S 118°19.0′E, trawl, 400 m, 27 January 1984, A.J. Bruce; 1 ♂, NTM Cr. 000607, TL 74 mm, RV "Soela", Station NWS-31, T/5, 18°00.8′S 118°17.0′E trawl, 296-412 m, 28 January 1984, A.J. Bruce; 1 ♂, NTM Cr. 000608, TL 86 mm, RV "Soela", Station NWS-32, T/6, 18°03.8′S 118°14.0′E, trawl, 402-408 m, 28 January 1984, A.J. Bruce; 1 ♂, AM P.34217, TL 51 mm, 1 ♂, BM (NH) 1986:300, TL 68 mm, 1 ovig. ♀, MP TL. 897, TL 67 mm, 1 ♀, RML D. 36516, TL 63 mm, 1 ♀, USNM 228682, TL 76 mm, RV "Soela", Station NWS-38, T/12, 18°52.5′S 116°11.1′E, trawl, 455-456 m, 30 January 1984, A.J. Bruce; 1 ♀, NTM Cr. 000611, TL 38 mm, RV "Soela", Station NWS-64, T/45, 16°24.0′S 120°20.4′E, trawl, 452-456 m, 5 February 1984, A.J. Bruce.

Diagnosis. Rostrum elongate triangular, dorsal surface concave, margins serrated with 8-10 spines. Gastric region gradually decending to base of rostrum; five carinae with rows of prominent horny spines. Cardiac region with median carina on anterior half. Scaphocerite long. Pereiopod 1 chelate, unequal and robust; chela thick, tuberculate on both surfaces, and crenulate on margin, dactylus high, sickle-shaped. Pleopod 1 of males two-segmented, distal segment being spatulate; that of females also two-segmented, distal being multiarticulate flagellum. Uropod exopod with transverse suture in outer half. Living in hexactinellid sponges.

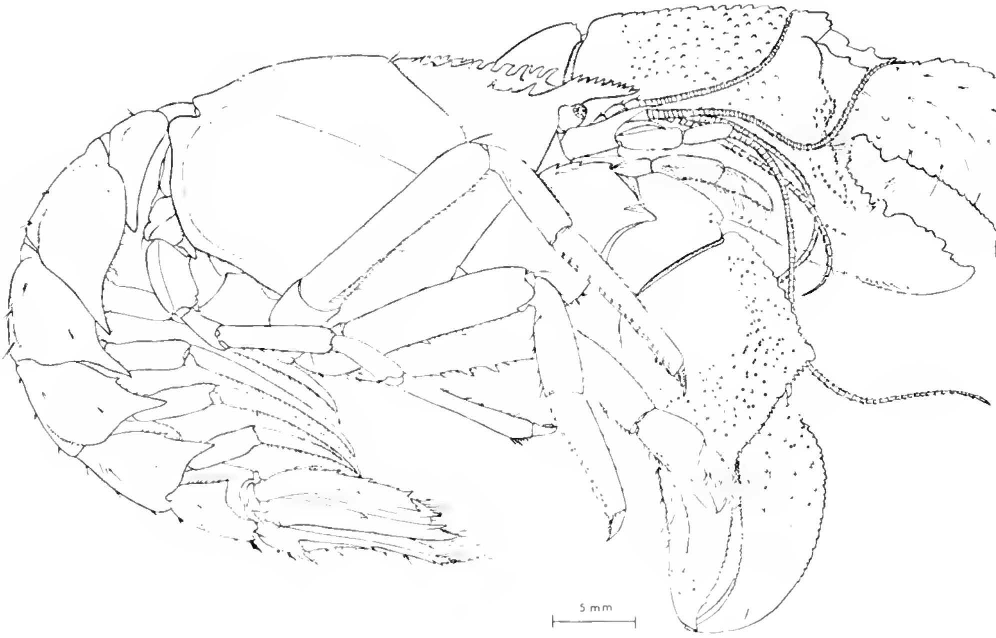


Fig. 1. *Axiopsis brucei* holotype. Total body length 77 mm.

Description. Rostrum (Figs 2A, 2B) elongate, triangular, almost twice as long as broad at base; dorsal surface largely concave, with median carina extending forwards halfway; tip acute, upturned, lateral margins with close-set series of eight to ten spines. Gastric region with five longitudinal carinae; median carina gradually descending to base of rostrum, with four prominent horny spines on anterior half, posterior spine posteriorly bearing small spine, with median tubercle, and with four sharp spines on posterior half; each submedian carina with seven to eight prominent horny spines, additional medial secondary row of two horny spines posteriorly; each outer lateral carina existing only on anterior half, with two to four horny spines, anterior spine conspicuous but remote from rostral base. Cardiac region with median carina extending backwards from cervical groove for half length. Anterior margin of carapace smooth, oblique ventrally; posterior margin dorsally sinuous with median convexity.

Abdominal somites (Fig. 1) smooth: first somite 2/3 length of second, dorsally with paired tufts of setae; second to fourth somites of sub-equal length along the mid-line, and dorsally with three paired tufts of setae; fifth somite slightly shorter than fourth, dorsally again with three tufts of setae but with an extra pair of distinct tufts of setae on posterior margin; sixth somite slightly shorter than fifth, with pair of oblique depressions extending posteriorly from anterior margin to median pit, dorsally with two paired tufts of setae on anterior half, and another pair of distinct tufts of setae on posterior margin, each with a small tooth on either side of its base.

First to fifth pleura distinctly pronounced on surface and extending posteroventrally into sharp narrow teeth; sixth pleuron smooth on surface and extending into a triangular tooth; fore margins of fourth and fifth pleura with a small tooth.

Eyestalk (Fig. 2A) subglobose, one third length of rostrum; cornea faintly pigmented, brown in alcohol. Antennular peduncle three-segmented, extending slightly beyond rostrum; basal segment clearly overreaching eyestalk; second segment about half length of first and slightly longer than third; flagellum about 3/4 length of carapace excluding rostrum. Antennal peduncle five-segmented; basal segment short and unarmed; second segment dorsally carinate, distally ending in a narrow acicle; scaphocerite slender, incurved, extending beyond acicle of second segment but shorter than fourth segment; third segment compressed, ventrally carinate, terminating in a triangular acicle.

Mandibular palp (Figs 3A, 3B) three-segmented, two proximal segments of subequal length, terminal segment sickle-shaped and about twice as long as second segment, bearing setae on anterior margin; cutting edge irregularly denticulated. Maxillule (Fig. 3C) bilobed; lower endite short and broad, and upper endite longer and more slender; palp two-segmented, ultimate half directed backwards ending in two slender spines. Maxilla (Fig. 3D) well developed; upper and lower endites bilobed, heavily armed with numerous setae; palp slender, distally directed mesially, ending in about ten long setae; scaphognathite well developed, posterior lobe bearing elongate seta with setules.

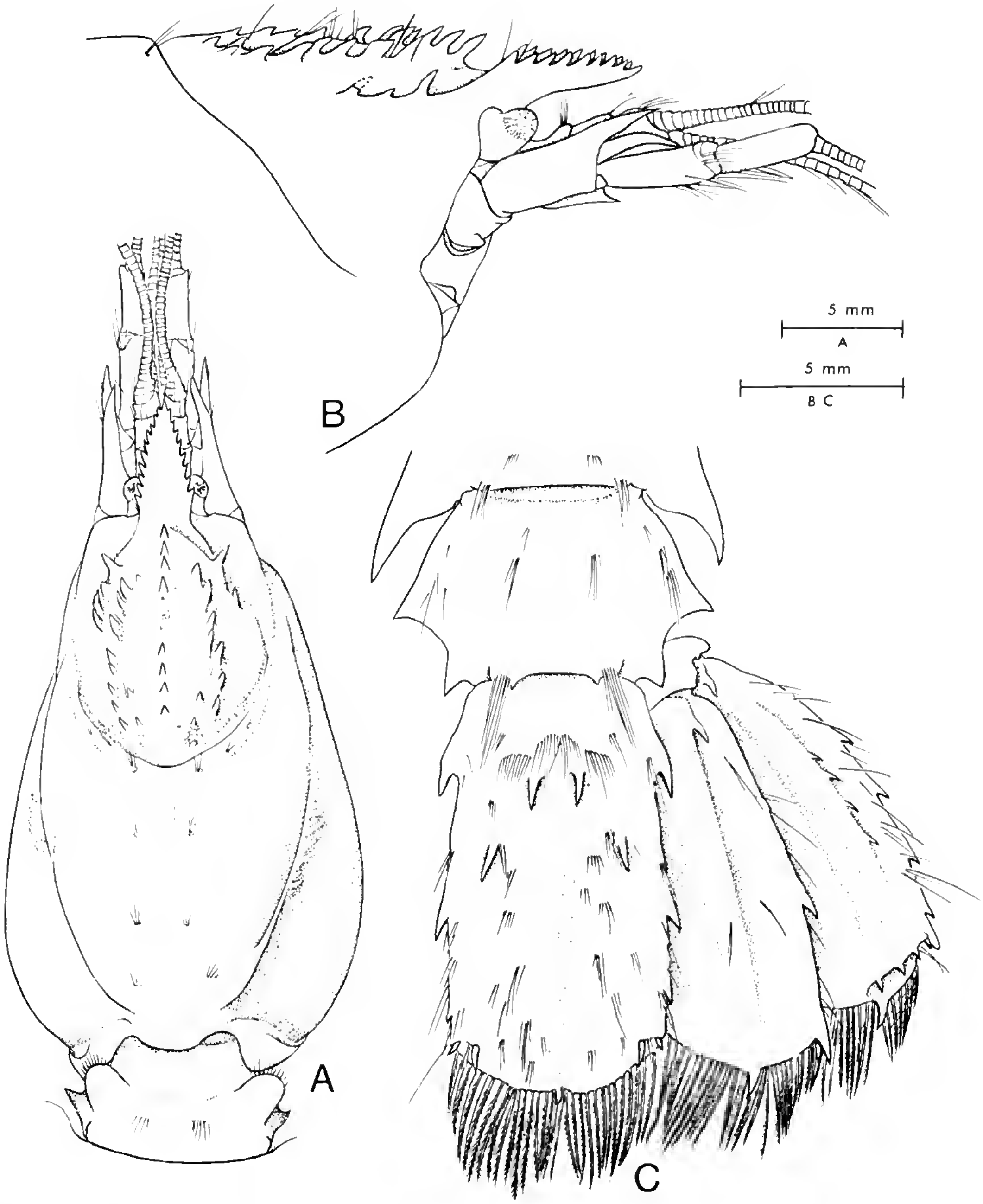


Fig. 2. *Axiopsis brucei* holotype: **A**, carapace and antennae, dorsal aspect; **B**, anterior carapace and antennae, lateral aspect; **C**, sixth abdominal segment and tail-fan, dorsal aspect.

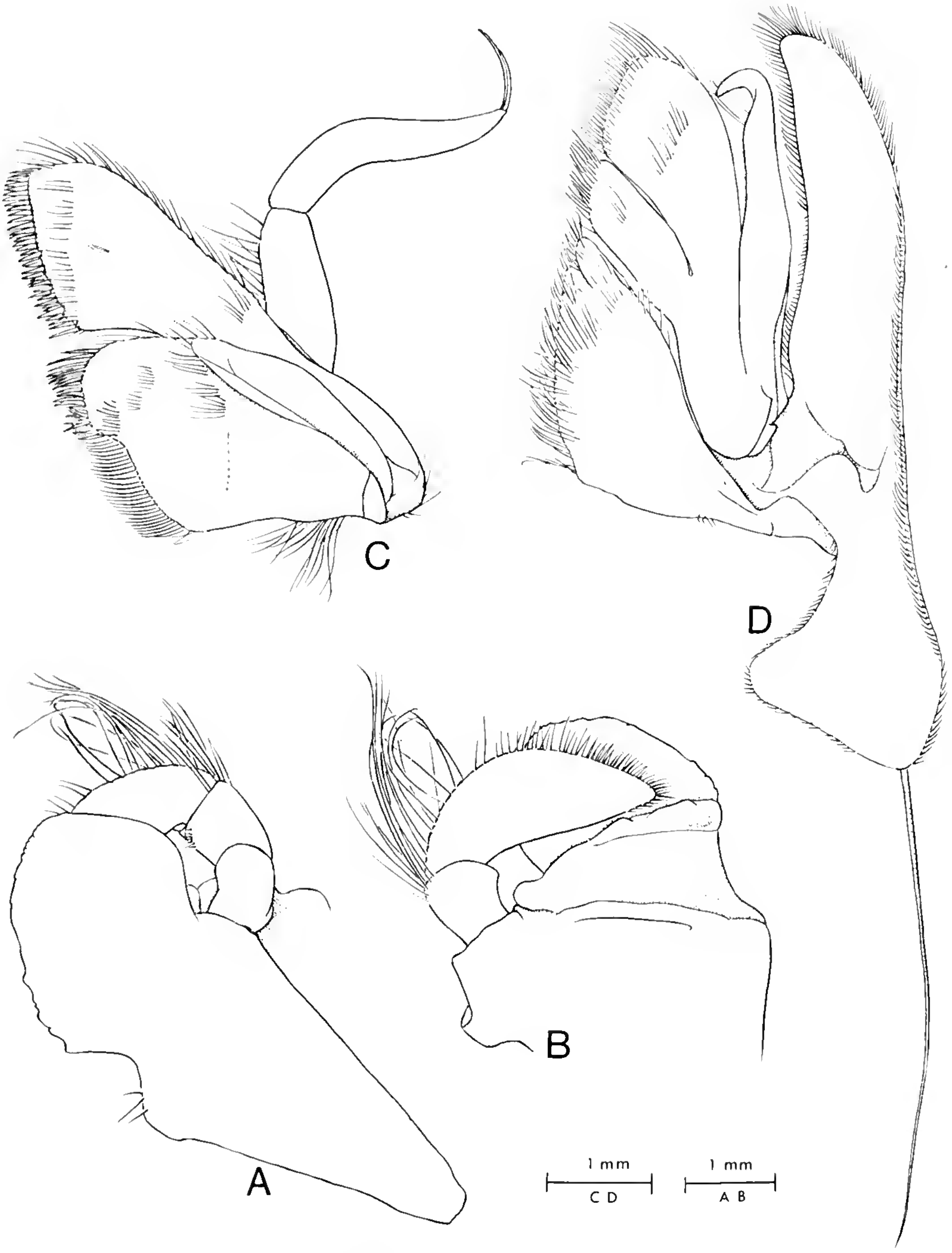


Fig. 3. *Axiopsis brucei* paratype, NTM Cr. 000605: **A**, mandible, outer aspect; **B**, same, inner aspect; **C**, maxillule, outer aspect; **D**, maxilla, inner aspect.

First maxilliped (Figs 4A, 4B) with large deflected epipod; exopod elongate, distally armed with segmented slender process tipped with plumose setae; palp two-segmented; endites of coxa and basis separated by notch. Second maxilliped (Fig. 5A) with leaf-like epipod bearing podobranch; exopod elongate, fringed with marginal setae, and endopod setose. Third maxilliped (Fig. 5B) with leaf-like epipod, with podobranch, and pair of arthrobranchs; endopod pediform, coxa mesiodistally with large tooth, basis unarmed, ischium bearing high serrated crest (Fig. 5C) on interior mesial margin widely separated by broad concavity from exterior mesial margin, largely extending beyond distal joint at tip; merus about as long as ischium, with large and small spine along inner margin; carpus with small spine at inner distal angle; propodus about as long as merus and slightly longer than dactylus.

First pereiopod large, chelate and asymmetrical.

In larger cheliped (Fig. 6A), coxa mesially forming rounded lower lobe with spine and setae on posterodistal margin. Basis small and unarmed. Ischium with small subdistal and distinct distal spines on ventral margin. Merus about 1.6 times as long as broad; dorsal margin carinate, subdistally deflected; ventral margin setose and with row of roughly interspersed spinules, distal spinule sharp, lying subdistally. Carpus inflated, about half meral length, and about 1.8 times as high as long, dorsal margin with smooth crest, ventral margin with subdistal denticle plus some small denticles; outer surface with some tubercles around dorsodistal part. Palm about 2.5 times carpal length on midline, and about 1.2 times as long as broad; outer and inner surfaces provided with numerous rounded tubercles; dorsal margin crenulate with rounded tubercles; lower external margin also crenulate with tubercles extending to tip of fixed finger. Fixed finger thin, outer and inner surfaces with numerous tubercles proximally; cutting edge crenulate with rough tubercles. Dactylus sickle-shaped, slightly shorter than palm, extending slightly beyond fixed finger; outer and inner surfaces flattened, and each with some tufts of setae; dorsal margin incurved, broadened proximally; cutting edge crenulate with rounded tubercles, tubercle in proximal third large.

Smaller cheliped (Fig. 6B) similar in shape to larger one. Merus distally with three inconspicuous denticles on dorsal margin. Carpus and chela slightly shorter and much narrower than larger chela; carpus 1.5 times as high as long, and palm about 1.5 times as long as carpus in mid-line; dactylus more than 1.5 times as long as palm.

Second pereiopod (Fig. 1) chelate, almost reaching distal margin of carpus of first pereiopod, coxa bearing mesial spinule and setae on posterodistal margin; basis small and unarmed; ischium with distroventral spine; merus with three interspaced acute spines plus subterminal spine on ventral margin, and with row of setae thicker on inner ventral margin than on outer; carpus unarmed, many long setae on internal surface; chela about 1.3 timeas as long as carpus, fingers thickly covered with setae on outer surface, each terminated by a transparent tooth, and serrated with fine transparent spinules on cutting edge; dactylus slightly overreaching fixed finger.

Third pereiopod chelate, coxa with a blunt mesial spine and spinule on posterodistal margin; basis and ischium similar to those of second pereiopod; merus with two interspaced spines plus subterminal spine on ventral margin; carpus unarmed; propodus with transverse rows of spinules on outer ventral surface, distal row being located on distal margin; dactylus short, terminated by acute translucent spine, with row of translucent spinules on cutting edge and also medially on outer surface.

Fourth pereiopod simple, coxa bearing a blunt mesial spine on posterodistal margin; merus unarmed on ventral margin, and propodus subterminally with cluster of long setae on interior surface. Fifth pereiopod subchelate, unarmed and more cylindrical than others; propodus terminated by row of transparent spines, and subterminally with cluster of long setae on outer surface; dactylus twisted, cutting edge with row of fine spinules on ventral margin, and with row of six sharp transparent spines on truncate distal margin.

Branchial formula shown in Table 1.

First pleopod of males (Fig. 6C) thin, two-segmented; distal segment about as long as basal segment, spatulate with truncate lobe on proximal half of mesial margin. First pleopod of females thin, two-segmented; distal segment two-thirds length of basal segment, showing multiarticulate flagellum curving backward distally. Second to fifth pleopods of both sexes biramous, each endopod with rod-like appendix interna ending in a cluster of small tubercles. Second pleopod of males with rod-like appendix masculina.

Caudal-fan (Fig. 2C) spinose and setose. Uropod exopod with proximal spine, and with three to four spines plus large distal spine on outer lateral margin; transverse

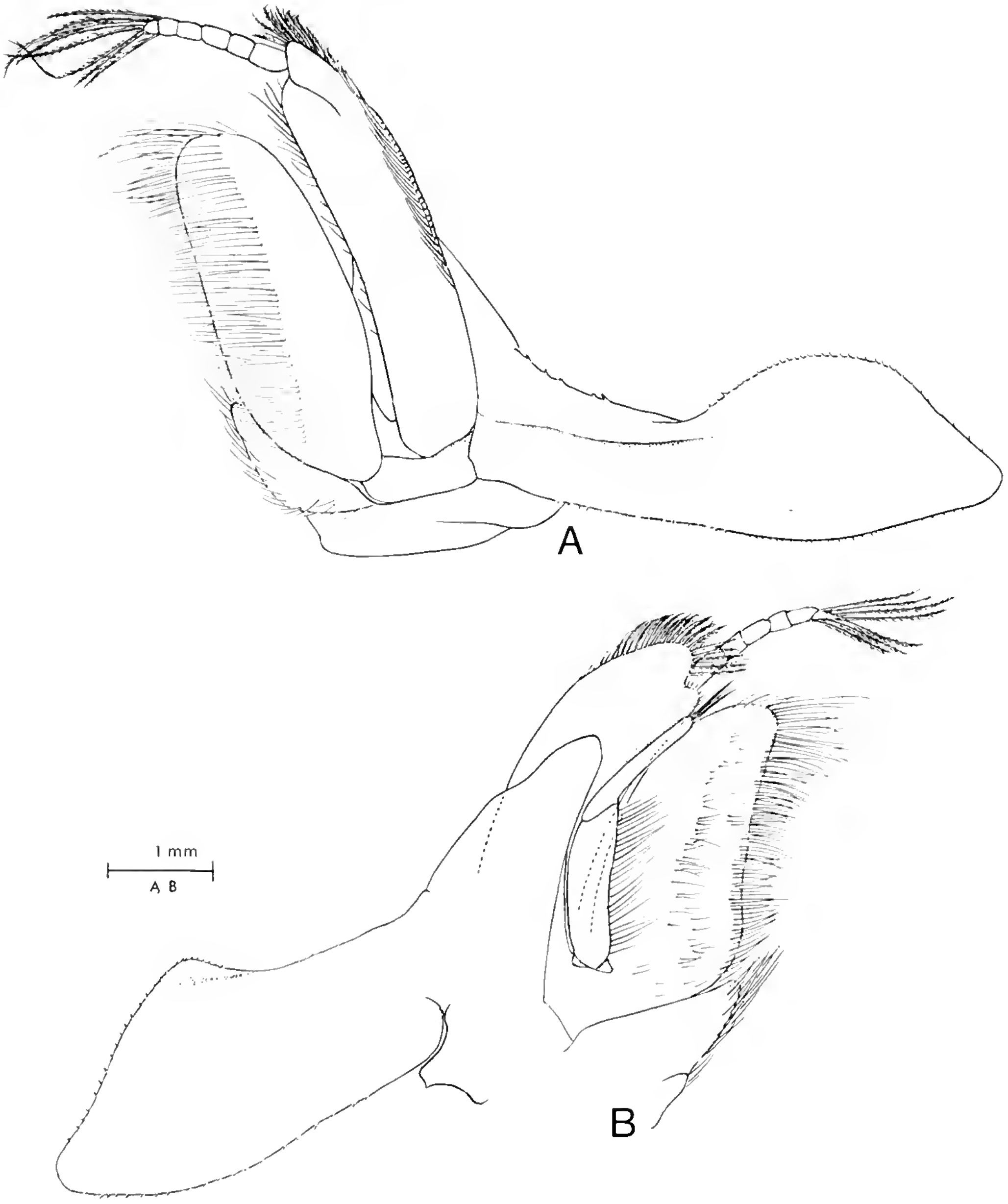


Fig. 4. *Axiopsis brucei* paratype, NTM Cr. 000605: **A**, first maxilliped, outer aspect; **B**, same, inner aspect.

suture defined only in outer half, bearing four interspaced spinules, outer spinule located at base of distal spine on outer margin; distal lobe with acute distal spine; dorsal surface with two rounded longitudinal ridges, outer ridge more distinct than inner, with row of four acute spinules. Uropod endopod with two to three spines on outer margin including outer distal spine; dorsal surface with single median ridge bearing proximal spine and distal marginal spine. Telson rectangular, about 1.8 times as long as broad, more than twice length of sixth somite, extending slightly beyond uropod, each lateral margin with three spines, proximal spine distinct, and with transverse ridge with two acute spinules at posterior angle; distal margin largely convex with median spine; proximal half of dorsal surface bearing two pairs of spines.

Etymology. This species is named after Dr A.J. Bruce of Darwin, Australia, who collected the specimens.

Remarks. The present species is most similar to *Axius (Axius) novaezealandiae* Borradaile, obtained from 70 miles east of North Cape, New Zealand, at 128 m and also from the Tasmanian Sea, 39°52'S 171°01'E, at 732 m (Balss 1933) especially in that each pleuron terminates by a sharp point, and the third to sixth each bear a spine on the fore edge. In the present species, however, the spine on the fore edge of each pleuron is found in both males and females, although it is weak in females, while in *A. novaezealandiae* it is present only in males. Other features also shown only by *A. novaezealandiae* are a flat gastric region with an elongate triangular patch of granules, the chela of the 1st pereiopods without marginal crenulation, the uropod endopod with about half a dozen spines on the median carina, and the uropod exopod without a transverse suture.

Concerning the form of the pleura, *Calocaris (Calastacus) oxypleura* Williams, obtained from the Straits of Florida, west of

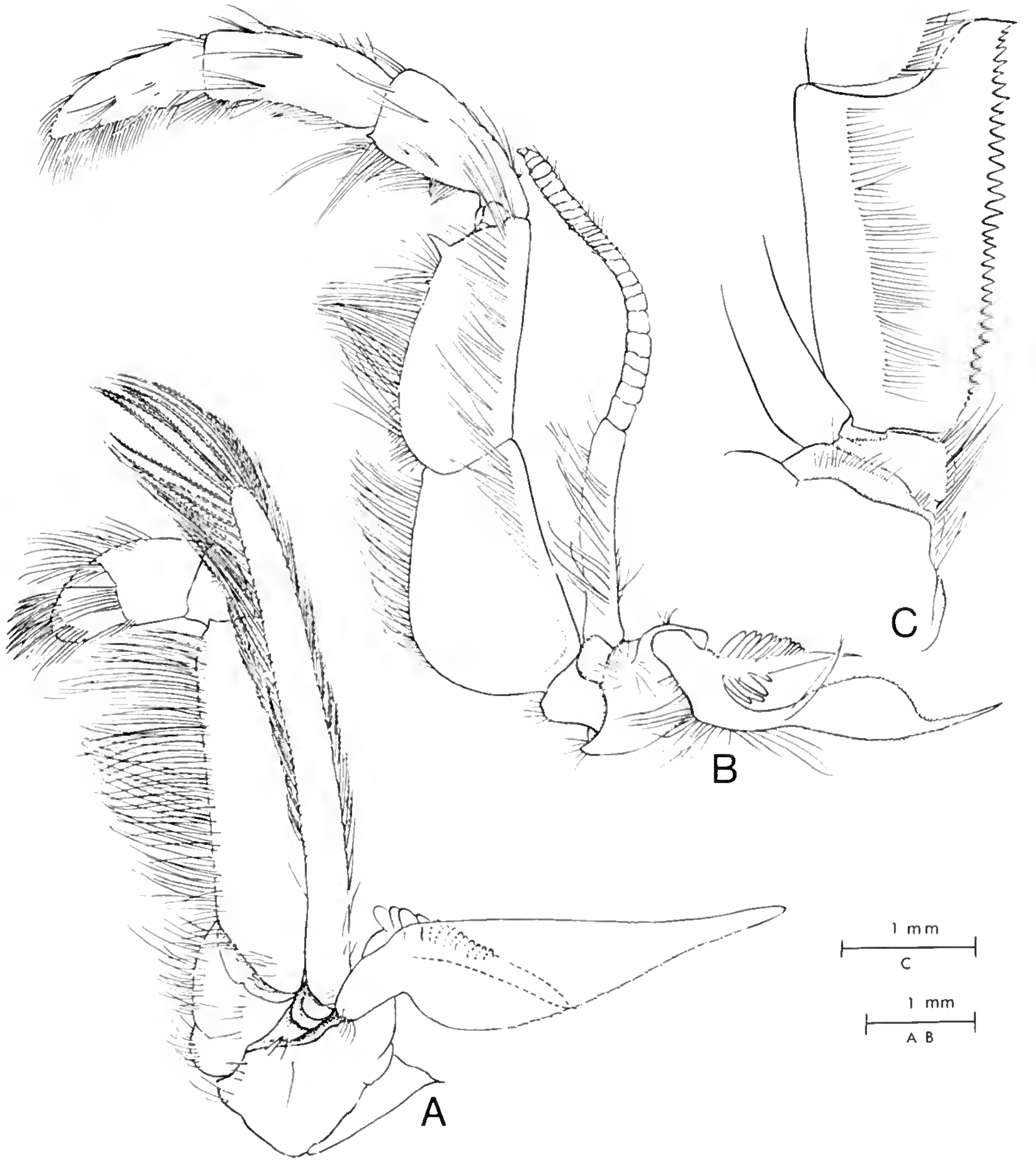


Fig. 5. *Axiopsis brucei* paratype, NTM Cr. 000605; **A**, second maxilliped, outer aspect; **B**, third maxilliped, outer aspect; **C**, ischium of third maxilliped, inner aspect.

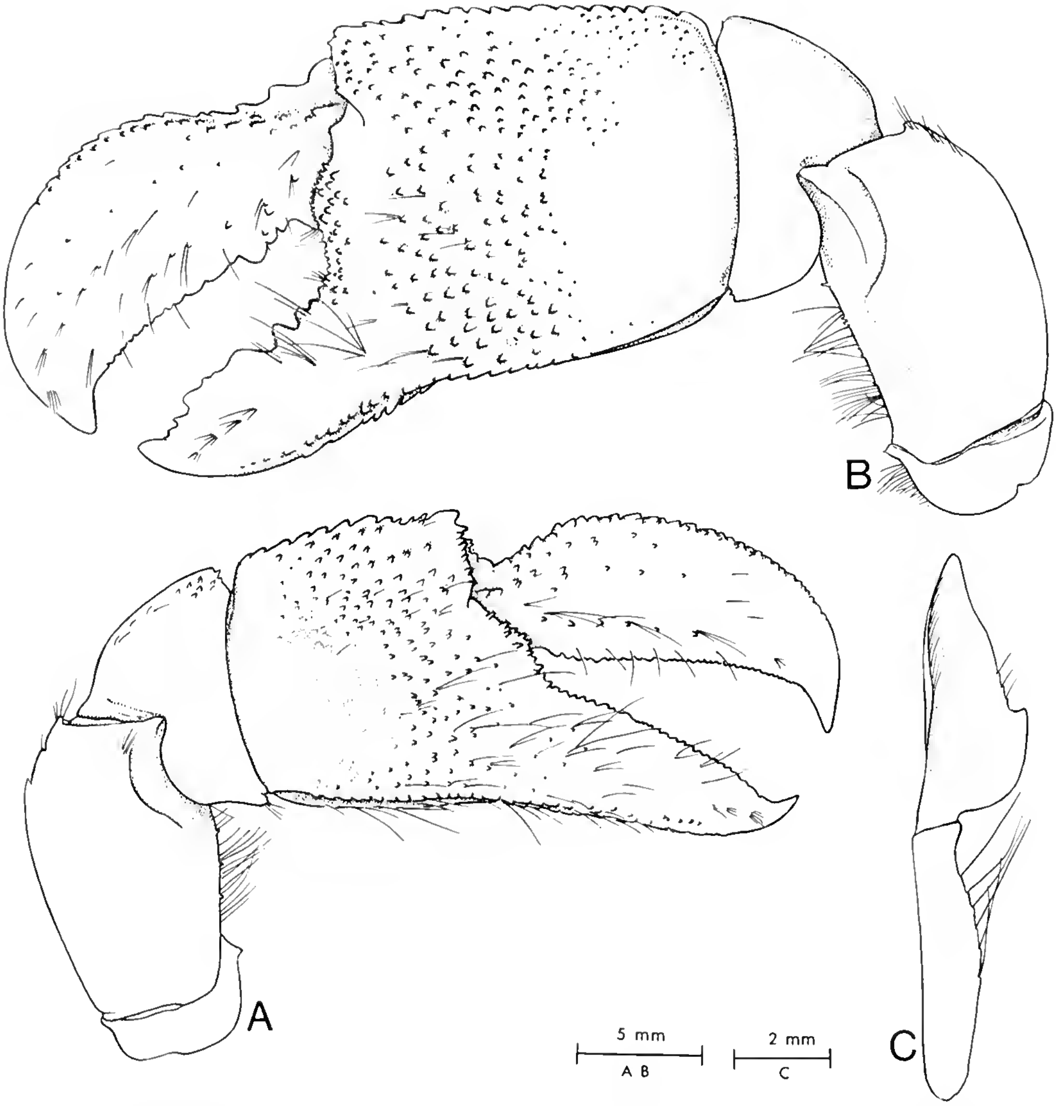


Fig. 6. *Axiopsis brucei* holotype: **A**, larger cheliped, outer aspect; **B**, smaller cheliped, outer aspect; **C**, first pleopod of male, posterior aspect.

Table 1. Branchial formula in *Axiopsis brucei*

	Maxillipeds			*Pereiopods*				
	1	*2*	*3*	*1*	*2*	*3*	*4*	*5*
Epipods and podobranchs	E	E+1	E+1	E+1	E+1	E+1	E	-
Arthrobranchs	-	-	2	2	2	2	2	-
Pleurobranchs	-	-	-	-	-	-	-	-

Riding Rocks at 365 m has similar pleura. However, the first to fifth pleura extend less posteroventrally to acuminate tips than in the present species and *A. novaezealandiae*.

The present species is superficially also related to *Axius (Eiconaxius) caribbaeus* (Faxon) from the West Indies, in being commensal with a hexactinellid sponge, and in the outlines of the 1st pereiopod and the pleura, but it readily distinguishable from the latter by such features as that in *A. (E.) caribbaeus* the rostrum is broadly rounded at the anterior end; the 1st pereiopod has no tubercles on its surfaces; the palm of the 2nd pereiopod is elongated; the pleura have no spine on the fore edge, and the uropod exopod has no transverse suture.

ACKNOWLEDGEMENTS

I am much indebted to Dr A.J. Bruce, Northern Territory Museum, Darwin, Australia, for providing me with specimens and data, and also for commenting on the manuscript.

REFERENCES

Balss, H. 1933 Ueber einige systematisch interessante indopacifische Dekapoden. *Mitteilungen aus dem Zoologischen Museum in Berlin* **19**: 84-97.

Borradaile, L.A. 1903 On the classification of the Thalassinidea. *Annals and Magazine of Natural History* (7) **12**: 534-551.

——— 1916 Crustacea. I. Decapoda. II. *Porcellanopagurus*: an Instance of Carcinization. *British Antarctic ("Terra Nova") Expedition 1910-1913 Natural History Report, Zoology* **3**: 75-126.

Boesch, D.F., and Smalley, A.E. 1972 A new Axiid (Decapoda, Thalassinidea) from the northern Gulf of Mexico and tropical Atlantic. *Bulletin of Marine Science* **22**: 45-52.

De Man, J.G. 1925 The Decapoda of the Siboga-Expedition. Part IV. The Axiidae collected by the Siboga-Expedition. *Siboga-Expeditie* **39** a5: 1-127.

Faxon, W. 1893 Reports on the dredging operations off the west coast of Central America to the Galapagos by the "Albatross". VI. Preliminary descriptions of new species of Crustacea. *Bulletin of the Museum of Comparative Zoology (Harvard University)* **24**: 149-220.

——— 1896 Supplementary notes on the Crustacea (Dredging U.S. steamer "Blake"). *Bulletin of the Museum of Comparative Zoology (Harvard University)* **30**: 151-166.

Kensley, B. 1981 Notes on *Axiopsis (Axiopsis) serratifrons* (A. Milne Edwards) (Crustacea: Decapoda: Thalassinidea). *Proceedings of the Biological Society of Washington* **93** (4): 1253-1263.

Kensley, B. and Gore, R.H. 1981 *Coralaxius abelei*, new genus and new species (Crustacea: Decapoda: Thalassinidea: Axiidae): A coral-inhabiting shrimp from the Florida Keys and the Western Caribbean Sea. *Proceedings of the Biological Society of Washington* **93**(4): 1277-1294.

Man, J.G. de 1925 see De Man, J.G.

Miyake, S. and Sakai, K. 1967 Two new species of Axiidae (Thalassinidea, Crustacea) from the East China Sea. *Journal of the faculty of Agriculture Kyushu University* **14**(2): 303-309.

Parisi, B. 1917 I Decapodi giapponesi del Museo di Milano. V. Galatheidea e Reptantia. *Atti della Societa Italiana di Scienze Naturali edel Museo Civico Storia Naturale di Milano* **56**: 1-24.

Poore, G.C.B. and Griffin, D.J.G. 1979 The Thalassinidea (Crustacea: Decapoda) of Australia. *Records of the Australian Museum* **32**(6): 217-321.

Saint-Laurant, M. de 1972 Un Thalassinide nouveau du golfe de Gascogne, *Calastacus laevis* sp. nov. Remarques sur le genre *Calastacus* Faxon. (Crustacea Decapoda Axiidae). *Bulletin du Muséum National d'Histoire Naturelle Zoolgoie* **29**: 347-356.

Williams, A.B. 1974. Two new Axiids (Crustacea: Decapoda: Thalassinidea: Calocaris) from North Carolina and the Straits of Florida. *Proceedings of the Biological Society of Washington* **87**(39): 451-464.

Accepted 28 April 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 21-27

TWO NEW SPECIES OF ALPHEID SHRIMP FROM AUSTRALIAN WATERS‡

DORA M. AND ALBERT H. BANNER*
Hawaii Institute of Marine Biology, University of Hawaii, Honolulu, U.S.A.

ABSTRACT

One new species of alpheid shrimp, *Alpheus soelae* sp. nov., collected by the CSIRO vessel, the R.V. "Soela", from the Australian Northwest Shelf, and one new species, *Alpheus stantoni* sp. nov., collected on Heron Island, on the Great Barrier Reef are described and illustrated.

KEYWORDS: taxonomy, Alpheidae, Australia, deep sea, coral reefs.

INTRODUCTION

The Division of Fisheries Research of the Commonwealth Scientific and Industrial Research Organisation has been engaged in a survey of the benthic resources of the Australian Northwest Shelf region, off Port Hedland, Western Australia.

This survey, during 1983-1985, resulted in extensive collections of little known or new crustaceans from the little studied waters. Numerous representatives of the family Alpheidae were collected, amongst which was a single example of a species that is here described as new. A description of another new species of *Alpheus* Fabricius from Heron Island, Queensland, at the southern end of the Great Barrier Reef, collected by Mr Frank G. Stanton, a post-graduate student of the University of Hawaii, is also provided. The present species raise to 84 the number of species of *Alpheus* now known from Australian waters.

SYSTEMATICS

Alpheus soelae sp. nov.

(Fig. 1)

Type Material. HOLOTYPE - ♀, Northern Territory Museum (NTM) Cr. 001994, TL 37 mm, bearing one possible small egg (irregular but yellow) at the upper interior margin of the first pleuron, collected in a trawl haul of the R.V. "Soela" (Operation 50, 18°41′S 120°07′E, 9 February 1984, 430 m, coll. T. Ward).

Description. Rostrum clearly longer than broad at base, tip reaching to middle of visible portion of first antennular article (note: anterior appendages appear to have been displaced forward in handling, exposing the bases of the antennular peduncles); rostrum dorsally rounded and extended only slightly posterior to middle of cornea. Cornea apparently of normal pigmentation. Orbital hoods only slightly inflated, with short, acute teeth arising abruptly from curvature of margin and reaching well past middle of rostrum; orbitorostral grooves shallow and poorly demarked.

Second antennular article 4.4 times as long as broad, 1.5 times as long as visible portion of first (which is exposed to its base) and 2.7 times as long as third article. Stylocerite acute, slightly overreaching first antennular article. Scaphocerite with outer margin slightly concave; squamous portion narrow, reaching to end of third antennular article; outer tooth acute, reaching slightly beyond squame. Carpocerite overreaching antennular peduncles by nearly length of third article. Basicerite with lateral tooth prominent, reaching to near level of end of stylocerite.

Articles of third maxilliped with ratio; 10:4:6; all articles bearing long setae; tip bearing setae only, not spines.

Large chela 3.8 times as long as broad, with fingers occupying distal 0.28. Dactylus with superior surface high but rounded, with plunger low and confluent, with surface of dactylus similar to that of *A. distinguendus* De Man (see Banner and Banner 1982:23, Fig. 4C); tip extending well beyond tip of propodal finger rounded in superior profile and flat on oppositive surface. Propodal finger with groove, not socket, to accommodate dactylus and with moderate tufts of long setae near dactylar articulation. Palm rounded in section with lateral face bearing a

---

‡ A contribution from the Hawaii Institute of Marine Biology.

* The co-author of this paper, Professor Albert H. Banner, died on 19 August 1985, and the author, Dora May Banner, on 15 December 1986.

low rounded ridge reaching proximally from dactylar articulation for about one-third length of palm; ridge separated on either side by broad, shallow and ill-defined grooves;superior groove lying below condylar crest, inferior groove extending into face of propodal finger. Medial face of palm without sculpturing. Palm bearing only scattered setae, slightly concentrated along inferior margin. Carpus normal. Merus 2.6 times as long as broad, bearing along inferointernal margin 6 short, slender spines interspersed by longer setae; neither superior nor inferior distal angles projecting. Ischium bearing on inferointernal margin and at distal angle a few spines similar to those of merus.

Small chela almost as long as large chela, with tips of fingers reaching to same level as does propodal finger of large chela, slender, 5 times as long as broad with fingers and palm almost equal in length. Lateral face of palm bearing a well-demarked 'v'-shaped groove running from near dactylar articulation to *linea impressa* (note: because of the 'v'-shape of the groove and its strong demarkation, we believe it to be an artifact from preservation, such as shrinking of muscular tissue in a strong alcoholic solution; whether the groove coincides distally with a shallow 'u'-shaped groove, such as that found on the large chela,. could not be determined). Dactylar articulation flanked on either side by a moderate, sub-acute tooth. Medial face of palm bearing some scattered setae, lateral face glabrous. Fingers straight and slender, and at most subbalaeniceps (see Banner and Banner 1982:22), with tips strongly hooked and crossing; both fingers bearing on either side a dense row of highly setiferous bristles that intermesh when chela is closed; rows on both fingers stopping abruptly before the hooked tips, and the rows on dactylus not meeting on superior surface of article. Merus 2.7 times as long as broad, bearing on inferointernal margin 4 small acute spines interspersed with long setae; margin projecting distally as a right-angled tooth; other distal angles not projecting. Ischium also bearing 2 small spines on inferodistal margin.

Carpal articles of second legs with ratio: 10:5.5:2.5:3.5.

Ischium of third leg 0.3 as long as merus, bearing a slender spine. Merus inermous, 2.8 times as long as broad. Carpus 5.5 as long as merus, with projection of superodistal margin rounded. Propodus 0.8 as long as merus, bearing on inferior margin 7 spines and a distal pair, interspersed with a few long setae. Dactylus simple, slightly curved and tapering uniformly to an acute tip; bearing on superior surface a slight notch with a few short setae inserted.

Telson 3.8 times as long as posterior margin is broad, anterior margin 1.5 times as wide as posterior margin; lateral margins with uniform taper, posterior margin projecting as a low arc. Posterolateral spines slender and short; anterior pair of dorsal spines located anterior to middle. Spine on outer uropod uncolored in preservative.

Colouration. Primarily white, with an extensive reddish zone of fine speckling medially along whole body length, most strongly marked on first to fourth abdominal segments, extending more feebly over upper parts of pleura and caudal fan. Antennal peduncles, third maxilliped, chelae, pereiopods and pleopods white. Antennal border of carapace red, antennal flagellae pink and corneas black.

Discussion. Two remarks should be made about this specimen: First, of the Indo Pacific alpheids known, this species is one of the deepest dwelling: at 430-450m, it is exceeded only by *Alpheopsis shearmii* (Alcock and Anderson) (1899:283) at 430 fathoms (785m) in the Arabian Sea and *Athanas phyllocheles* Banner and Banner (1983:152, Fig. 14) from 450 m in the western Indian Ocean (off Reunion). Second, for an alpheid dwelling in deep water, in contrast to the more littoral forms, it shows surprisingly little modification (see, for example, the species reported from around 200 m collected by the MUSORSTOM Expedition (Banner and Banner 1981:218).

In most characteristics, including the form of the large chela, the rostrum and orbital teeth, etc., the species appears to be firmly within the *sulcatus* group. The dense rows of setiferous bristles on the sides of the fingers of small chela of the female separate it from all other members of the group — indeed, we do not recall any species of the genus *Alpheus* with a similar modification. Because marked sexual dimorphism in the small chelae is rare in the Sulcatus Group, we suspect the male small chela will be similar to that of the female. The species is clearly separated from the members of the group without orbital

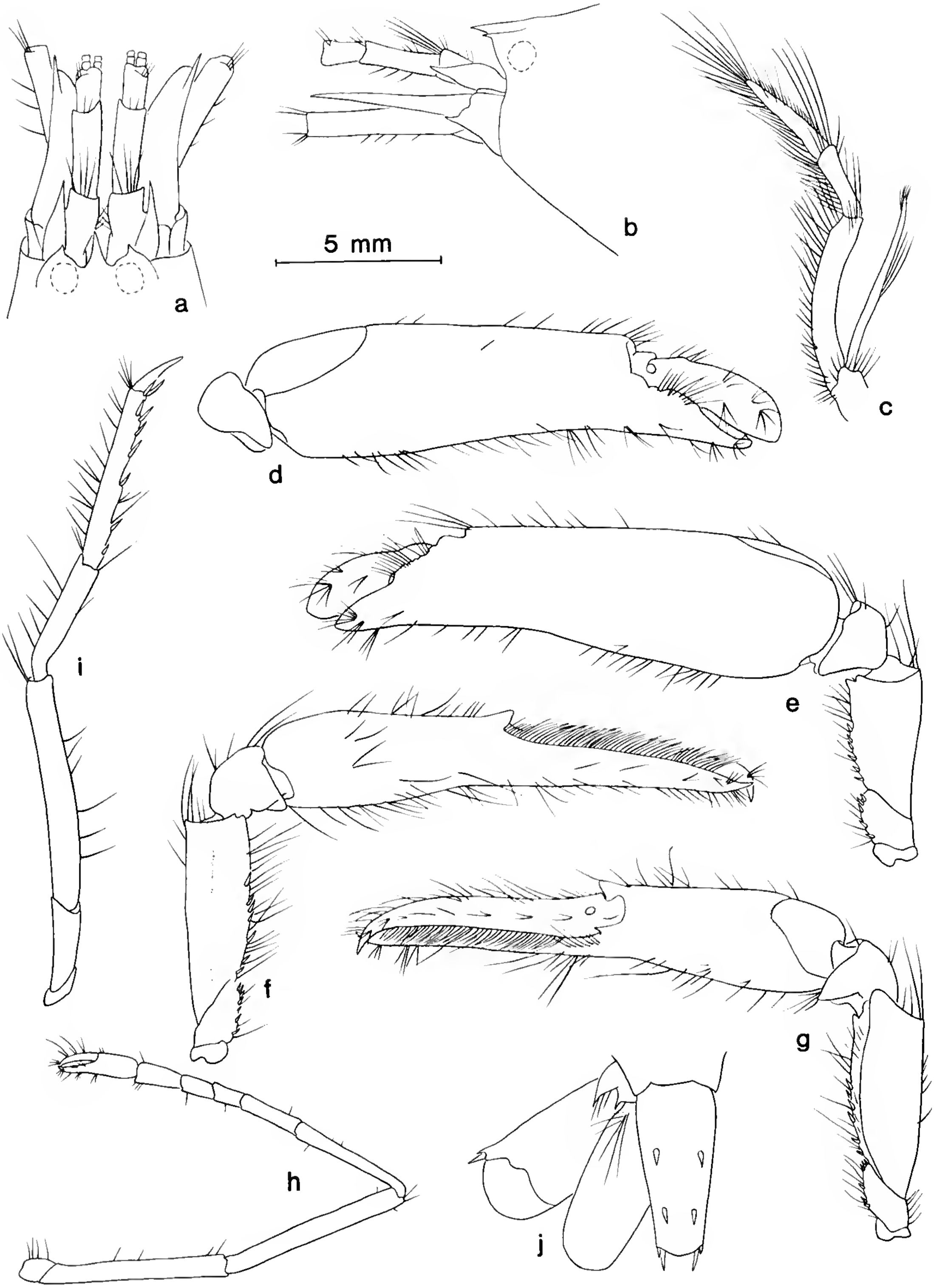


Fig. 1. *Alpheus soelae*: **a, b,** anterior region, dorsal and lateral views; **c**, third maxilliped, lateral face; **d, e,** large chela, medial and lateral faces; **f, g,** small cheliped, superolateral and medial faces; **h,** second leg; **i,** third leg; **j,** telson and uropods. All drawings same scale.

teeth, like *A. sulcatus* Kingsley. Of the larger group with orbital teeth, many have the dactyli of the third legs biunguiculate: these include *A. architectus* De Man, *A. canaliculatus* Banner and Banner, *A. gracilis* Heller, *A. parasocialis* Banner and Banner, *A. socialis* Heller, *A. tungii* Banner and Banner, and *A. villosus* (Olivier). *A. lottini* Guérin has orbital teeth and lacks a biungulate dactylus on the walking legs, but it is easily separated from this and all other species of *Alpheus*, by the heavy and bluntly rounded shape of the dactyli of the three posterior pair of the thoracic legs. Five species share the teeth on the orbital hoods and simple dactyli with *A. soelae*; in addition to the unique fringe of setae on the small chela, they may also be separated from the new species by the following characteristics: *A. brucei* Banner and Banner bears a transverse groove on the large chela proximal to the dactylar articulation; *A. facetus* De Man bears a more marked groove on the superior face of the large chela, but lacks the low ridge and inferior groove on the lateral face; the large chelae of *A. coetivensis* Coutiére, *A. supachai* Banner and Banner and *A. splendidus Coutiére* all lack grooves on the palm of the large chela; and *A. splendidus* can further be separated by the location of the orbital teeth, high on the orbital hoods, not on the margins.

This new species may be inserted in our key to the species of *Alpheus* of Australia (1981:26) by inserting the following couplet after the present couplet 12:

13(12). Both margins of both propodal finger (pollex) and dactylus of small chela bearing dense rows of setiferous bristles .... *A. soelae*

Fingers of small chela bearing at most scattered setae .... 13a.

Then the present couplet 13 can be renumbered as 13a and the following key be continued in its present arrangement.

Alpheus stantoni sp. nov.

(Fig. 2)

Type material. HOLOTYPE - ♀, NTM Cr. 003435, TL 26 mm, Heron Island, Great Barrier Reef, Australia, dug out of coral rubble at 13 m, 26 August 1983, coll. F.G. Stanton.

Description. Rostrum relatively long with tip reaching near end of first antennular article (in lateral view). Broad with length about twice breadth at base posterior to orbital hoods, dorsally flattened without trace of carina. Orbital hoods distinct and somewhat inflated with anterior margin curved. Orbitorostral grooves deep and well demarked, with lateral margins of rostrum definitely overhanging medial wall of groove; rostrum continuing posteriorly to posterior margin of orbital hoods. Orbitorostral margin only slightly concave between anterior margins of hood and lateral margins of rostrum.

Second antennular article 1.3 times as long as visible part of first and about 2 times as long as wide, third article half as long as second. Distal margins of articles bearing long fine setae. Stylocerite acute, reaching just past end of first antennular article. Outer margin of scaphocerite slightly concave, lateral tooth reaching well beyond antennular peduncle with squamous portion short and narrow and a little shorter. Lateral tooth of basicerite small but acute. Carpocerite 5.6 times as long as broad, viewed laterally, and as long as squame.

Ratio of articles of third maxilliped: 10:3.0:5.4. Lateral margin of first article bearing distally a rounded tooth. Third article distally bearing strong setae.

Large chela 3.0 times as long as broad, fingers occupying distal third; superior saddle well developed, proximal shoulder rounded and projecting above saddle, distal shoulder rounded. Lateral palmar groove triangular with apex extending to near proximal articulation (proximal portion of groove may be an artifact from handling). Medial surface of palm similar to lateral except lower margin bearing a more pronounced shoulder; proximal extension of groove reaching along crest of palm; crest bearing a few long setae. Merus 2.3 times as long as broad and distally bearing on superior margin slight rounded projection beset with a few long hairs; inferointernal margin irregularly serrate with few setae and distally bearing strong tooth.

Small chela of female 4.6 times as long as broad with fingers 1.3 times as long as palm; palm and fingers bearing long setae with more setae on fingers than palm. Merus 3.8 times as long as broad, similar to large chela except inferointernal margin not serrate and distal tooth smaller. Male chela unknown.

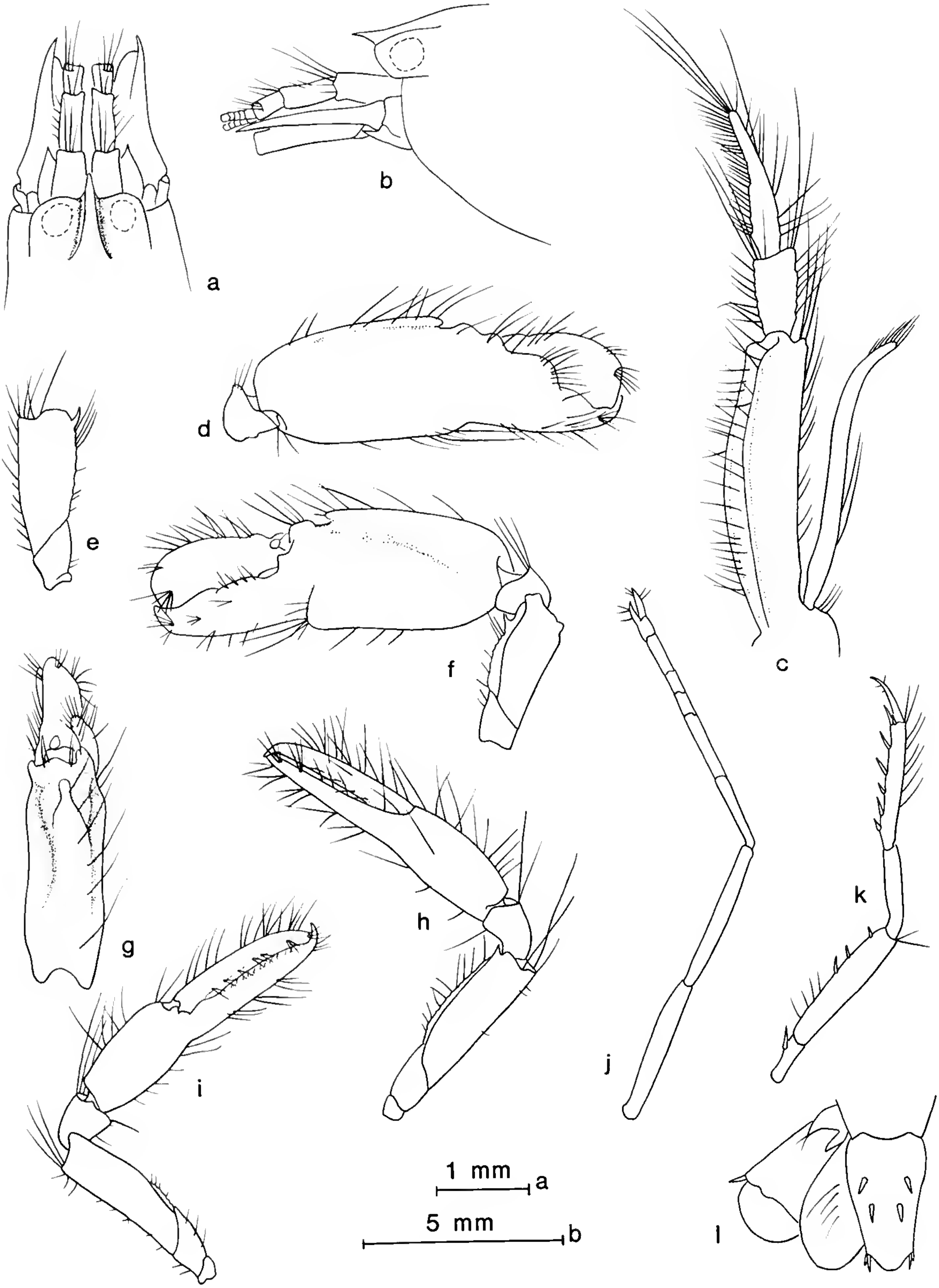


Fig. 2. *Alpheus stantoni*: **a, b,** anterior region, dorsal and lateral views; **c,** third maxilliped, lateral face; **d, e,** large chela and merus medial faces; **f,** large cheliped, lateral face; **g,** large chela, superior face; **h, i,** small cheliped medial and lateral faces; **j,** second leg; **k,** third leg; **l,** telson and uropods. All drawings except c, scale b.

Carpal articles of second leg with ratio: 10:10:3:3:5.

Ischium of third leg bearing spine. Merus 5 times as long as broad with inferior margin bearing 3 spines and a few setae but no distal tooth. Carpus 0.7 as long as merus and 6.2 times as long as broad. Propodus 0.9 times as long as merus, bearing on its inner margin 5 moderate-sized spines and a pair distally. Dactylus simple, curved, 0.5 as long as propodus. Fourth leg with merus 6.6 times as long as broad, with inferior margin bearing 2 small spines and some stiff setae.

Telson with maximum breadth slightly posterior to articulation and with breadth at this point 1.6 times that of posterior breadth. Length 2.6 times posterior breadth. Posterior margin arcuate and projecting, with posterolateral spines relatively weak. Dorsal spines normal and strong, with anterior pair anterior to middle and posterior pair near middle.

Colouration. (From a color transparency taken by Mr Stanton of the living specimen, shown in dorsal view): Basically scattered light red chromatophores on a transparent to translucent white ground color, with concentrations of the chromatophores in the anterior region including the bases of the first and second antennae, as indistinct transverse bands on the terga of the second and sixth abdominal segments and on the tail fan. The chelae are solid red with white fingers on the large chela; the following thoracic legs bear a single red band on the ischium and the proximal end of the merus and another band on the distal end of the merus; otherwise, the appendages and the antennular and antennal flagellae are transparent. No lateral markings are discernible in photograph.

Biological notes. The sole specimen was collected by Mr Stanton while he was studying alpheid-goby associations off Heron Island, Great Barrier Reef, Australia. The specimen came from a sand and coral rubble bottom beyond the edge of the northwest corner of the Heron Island fringing reef in 13 m of water. Mr Stanton's technique would be to observe a shrimp-goby hole with its occupants, then plunge a "plastic spade" into the substrate behind them in an effort to prevent the occupants from fleeing to further reaches of the tunnel. He would then excavate the sand-rubble by hand, usually 5-10 cm deep and 30-40 cm wide. Such an excavation produced this shrimp, but Mr Stanton is emphatic that it was not the same species of shrimp as the one he saw associated with the goby (*Amblyeleotris* sp.) at the mouth of the burrow. Whether it lived independently or associated with another goby he does not know.

Discussion. The presence of movable spines on the merus of the third leg is rare in the genus *Alpheus* — we can recall only *A. philoctetes* De Man and *A. lanceloti* Coutière in the Diadema Group and *A. alcyone* De Man in the Crinitus Group bearing them — and they do not occur in any Indo-Pacific members of the Edwardsii Group, yet the sculpturing of the chela in this species plainly places it within the last group.

The species within the Edwardsii Group that have a rostrum similarly flattened dorsally are *A. bisincisus* De Haan (see Banner and Banner 1982:263, Fig. 81), *A. proseuchirus* De Man (1908:111; 1911:407, Fig. 96) and *A. spatulatus* Banner and Banner (1968:146, Fig. 3). Of these three, *A. stantoni* is somewhat similar in the rostral base to *A. proseuchirus*, but in the latter species the sculpturing on the large chela is greatly reduced — for example, the inferior shoulder on the outer face is lacking and the third legs are more slender and elongate. In *A. bisincisus* the rostral base does not overhang the orbitorostral grooves and the sculpturing of the large chela is heavier with the inferior shoulder protruding as an acute tooth. *A. spatulatus* can most easily be distinguished by the spatulate condition of the dactyli of the third and fourth legs as well as by the length of the rostrum and proportions of the meri of the large and small chelae.

In our key to the genus *Alpheus* from Australia (1982:30) this species can be separated easily by inserting the following dichotomy after couplet 51:

52(1). Meri of third and fouth legs bearing movable spines .... *A. stantoni*

Meri of third and fourth legs perhaps bearing a fixed tooth but not movable spines .... 52a.

Then the present couplet 52 can be remembered as 52a and the following key be continued in its present form.

This species has been named for its collector, presently a doctoral candidate in the Department of Zoology, University of Hawaii.

ACKNOWLEDGEMENTS

We wish to thank Dr A.J. Bruce of the Northern Territory Museum, Darwin, for his cooperation in sending us the specimen from Northern Australia.

REFERENCES

Alcock, A. and Anderson, A.R. 1899 An account of the deep-sea Crustacea dredged during the surveying-season of 1897-98. XLIII. Natural history notes from H.M. Royal Indian Marine Survey Ship "Investigator", Commander T.H. Heming, R.N., commanding. Series III, No. 2. *Annals and Magazine of Natural History* (7) **3**:278-292.

Banner, A.H. and Banner, D.M. 1968 Three new species of the genus *Alpheus* (Decapoda, Alpheidae) from the International Indian Ocean Expedition. *Crustaceana* **15**(2):141-148.

——— 1981 Decapod Crustacea, Alpheidae. In: Resultats des campagnes MUSORSTOM. I. Philippines (18-28 Mars, 1976). *Memoirs ORSTOM* **91**:217-235.

Banner, D.M. and Banner, A.H. 1982 The alpheid shrimp of Australia. Part III. The remaining alpheids principally the genus *Alpheus*, and the family Ogyrididae. *Records of the Australian Museum* **34**(1):1-357.

Banner, A.H. and Banner, D.M. 1983 An annotated checklist of the alpheid shrimp from the Western Indian Ocean. *Travaux et Documents ORSTOM* **158**:1-164.

Coutière, H. 1905 Les Alpheidae. In: J.S. Gardiner (ed.) *The fauna and geography of the Maldive and Laccadive Archipelagos* **2**(4):852-921. University Press: Cambridge, England.

De Man, J.G. 1908 Diagnosis of new species of macrurous decapod Crustacea from the "Siboga-Expedition." III. *Notes Leyden Museum* **30**(14):98-112.

——— 1911 The Decapoda of the Siboga Expedition. Part II. Family Alpheidae. *Siboga-Expeditie* **39a**^{1}(2):133-465.

——— 1915 Supplement...Explanation of plates of Alpheidae. *Siboga-Expeditie* **39a**^{1}(2):23 plates.

Accepted 7 May 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 29-50

REVISION OF AUSTRALIAN *CORANUS* CURTIS (HETEROPTERA: REDUVIIDAE: HARPACTORINAE)

M.B. MALIPATIL
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Eight new species, *Coranus fuscatus* sp. nov., *C. aridellus* sp. nov., *C. bicoloratus* sp. nov., *C. fuscilineatus* sp. nov., *C. westraliensis* sp. nov., *C. nigritus* sp. nov., *C. monteithi* sp. nov., and *C. dalyensis* sp. nov. are described from Australia. *Coranus australicus* Reuter, 1881 is synonymized with *Colliocoris griseus* var. *sydnicus* Mayr, 1866, and the latter elevated to species level. Two species, *Austrocoranus mundus* Miller, 1954 and *Eyreocoris distinctus* Miller, 1951 are transferred to the genus *Coranus* Curtis. A key to the Australian species is given. Lectotypes have been designated for *C. trabeatus* Horváth. The genera *Austrocoranus* Miller, 1954 and *Eyreocoris* Miller, 1951 are synonymized with the genus *Coranus*.

KEYWORDS: taxonomy, Heteroptera, Reduviidae, *Coranus*, new species, Australia.

INTRODUCTION

Coranus Curtis is a large genus with more than 40 described species from all zoogeographical regions. Prior to this study the genus was represented in Australia by the following described species : *callosus* Stål, *trabeatus* Horváth, *erythraeus* (Stål), *granosus* Stål, *australicus* Reuter and *griseus* var. *sydnicus* (Mayr).

Two monotypic genera *Austrocoranus* Miller, 1954 and *Eyreocoris* Miller, 1951, after detailed examination have been synonymized with *Coranus*.

Several species of the genus, particularly *callosus, sydnicus, mundus* Miller, *distinctus* Miller and *nigritus* sp.nov., exhibit wing polymorphism, viz. macroptery — submacroptery (M), brachyptery (B) or microptery (MI). The wing modifications may be found even within one geographic population. Normally there is correlation between the modification of the wings and those of some other structures, particularly the scutellum and pronotum. From macroptery to microptery the scutellum and the pronotum, particularly the posterior lobe area, tends to become shorter, the head generally appears narrower and longer in proportion to pronotum, and the ocelli smaller.

All measurements are in millimetres. In all pinned specimens the fourth antennal segment is strongly curved, hence no measurement was taken.

The following abbreviations are used for the names of the museums and other institutions where the specimens are held: AM Australian Museum, Sydney; ANIC Australian National Insect Collection, Canberra; BM British Museum (Natural History), London; MV Museum of Victoria, Melbourne; NSWDA New South Wales Department of Agriculture, Rydalmere; NTM Northern Territory Museum, Darwin; QM Queensland Museum, Brisbane; SAM South Australian Museum, Adelaide; UQ University of Queensland Insect Collection, Brisbane; WAM Western Australian Museum, Perth.

SYSTEMATICS

Genus *Coranus* Curtis

Coranus Curtis, 1833: 453-4 (type-species *Cimex subapterus* De Geer, 1773, designated by Curtis 1833:453).

Eyreocoris Miller, 1951:953-955. Syn.nov.

Austrocoranus Miller, 1954:237. Syn.nov.

The genus may be characterized by the following:

Diagnosis. Body elongate, widened posteriorly, covered with fine pubescence in addition to long bristly hairs. Head dorsally with transverse impression in front of ocelli and almost near hind margin of eyes; labium in repose not exceeding fore coxae, 3 segmented, strongly curved. Pronotum with distinct transverse impression separating lobes, margin in front of scutellum concave; scutellum triangular, distal area bluntly rounded or pointed. Fore femora moderately incrassate, unarmed, surface even or ridged, tarsi 3 segmented. Hemelytra fully covering or exceeding abdomen in macropters, greatly abbreviated in micropters.

Male genitalia: Pygophore with a pair of processes on posterior end; paramere laterally flat, particularly on distal area; aedeagus with sclerotized dorsal phallothecal sclerite, endosoma not differentiated into conjunctiva and vesica, armed with spines of varying sizes arranged in two irregular series, spine number in a series variable even within one specimen.

Notes. Miller described the monotypic genera *Eyreocoris* and *Austrocoranus* in 1951 and 1954 respectively based only on scanty material of micropterous form. He commented that the affinity of the former genus is doubtful and the latter is closely allied to *Coranus*. In the present study I have examined a long series of specimens of both submacropterous-macropterous and micropterous forms and found no major distinguishing characters, including of male genitalia, between these two genera and the *Coranus*. All characters which Miller (1954) noted as distinguishing *Austrocoranus* from *Coranus* are only minor variations between the wing morphs. I therefore synonymize *Eyreocoris* and *Austrocoranus* with *Coranus*.

Included Australian species:

Coranus erythraeus (Stål, 1863)
Coranus sydnicus (Mayr, 1866)
Coranus callosus Stål, 1874
Coranus granosus Stål, 1874
Coranus trabeatus Horváth, 1902
Coranus mundus (Miller, 1954)
Coranus distinctus (Miller, 1951)
Coranus fuscatus sp.nov.
Coranus aridellus sp.nov.
Coranus bicoloratus sp.nov.
Coranus fuscilineatus sp.nov.
Coranus westraliensis sp.nov.
Coranus nigritus sp.nov.
Coranus monteithi sp.nov.
Coranus dalyensis sp.nov.

Key to Australian Species of *Coranus*

1. Larger insects (body > 15 mm) .. 2
— Smaller insects (body < 15 mm) . 3
2(1). Black insects .... *distinctus*
— Yellow insects .... *erythraeus*
3(1). Scutellum with median carina apically broadly rounded, not pointed; paramere of male in apical $1/3$ broadened and spatulate 4
— Scutellum with median carina apically gradually pointed and produced; paramere of male in apical $1/3$ not distinctly broadened and spatulate 6
4(3). Posterior lobe of pronotum, corium and broad median and lateral areas on abdominal sternum reddish .... *trabeatus*
— Not as above 5
5(4). Connexivum uniformly coloured, not banded with dark and pale markings .... *fuscatus*
— Connexivum banded with dark and pale markings .... *callosus*
6(3). Fore femoral basal $1/2$-$2/3$ surface almost even or smooth 7
— Fore femoral basal $1/2$-$2/3$ surface distinctly ridged 12
7(6). Connexivum banded, with dark and pale markings 8
— Connexivum uniformly pale 10
8(7). Pronotum with minute tubercles; (apex of scutellum abruptly projected dorsally or postero-dorsally) .... *granosus*
— Pronotum without tubercles, but only with punctures 9
9(8). Corium uniformly coloured throughout; pronotum with posterior lobe ca 2× as long as anterior lobe .... *aridellus*
— Corium with basal $1/2$-$2/3$ paler than apical area; pronotum with posterior lobe < 2× as long as anterior lobe .... *bicoloratus*
10(7). Femora with dark longitudinal areas; (pygophore processes of male notched at about midlength) .. *fuscilineatus*
— Femora uniformly coloured, without longitudinal dark areas 11
11(10). Fore and mid tibiae with subproximal pale ring .... *westraliensis*
— Fore and mid tibiae without subproximal pale ring .... *nigritus*

12(6). Connexivum almost uniformly pale .... *monteithi*
— Connexivum banded, with alternate pale and dark areas 13
13(12). Abdominal venter with broad yellow median longitudinal band in posterior ⅔ .... *dalyensis*
— Abdominal venter with a median longitudinal fuscous/dark brown line, and yellow spots 14
14(13). Median carina on apical part of scutellum strongly curved upwards, coloured fuscous similar to rest of scutellum .... *mundus*
— Median carina on apical part of scutellum not strongly curved upwards, coloured pale in contrast to fuscous rest of scutellum...*sydnicus*

Coranus callosus Stål
(Figs 1-7)

Coranus callosus Stål, 1874:19.

Type material. HOLOTYPE - ♂ M, "Australia", *callosus* Stål, "Typus", in Naturhistoriska Riksmuseet, Stockholm.

Additional Material. AUSTRALIAN CAPITAL TERRITORY: Canberra 2 ♂ B, in ANIC. NEW SOUTH WALES: Belubula caves 1 ♂ B, in AM; North Albury 1 ♀ B, in NSWDA; Nyngan district 1 ♂ M, in UQ; Wamoon 1 ♀ B, in NSWDA. QUEENSLAND: Bundaberg 1 ♀ M, in QM; Maryborough 1 ♀ M, in SAM; Richmond 1 ♂ M, in ANIC. SOUTH AUSTRALIA: Adelaide 1 ♂, 1 ♀ B, in SAM; Lueindale 1 ♀ B, in SAM; Normanville 2 ♀ B, in SAM; Spilsby Is. 1 ♀ B, in SAM; Stonywell 1 ♀ B, in SAM. VICTORIA: Bamawn 2 ♂, 1 ♀ B, in SAM; Dandenong 1 ♀ M, in MV; Gembrook 1 ♀ SM, in MV; Lakes Entrance 1 ♂ M, in MV; Mordiallae 1 ♂ M, in MV. WESTERN AUSTRALIA: Borden 1 ♀ B, in SAM; Dumbleyung 1 ♂, 2 ♀ M, 1 ♂ B, in WAM; Ongerup 2 ♂, 1 ♀ B in SAM; Toompup 1 ♂ B, in AM, 1 ♂, 1 ♀ B, in SAM; Wickepin 1 ♀ M, in SAM.

Description. General body colour black with greyish short pubescence; median carina of scutellum ivory white; connexivum with posterior ⅔-½ area of at least 5 visible segments with alternate black and yellow bands; abdominal venter with a row of subventral yellow spots on each side of midline and irregular pale spots and areas scattered between these rows.

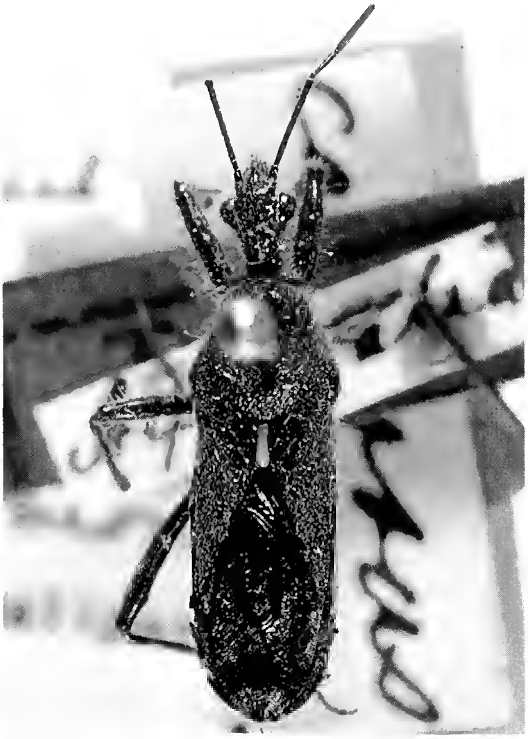


Fig. 1 *Coranus callosus* holotype, dorsal view. Total body length 11.4mm.

Measurements are of macropterous holotype ♂, followed by ranges of other specimens examined in parentheses. Total length 11.4 (9.9-12.3); maximum width 3.06 (3.55-4.24).

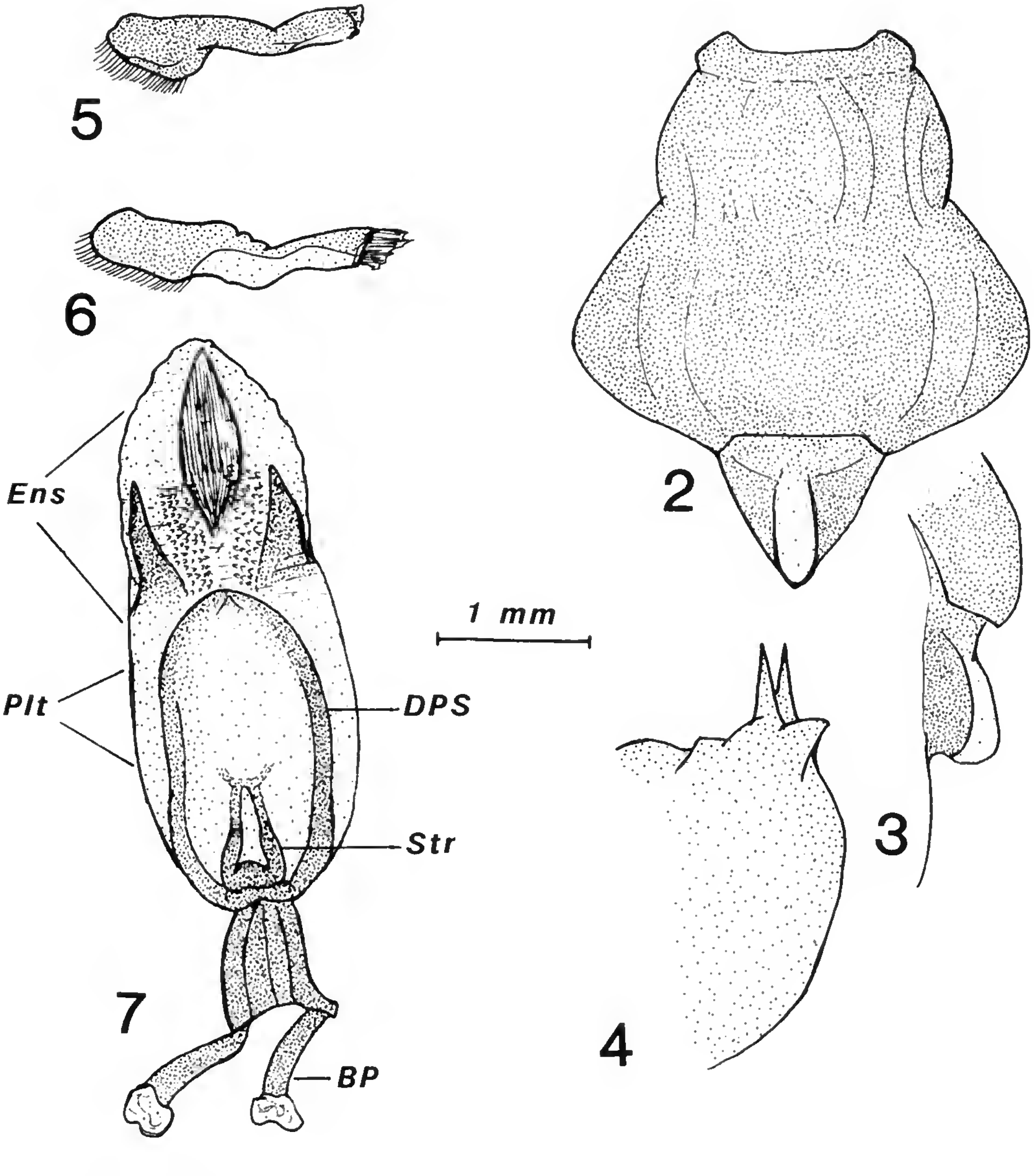
Head: Length 2.61 (2.28-2.60), width across eyes 1.51 (1.52-1.53), interocular space 0.90 (0.80-0.87), interocellar space 0.54 (0.40-0.50), eye-ocellar space 0.30 (0.24-0.31); length of antennal segments: I, 2.00 (1.88-2.04); II, 0.80 (0.70-0.72); III, 1.00 (0.72-0.89).

Thorax: Length pronotum 2.88 (2.30-2.72), maximum width 3.15 (2.48-3.40); scutellum length 0.99 (0.80-1.13), width 1.35 (0.97-1.37); hemelytra almost fully covering abdomen in macropters, extending to anterior margin of 3rd visible tergum in brachypters, length hemelytra 6.63 (8.16) (macropters), 2.90 (micropters); length corium 4.42 (4.56) (macropters), 2.50 (micropters); width membrane 2.21 (2.56) (macropters), 0.92 (micropters).

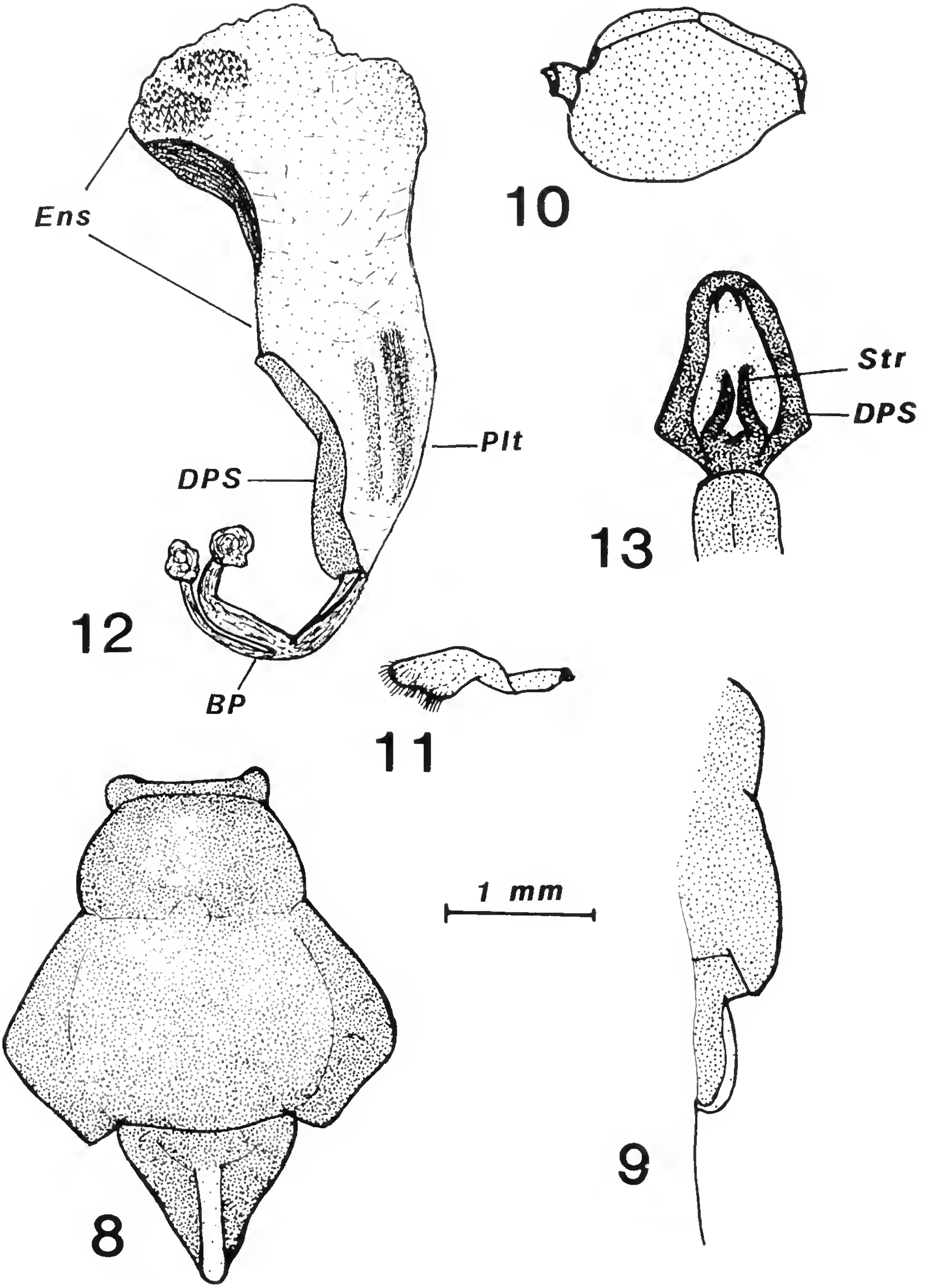
Male genitalia: Pygophore with processes on posterior end as in Fig. 4; paramere in macropters as in Fig. 5, in micropters as in Fig. 6; aedeagus as in Fig. 7.

Distribution. Known from all mainland Australian States and the Australian Capital Territory.

Notes. There is considerable variation in colour intensity and pattern. Some specimens almost completely lack yellow areas on venter (e.g. Maryborough and Bundaberg); some have yellow areas particularly on femora, base of tibiae, oblique line behind eyes, median line near base of head, and sides of anterior lobe of pronotum.



Figs 2-7. *Coranus callosus:* **2**, pronotum and scutellum, dorsal view; **3**, scutellum, lateral view; **4**, pygophore, lateral view; **5**, left paramere in macropter; **6**, same in micropter; **7**, aedeagus, dorsal view. Abbreviations: **BP**, basal plate; **DPS**, dorsal phallothecal sclerite; **Ens**, endosoma; **Plt**, phallotheca; **Str**, strut. Figs 4-7, not to scale.



Figs 8-13. *Coranus trabeatus*: **8**, pronotum and scutellum, dorsal view; **9**, same, lateral view; **10**, pygophore, lateral view; **11**, left paramere; **12**, aedeagus, side view; **13**, dorsal phallothecal sclerite and associated structures, enlarged. Abbreviations as in Fig. 7. Figs 10-13, not to scale.

Coranus trabeatus Horváth
(Figs 8-13)

Coranus trabeatus Horváth, 1902:609.

Type Material. LECTOTYPE - ♀ (designated here) "Tweed R. Lea", (following missing: left mid leg, right mid and hind tarsi, 4th segment of left antenna); in Hungarian Natural History Museum, Budapest. PARALECTOTYPE - ♀, "Tamworth", in Hungarian Natural History Museum, Budapest.

Additional Material. NEW SOUTH WALES: 1 ♀, in QM; Comboyne 1 ♀, in SAM; Coonabarabran 1 ♀, in SAM; Moree 1 ♂, in ANIC; Narrabri 1 ♀, in UQ; Waiwera, Narrabri 2 ♀, in ANIC. NORTHERN TERRITORY: Bessie Spring 8 km ESE Cape Crawford, 16°40'S 135°51'E, 1 ♀, in ANIC; Daly River, 14°06'S 130°18'E, 1 ♂, in ANIC; Leaeh Lagoon, 14°38'S 132°38'E, 1 ♂, in NTM. QUEENSLAND: Areherfield 1 ♀, in UQ; Brisbane 1 ♂, in MV, 2 ♀, in UQ; Bundaberg 3 ♂, 3 ♀, in ANIC; Cleveland 1 ♀, in UQ; Eidsvold 1 ♀, in ANIC; Eubenangee 1 ♂, in UQ; Gatton 1 ♂, in UQ; Gayndah 1 ♀, in UQ; Jondaryan 1 ♂, in UQ; Mareeba 1 ♂, 1 ♀, in UQ; Ormiston 1 ♀, in UQ; Rockhampton 1 ♂, in ANIC; Somerset Dam 1 ♀, in UQ; Toowoomba 1 ♀, in UQ; Townsville 2 ♂, in SAM. SOUTH AUSTRALIA: Tapanappa near C. Jervis 1 ♂, in SAM. TASMANIA: Dodges Ferry 1 ♀, in ANIC; Launceston 2 ♂, 1 ♀, in SAM; Ridgeway 1 ♀, in MV; Swansea 1 ♀, in Tasmanian Museum, Hobart. VICTORIA: Boronia 3 ♂, 4 ♀, in MV; Camperdown 1 ♀, in MV; Lilydale district 2 ♀, in MV; Neerim, Gippsland 1 ♀, in MV; Valencia Creek, Gippsland 1 ♀, in SAM; Warburton district 1 ♀, in MV. WESTERN AUSTRALIA: Busselton-Bunbury Road 1 ♂, in SAM; Deep Dene, Karridale 1 ♀, in ANIC; Furnissdale 1 ♀, in SAM; Herdsmans Lake 1 ♂, in WAM; N of Molecap Hill 2 ♂, in WAM.

Description. Colour as in original description.

Measurements are of lectotype ♀, followed by ranges of other specimens examined in parentheses. Total length 10.7 (9.4-11.1), maximum width 3.57 (2.56-3.55).

Head: Length 1.98 (1.86-2.20), width across eyes 1.53 (1.32-1.53), interocular space 0.90 (0.74-0.84), interocellar space 0.40 (0.39-0.45), eye-ocellar space 0.20 (0.19-0.22); length of antennal segments: I, 1.76 (1.59-1.95); II, 0.56 (0.50-0.63); III, 0.80 (0.88-0.97).

Thorax: Pronotum in dorsal view (Fig. 8), lateral view (Fig. 9), length 2.61 (2.02-2.45); maximum width 3.24 (2.52-2.90); scutellum length 0.99 (0.88-1.20), width 1.35 (1.08-1.40); hemelytra fully covering abdomen, length 6.63 (5.60-6.70), length corium 4.25 (3.47-4.16), width membrane 2.72 (2.30-2.40).

Male genitalia: Pygophore (Fig. 10), paramere (Fig. 11), aedeagus (Fig. 12), with dorsal phallothecal sclerite enlarged as in Fig. 13.

Distribution. Known from all Australian States and the Northern Territory.

Notes. The species may be readily distinguished from *callosus* by its reddish dorsal body and broad lateral areas on abdominal sternum.

Coranus fuscatus sp.nov.
(Figs 14 - 17)

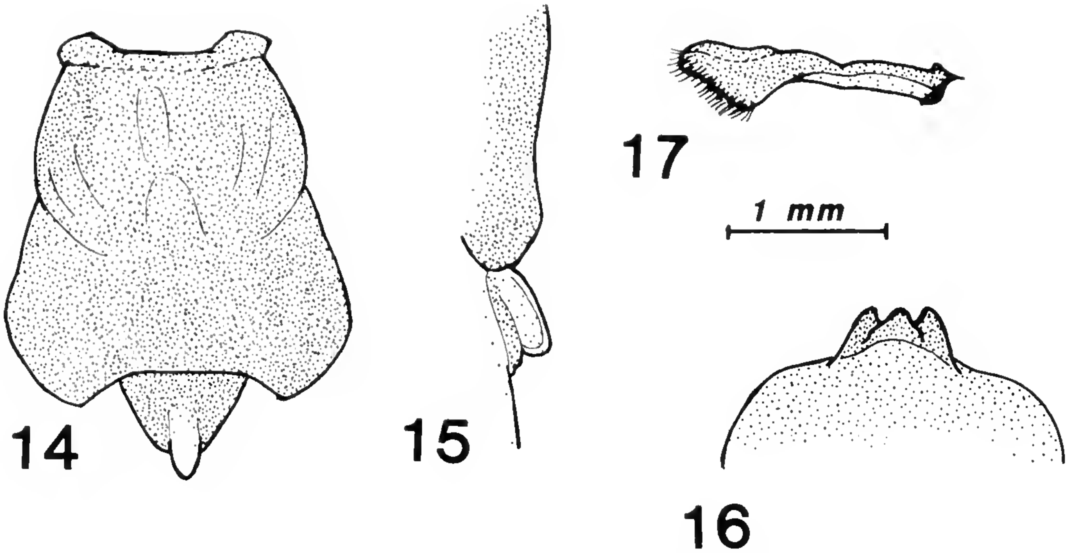
Type material. HOLOTYPE - ♂ B, N.W. Bundaberg, Queensland, on log, 3 June 1973, H. Frauca, in ANIC. PARATYPES - 1 ♂, 4 ♀ B, same data as holotype, in ANIC and NTM.

Additional material. AUSTRALIA: 2 ♂ B, BM 1935-545, in BM. NEW SOUTH WALES: Armidale, on rat carcass 1 ♀ B, in ANIC; Barrington house Salisbury 1 ♂ M, in UQ; Kincumber, SW Terrigal 1 ♀ M, in ANIC; Liverpool, 33°57'S 150°56'E, on *Alternanthera philoxeroides* 1 ♂ M, in UQ. QUEENSLAND: Aratula 1 ♀ B, in UQ; Brookfield 1 ♂ B, in UQ; Fletcher 1 ♂ B, in QM; Lamington N.P. 1 ♂ B, in UQ; Levers Plateau 1 ♀ B, in UQ; Roma 1 ♀ M, in SAM; Tamborine 1 ♀ B, in UQ.

Description. Generally uniformly black; median carina of scutellum particularly in apical ½ ivory white-yellow; oblique lines behind eyes, median line on neck area, base of tibiae yellowish; connexivum uniformly pale throughout; abdominal venter with indistinct pale spots.

Body narrow, elongate.

Measurements are of holotype ♂, followed by ranges when different, in parentheses. Total length 10.9 (11.3-12.4); maximum width 2.90 (3.00-4.00).



Figs 14-17. *Coranus fuscatus*: **14**, pronotum and scutellum in brachypters, dorsal view; **15**, same, lateral view; **16**, apical part of pygophore; **17**, left paramere. Figs 16,17, not to scale.

Head: Length 2.28 (2.40-2.56), width across eyes 1.45 (1.45-1.53), interocular space 0.80 (0.80-0.81), interocellar space 0.40 (0.48), eye-ocellar space 0.24; length of antennal segments: I, 2.04 (1.99-2.31); II, 0.72; III, 1.07 (0.96-0.97).

Thorax: Pronotum in dorsal and lateral view as in Figs 14 and 15, length 2.12 (2.40-2.50), maximum width 2.20 (2.40-2.50); scutellum length 0.64 (0.80-0.90), width 0.72 (0.72-0.85); hemelytra extending to posterior margin of last abdominal tergum in submacropters-macropters, narrowed, exposing lateral parts of body and extending to middle of 3rd visible abdominal tergum in brachypters, brachyptery more common than macroptery and submacroptery, length hemelytra 6.20 (macropters), 2.48 (2.50) (brachypters), length corium 1.96 (1.65) (macropters), 2.28 (2.28) (brachypters).

Male genitalia: Posterior area of pygophore as in Fig. 16; paramere (Fig. 17).

Other details as in *callosus* and *trabeatus*.

Distribution. Known from New South Wales and southern Queensland.

Notes. In some specimens the pale spots on abdominal venter are almost absent. The species is related to *callosus* and *trabeatus*, but differs from both in having a narrow and uniformly black body.

Coranus erythraeus (Stål)
(Fig. 18)

Colliocoris erythraeus Stål, 1863:41.
Coranus erythraeus Stål, 1874:20.

Type Material. HOLOTYPE - ♀, "New Holl. 44 4", "*erythraea* Stål," both antennae except left 1st segment, right tibia and tarsi missing, in BM.

Description. Body generally dirty yellow, distal 2 segments of labium and apical ½ of membrane fuscous.

Body and appendages excluding hemelytra with short erect pilose hairs. Total length 15.8; maximum width 5.10.

Head: Length 3.42, width across eyes 2.25, interocular space 1.17, interocellar space 0.52, eye-ocellar space 0.16; length antennal segments; I, 3.15; remaining segments missing.

Thorax: Pronotum as in Fig. 18, lobes subequal, length 4.14, maximum width 4.32; scutellum length 1.08, width 1.89; hemelytra extending to last visible segment, length 9.01, length corium 5.44, width membrane 3.06; femoral surface without ridges in basal ⅔.

Distribution. Known from Australia (no precise locality).

Notes. The species is allied to *distinctus*, but differs from the latter by its dirty yellow colour.

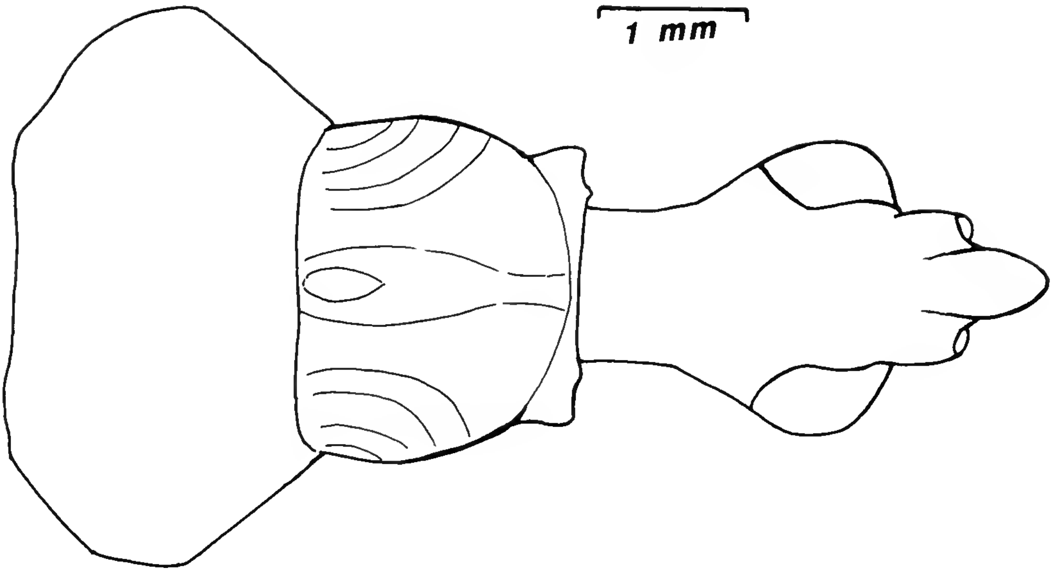


Fig. 18. *Coranus erythraeus*, head and pronotum, dorsal view.

Coranus distinctus (Miller), comb.nov.

(Figs 19 - 21)

Eyreocoris distinctus Miller, 1951:953-955.

Type material. HOLOTYPE - ♀ MI, Killalpanima, 160 km E of Lake Eyre, H.J. Hillier (BM 1905-232), in BM.

Additional material. SOUTH AUSTRALIA: Adelaide 1 ♀ MI, in SAM; Belgowan near Maitland, 34°20'S 137°30'E, 1 ♀ MI, in ANIC; Blackburn 1 ♂ M, in SAM; Callabonna 1 ♀ MI, in MV; Cooper's Creek 2 ♀ MI, in SAM; Coward Springs 1 ♀ MI, in SAM; Lake Eyre North Madigan Gulf, sulphur peninsula 1 ♂ M, in SAM; Lake Gairdner 1 ♀, in SAM; Innamincka 1 ♀ MI, in SAM; Koonalda Cave area, above ground 1 ♀ MI, in SAM; Mt Lofty 1 ♀ M, in SAM; Reed Beds 1 ♀ MI, in SAM; Wallaroo N beach sandhills 1 ♂ MI, in SAM; Whyalla 2 ♀ MI, in SAM. WESTERN AUSTRALIA: Lake Varley 1 ♂ M, in WAM; Southern Cross 1 ♀ M, in AM.

Description. Following are additions and/or alterations to the original description. Colour variable considerably: femora uniformly black and not ferruginous in all specimens; middorsal stripe on abdomen almost lacking in some.

Macropterous or micropterous.

Measurements are of micropterous holotype ♀, with those of a macropterous ♂ in parentheses. Total length 18.5 (17.9); maximum width 7.40 (6.20).

Head: Length 4.05 (3.72), width across eyes 2.61 (2.40), interocular space 1.44 (1.37), interocellar space 0.90 (0.72), eye-ocellar space 0.45 (0.32); length antennal segments: I, all segments missing in holotype (3.80); II, (1.29); III, (1.88).

Thorax: Pronotum with posterior lobe slightly longer than anterior lobe, length 4.50 (4.16), maximum width 4.86 (4.88); scutellum length 0.54 (1.68), width 0.81 (2.74); length hemelytra 1.19 (11.20), length corium (7.16), width membrane (4.08).

Male genitalia: Pygophore posterior margin with processes as in Fig. 19; paramere spatulate as in Fig. 20; aedeagus as in Fig. 21.

Distribution. Known from South Australia and Western Australia.

Notes. In one macropterous specimen (Lake Gairdner) the connexivum is uniformly pale, but not banded.

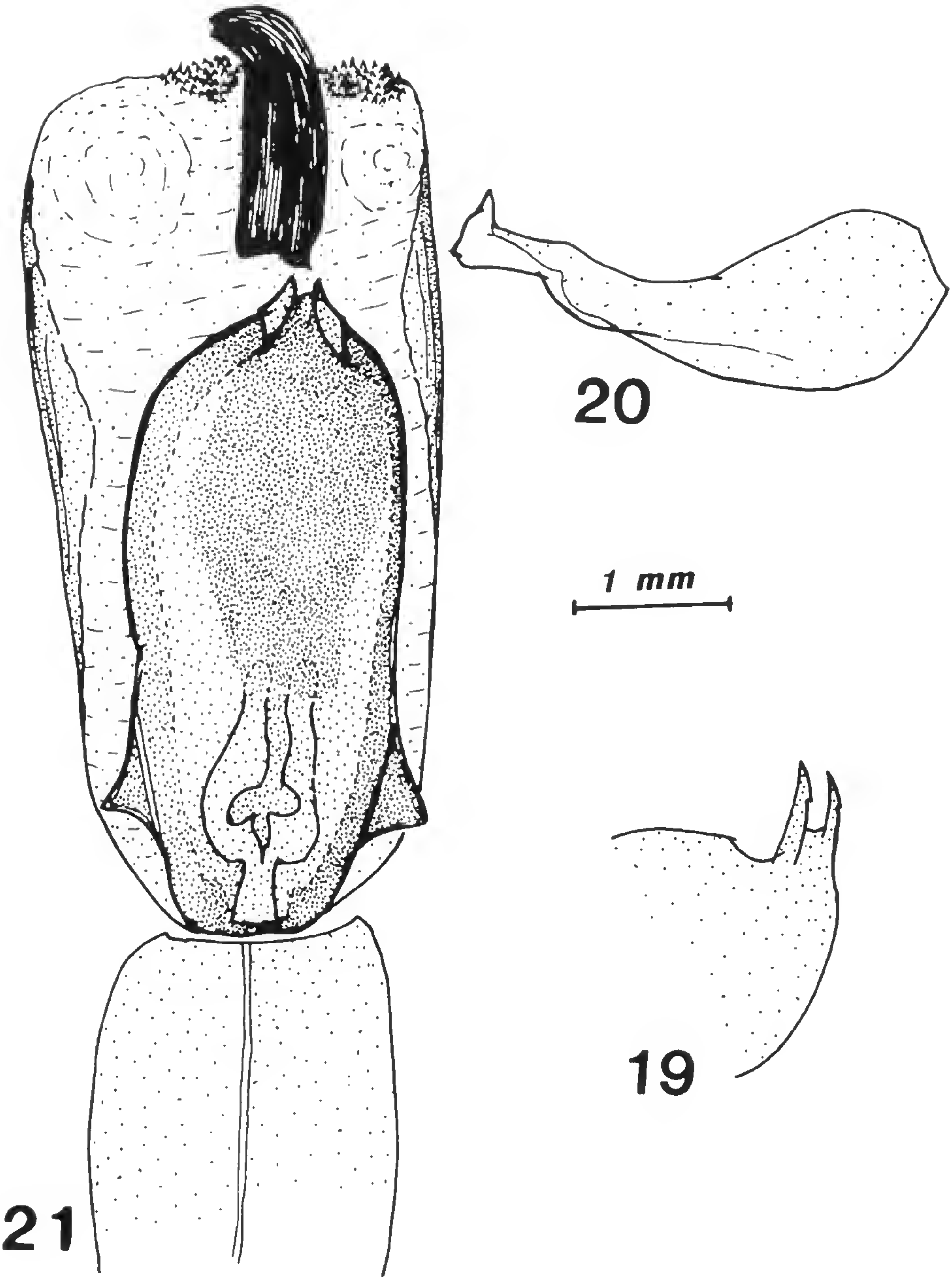
The species is allied to *erythraeus*, but differs from the latter in its black colour.

Coranus granosus (Stål)

(Figs 22-27)

Coranus granosus Stål, 1874:20.

Type material. HOLOTYPE - ♀, "Adelaide", "Typus", in Naturhistoriska Riksmuseet, Stockholm.



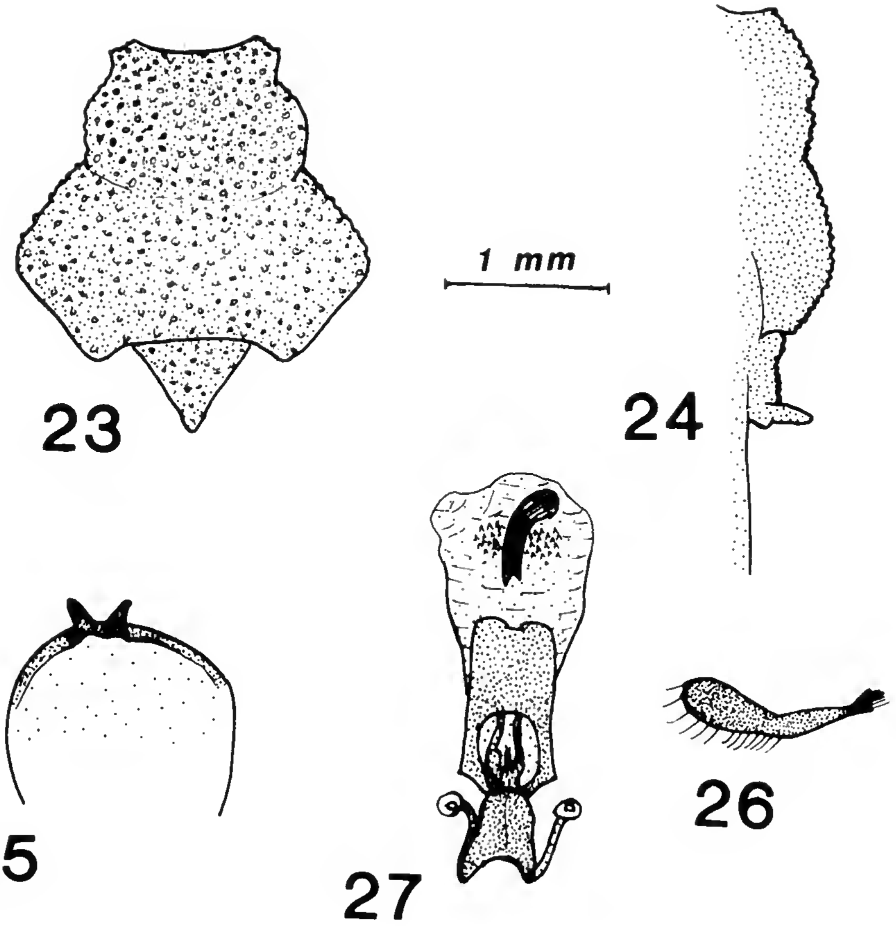
Figs 19-21. *Coranus distinctus*: **19**, apical part of pygophore; **20**, right paramere; **21**, aedeagus, dorsal view.

Additional material. NEW SOUTH WALES: Barrington Tops 1 ♀, in AM; Bogan R. 2 ♀, in AM; Bourke 1 ♂, in AM; Broken Hill 3 ♂, 1 ♀, in SAM, 1 ♂ in QM; Cabbage Tree Creek, Clyde Mt 1 ♀, in ANIC; Caldwell 1 ♀, in MV; Mt Kosciusko 1 ♀, in SAM; Nyngan 1 ♂, 1 ♀, in UQ; Terrigal 1 ♀, in ANIC; Tibooburra 1 ♀, in ANIC. NORTHERN TERRITORY: 38 km NE by N Andado Homestead, 25°07'S

135°30′E 2 ♀, in ANIC; Coniston Station near Alice Springs 1 ♀, in SAM; Darwin 1 ♂, in NTM; Finke R. 1 ♂, in SAM; Iwupataka, 23°48′S 133°30′E 1 ♂, in NTM; W of Mt Olga 1 ♀, in WAM; Southern Cross bore 40 km NW The Garden Homestead 1 ♀, in ANIC; 30 km N of Wauchope, 20°22′S 134°14′E 1 ♂, in ANIC. QUEENSLAND: Coen R. 1 ♂, in SAM; Diamantina R. 1 ♂, 2 ♀, in SAM; Glenmorgan 1 ♂, in UQ; Muttaburra 1 ♀, in UQ; Noccundra 1 ♀, in ANIC; Richmond 2 ♂, in UQ. SOUTH AUSTRALIA: Adelaide 2 ♂, 4 ♀, in SAM; Arkaba 1 ♀, in SAM; Pt Augusta 1 ♂, in SAM; Mt Barker 1 ♀, in SAM; Bosc, Mt Alec 1 ♀, in SAM; Burra, 128 km NNE Adelaide 1 ♂, in SAM; L. Callabonna 3 ♀, in SAM; Callana 2 ♀, in SAM; Cannewaukaninna dune, 16 km W of Ekadunna Homestead 2 ♀, in SAM; Coorong 1 ♀, in SAM; 32 km W Corowie Stn 1 ♂, in AM; Mt Eba Station 1 ♀, in SAM; 18 km south of Edwards Creek 28°30′S 135°52′E 1 ♀, in ANIC; Everard Rgs to Warburton Rgs (W.A.) 1 ♂, in SAM; Lake Eyre, Madigan Gulf, N. Sulphur Peninsula 2 ♂, 7♀ in SAM; Lake Eyre, Madigan Gulf, Sulphur Pen., Campbell's causeway 1 ♂, 2 ♀, in SAM; C. Jervis 1 ♂, in SAM; Kangaroo I. 1 ♀, in SAM; Ketchowla Stn. East of Hallett 1 ♀, in SAM; Lewiston Reserve, Two wells 1 ♀, in SAM; Mt Lofty 2 ♀, in SAM; Moolooloo, 660m, Flinders Ra 1 ♂, in SAM; 8km N Morgan near Murray River 1 ♀, in SAM; Murray River 1 ♀, in SAM; Nimbrin 1 ♂, 1 ♀, in SAM; Oodnadatta to Blood Creek 1 ♂, in SAM; Ooldea 2 ♂, 3 ♀, in SAM; Orrorro 1 ♀, in SAM; Owieandana N Flinders Ra 1 ♀, in SAM; Pearson I. 1 ♂, in SAM; Peterborough 2 ♂, 2 ♀, in SAM; Prospect 1 ♀, in SAM; 5 km from Roppermanna bore no. 2 (Etadunna) 1 ♀, in WAM; Spring Gully National Park near Clare 1 ♀, in SAM; Stoneleigh Pk 1 ♂, in SAM; Tirari Desert, L. Kittakittoloo S. Shore end of 1 ♂, in WAM; Wardang I. 1 ♀, in SAM; Whyalla 1 ♂, 2 ♀, in SAM; Wilpena Ck, under *Eucalyptus camaldulensis* bark 2 ♀, in SAM; Woods Flat 1 ♂, in SAM; 40 km S or Yunta 1 ♀, in SAM. VICTORIA: Bendigo 1 ♀, Lake Hattah 3 ♂, 6 ♀, Inglewood 1 ♀, Kerang 2 ♂, Millgrove 1 ♀, Redcliff 1 ♀; all in MV. WESTERN AUSTRALIA: Balladonia Camp 5 ♂, 7 ♀, in SAM; Broomehill 4 ♂, 3 ♀, in WAM; Bulle 1 ♀, in ANIC; Buntine 1 ♂, in SAM; Caiguna 1 ♂, in SAM; Cheritons Find 1 ♂, in WAM; Eneabba 29°49′S 115°16′E 1 ♂, in WAM; 3 km NE of Fraser Range Homestead 1 ♂, in ANIC; Fremantle 1 ♀, in ANIC; 5.6 km NW of Glen Eagle Picnic Area (63 km SE Perth) 1 ♂, in WAM; Greenough River mouth 1 ♀, in WAM; 7 km E Merredin 1 ♀, in WAM; Minnivale 1 ♀, in WAM; Moorine Rock 1 ♂, in WAM; Mullewa 5 ♀, in SAM; Nedlands 1 ♀, in ANIC; Nomans Lake 1 ♀, in ANIC; 70-75 km ENE of Norseman 1 ♂, in WAM; Penguin I. 1 ♀, in WAM; Swan R. 1 ♀, in SAM; Twilight Cave, Eucla Basin 1 ♂, 1 ♀, in ANIC; E Wallabyl 1 ♀, in WAM; 37 km SW Youanmi 28°45′S 118°31′E 1 ♂, in WAM.


Fig. 22. *Coranus granosus* holotype, dorsal view. Total body length 8.9mm.

Description. Generally fuscous. Following light yellowish brown: antennae, median line between ocelli and behind eyes, lateral areas of anterior lobe of pronotum, apical upcurved area of scutellum, connexivum with posterior ½ of each segment, sparse irregular spots latero-ventrally on abdomen,



Figs 23-27. *Coranus granosus*: **23**, pronotum and scutellum, dorsal view; **24**, same, lateral view; **25**, apical part of pygophore; **26**, left paramere; **27**, aedeagus. Figs 25-27, not to scale.

irregular spots on femora, rings near base of tibiae. Membrane greyish with fuscous veins.

Body elongate ovate; body dorsally and appendages covered with minute granules in addition to grey silky hairs, bristles borne on granules.

Measurements are of holotype ♀, followed by ranges of other specimens examined in parentheses. Total length 8.9 (8.6 - 9.1); maximum width 2.91 (2.32-2.90).

Head: Length 1.78 (1.60-1.74), width across eyes 1.17 (1.13-1.18), interocular space 0.73 (0.64-0.67), interocellar space 0.33 (0.31-0.38), eye-ocellar space 0.15 (0.15-0.18); base of 1st and 2nd antennal segments subdivided, length of segments: I, 1.69 (1.53-1.86); II, 0.45 (0.48); III, 0.88 (0.80-1.13).

Thorax: Pronotum (Fig. 23) length 1.86 (1.80-1.82), maximum width 2.18 (2.04-2.19); scutellum median keel with blunt tip and curved upwards abruptly (Fig. 24), length 0.70 (0.54-0.68), width 0.82 (0.62-0.72); femoral surface slightly ridged; hemelytra slightly exceeding abdomen, lateral abdominal areas exposed, more in ♀ than in ♂, length hemelytra 5.60 (5.40-5.60), length corium 3.47 (3.23-3.45), width membrane 1.80 (1.68-1.76).

Male genitalia: Pygophore posterior margin as in Fig. 25; paramere (Fig. 26); aedeagus (Fig. 27), endosoma with a large sclerotized plate and two groups of minute spines or denticles.

Distribution. Known from all over Australia except Tasmania.

Notes. There is considerable variation in colouration: in some specimens most of abdominal venter almost uniformly yellowish brown except for median fuscous line; in some most of tibiae also yellowish brown. This and the following species (*sydnicus*) agree with each other in having the femoral surface ridged, the connexivum with alternate dark and pale areas, and the general structure of the male genitalia. However *granosus* differs from *sydnicus* in having distinct granules on head and pronotum, a distinct fuscous reticulation to membrane, and the tip of scutellum abruptly curved upwards.

Coranus sydnicus (Mayr), stat.nov.

(Figs 28 - 32)

Colliocoris griseus var. *sydnicus* Mayr, 1866:141.
Coranus griseus var. *sydnicus* Stål, 1874:19.
Coranus australicus Reuter, 1882:6. Syn.nov.

Type Material. Type of *Colliocoris griseus* var. *sydnicus* can not be found and is possibly lost. *Coranus australicus* Reuter, 1882, HOLOTYPE - ♂ M, "Austral boreal", "Thorey", "*australicus* Reuter Type", in Naturhistoriska Riksmuseet, Stockholm.

Additional material. NEW SOUTH WALES: Bogan R. 1 ♀ M, in AM; Bondi 1 ♂ M, in AM; Coogee 1 ♂ M, in AM; Nyngan district 1 ♂ M, in UQ; Sydney 2 ♂, 1 ♀ M, in AM; Warrah 1 ♂ M, in ANIC. NORTHERN TERRITORY: Brock's Creek 1 ♀ M, in ANIC; Finke R. 1 ♂ M, in SAM. QUEENSLAND: Almaden 1 ♀ B, in AM; Bin Bin Range via Didcot 1 ♂ M, in ANIC; Birdsville 1 ♀ M, in SAM; Brisbane 1 ♀ M, in QM; Cairns 1 ♂ M, in AM; Clermont 1 ♂, 1 ♀ M, in AM; Cunnamulla district 1 ♀ M, in AM; Dunwich N Stradbroke I. 1 ♀ B, in UQ; Eidsvold 1 ♂ M, in ANIC; Ferny Grove 1 ♀ M, in UQ; Fletcher 1 ♀ M, in QM; Lansdown Station 1 ♂ M, in ANIC; Moggill 1 ♀ M, in UQ; Stanthorpe 1 ♂ M, in QM; Toowoomba 1 ♂ M, in UQ. SOUTH AUSTRALIA: Cannewaukaninna dune 1 ♀ M, in SAM; Ferries - McDonald N.P. 2 ♂ M, in SAM; Flinders I. 1 ♀ M, in SAM; Parachilna, Flinders Range 1 ♀ M, in SAM; Vivonne Bay, Kangaroo I. 1 ♀ M, in SAM. VICTORIA: Gunbower 1 ♀ B, in MV. WESTERN AUSTRALIA: Halletts Cove 1 ♂ B, in SAM; Mullewa 1 ♂, 3 ♀ M, in SAM.

Description. Generally fuscous with dense short greyish pubescence in addition to grey hair; antennae testaceous, base of corium margin, longitudinal lines above and below head and between and behind ocelli, median carina on scutellum, connexivum with posterior ½ of each segment pale or testaceous; abdomen above black, below fuscous black, pale spots all over; femora with extreme apices dirty testaceous, with fascia and longitudinal lines fuscous, tibia and tarsi dirty testaceous, tibia with fuscous base, a subbasal pale ring, remainder dirty testaceous; last tarsal segment fuscous; membrane uniformly fuscous.

Body elongate ovate. Measurements are of macropterous holotype ♂ of *Coranus australicus* Reuter, followed by ranges of other macropterous specimens examined in parentheses. Total length 8.7 (9.6-11.0); maximum width 2.21 (2.56-3.43).

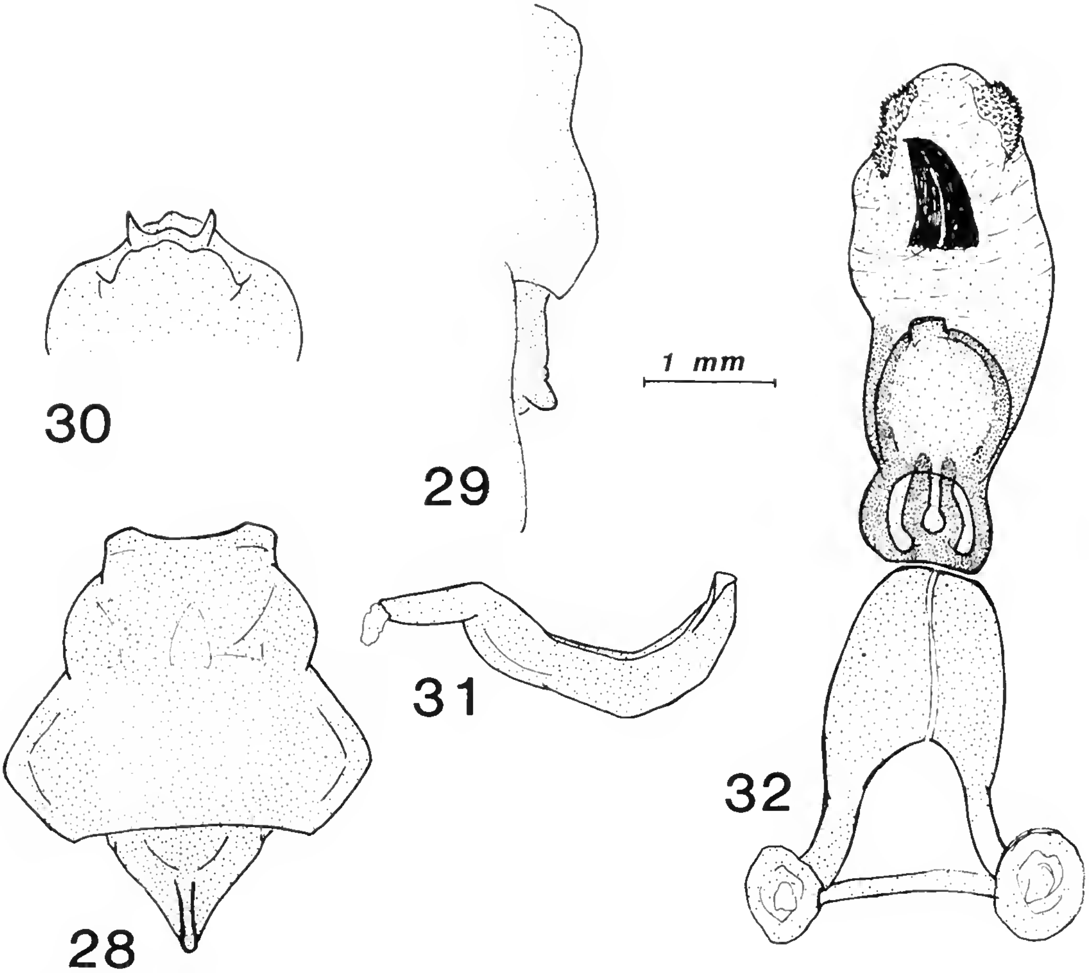
Head: Length 2.15 (2.04-2.30), width across eyes 1.44 (1.29-1.42), interocular space 0.72 (0.72-0.80), interocellar space 0.45 (0.32-0.41), eye - ocellar space 0.22 (0.16-0.25); length of antennal segments: I, 1.89 (1.76-1.88); II, 0.67 (0.65-0.70); III, 1.17 (0.97-1.29).

Thorax: Pronotal constriction laterally deep (Fig. 28), length 2.16 (2.28-2.36), maximum width 2.25 (2.40-2.64); scutellum with median carina gradually curved upwards (Fig. 29), length 0.54 (0.55-0.71), width 0.90 (0.85-0.95); femoral surface ridged; hemelytra fully covering abdomen in macropters, up to last 1½ visible segments exposed in submacropters, last 2½ segments (in ♂) and 2½-3½ segments (in ♀) exposed in brachypters, length hemelytra 4.76 (5.60-5.65), length corium 3.06 (3.40-3.70), width membrane 1.80 (1.90-2.40).

Male genitalia: Pygophore posterior part as in Fig. 30; paramere (Fig. 31); aedeagus (Fig. 32).

Distribution. Known from all Australian states and Northern Territory except Tasmania.

Notes. *Reduvius griseus* Rossi, 1790, a South African species, was transferred to the genus *Colliocoris* and the Australian specimens treated as its variety, *sydnicus*, since they differed in general colouration (Mayr 1866). Stål (1874) synonymized *Colliocoris griseus sydnicus* and the South African *Harpactor capicola* Stål, 1859 with another South



Figs 28-32. *Coranus sydnicus*: **28**, pronotum and scutellum, dorsal view; **29**, same, lateral view; **30**, apical part of pygophore; **31**, right paramere; **32**, aedeagus. Figs 30-32, not to scale.

African species, *Colliocoris papillosus* Thunberg, 1822, and transferred it to the genus *Coranus*. The types of *sydnicus* and *papillosus* cannot be located and are possibly lost. However the types of *C. capicola* and *C. australicus* Reuter, 1881 are held at the Naturhistoriska Riksmuseet, Stockholm. On examination, the latter species is found to differ from the former in the following : the head longer, the pronotal furrow deeper, the dorsal longitudinal ridges connecting anterior and posterior lobes more distinct, and the apex of scutellum more raised. The type of *australicus* agrees well with the description, though scanty, of *sydnicus* in most major characters, and hence is synonymized in the present study with the latter which is elevated to species level to distinguish it as a species restricted to Australia only. *C. sydnicus* differs from *C. griseus (sensu stricto)* in having labium pitchy black, abdomen above black, its middle with large elliptical red spot, inside of connexivum black, abdomen below pitchy black, margins with yellow and black spots.

There is considerable variation in colouration even within one series, particularly of pronotum, legs and abdomen, but the basic pattern is similar to that described above.

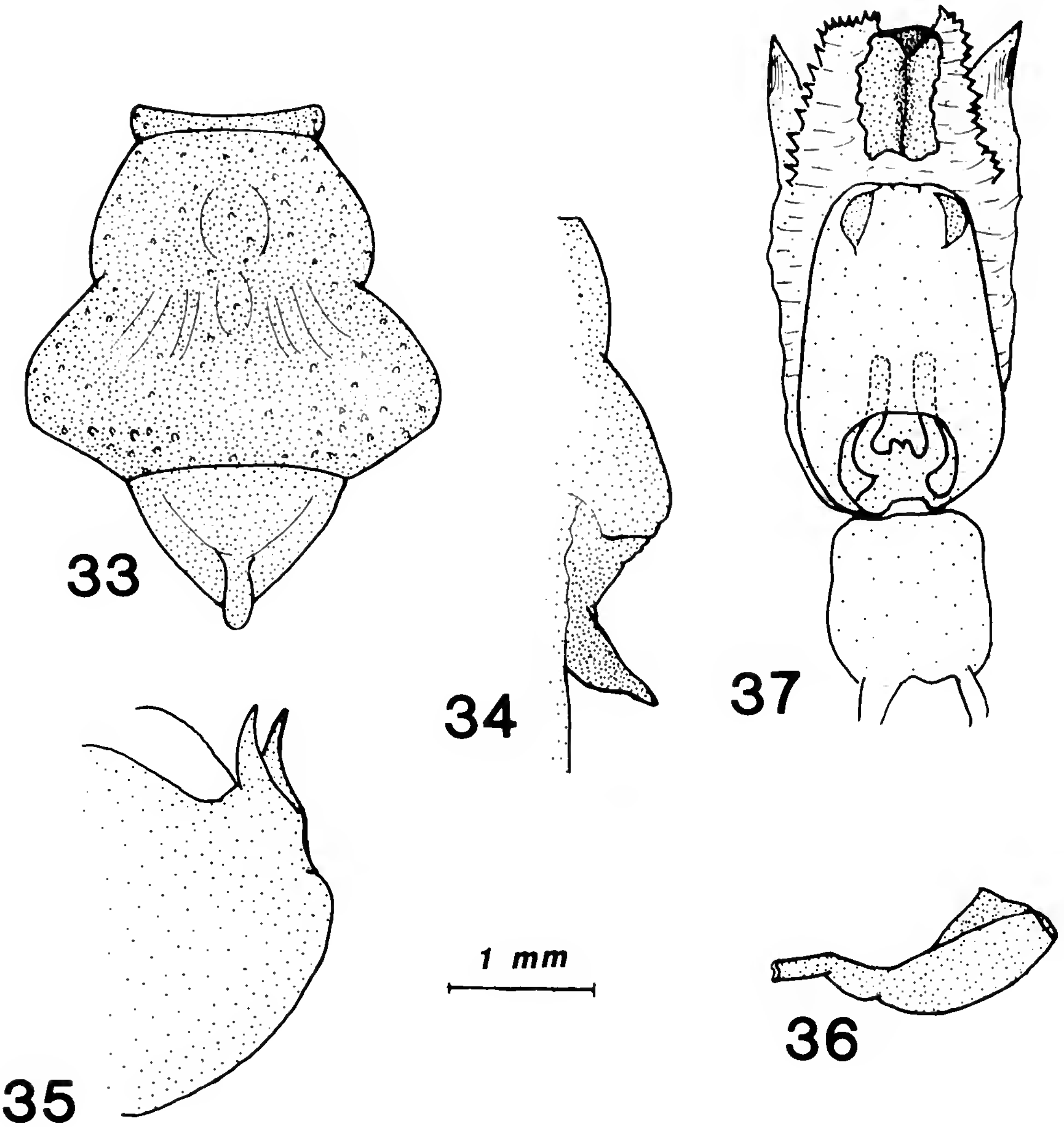
Coranus mundus (Miller), comb.nov.

(Figs 33-37)

Austrocoranus mundus Miller, 1954:237-238.

Type material. HOLOTYPE - ♂ MI, Armadale, Western Australia, 12 May 1934, K.R. Norris, in ANIC. PARATYPE - 1 ♂ MI, same data as holotype, in BM.

Additional material. AUSTRALIAN CAPITAL TERRITORY: Canberra 2 ♂ MI, in ANIC; Mt Tidbinbilla 1 ♂ MI, in ANIC. NEW SOUTH WALES: Helensburgh 1 ♂ MI, NSWDA; Nyngan district 1 ♂ MI, in UQ. QUEENSLAND: Mt Tamborine 1 ♀ MI, in MV. SOUTH AUSTRALIA: Coonalpyn 1 ♀ MI, in SAM; 10 km SW Culburra 1 ♂ MI, in SAM; Eyre Peninsula near the Frenchman 1 ♀ MI, in SAM; Mt Lofty 1 ♂ MI, in SAM; Murray River 1 ♀ MI, in MV, 1 ♂ MI, in SAM; Pondalowie Bay, Yorke Peninsula 1 ♀ MI, in SAM; Stenhouse Bay 1 ♂ MI, in ANIC; Warbla Cave Area Nullarbor Plains 1 ♀ MI, in SAM; Weebubbie 1 ♀ MI, in SAM. TASMANIA: Conara near Campbelltown 1 ♂ MI, in UQ. VICTORIA: Hattah Lakes N.P. 2 ♀ MI, in UQ; Melbourne 1 ♀ MI, in MV; Murrayville 1 ♀ M, in MV. WESTERN AUSTRALIA: Abrucurrie 1 ♂ MI, in UQ; Applecorss 1 ♀ MI, in WAM; Balladonia Camp 1 ♀ MI, in SAM; 40 km E by N Balladonia Homestead 1 ♂ MI, in ANIC; Beverley 1 ♀ MI, in SAM; 60 km E of Esperance 1 ♂ , 1 ♀ MI, in ANIC;



Figs 33-37. *Coranus mundus*: **33**, pronotum and scutellum, dorsal view; **34**, same, lateral view; **35**, apical part of pygophore; **36**, left paramere; **37**, aedeagus. Figs 35-37, not to scale.

Fitzgerald River N.P. 1 ♂ M, in WAM; Frenchman Bay 1 ♀ MI, in ANIC; Geraldton 1 ♀ MI, in ANIC; 27 m W by N Gingin 1 ♂ MI, in ANIC; 10 km E Greenhead, 30°04′S 114°58′E 2 ♀ MI, in WAM; 60 km E of Madura 1 ♀ MI, in WAM;Madurah 1 ♂ MI, in SAM; Mundaring Weir 2 ♀ MI, in WAM; Naturaliste 1♂, 1 ♀ MI, in ANIC; South Stirlings 1 ♀ M, in WAM; Thomas R. 23 km NW by W of Mt Arid Cape Arid 1 ♀ MI, in ANIC; Mt Yokine 1 ♀ MI, in MV.

Description. Generally black; ringlike subbasal area of tibia, irregular areas on ponotum yellow; connexivum with subapical area of segments 2-6 dark yellow; membrane uniformly fuscous; antennae brown; abdomen ventrally light brown with a median longitudinal narrow dark brown stripe.

Measurements are of micropterous holotype ♂, with range of macropterous specimens in parentheses. Total length 12.5 (10.2-11.0), maximum width 4.40 (2.98-3.96).

Head: Dorsum with few sparse granules, length 3.06 (2.45-2.53), width across eyes 1.96 (1.47-1.51), interocular space 1.08 (0.78-0.80), interocellar space 0.45 (0.42-0.46), eye-ocellar space 0.36 (0.27-0.30); all antennal segments of uniform thickness, length of segments: I, antennae missing in holotype (2.41); II, (0.78-0.85); III, (1.20-1.28).

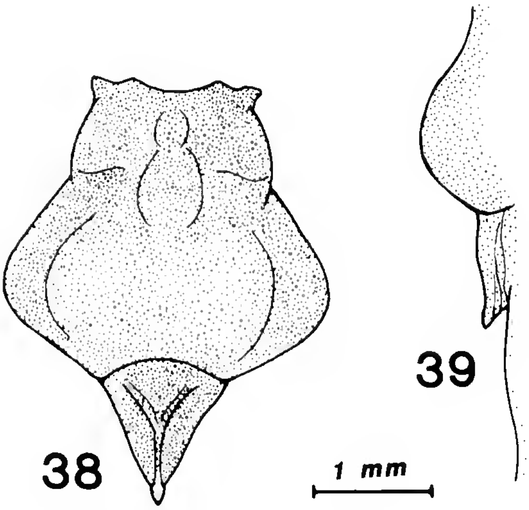
Thorax: Pronotum length (Fig. 33) 2.52 (1.33-2.34), maximum width 2.52 (2.53-2.61); scutellum strongly curved dorso - posteriorly in apical ½ (Fig. 34), length 0.58 (0.58-0.65), width 0.97 (1.16-1.40); hemelytra almost fully covering abdomen in macropters, length hemelytra (5.48), length corium (3.55), width membrane (2.04-2.14), hemelytra reduced to about as long as scutellum in micropters.

Male genitalia: Pygophore posterior margin as in Fig. 35; paramere (Fig. 36); aedeagus as in Fig. 37.

Distribution. Known from southern Australia including Tasmania.

Notes. In some specimens the abdominal venter is uniformly fuscous. The granules on the posterior lobe of pronotum are not so distinct in several specimens.

The species is allied to *australicus* but differs from the latter in possession of sparse hirsute granules on the posterior lobe of pronotum, the more pronounced curvature on the distal part of scutellum, and the slightly broader distal ½ of paramere.



Figs 38-39. *Coranus dalyensis:* **38**, pronotum and scutellum, dorsal view; **39**, same, lateral view.

Coranus dalyensis sp.nov.
(Figs 38-39)

Type material. HOLOTYPE - ♂, 76 km SW of Daly River, 14°11′S 130°08′E, Northern Territory, 2 September 1968, M. Mendum, distal 3 segments of right and 4th segment of left antennae, right mid tarsus missing, in ANIC.

Description. Generally fuscous; abdomen fuscous except for irregular small median areas of last 3 or 4 sternites and connexivum with posterior ½ of each abdominal segment and tip of scutellum yellow or pale.

Total length 9.8; maximum width 2.74.

Head: Length 2.06, width across eyes 1.16, interocular space 0.62, interocellar space 0.42, eye - ocellar space 0.12, length of antennal segments: I, 1.90; II, 0.58; III, 0.79.

Thorax: Pronotum dorsally as in Fig. 38, laterally as in Fig. 39, length 2.25, maximum width 2.58; scutellum only slightly curved dorso - posteriorly (Fig. 39) in apical area, length 1.16, width 1.04; legs slender, fore femora not much thicker than other femora; hemelytra fully covering abdomen, length 5.60, length corium 3.47, width membrane 1.76.

Male genitalia: Generally as in *westraliensis* (Figs 45-49).

Distribution. Known only from Daly River area (N.T.).

Notes. The species is allied to *mundus* but differs from the latter in lacking granules on pronotum, apex of scutellum only slightly curved, and lacking pale or yellow spots on the lateral area of pronotum.

Coranus monteithi sp.nov.

(Figs 40-44)

Type material. HOLOTYPE - ♂, Lockerbie Area, Cape York, Queensland 23-27 April 1973, G.B. Monteith, in QM (Reg. No. T.10244). PARATYPE - ♂, same data as holotype except 14-18 April 1973, in QM (Reg. No. T.10245).

Additional material. AUSTRALIA: W.W. Froggatt Collection 1 ♂, in ANIC.

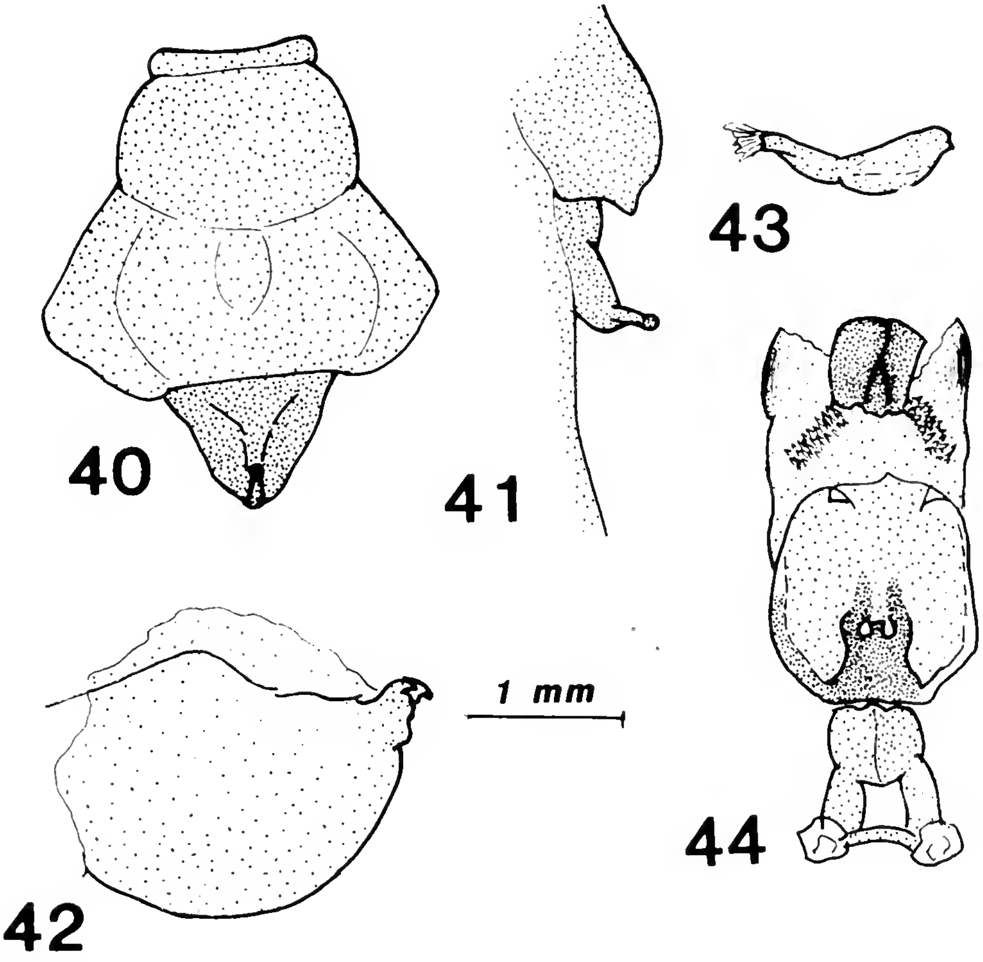
Description. Generally black; following yellow; apex of scutellum, connexivum, pygophore, paramere and disc of venter of 2-3 segments preceeding pygophore; basal lateral area of hemelytra pale.

Body with brush of bristle-like hairs in addition to shiny greyish pubescence.

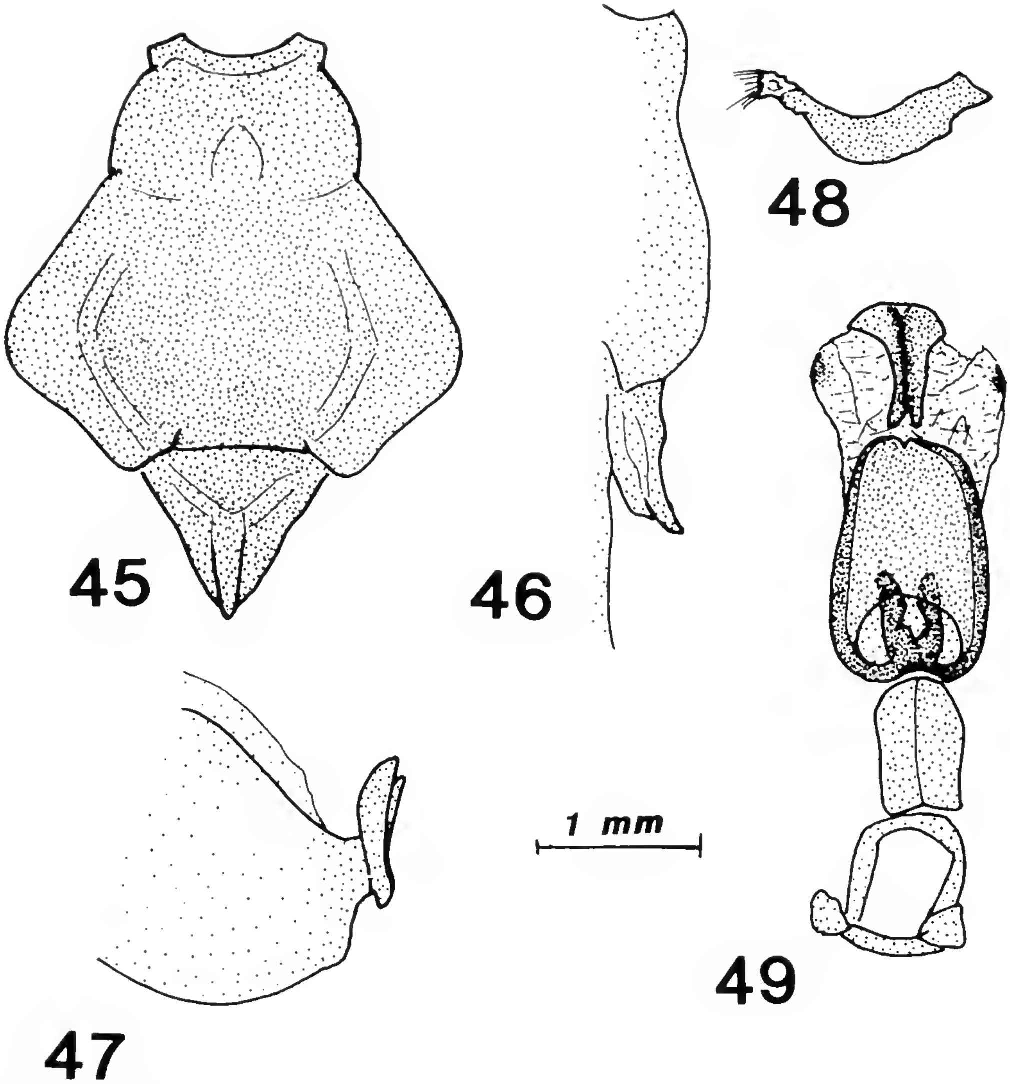
Body elongate-ovate; appendages particularly antennae slender. Total length 9.5; maximum width 2.40.

Head: Length 2.02, width across eyes 1.32, interocular space 0.67, interocellar space 0.34, eye - ocellar space 0.20, antennal segment 3 thicker than other segments, length of segments: I, 2.21; II, 0.58; III, 1.55.

Thorax: Pronotum with posterior lobe area coarsely punctate, length 1.98, maximum width 2.12; scutellum median



Figs 40-44. *Coranus monteithi:* **40**, pronotum and scutellum, dorsal view; **41**, same, lateral view; **42**, pygophore; **43**, left paramere; **44**, aedeagus. Figs 42-44, not to scale.



Figs 45-49. *Coranus westraliensis:* **45**, pronotum and scutellum, dorsal view; **46**, same, lateral view; **47**, apical part of pygophore; **48**, left paramere; **49**, aedeagus. Figs 47-49, not to scale.

carina strongly curved dorsally, apically rounded, length 0.66, width 0.96; hemelytra well exceeding abdomen, length 5.60, length corium 3.30, width membrane 1.96.

Male genitalia: Pygophore as in Fig. 42; paramere (Fig. 43); aedeagus (Fig. 44).

Distribution. Known only from northern Queensland.

Coranus westraliensis sp.nov.

(Figs 45-49)

Type material. HOLOTYPE - ♂, 7 km South Karratha, N.W. Coastal Hwy, Western Australia, 17 February 1973, E.M. Exley, distal 2 segments of left and 4th segment of right antennae missing, in QM (Reg. No. T.10246). PARATYPES - 1 ♂, same data as holotype, in UQ; 1 ♂, Coppin Pool area 30 km South of Mt Bruce, N.W. Divide, Western Australia, 10-13 May 1980, T.F. Houston *et al.*, in WAM.

Description. Dorsally fuscous; abdomen generally orange - brown, with irregular broad sublateral bands and a median line fuscous.

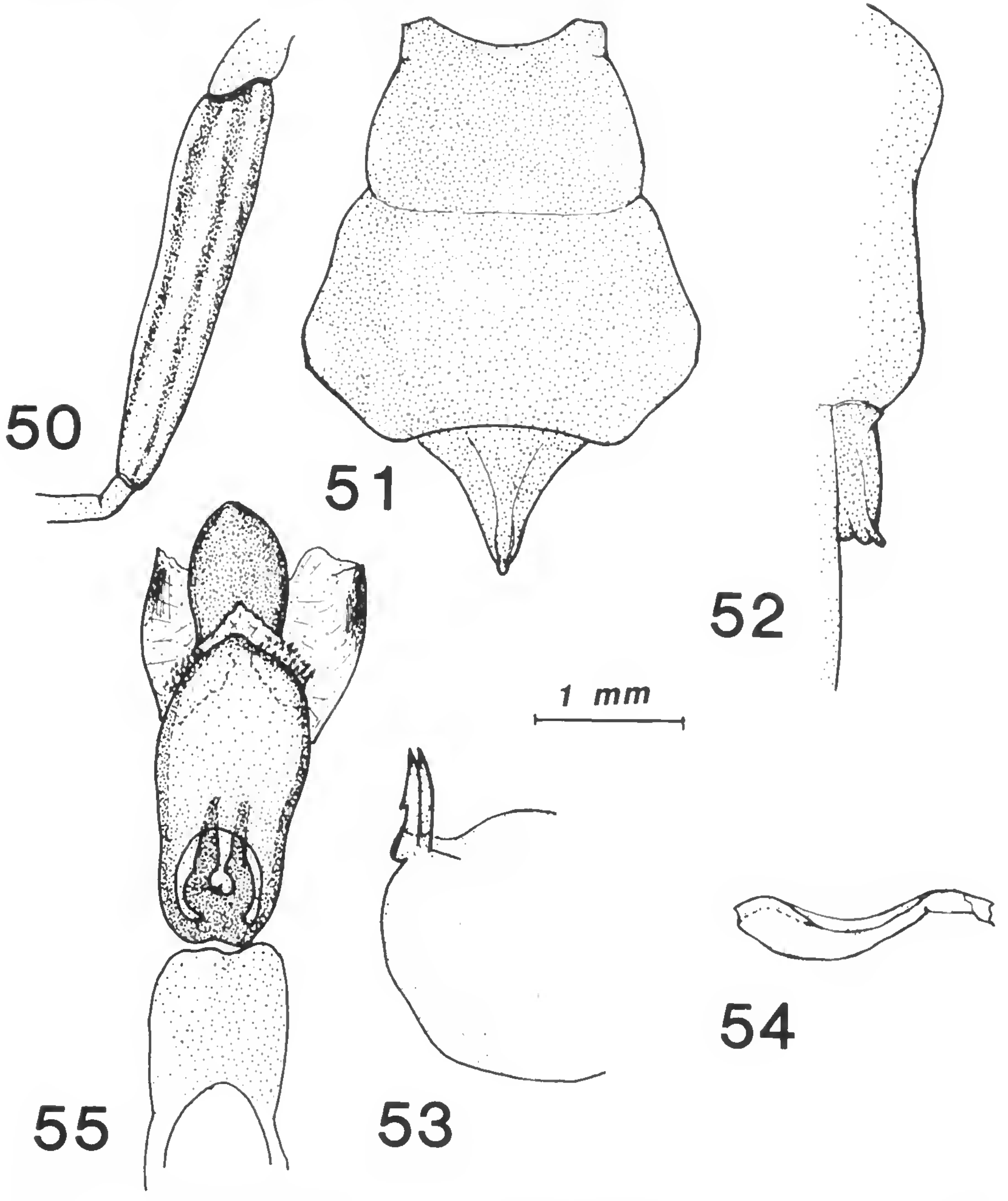
Measurements are of holotype ♂, followed by those of a paratype ♂ in parentheses. Total length 10.5 (10.2); maximum width 3.06 (3.00).

Head: Length 2.17 (2.10), width across eyes 1.26 (1.20), interocular space 0.60 (0.59), interocellar space 0.35 (0.34), eye - ocellar space 0.19 (0.21); antennal segments I - III subdivided near base, length of segments: I, 1.75 (1.65); II, 0.42; III, 1.00 (0.93).

Thorax: Pronotum (Fig. 45) coarsely punctate particularly on posterior lobe, length 2.33 (2.45), maximum width 2.82 (2.90); scutellum with apex slightly curved postero-dorsal (Fig. 46), length 0.97 (0.96), width 1.13 (1.10); hemelytra fully covering abdomen, length 5.90 (5.60), length corium 3.72 (3.60), width membrane 2.04 (2.00).

Male genitalia: Pygophore with projection on posterior margin as in Fig. 47; paramere (Fig. 48); aedeagus (Fig. 49), conjunctiva without distinct spinule area.

Distribution. Known only from Western Australia.



Figs 50-55. *Coranus fuscilineatus:* **50**, fore femur showing colour pattern; **51**, pronotum and scutellum, dorsal view; **52**, same, lateral view; **53**, apical part of pygophore; **54**, left paramere; **55**, aedeagus. Figs 53-55, not to scale.

Coranus nigritus sp.nov.

Type material. HOLOTYPE - ♀, Whyalla, South Australia, 30 August 1947, D.S., antennae, mid right leg, tarsi of fore and hind legs missing, in MV.

Description. Differs from *westraliensis* in the following:

Generally black; connexivum, two broad submedian bands on abdominal venter and irregular spots in between bands pale.

Total length 10.9; maximum width 3.23.

Head: Length head 2.32, width across eyes 1.53, interocular space 0.72, interocellar space 0.48, eye - ocellar space 0.24.

Thorax: Pronotum with posterior lobe less than 2× as long as anterior lobe, length 2.56, maximum width 2.56; scutellum more abruptly curved postero-dorsal, length 0.72, width 0.89; femora more thickened in proportion to other segments of legs; length of hemelytra 6.44, length corium 3.96, width membrane 2.25.

Distribution. Known only from South Australia.

Coranus fuscilineatus sp.nov.
(Figs 50-55)

Type material. HOLOTYPE - ♂, 60 km SE of Normanton, Queensland, 13 October 1965, A. Mesa and R. Sandulski, 4th segment of both antennae missing, in ANIC.

Description. Generally dirty yellow; dorsum of head excluding median yellow line behind eyes, longitudinal areas on anterior lobe of pronotum, apex of labium, eyes, longitudinal lines on femora as in Fig. 50, fuscous; 3 median and submedian ventral bands on abdomen light fuscous.

Body and appendages with short greyish shiny pubescence in addition to long bristly hairs.

Body elongate ovate. Total length 11.1; maximum width 2.82.

Head: Length 2.41, width across eyes 1.24, interocular space 0.70, interocellar space 0.42, eye-ocellar space 0.31; length of antennal segments: I, 2.56; II, 0.66; III, 1.08.

Thorax: Pronotum with posterior lobe about 1½ times as long as anterior lobe (Fig. 51), length 2.53, maximum width 2.41; scutellum postero-dorsally curved as in Fig. 52, length 0.80, width 0.89; hemelytra fully covering abdomen, length 6.12, length corium 3.63, width membrane 1.60.

Male genitalia: Pygophore paired apical processes notched at about half length (Fig. 53); paramere (Fig. 54); aedeagus (Fig. 55).

Distribution. Known only from north Queensland.

Notes. The species may be distinguished from *westraliensis* by its general coloration, and its pair of notched processes on the pygophore.

Coranus aridellus sp.nov.
(Figs 56-61)

Type material. HOLOTYPE - ♂, 5 km SE of Ooraminna Rockhole, Northern Territory, 9 April 1981, M.B. Malipatil and J. Hawkins, in NTM. PARATYPES - 1 ♂, same data as holotype, in NTM; 1 ♀, 5 km South of Aileron, Northern Territory, 5 April 1981, M.B. Malipatil and J. Hawkins, in NTM; 1 ♂, Nyngan district, New South Wales, 1-9 February 1960, T.E. Woodward, in UQ.

Additional material. NEW SOUTH WALES: Fowlers Gap Research Station, 31°05′S 141°42′E, 1 ♀, in ANIC. WESTERN AUSTRALIA: Nullarbor 1 ♀, in ANIC.

Description. Generally fuscous; most of scutellum particularly Y - shaped carina, broad areas on pronotal posterior lobe, median line on head behind ocelli, area surrounding ocelli, areas on legs particularly femora and tibia, lateral areas of abdominal venter yellow; connexivum with anterior ⅓ of each segment blackish; disc of abdominal venter fuscous with yellow spots.

Elongate ovate insects. Measurements are of holotype ♂ with paratype ♀, when different, in parentheses. Total length 9.5 (8.9); maximum width 2.74 (2.73).

Head: Length 1.95 (1.78), width across eyes 1.14 (1.13), interocular space 0.50 (0.61), interocellar space 0.35 (0.35), eye - ocellar space 0.18 (0.20). Length antennal segments: I, 1.40 (1.43); II, 0.46; III, 0.60 (0.59).

Thorax: Pronotum length 1.95, maximum width 2.40 (2.56); scutellum broad, apex abruptly pointed or narrowed (Fig. 57), length 1.04 (1.12), width 1.21 (1.15); hemelytra fully covering abdomen, length 5.12 (5.20), length corium 3.31 (2.98), width membrane 1.88 (1.90).

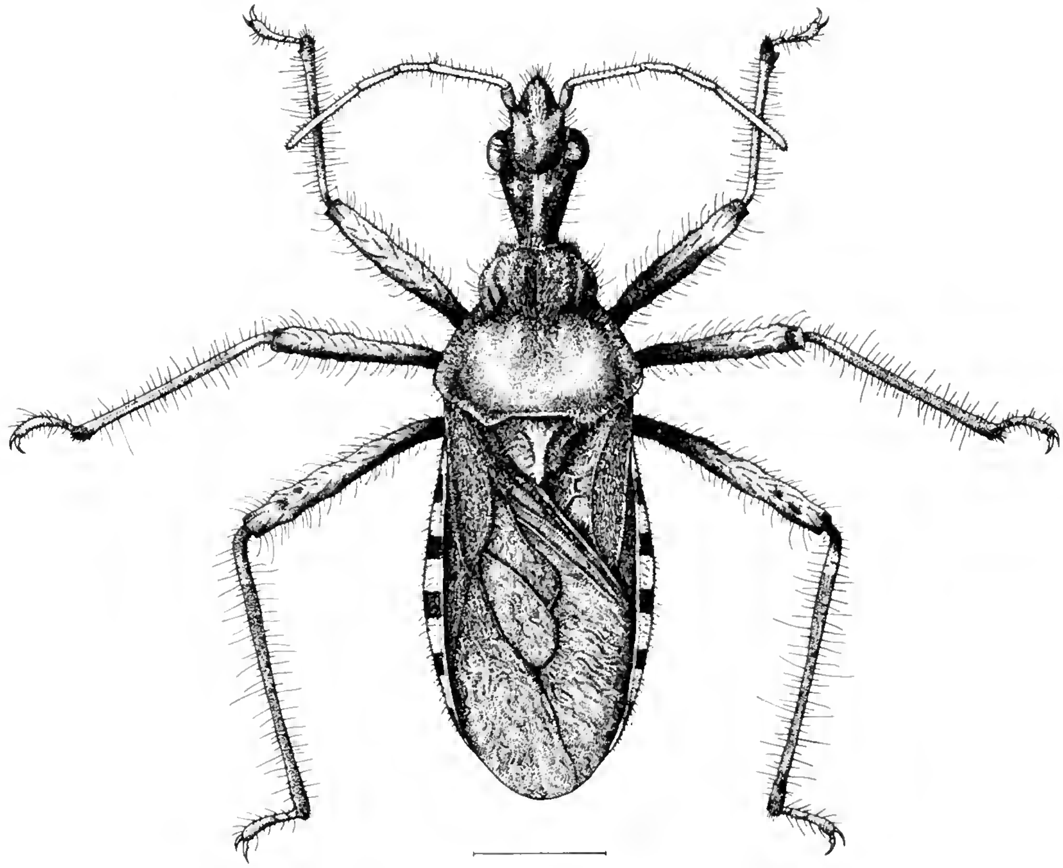


Fig. 56. *Coranus aridellus* holotype , dorsal view. Scale line 1.75mm.

Male genitalia: Pygophore with apical end produced as in Fig. 59; paramere (Fig. 60), aedeagus (Fig. 61).

Distribution. Known from arid inland areas of New South Wales, Western Australia and the Northern Territory.

Notes. There is considerable variation in coloration even within the topotypic series; in the Ooraminna Rockhole paratype most of the abdominal venter disc is pale; in the Nyngan district paratype almost the entire abdominal venter is uniformly pale; in all females most of the abdominal venter is uniformly black; in the Aileron paratype most of pronotal posterior lobe is pale.

Coranus bicoloratus sp.nov.

(Figs 62-63)

Type material. HOLOTYPE - ♀ , Lake Eyre, North Madigan Gulf, South Australia, dead on salt surface, 1 November 1966, G.F. Gross, in SAM.

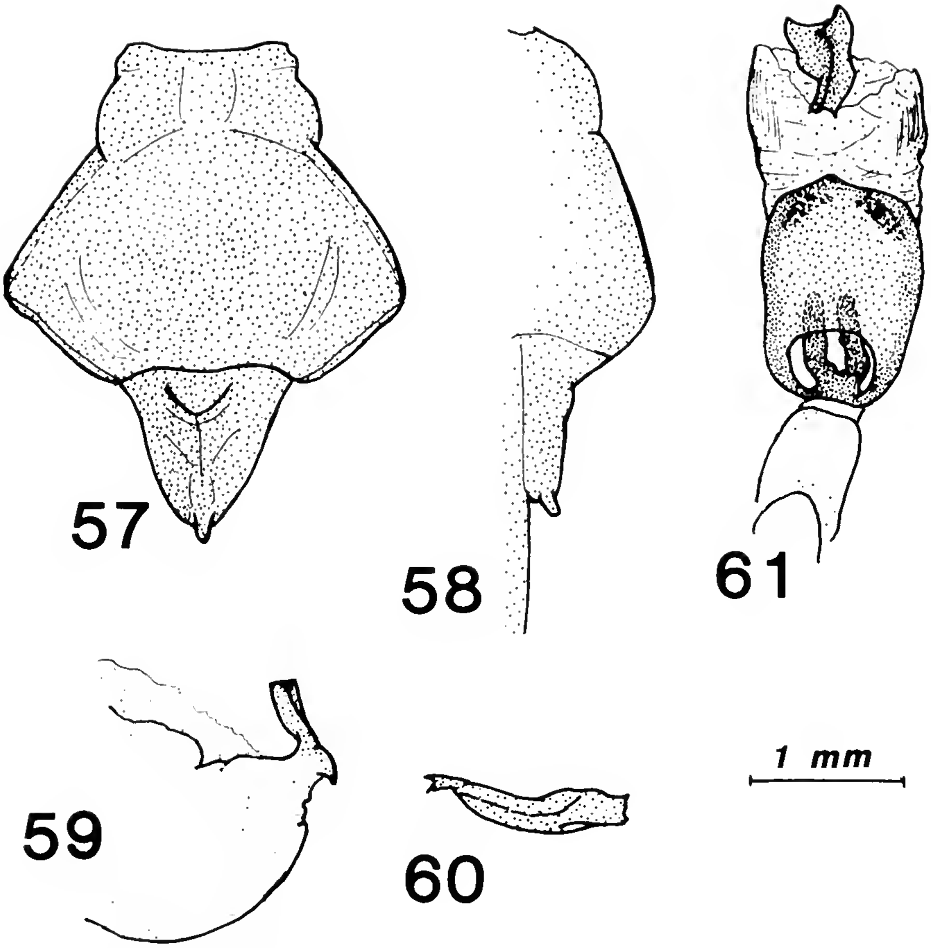
Description. Generally black; most of corium, apical ½ projected area of scutellum, connexivum with distal ½ of each segment yellow; apical ⅓ of corium fuscous; abdomen appearing banded from above owing to alternate fuscous and yellow areas.

Total length 8.5; maximum width 2.64.

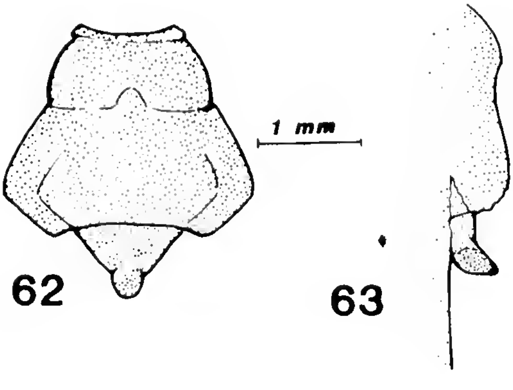
Head: Length 1.75, width across eyes 1.05, interocular space 0.51, interocellar space 0.42, eye - ocellar space 0.11; length of antennal segments: I, 1.78; II, 0.46; III, missing in type.

Thorax: Pronotum with posterior lobe slightly less than 2× as long as anterior lobe, length 1.86, maximum width 2.20; scutellum gradually curved dorso-posteriorly, apex narrowly rounded, length 0.60, width 0.96; hemelytra fully covering abdomen, length 2.74, length corium 1.68, width membrane 1.76.

Distribution. Known only from South Australia.



Figs 57-61. *Coranus aridellus:* **57**, pronotum and scutellum, dorsal view; **58**, same, lateral view; **59**, apical part of pygophore; **60**, left paramere; **61**, aedeagus. Figs 59-61, not to scale.



Figs 62-63. *Coranus bicoloratus:* **62**, pronotum and scutellum, dorsal view; **63**, same, lateral view.

ACKNOWLEDGEMENTS

I thank the curators of the above mentioned museums and institutions for the loan of specimens. Types held at the British Museum (Natural History), London and Naturhistoriska Riksmuseet, Stockholm were examined while I held a Churchill Fellowship. I am grateful to Dr G. Monteith (Queensland Museum) for going through the manuscript, and Mr D. Percival for preparing Fig. 56.

REFERENCES

Curtis, J. 1833 British entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland. Volume 10. Author: London.

Horváth, G. 1902 Descriptions of New Hemiptera from New South Wales. *Termeszetrajzi Fuzetek* **25**:601-612.

Mayr, G. 1866 Hemiptera. In: *Reise der Ostereichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859. Zoologischer Teil 2. Abt. 1.* Karl Gerold's Sohn: Wien.

Miller, N.C.E. 1951 XC. - New Reduviidae in the Collection of the British Museum (Natural History) - VI. *Annals and Magazine of Natural History* (12)**4**:945-955.

Miller, N.C.E. 1954 A new subfamily and new genera and species of Australian Hemiptera - Heteroptera. *Proceedings of the Linnean Society of New South Wales* **78**:233-240.

Reuter, O.M. 1881 Ad cognitionem Reduviidarum mundi antiqui. *Acta Societas Sciantiarum Fennicae* **12**:271-339.

Stål, C. 1863. Formae Speciesque novae Reduviidarum. *Annales de la Societe Entomologique de France* **(4)**3:25-58.

Stål, C. 1874 Enumcratio Reduviidarum Europae, Africae, Asiae et Australieae. *Kongl Svenska Vetenskaps - Akademiens Handlingar* **12**(1):3-186.

Accepted 10 June 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 51-57

A NEW SPECIES OF CLUPEID FISH (PISCES: PRISTIGASTERIDAE) FROM NORTHERN AUSTRALIA AND PAPUA

PATRICIA J. KAILOLA
Department of Zoology, University of Adelaide,
Adelaide, SA 5000, Australia

ABSTRACT

Ilisha lunula sp.nov., a clupeid species from northern Australia and Papua is described. The new species is distinguished from other species of *Ilisha* by its long caudal fin lobes. Comparison is made with four other congeners possessing paired post-coelomic swimbladder extensions.

KEYWORDS: taxonomy, Pristigasteridae, *Ilisha*, northern Australia, Papua.

INTRODUCTION

Ilisha Richardson and *Pellona* Valenciennes are superficially similar genera within the clupeid family Pristigasteridae (Whitehead 1986). They share such characters as a prominent lower jaw and a long-based anal fin, but can be separated from each other on the presence (*Pellona*) or absence (*Ilisha*) of a toothed hypomaxilla. More satisfactory identification of Indo-Pacific *Ilisha* has prompted several recent reviews and synopses (Whitehead 1973; Seshagiri Rao 1972, 1973, 1976; Ramaiyan and Whitehead 1975; Ramaiyan and Natarajan 1979; Wongratana 1980). When Wongratana (1983) described two new species from the Arabian Sea and India, the complement of valid Indo-West Pacific *Ilisha* rose to 11 (including the valid *I. sirishai* Seshagiri Rao, 1975). All of these species occur in an area bounded by the Persian Gulf, India, China and Japan, Borneo and Java. In addition, two species occur in the New World, and one off the coast of West Africa.

Specimens referable to *Ilisha* first came to my notice in 1982. They had been trawled off northern and northwestern Australia during an exploratory fishing programme conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Initially, the specimens appeared distinct from known species of *Ilisha* by their colouration and long tail. Additional material from Papua and Eastern Australia was later found in museum collections. Examination of a series of specimens, and comparison with material of related species, revealed other substantial differences which confirmed the northern Australian species as new.

A number of characters distinguish species of the genus *Ilisha*. Seshagiri Rao (1972) recognised two different frontal bone striation (ridge) patterns in *Ilisha*. This character has subsequently been rather widely used for species identification, although Ramaiyan and Natarajan (1979) claimed discrepancies in the striae pattern described for *I. melastoma* (Schneider), and T. Wongratana (pers. comm.) found it inadequate to separate species of *Ilisha*. Relative chin depth, a character introduced by Seshagiri Rao (1973) to distinguish *I. megaloptera* (Swainson) from *I. melastoma*, was however, left unexplained and unquantified. The pattern of scale striation is a taxonomically valuable character (Seshagiri Rao 1973), but the form of the pseudobranch (Seshagiri Rao 1974a) and arrangement of the gillraker setae (Seshagiri Rao 1974b) are less so. An axillary pelvic scale is either absent (see Seshagiri Rao 1973; Ramaiyan and Natarajan 1979) or present (as in *I. pristigastroides* (Bleeker), *I. kampeni* (Weber and de Beaufort), *I. striatula* Wongratana, *I. obfuscata* Wongratana). All of the species I examined have an edentulous space at the symphysis of the lower jaw, which is narrow in *I. kampeni, I. striatula* and *I. melastoma,* but comparatively wide in the new species.

Ramaiyan and Natarajan (1979) assessed the taxonomic value of some of these characters, adding colour, otolith shape and vertebral number. Wongratana (1983) considered the number and length of the pyloric caecae a good character, and again emphasised the importance of colouration.

Detailed study of the Australo-Papuan specimens and comparison with related forms, has revealed differences in the number of dorsal rays, predorsal scales and gill rakers, pattern of the scale striations, the number and length of the pyloric caecae and the length of the posterior extensions to the swimbladder.

On the basis of these differences, a new species of *Ilisha* is proposed. In this paper, I describe the new species and compare it with the four most closely-related species of *Ilisha: I. melastoma, I. kampeni, I. striatula* and *I. obfuscata*.

The format and terminology used in the description follow Whitehead *et al.* (1966), Seshagiri Rao (1972), Seshagiri Rao (1974a) and Ramaiyan and Natarajan (1979). Chin (or lower jaw) depth is an oblique measurement from upper to lower surface at the level of the symphysis. Where different from the holotype, the measurements for the paratypes are indicated in parentheses following the holotype data. These trawl-caught specimens are not in perfect condition; most fins are tattered to some extent and scales have been dislodged; the pectoral and pelvic fins could not be measured in some specimens.

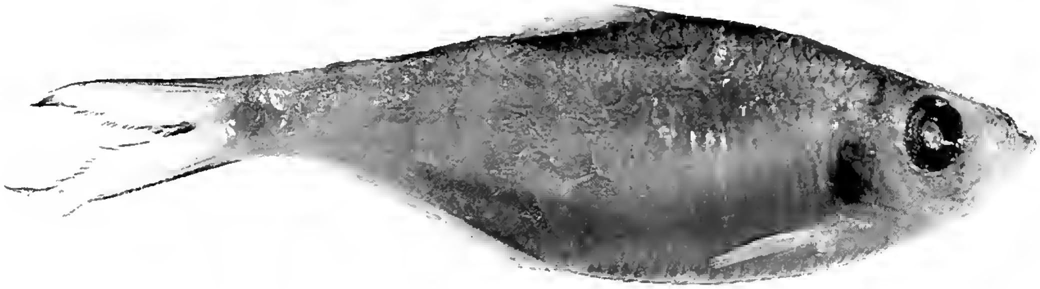


Fig. 1. *Ilisha lunula* holotype, lateral view, 142.5 mm SL.

Material is deposited in the Australian Museum, Sydney (AMS); British Museum (Natural History), London (BMNH); California Academy of Sciences, San Francisco (CAS); Ian S.R. Munro Ichthyological Collection, CSIRO, Hobart (CSIRO); Northern Territory Museum, Darwin (NTM); and the Fisheries Research Division Laboratory at Kanudi, Port Moresby, Papua New Guinea (KFRS).

SYSTEMATICS

Ilisha lunula sp.nov.

(Figs 1-3, Table 1)

Ilisha sp. Gloerfelt-Tarp and Kailola, 1984: 48, 49, 302; Sainsbury, Kailola and Leyland 1985: 64, 65, 332.

Type material. HOLOTYPE - CSIRO, B.4111, 142.5mm SL, Arafura Sea, 11°43′S 136°18′E, bottom trawl from RV "Soela", 24 m, CSIRO, 24 June 1981. PARATYPES - CSIRO B.2104, 11 specimens, 114-157 mm SL, Timor Sea - Joseph Bonaparte Gulf, 14°08′S 128°34′E, bottom trawl from RV "Soela", 42 m, CSIRO, 29 June 1980; BMNH 1982.7.20:184-195, 12 specimens, 99-162mm SL, 14°08′S 128°34′E, bottom trawl from RV "Soela", 19 m CSIRO, 18 November 1980; NTM S.10203-002, 4 specimens, 57-79 mm SL, King Creek, Shoal Bay, 12°21′S 131°00′E, trawl, N.T. Fisheries, no date; NTM S.10404-003, 4 specimens, 70-79 mm SL, King Creek, Shoal Bay, 12°21′S. 131°01′E, trawl, N.T. Fisheries, 2 February 1974; BMNH 1982.7.20:196-216, 20 specimens, 110-159 mm SL, Arafura Sea, 11°04′S 131°18′E, bottom trawl from RV "Soela", 35 m, W. Okera, 6 July 1980; NTM S.10095-007, 1 specimen, 139 mm SL, Chambers Bay, Van Diemen Gulf, 12°13′S 131°35′E, trawl, 5-10 m, N.T. Fisheries, 5 May 1977; NTM S.10051-007, 1 specimen, 140 mm SL, 13 km west of Murganella Creek, 11°52′S 132°31′E, trawl, 14-18 m, N.T. Fisheries, 26 October 1977; AMS I.21962-004, 1 specimen, 163 mm SL, Arafura Sea, 11°50′S 134°48′E, bottom trawl from RV "Soela", 19m, CSIRO, 18 November 1980; CSIRO B.2105, 6 specimens, 136-168 mm SL, Arafura Sea, 11°43′S 136°18′E, bottom trawl from RV "Soela", 24 m, CSIRO, 24 June 1981; AMS I.15557-023, 1 specimen, 114 mm SL, Gulf of Carpentaria, 17°00′S, 140°14′E, bottom trawl, 14 m, I.S.R. Munro, 9 September 1963; AMS IB.3159, 1 specimen, 85 mm SL, Bynoe River mouth, Gulf of Carpentaria, 17°56′S 140°51′E, field stn 2715, no date; NTM S.11676-001, 2 specimens, 135 and 142 mm SL, Orokolo Bay, Papua, 7°58′S 145°18′E, bottom trawl, 37-

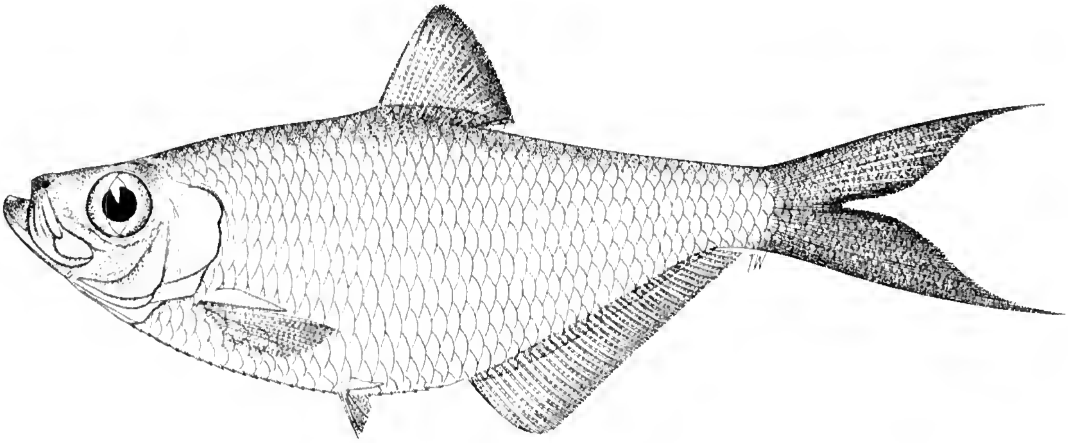


Fig. 2. *Ilisha lunula* paratype,NTM S.10095-007, from Chambers Bay, Van Diemens Gulf 139 mm SL, drawn by T. Wongratana.

47 m, S. Frusher, 25 September 1976; KFRS unreg., 1 specimen, 121 mm SL, Freshwater Bay, Papua, 8°12′S 146°35′E, bottom trawl, 15 m, S. Frusher, 25 August 1976; AMS IB.1268, 7 specimens, 30-43 mm SL, Mackenzie Island, Fitzroy River estuary, 23°31′S 150°52′E, G.P. Whitley, 19 March 1943.

Comparative material. *I. melastoma:* BMNH 1975.3.20:769-801 (in part), 6 specimens, 106-127.5 mm SL, Bolar, Mangalore, India (west coast); *I. kampeni:* BMNH 1979.8.24:154-155, 2 specimens, 94 and 96 mm SL, Kotabaru fish market, Kalimantan, Indonesia, 25 June 1978; *I. striatula*: BMNH 1975.3.20:673-679, 6 specimens, 140.5-158 mm SL, Waltair near Vizakapatnam, Andhra Pradesh, India; *Pellona ditchella* Valenciennes: NTM S.11346-003, 1 specimen, 122 m SL, Teluk Awang, Lombok, Indonesia, August 1984.

Diagnosis. A species of *Ilisha* with symmetrical paired post-coelomic extensions of the swimbladder on either side of the haemal spines, vertical scale striae overlapping or joining at the scale centre, 14-17 pre-dorsal scales, a total of 18-20 dorsal rays, 18-20 lower gillrakers, caudal fin lobes with extended tips - their longest rays about 4-7 (mean 5) times length of the middle rays, dark margin to all of caudal fin, 19-24 long pyloric caecae, and frontal bones with two prominent ridges in the "megaloptera" pattern.

Description. Branchiostegals 6; dorsal-fin ray total 17 (13-16, of iii-iv, 15-17); pectoral-fin rays 17 (16-18); pelvic-fin rays 6 (7); anal-fin rays 44 (41-46); gillrakers 11 + 19 (9-12 + 18-20); scutes 19 + 9 (18-22 + 8-10); scales in lateral series 44 (41-46); pre-dorsal scales 16 (14-17); number of vertebrae - (in 4 paratypes: 43-45).

In percentages of SL: body depth 34.9 (32.8-39.2); head length 26.1 (25.4-27.9); snout length 8.1 (7.1-8.5); eye diameter 8.5 (7.8-9.7); length of upper jaw 12.8 (12.6-14.6); length of lower jaw 13.1 (12-14.1); pectoral-fin length 17.8 (16.1-20.4); pelvic-fin length 6 (5.8-7.2); length of anal-fin base 37 (33.6-39.9); pre-dorsal distance 47.5 (45.5-50.1); pre-pectoral distance 26 (25.2-29.1); pre-pelvic distance 44.3 (43.5-51.3); pre-anal distance 60.2 (57.6-68); pectoral-pelvic interspace 19.3 (19.1-24.8); pelvic-anal interspace 16.9 (14.9-21).

Body strongly compressed, its depth greater than head length; belly sharply keeled. Dorsal body profile slightly convex to almost straight, ventral profile moderately to very convex (Fig. 2). Snout slightly shorter than eye diameter; lower jaw (chin) strongly projecting and deep, its depth 3 (2.5-4.4, mean 3.1) in eye diameter. Single, short row of small, curved conical teeth in each jaw at either side of edentulous symphysis; no hypomaxilla; small granular teeth on tongue; two supramaxillae - first (anterior) slender, ovate; second strongly tapered anteriorly, expanded posteriorly; ventral premaxillary and maxillary margins finely serrated, their bones separated by a smooth ligament. Maxilla reaches to vertical from front margin of pupil or slightly further.

Frontal bones with prominent ridges usually of the "megaloptera" pattern (see

Seshagiri Rao 1972), i.e. with pair of ridges arising on median line near nostrils and gradually diverging posteriorly, and second pair of ridges arising from opposite anterior eye border paralleling first pair, ridges of each side joining at hind end of skull (Fig. 3a).

Pseudobranchiae 12-20, half to two-thirds of their length concealed by membrane Gillrakers slender, slightly longer than gill filaments; numerous fine serrae distributed over all of gillrakers, though sparser toward tip. Pyloric caecae very long, about 19-24. Swimbladder prolongations extend to between level of anal fin origin (small fish) or 37th anal ray.

Scutes begin well forward on isthmus; cycloid scales crossed by 0-2 unbroken vertical striae in exposed portion, by 4-6 mostly overlapping interrupted striae (or anterior 1-2 unbroken) in unexposed portion (Fig. 3b).

Dorsal fin begins one eye diameter nearer to snout tip than to tail base; pectoral fin not reaching pelvic-fin origin, both fins with axillary scale; pelvic-fin base slightly nearer to anal-fin origin than to pectoral base; anal origin opposite middle or posterior third of dorsal fin. Caudal fin deeply forked, lobes slender, tips attenuated such that expanded fin is strongly lunate; undamaged filamentous caudal rays 4.3 (3.8-6.8, mean 5) longer than middle rays.

Colour (fresh). Silvery, upper back and top of head olive brown; snout and chin brown. Golden lustre on operculum, cheeks and temporal region; silvery streak from head to upper caudal peduncle. Pectoral fin golden; dorsal and caudal fins dusky yellow, dorsal tip and all of caudal-fin margin dark brown or charcoal.

Colour in preservative. Yellowish fawn; upper sides and abdominal region tan, top of head and back down midline brown, scales finely stippled and margined brown. Elongate-oval brown-stippled blotch on operculum; paired brown spots on parietal region of head; snout and chin dark brown or charcoal. Dorsal, pectoral and pelvic fins pale yellow, the former two finely dusted with brown; extreme tip of dorsal rays black; caudal fin yellow, its upper, lower and hind margins dark brown or charcoal.

Comparisons. *I. lunula* is characterised by having long caudal fin lobes. Specimens of *I. elongata* (Bennett) from China (CAS SU28168) also have produced caudal lobes (T. Wongratana, pers. comm.). However, *I. elongata* is otherwise easily distinguished from *I. lunula* by having only one post-coelomic swimbladder extension (two in *I. lunula*), 22-23 lower gill rakers (v. 18-20), 17-20 pre-dorsal scales (v. 14-17), 24-25+12-14 scutes (v. 18-22+8-10), 47-52 anal rays (v. 41-46), 16-18 dorsal rays (v. 18-21) and body depth 28.5-33% SL (v. 33-39).

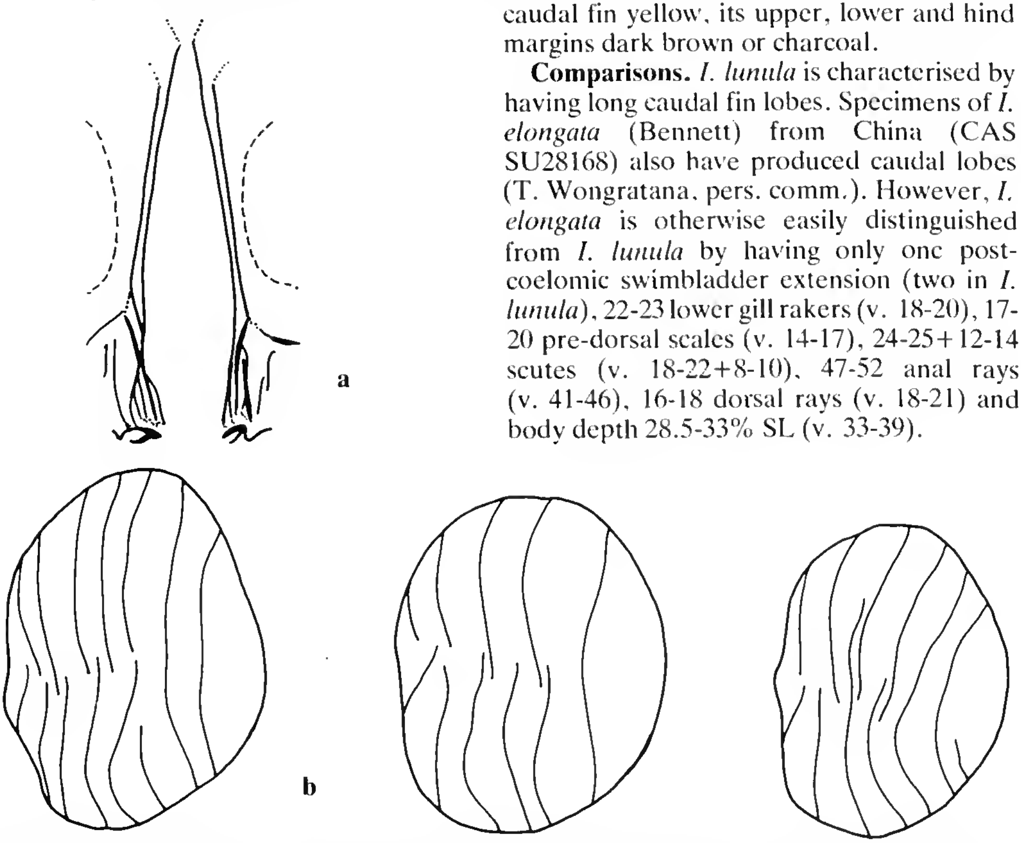


Fig. 3. *Ilisha lunula:* **a**, frontal ridges showing "megaloptera" pattern; **b**, scales from side of body above anal fin origin showing striation pattern, x4.

Species of *Ilisha* can be separated primarily into three groups depending on the presence and/or number of post-coelomic extensions to the swimbladder: *I. novacula* Valenciennes [Wongratana has found this is a senior synonym to *I. sladeni* (Day)] and *I. sirishai* (see earlier comment) lack post-coelomic swimbladder extensions; *I. pristigastroides*, *I. filigera* (Valenciennes), *I. elongata*, *I. macrogaster* Bleeker and *I. megaloptera* possess a single post-coelomic extension on the right side; and *I. melastoma*, *I. kampeni*, *I. striatula* and *I. obfuscata* have paired post-coelomic extensions.

I. lunula falls into the last group, but can be easily distinguished from the other four species of the group by having long, fully dark-margined caudal lobes. Of the other species which have paired post-coelomic extensions to the swimbladder, *I. striatula* (Bay of Bengal; Indonesia) has fewer predorsal scales, a shorter snout and upper jaw, slightly longer anal base, shorter and many more pyloric caecae, a different pattern of frontal ridges, vertical scale striae discontinuous at scale centre - separated by a wide space - and a dark band along the flanks; *I. obfuscata* (southern India) has a higher number of gill rakers and shorter swimbladder extensions; *I. kampeni* (India; Indonesia) has fewer vertebrae and slightly fewer lateral scale rows, a more slender body, longer lower jaw, pseudobranchiae almost covered by membrane and vertical scale striae not overlapping; and *I. melastoma* (Persian Gulf to western Indonesia; Taiwan) has a few more gillrakers, fewer predorsal scales, many more pyloric caecae and a faint dark band along the upper sides. *I. lunula* was previously misidentified by Whitehead and Wongratana (1984) as *I. melastoma*.

Table 1. Comparison of meristic and morphological characters in species of *Ilisha* with paired post-coelomic swimbladder extensions. Table compares data from both literature and specimen examination. (**Note:** *I. obfuscata* data given below).

Character	*I. lunula*	*I. striatula*	*I. melastoma*	*I. kampeni*
dorsal fin rays	iii-iv,15-17	iii-iv,12-15	iii-iv,12-15	iii-iv,13-14
anal fin rays	41-46	43-47	36-48	36-44
pectoral fin rays	16-18	15-17	15-17	15-16
gill rakers	9-12+18-20	8-12+19-22	10-14+19-25	7-9+19-25
scutes	18-22+8-10	17-20+7-8	18-22+7-10	18-21+7-9
lateral scale rows	41-46	42-45	39-44	38-43
transv. scale rows	13-16	12-15	11-13	12-13
predorsal scales	14-17	11-15	11-15	14-18
Vertebrae no.	43-45	42-43	42-44	41-42
%SL body depth	33-39	32-39	30-42.5	24-32
%SL pect. fin length	16-20.5	18-21	17-21.5	14.5-18.5
%SL snout length	6.5-8.5	5.6-7	6-10.5	6.5-10.5
%SL predorsal space	44.5-50	44-46.5	44-56	41-55
%SL upper jaw length	12.5-15	11.5-12.5	12.5-14	14.5-15
%SL lower jaw length	12-14	12.5-13	13.5-14	16.5-17
%SL anal fin base	33.5-40	38-43.5	33-38	34.5-35
%SL pelvic-anal space	15-21	16-18	16-18.5	14.5-17.5
%SL chin depth	2.5-3.5	2.2-3	2.5-3.5	3-3.5
mid-caud. ray in longest ray	4-7	3-3.5	3-4	3
chin depth in eye diam.	2.5-3.5	3-4	3-4	2.5-3
pelvic axillary scale	present	present	absent?	present
pseudobranchiae	to ½ covered	to ¼ covered	to ¼ covered	nearly all covered
pyloric caecae	long, 19-24	short, ca. 38	ca.51	long, 15-19
frontal ridge pattern	"megaloptera"	"indica"	"indica"	"megaloptera"
scale striae at scale centre	overlap or continuous	separated by wide space	overlap or continuous	small or wide space
colour on sides	no dark band	dark band	faint dark band	no dark band
caudal fin margins	all dark	hind one dark	hind one dark	none dark

I. obfuscata: Limited information is available from the types only: scale striae overlap at centre; no dark band on flanks; swimbladder extensions to above 8-9th anal ray; GR 10-12+27-28; scutes 19-20+8; dorsal rays iii,13; anal rays 39-42; pectoral rays 15; scale rows 40; predorsal scales 13. (Data from Whitehead (1967) and Wongratana (1983)).

Additional comparative data are presented in Table 1.

Wongratana (pers. comm.) has drawn to my attention the relative length of the swimbladder extensions in the five *Ilisha* species possessing paired extensions: their development in *I. lunula* is usually less than for the other species. Moreover, the right hand side extension is often better developed than that on the left hand side. In the type material I dissected, the right hand side extension was longer in 65% of fish, the left extension longer in 22%, and in 13% they were of about equal length. The left hand side extension in smaller specimens (less than 80 mm SL) is frequently undeveloped (Wongratana, pers. comm.) and there is some tendency for extensions to lengthen with increase in body size (extension length matched to anal ray number opposite its termination). However, I consider the taxonomic value of this character cannot be ranked highly in preserved material because of damage to the extensions from lost elasticity, and shrinkage.

Distribution. *I. lunula* ranges from the Timor Sea near northwestern Australia, through the Arafura Sea, northern Australia, Gulf of Carpentaria, Gulf of Papua and southward along the Queensland coast at least to the Fitzroy River mouth (here based on AMS IB.1268).

Etymology. This species is named *I. lunula* in reference to its lunate, extended caudal fin.

ACKNOWLEDGEMENTS

Comparative material was generously loaned by P.J.P. Whitehead (BMNH), B.C. Russell and H.K. Larson (NTM), P.R. Last (CSIRO) and M. McGrouther (AMS). Thanks are due to Ross MacDonald and Mark Rivett (Adelaide Dental Services) for radiographs, Phil Kempster (Adelaide University Zoology Department) for photography, and P.J.P. Whitehead, who encouraged my study of this species. Thosaporn Wongratana (Chulalongkorn University, Bangkok) generously supplied an original drawing of a paratype of *I. lunula*, as well as unpublished data on *Ilisha* specimens. The manuscript was reviewed by P.J.P. Whitehead, T. Wongratana, B.C. Russell and H.K. Larson. The assistance of the NTM fish curators in the final preparation of the manuscript is gratefully acknowledged.

REFERENCES

Gloerfelt-Tarp, T. and Kailola, P.J. 1984 *Trawled fishes of southern Indonesia and northwestern Australia.* Australian Development Assistance Bureau; Directorate General of Fisheries, Indonesia; German Agency for Technical Cooperation: Jakarta.

Ramaiyan, V. and Natarajan, R. 1979 Systematic revision of the Indian species of *Ilisha* Richardson, 1846 (Pisces: Clupeiformes). *Proceedings of the Indian Academy of Sciences* B**46**(1):8-22.

Ramaiyan, V. and Whitehead, P.J.P. 1975 Notes on Indian species of *Ilisha* (Pisces: Clupeidae). *Journal of the Marine Biological Association of India* **17**(1):187-198.

Sainsbury, K.J., Kailola, P.J. and Leyland, G.G. 1985 *Continental shelf fishes of northern and northwestern Australia. An illustrated guide.* Clouston & Hall and Peter Pownall Fisheries Information Service: Canberra.

Seshagiri Rao, B.V. 1972 Identity of the clupeid fishes, *Ilisha megaloptera* and *Ilisha indica*. *Copeia* **1972**(4):881-882.

Seshagiri Rao, B.V. 1973 Redescription of the clupeid fishes *Ilisha megaloptera* and *I. melastoma*. *Copeia* **1973**(4):735-739.

Seshagiri Rao, B.V. 1974a *Ilisha whiteheadi*, a new species of clupeid fish from the Bay of Bengal. *Copeia* **1974**(4):861-864.

Seshagiri Rao, B.V. 1974b On the form of gill raker serrae in the Indian *Ilisha*. *Current Science* **43**(13):420-421.

Seshagiri Rao, B.V. 1975 A new species of clupeid fish, *Ilisha sirishai*, from Visakapatnam, India. *Hydrobiologia* **47**(3-4):463-468.

Seshagiri Rao, B.V. 1976 Notes on the Indo-west Pacific species of the clupeid fish genus *Ilisha*, with a key to their identification. *Copeia* **1976**(3):503-509.

Whitehead, P.J.P. 1967 The clupeoid fishes described by Lacepède, Cuvier and Valenciennes. *Bulletin of the British Museum (Natural History), Zoology Supplement* **2**:1-180.

Whitehead, P.J.P. 1973 A synopsis of the clupeoid fishes of India. *Journal of the Marine Biological Association of India* **14**(1):160-256.

Whitehead, P.J.P. 1986 FAO Species Catalogue Vol. 7. Clupeoid fishes of the World (Suborder Clupeoidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 1 - Chirocentridae, Clupeidae and Pristigasteridae. *FAO Fisheries Synopsis* (125) 7(1): i-x, 1-303.

Whitehead, P.J.P., Boeseman, M. and Wheeler, A.C. 1966 The types of Bleeker's Indo-Pacific elopoid and clupeoid fishes. *Zoologische Verhandelingen, Leiden* **84**:1-159.

Whitehead, P.J.P. and Wongratana, T. 1984 Clupeidae - Herrings, shads, sardinellas, sprats, sardines: 1-58. In: W. Fischer and G. Bianchi (eds) *FAO species identification sheets for fishery purposes.*

Western Indian Ocean (Fishing Area 51). Volume 1. Food and Agricultural Organization of the United Nations: Rome.

Wongratana, T. 1980 *Systematics of the clupeoid fishes of the Indo-Pacific region*. Ph.D Thesis. Imperial College, University of London.

Wongratana, T. 1983 Diagnoses of 24 new species and proposal of a new name for species of Indo-Pacific clupeoid fishes. *Japanese Journal of Ichthyology* **29**(4):385-407.

Accepted 20 June 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 59-70

UNMUDDLING THE MUDLOBSTER; OBSERVATIONS ON THE AGE AND TAPHONOMY OF FOSSIL *THALASSINA*

PETER F. MURRAY AND J. RUSSELL HANLEY
Northern Territory Museum of Arts and Sciences
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

The natural history of the mudlobster *Thalassina anomala* (Herbst) explains the abundance of fossils of these creatures. After each moult, the cast off exoskeleton remains in the burrow where it undergoes rapid carbonate permineralization. The condition of the fossil exoskeletons give direct evidence of the moulting process of *Thalassina* Latreille. A general account of living mud lobster natural history is given and an estimate of the age of local *Thalassina* fossils is made.

KEYWORDS: *Thalassina anomala*, mudlobsters, burrows, exuviae, fossilization, Recent age.

INTRODUCTION

Attractive crustacean fossils known locally as "scorpions" or by other misnomers have been popular items with amateur collectors in northern Australia for many years. Specimens of fossil mudlobsters (*Thalassina* sp.) are available as souvenier items from several commercial outlets in Darwin. Recently improved access to one of the best known localities of fossil *Thalassina* sp. has meant attractive examples for amateur collections, display and commercial purposes can be found in reasonable abundance (Figs 1,2) Several members of the curatorial staff of the N.T. Museum have experienced an increase in public requests for information on specimens they have found or purchased. Public enquiries usually concern identification, age, commercial value and legality of export. We have also been casually monitoring the possible depletion of the resource and destruction of source areas by digging or increased vehicle access. It has come to our attention that bulk shipments of these fossils have been apprehended by customs officials before they could be shipped overseas. While we have no indication of the market value of *Thalassina* sp. fossils in overseas markets, we can assume, from the extent of price ranges within Australia ($1.50-$50.00) that it will be inflated and that misinformation or lack of information about the fossils will accompany the sales. In 1984 a Darwin newspaper and a local radio interview program innocently contributed to the bulk of misinformation about the fossil mudlobsters through interviews with a French "Palaeontologist" who vented his spleen on the complacency of local scientists with regard to the study of the *Thalassina* Latreille fossils, which he considered to be millions of years old.

In fact, there is an adequate though scattered and somewhat obscure literature on living and fossil mudlobsters that would give any interested person a reasonable account of them, beginning with Professor Thomas Bell's paper in the *Proceedings of the Geological Society* for 1884. Etheridge (1916) summarizes the literature on *Thalassina* from Australia up to the time of publication. Subsequent popular notes have appeared among which Bennett (1968) stands out as the most useful.

This paper provides information on the natural history of living *Thalassina* species including information we consider relevant to the interpretation of the fossil material that clarifies many poorly understood aspects of their palaeontology. An account of their distribution as living and fossil forms and how anatomical structure and habits relate to their appearance and mode of occurrence as fossils is provided, as is an estimation of their geological age.

THALASSINA NATURAL HISTORY

Mudlobsters are shy, secretive creatures rarely seen by even the keenest observer. Inhabiting burrows up to two metres in depth and seldom venturing to the surface, much of the life and habits of these animals is mysterious. Records of mudlobsters (see Rollet 1981 for bibliography) indicate the animals are always associated with mangrove habitats,

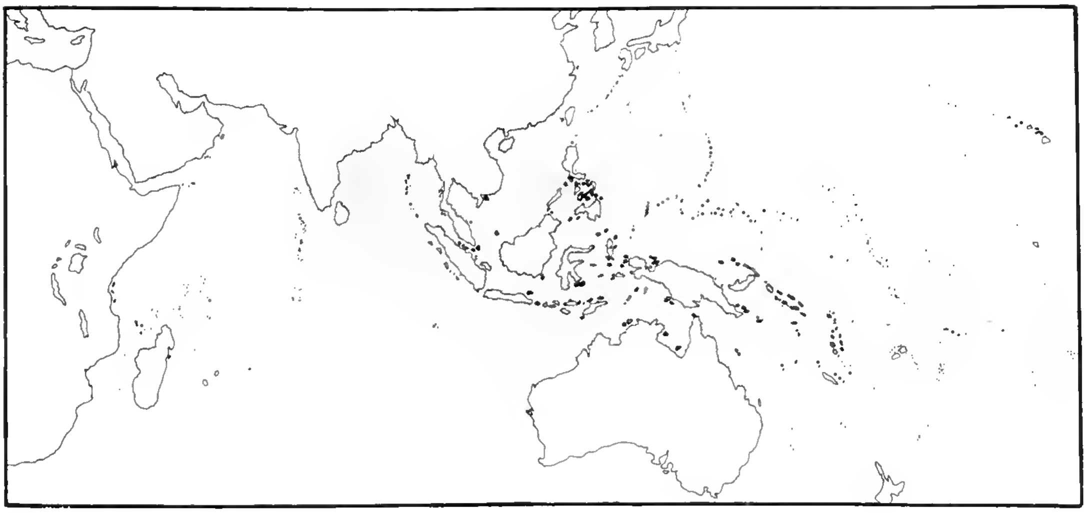


Fig. 1. Distribution of *Thalassina anomala.*

either living within mangroves or immediately adjacent to them. This association is because both mudlobsters and mangrove trees require muddy substrates. The genus *Thalassina* has a tropical Indo-West Pacific distribution (MacNae 1968) in common with a large component of the fauna of mangroves in our region (Fig. 1). Several species or varieties have been identified, though at present the taxonomy of the genus is in a state of flux. Although all Australian material has been referred to *T. squamifera* De Man by Poore and Griffin (1979), we propose to include all local living and fossil *Thalassina* species under *T. anomala* (Herbst) pending a revision of the genus.

In Australia *T. anomala* occurs from Exmouth on the north-west coast (Jones, pers. comm.), northwards along the tropical coastline whenever suitable conditions occur, down to Gladstone on the north-east coast (Gillies 1951; MacNae 1966). Cooler temperatures exclude the majority of mangrove tree species from subtropical and temperate latitudes and is possibly also the limiting factor in the explanation of the distribution of *T. anomala.*

Within a mangrove mudlobsters occur from the seaward edge up to a level that depends on the physical characteristics of the site. In the monsoonal tropics where coastal environments experience a protracted dry season mudlobsters do not occur at the upper levels of the intertidal zone. At these high levels on the shore it is likely an animal susceptible to dehydration like *T. anomala* (Sankolli 1963) is restricted in distribution by the increasing depth to which it has to burrow to enter the water table. In the everwet regions of the tropics, this restriction does not apply and mudlobsters can be found in the brackish water swamps of the upper intertidal zone (MacNae 1968) where its digging activities can produce large islands of mud.

The first overt sign of mudlobsters in a mangrove are the large piles of mud the animals have excavated from their extensive network of burrows. The burrow is a complicated structure, full of interconnections and blind endings. The burrowing activities of mudlobsters have several important ecological ramifications.

A proportion of the water-borne nutrients entering mangrove ecosystems eventually diffuse through the aerated surface layers of the muddy substrate to a depth beyond the reach of the root systems of mangrove trees. The copious amounts of mud from depths up to two metres brought to the surface by *T. anomala* returns nutrients to the surface layers from which they are absorbed by the nutritive roots of mangrove trees. Another benefit of mudlobster and other burrowing fauna excavations is the increased depth of aerated soil in mangrove habitats.

The abundance of *T. anomala* occurring in a typical muddy location has never been accurately assessed — hardly surprising considering if it were not for the distinctive piles of mud ejected from their burrows we would have little idea of their presence at all. However, we believe a reasonable estimate of density can be derived from a walk through a mangrove after the tide has just uncovered the seaward fringe. At this time many of the resident mud lobsters are in the process of ejecting mud from their burrows. The much darker coloured freshly deposited mud is easily recognized signifying a mudlobster in occupancy of the burrow. On this basis, several of the seaward fringes of mangroves in the Darwin region would support something in the order of 3-4 individuals per 10 square metres. At higher levels of the intertidal zone the mounds of mud above each burrow are much larger as there is less erosion by tidal currents. There are fewer burrows at these higher levels.

Populations of *T. anomala* can be large enough to support commercial exploitation. In Fiji, an ingenious method of trapping mudlobsters (Pillai 1985) supplies 19 per cent of the crustaceans available for sale in local markets, even though the animals are only caught for six months of the year.

Interviews with local indigenes in northern Australia have established that mud-lobsters are a component of the diet of coastal aborigines. The importance of this resource or the method of collection is not known.

There is some disagreement among authors as to what mudlobsters eat. Pearse (1911) reported the presence of vegetable matter in the gut of a specimen he examined and concluded the animal had been feeding on the stems of vascular plants. After the examination of a dozen specimens of mud lobsters from mangroves in Malaya, Johnson (1961) proposed the animals are mud feeders, ingesting mud while in the burrow and digesting the algae, protozoa and detritus adhering to each particle of mud. He found the mouthparts and gut exhibited features consistent with mud feeding. It is possible, however, that mudlobsters eat the softer root tissues of mangrove trees, something that could be accomplished in the burrow and would not require mouthparts adapted for

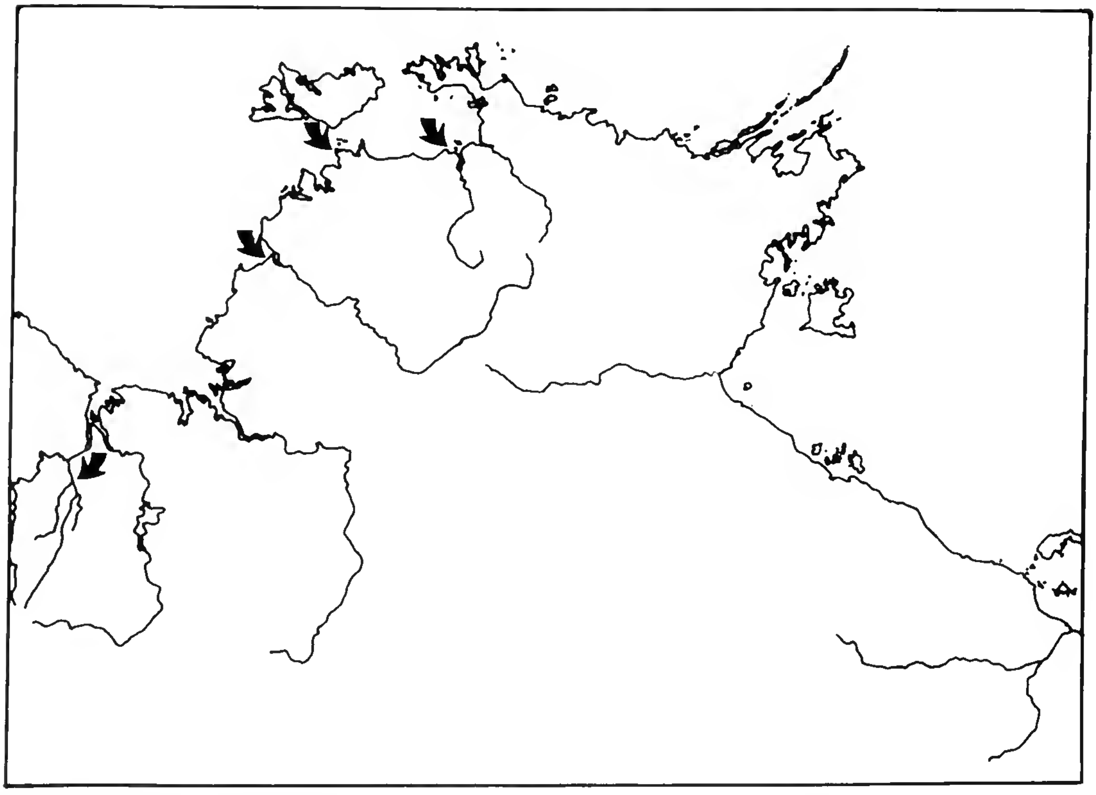


Fig. 2. Location of fossil *Thalassina* sites in northern Australia. From left to right: King River, Daly River, Gunn Point-Darwin, South Alligator River.

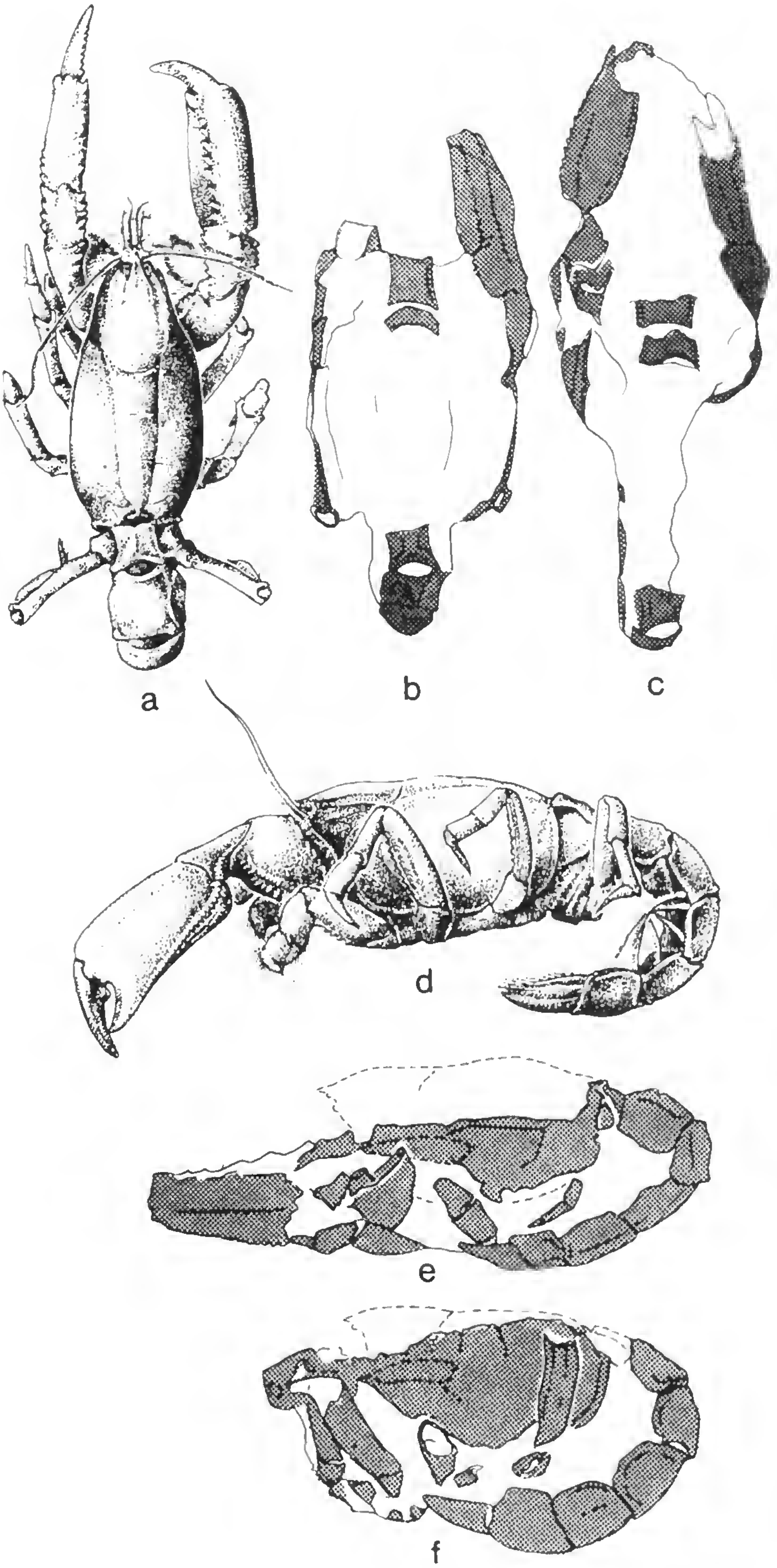


Fig. 3. Comparison between preserved and fossil *Thalassina* material: **a-c**, dorsal view; **d-f** lateral view.

eating hard vegetation. Therefore, the question of diet must await further investigation.

We know even less about mudlobster reproductive behaviour and can only assume mating occurs in the burrow. Pillai (1985) records that at Laucala, Rewa, in the Fijian islands, the spawning peak of mudlobsters is between September and November, with berried females carrying up to 100,000 eggs on the pleopods. It is thought that the female mudlobsters come to the surface during nocturnal high tides to disperse the pelagic zoea larvae. The larvae spend some two to three weeks in the plankton before migrating to brackish water for the latter stages of larval life.

THALASSINA MORPHOLOGY

Detailed descriptions of *Thalassina* species for systematic or functional anatomical purposes should be sought elsewhere (De Man 1928). Adult *T. anomala* range between 150 mm and 250 mm in length from the tip of the rostrum to the end of the telson. Female fossil *Thalassina* specimens can be distinguished from the males by their broader, deeper tergites (abdominal plates) and deeper more flared abdominal pleurites (ventro-lateral extentions of the terga) (Fig. 3). The main body parts consist of a large cephalothorax and a long, narrow abdomen composed of 6 dorsal segments and a telson. Typical of anomuran decapods, *Thalassina* has five pairs of legs. The first of these, the chelipeds, are equipped with large claws. The second pair of legs are smaller versions of the first chelipeds. The remaining three pairs are walking legs, of which the last pair (5th) are weak and spindly. Each walking leg terminates in a pointed dactyl. *Thalassina* specimens often have one first cheliped that is much larger than the other. In forms where this is a consistent dimorphic feature it is called the major cheliped. This feature is inconsistent and variable in the fossil *Thalassina* sample from the Darwin area.

In fossil specimens details of the oral and sensory region underlying the rostral projection of the anterior carapace ("head") are usually damaged or obscured. Living *Thalassina* have a pair of diminutive eyes on short stalks laterally protected by an orbital spine that projects from each side of the rostrum. Paired antennae arise ventrolaterally from below the ocular peduncles. The smaller antennules arise from paired bases situated medially to the antennae. The antennae and antennule bases bear an arrangement of spines that are species diagnostic for *Thalassina*. These structures have not been examined in detail on the fossil specimens for the reasons already mentioned.

The carapace structure of *Thalassina* is of importance for understanding the presentation of *Thalassina* fossils (Fig. 3). The large paired lateral portions of the cephalothorax (branchiostegites) are usually well preserved in the fossils. The mid-posterodorsal portion of the carapace however, is invariably missing in fossil specimens resulting in a wide gap between the branchiostegites. The anterior carapace is attached to the posterior or gastro-cardiac portion by a deep crease called the cervical groove. Another pair of grooves called the *lineae thalassinica* delineate the attachment of the sides of the posterior carapace with the branchiostegites. These and other relevant structures are shown in Fig. 3.

PRESENTATION AND MODE OF OCCURRENCE

Fossil *Thalassina* specimens exhibit a striking uniformity in their appearance and presentation. They occur in concretionary nodules of calcareous mudstone, being weathered to various degrees, that may obscure all but a few portions of the most prominently projecting structures of the carapace. Conversely, specimens may weather to the extent that the more durable carapace material, except for its subtending and interstitial matrix, becomes almost entirely exposed.

Concretions containing mudlobster fossils are easy to recognize on the basis of their size and length to diameter proportions, but most specimens occur in a partially weathered condition in which the abdominal segments and the tips of the chelipeds are exposed. The exoskeleton invariably occurs with its chelipeds extended horizontally in front of the carapace, the latter being represented by paired side plates (the branchiostegites) that are deflected away from the midline of the thorax resulting in a greatly expanded basin or trough in which the slumped anterior carapace, or "head end" of the animal can usually be found. The abdominal segments commence immediately posterior to the gaped branchiostegites where in dorsal aspect, two or three of the anterior most tergites are often visible. The remaining portion of the abdomen, viewed in ventral aspect, is flexed tightly beneath the thoracic region where the distal end of the telson comes to lie as far forward as the third leg base. Amateur collectors commonly confuse the dorsal for the ventral side of the animal which gives the impression of a long, segmented abdomen curling tightly over a broad, compressed "back". This, in conjunction with the fully extended chelipeds has resulted in the widespread misconception that the mudlobster fossils are "scorpions".

The hardness, texture and colour of the matrix and colour and hardness of the preserved exoskeleton of fossil *Thalassina* differs from one locality to the next. Specimens from the Daly River estuary are typically light bluish grey in a light tan matrix with a chalky texture which is easily scraped away by the thumbnail. *Thalassina* fossils from the mouth of the South Alligator River are greyish white, embedded in a homogeneous tan-grey matrix which also readily scrapes away on the surface, but grades into a harder, dark grey material a few millimetres deep from the surface. The concretions from South Alligator River are often large and somewhat irregular in shape. Fossil *Thalassina* collected by Russell Hanley from the King River, Kimberleys, Western Australia, while typical in all basic characteristics, but having thin, patchy representation of the exoskelton are the least well preserved. Four of the five specimens in our collection consist entirely of internal casts of light grey mudstone. Specimens collected from Ludmilla swamp, a mangal located about 5 km from the N.T. Museum, have well preserved exoskeletal elements of a yellowish-tan colour embedded in an organically rich compound of shelly, bioturbated mudstone with iron oxide flecks.

The most attractive and sought after specimens from the Darwin area are collected at low tide from a sandy beach located near Gunn Point, several kilometres north of a minor estuary called Hope Inlet. These have very hard, rich reddish-brown to black exoskeletons embedded in a fine, homogeneous reddish brown to light reddish tan coloured matrix that resists scratching by the thumbnail. Because the matrix is very hard and the exoskeleton is darkly stained and evenly polished by having rolled around in the sandy littoral zone of the beach, they give an impression of greater antiquity than the

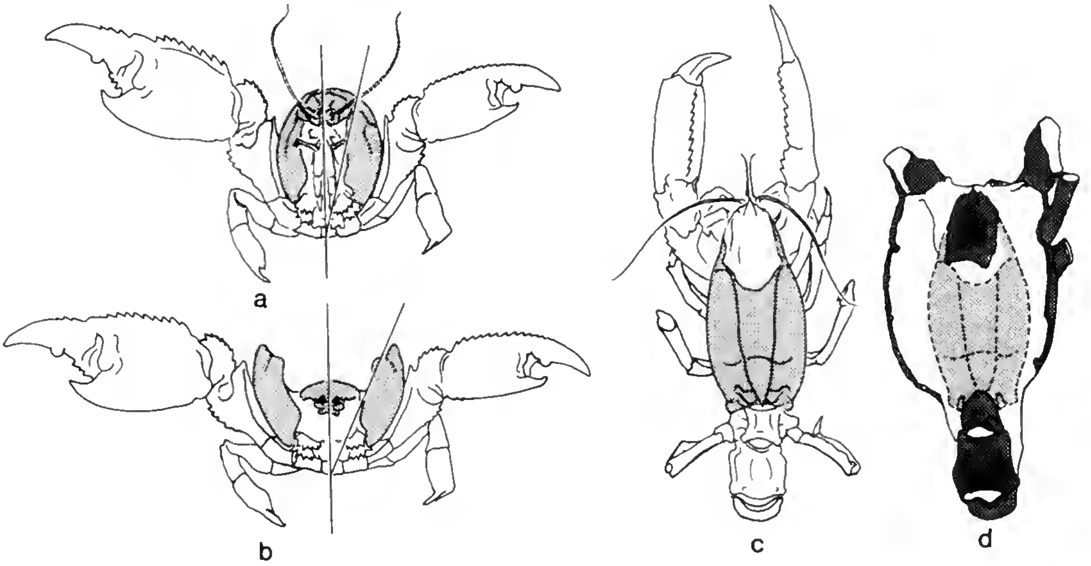


Fig. 4. Relative positions of carapace sections before and after moult: **a**, stippled area shows shape of carapace in a live specimen; **b**, the branchiostegites have been displaced laterally and the dorsal sections of the carapace sink into the body cavity; **c**, dorsal view of intact carapace in a live specimen; **d**, during the moult, the branchiostegites are displaced laterally and the head cap is tilted forward. The posterior section of the carapace cannot be seen in the fossil specimen shown.

rest. The matrix of specimens from all localities show a strong reaction to acid but vary somewhat in amount of incorporated organic debris and metallic oxide staining. These differences relate to the nature of the substrate in which the fossils formed, the proximity of iron and manganese oxide deposits (principally laterites) and certain post-depositional processes that have affected fossil assemblages after removal from their beds of origin. More will be said about this under fossilization processes and dating.

Thalassina fossils are by far the most common species in these assemblages. At Gunn Point, *Thalassina* concretions comprise about one third of the total identifiable material consisting primarily of fossilized wood fragments, teredo worm tubes, mud whelk shells and mud crab chelipeds (rarely the carapace). Segments of burrow casts, some undoubtedly representing *Thalassina* burrows, others possibly representing various burrowing crustacea and polychaete worms are also common. The great abundance of fossil *Thalassina* remains has resulted in much verbal speculation as to the circumstances of their origin. Most of these ideas involve some notion of mass mortality or a specific, temporally defined geomorphological event that might facilitate the preservation of such material. Hyposalinization of an estuary due to flooding with fresh water, possibly during a cyclone; hypersalinization of the habitat due to stream course changes, estuarine remodelling or drought; local uplift; sea level depression and increased sediment loads resulting in a rapid infiltration of *Thalassina* burrows with silt have been suggested as causal factors. As will be demonstrated, an explanation of the abundance of *Thalassina* fossils requires none of these elaborate hypotheses, because they represent moulted exoskeletons, a considerable number of which are shed by each individual during its normal life cycle.

EVIDENCE THAT THALASSINA FOSSILS REPRESENT MOULTS

Thalassina fossils occur in a characteristic posture consisting of a horizontal extension of the chelipeds, inferior and backward displacement of the anterior carapace ("head"), the branchiostegites (side walls of the thorax) are displaced laterally and the tail (abdominal segment) is curled tightly beneath and is closely approximated to the inferior thorax. On some specimens, the dorsal midline plate which in the living animal forms the back of the carapace, has come to lie in front of the anterior carapace. This posture, known as "Salters position" is commonly seen in ecdysized (moulted) crustacean exoskeletons. Among the hundreds of specimens from the Darwin area examined by us, any exception to this characteristic position would be regarded as highly unusual.

In dorsal aspect, the fossil mudlobsters are 1.5 to 2.0 times as wide across the carapace than living or preserved specimens of equal length. The reason for this is readily observed in frontal view. The anterior margins of the branchiostegites are nearly vertical relative to the midline in living specimens whereas the fossils describe a much greater angle (Fig. 4), suggesting that they have been pushed outwards. This "exploded" condition contributes to the superficially scorpion-like appearance of the fossil specimens, as does the fully-extended position of the chelipeds. The anterior carapace, having collapsed inferiorly and the absence of the posterior carapace (both are usually partially or wholly obscured by the matrix that has infiltrated the interior of the thorax) create the impression of a low profile arthropod, whereas the intact *Thalassina* has a very deep carapace with a convex profile.

The lateral displacement of the branchiostegites, the displacement anteriorly or laterally of the dorsal, posterior carapace, the consistent, posteriorly retracted and inferior displacement of the "head" (anterior carapace), and tightly adducted abdominal segments (Fig. 5) provide the strongest evidence for the mudlobster fossils representing preserved successive, moulted exoskeletons of *Thalassina*. This fact also accounts in part for the local abundance of the fossils which seems out of proportion to the other fossil mangrove species that occur in association with them. The other factor of singular importance is that the mudlobsters undergo ecdysis in their burrows, in conditions more conducive to preservation than surface-moulting crustaceans. It is therefore unnecessary to postulate instances of mass mortality due to freshwater flooding (to which *Thalassina* is very resistant) or prolonged periods of drying of the substrate due to uplift, estuarine channel shifts or other geomorphological phenomena to account for the abundance of mudlobster fossils.

The condition of fossil *Thalassina* permits the reconstruction of the general pattern of exoskeletal exuviation, which to our knowledge, has not been recorded from a living specimen.

MODE OF ECDYSIS INFERRED FROM FOSSIL THALASSINA

In common with all Anomura, *Thalassina* emerges from the dorsal midline of its moulted carapace through a trap-door mechanism in the posterior cephalothorax. (see Fig. 6). The adaptation is well suited to moulting in confined spaces because the posterior and arching component of withdrawl from the old carapace is minimized. The gastric and cardiac segments of the postero-dorsal cephalothorax are separated from the branchiostegites by a clearly defined pair of grooves, the *lineae thalassinica*. Hormonal changes that initiate the molt reduce the integrity of the seams that finally give way to muscular pressure resulting in the separation of a long tapering flap of exoskeleton. As the animal arches and withdraws posteriorly, the gastric flap is forced upwards, remaining connected by thin membranes on either side of the posterolateral margins of the cervical groove. As the "head" is withdrawn from the anterior carapace, which has simultaneously separated from the branchiostegites in the area of the hepatic groove, the anterior carapace is dragged posteriorly and eventually collapses to lie well inferior to its original position. Having freed its anterior end, the mudlobster commences withdrawing its chelipeds and anterior appendages while moving its whole body anteriorly. The forward movement often pushes the gastric plate over the anterior carapace so that it may come to lie anterior to it, although in an equal number of fossils, the gastric plate is pushed sideways where it comes to lie alongside the anterior carapace. The action of withdrawing the chelipeds results in the extension of the cheliped exuviae into a horizontal plane parallel with the body. A specialized anterior abdominal tergum (the first dorsal plate on the abdomen) rotates backwards to facilitate the withdrawal of the abdomen. The muscular action of the abdominal withdrawal process results in characteristic tightening of the curl of its tail, the last segment of which comes to lie much further anteriorly beneath its body than in its usual living posture. The newly moulted *Thalassina*, freed from its old carapace, probably remains in the moulting chamber at least long enough to harden its carapace for renewed digging activity. This may result in secondary, though slight, disturbance of the classic Salter's position of the moulted carapace. It may also initiate the fossilization process of the moult by backfilling the evacuated chamber with finely turbated material that may have accumulated during the resting period.

TAPHONOMY AND DATING OF THALASSINA FOSSILS

All of the known sources of *Thalassina* fossils in northern Australia occur in or in close proximity to present day mangrove littoral deposits where living *Thalassina* are known to occur. Comparison of living and fossil *Thalassina* specimens from the same general area indicate they are probably the same species. Synonomy has not yet been verified by systematists because the diagnostic features revealed by the antennule and antenna bases are either obscured by matrix or eroded away. We consider the local living species to be *T. anomala* and the local fossil species to be *T.* cf. *anomala*. Some fossil *Thalassina* localities contain *in situ* fossils. These beds are exposed during low tides. The fossils can be seen protruding slightly above the surface of mud bars in the mouth of the Daly River. At Kapalga Landing, South Alligator River, the concretionary nodules containing *Thalassina* occur scattered on the muddy surface exposed at low tide. However, the Shoal Bay specimens collected from the sandy beach South of Gunn Point are found several kilometres from the estuary (Hope Inlet) where a vast area of suitable habitat for the species *T. anomala* is located. Surveys of the Shoal Bay beach have revealed no likely source for them in the immediate area of their greatest abundance. The only consolidated sedimentary rocks exposed above the high water mark are beach rock and recent calcarenites that are lithologically incompatible with the fossils. The Cretaceous rocks exposed at very low water in the area are also lithologically incompatible with the mud lobster fossil matrix. Shoal Bay *Thalassina* fossils were occasionally reported to have come from visible outcrops but none of these could be verified. Concretions are secondarily deposited in crevices in the beach rock and calcarenites by wave action, along with other strand debris; providing a likely explanation for the observations. The Shoal Bay locality can therefore be narrowed down to two possible sources for the fossils: they originate from the tidal estuary of Hope inlet and are carried by strong currents to the approximate central portion of the beach or they are eroded from sediments below the low water mark to seaward of the area of their greatest abundance. Either way, their original source is equally distant as exploration of the beach on the lowest spring tides indicates the sand deposit extends at least several kilometres into Shoal Bay waters. The latter hypothesis infers a major change in the Hope Inlet-Shoal Bay shore line geomorphology, whereas the Hope Inlet source does not require elaboration.

Recently excavated drains cut through the Ludmilla mangal provided a unique opportunity to examine extensive sections through a typical muddy littoral deposit in which mudlobsters occur. We found not only the extensive burrow net-works of living mudlobsters, but *in situ* fossil *Thalassina*. Examination of the sediments in the bottom of ditches and in section along the sides gave a strong indication that hard. concretionary fossils and burrow casts *in situ* could not be distinguished stratigraphically from active burrow systems, and in many instances proved to be interconnected. Moreover, in the organic-rich, high littoral areas where the cuttings were made, the concretions encasing mud lobster fossils contained organic debris in the same, apparently very recently incorporated, state of preservation as in the surrounding, presently actively bioturbated substrate. From a geological point of view, the Ludmilla mudlobster fossils are essentially modern. The Ludmilla substrate is much coarser than the substrates represented in lower littoral fossil mudlobster sources that are only exposed at low water. This is due to a higher detrital content and more prolonged periods of exposure to the air and higher ambient temperatures at the surface which seem to encourage the formation of concretionary nodules. The high density of concretions, consisting primarily of *Thalassina* burrow casts, made excavation by shovelling extremely difficult. It is of course, possible that the occurrence of *in situ* fossil mudlobsters and their burrows along with living, actively burrowing mudlobsters is due to a previous lowering of the sea level with resultant fossilization, followed by a re-invasion of the area by mudlobsters after the sea level returned to its present level. However, the uniformity in the conditions of organic material in the fossil concretions and adjacent active burrows, and the lack of any distinctive bands of previous laterite development seem to support the probability of an ongoing, continuous process of fossilization of mudlobsters at Ludmilla swamp throughout later Holocene times to the present.The Ludmilla swamp example indicates that the majority, if not all of the mudlobster fossils are of very recent origin, probably mid-Holocene and less in age (5000 B.P.) and accounts for the lack of clearly defined stratigraphic delineations for beds containing the concretions. Their abundance and widespread distribution is also explained by the fact that they represent successive moults of numerous individuals. The fossilization process is continuous, rapid and occurs in virtually every major estuary in northern Australia. The rate of the fossilization process is indicated by the rapidity at which mangrove mud, taken from mudlobster burrows attains a concrete-like hardness. Mud samples removed from Ludmilla were gently compacted in balls of approximately 10 x 15 cm and sealed in plastic bags. These hardened to a thumbnail scratch consistency within a month, although they are less hard and have less mass by volume than the naturally occurring concretions. Iron oxide stains and incipient mineralization of the mudballs had also commenced. The natural casts and concretions differ in having formed around a nucleus of carbonate-rich material, either shells or mudlobster exoskeletons. They have also undergone *in situ* lateritization in which metallic oxides have been mobilized by the tidal fluctuations of the water table. While there is no experimental evidence other than the "mudballs" to support our observations, it seems very probable that very hard, dense concretions can develop in a matter of a few years of mineralogical transfer, recrystallization and oxidation in a carbonate rich environment with a rapidly fluc-

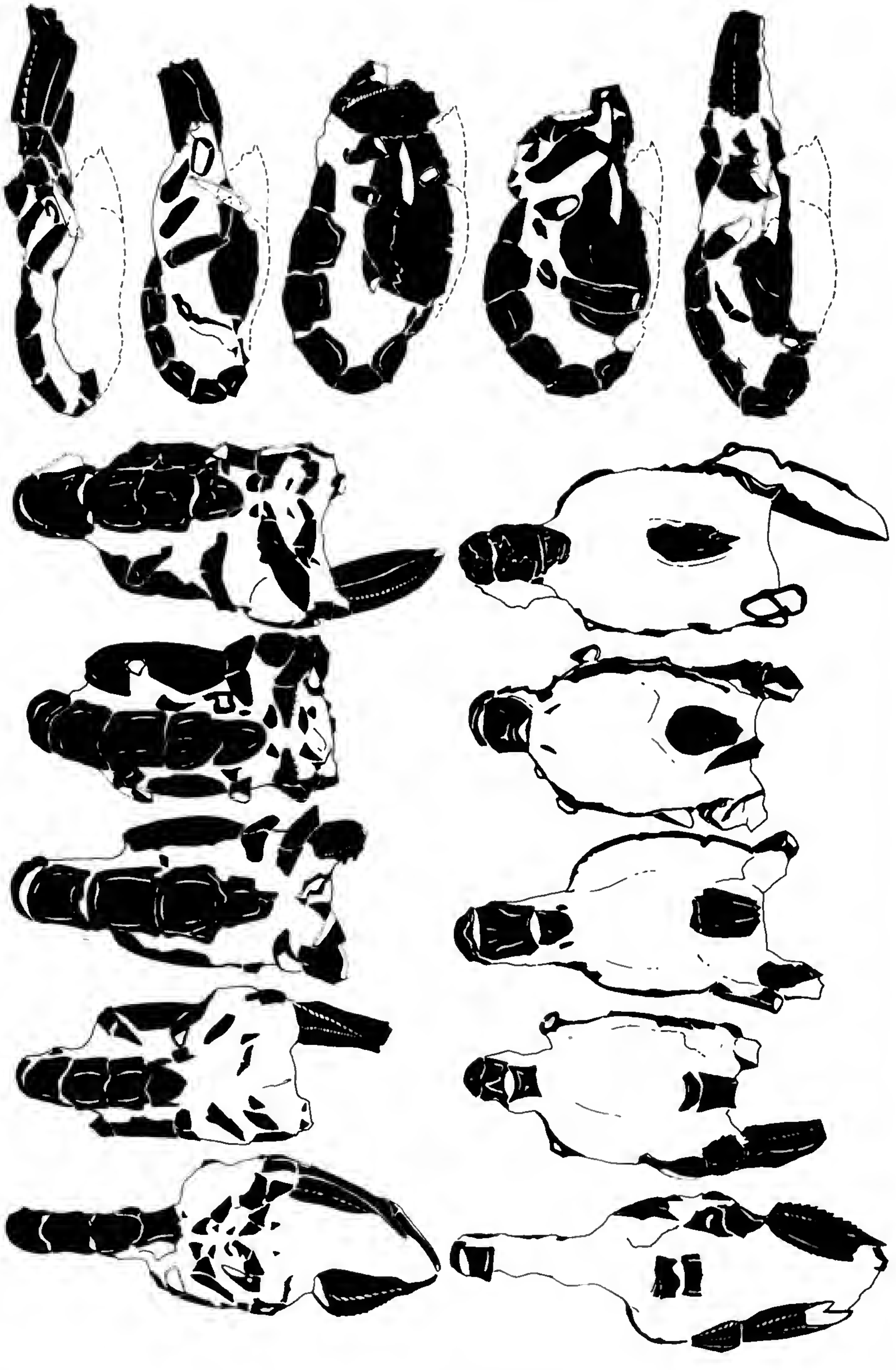


Fig. 5. A range of *Thalassina* fossils showing little variation in the relative positions of body parts. The similarity of all fossil mudlobsters configurations demonstrates the moulting process is the likely cause.

tuating water table and high water temperatures.

The Shoal Bay mudlobster fossil mode of occurrence and appearance can be explained as being the result of circumstances of fossilization similar to that of Ludmilla swamp. The source of the fossils however, is from a finer sedimentological regime nearer the low water mark than those of Ludmilla swamp. Mudlobsters moult within a chamber developed as a *cul de sac* in their burrow network. The exuviated exoskeleton forms a nucleus for the development of a concretion from the backfill of the chamber abandoned by the emergent *Thalassina*. The concretions are eventually brought to the surface of the substrate by normal bioturbation and local changes in erosional foci after which they are tumbled along an expanse of several kilometres of sea bed by strong tidal currents and washed ashore by wave action. All of the specimens from Shoal Bay beach are extensively rolled, indicating a relatively long distance of transport from their original source. If the source were immediate to their area of occurrence we would expect to find some unweathered examples, ie. if washed straight in from a subtidal source directly out from their stranded position. The difference in colouration and greater hardness of the Shoal Bay or Gunn Point mudlobster fossils is due to a process of secondary permineralization due to contact with the iron- manganese rich sediments of the local Shoal Bay sea bed that, as it is carried in solution, is attracted to the carbonate-laden concretionary material and exoskeleton. The differential colouration of the shell and matrix is directly related to the proportion of carbonates to other minerals present, resulting in a higher infiltration of oxides in the predominately carbonate exoskeleton. The iron-manganese source in the Shoal Bay area is eroded laterite material which comprises a significant fraction of the beach sand.

EVIDENCE FROM MANGROVE SWAMP DATING AND GEOMORPHOLOGY

Recent studies of mangrove swamp development in the Northern Territory coastline (Woodroffe, Thom and Chappell 1985) indicate that the formation developed from 6,500 to 7000 radiocarbon years ago, coincident with the last stage of the post glacial sea level rise. Subsequent to its initial, very extensive spread, as determined by core drilling, the mangrove swamps underwent a dramatic reduction in extent by about 5,500 years ago in response to continued sedimentation resulting in black soil plains. The present extent and pattern of mangrove facies was established in mid-Holocene times indicating that the mud-lobster fossils can be no older than about 7000 radiocarbon years if recovered *in situ* from the oldest mangrove facies, but are more likely to be younger than 5,500 years old if they are recovered from derivative deposits such as Shoal Bay beach (Gunn Point). It is unlikely the phase of mangrove swamp reduction that occurred between 7000 and 6500 years ago was solely responsible for the mudlobster fossil deposits because subsequent extensive down cutting and substantial stream channel changes would be necessary to expose the previously choked out beds. However even if the fossils could be attributed primarily to a single event of approximately 1000 years duration, their recent origin is well established.

We conclude that the mudlobster fossils are all post-Pleistocene age, no older than 7000 radio carbon years, and probably considerably younger. Because they invariably represent moulted exoskeletons, the evidence for an event based mass mortality of *Thalassina* due to increased sedimentation seems unlikely. The evidence from Ludmilla Swamp supports the proposition that the formation of *Thalassina* fossils is a continuing process, but the rate at which the concretions develop has not yet been established.

ACKNOWLEDGEMENTS

Thanks to Diana S.Jones of the Western Australian Museum for information on the distribution of mudlobsters in that State. Dirk Megirian collected fossils and provided his thoughts on the material. Dave Percival demonstrated to us that live mudlobsters could be caught on every outing using a mixture of guile, agility and foolhardiness. Lorna Watt deciphered our heiroglyphics and provided a printed manuscript.

Fig. 6. Stages in the moult of *Thalassina anomala*; **a**, rupture of cephalothorax along lineae thalassinica; **b**, posterior dorsal section of cephalothorax pivots around hepatic groove and is rotated forward and laterally by bulging out of animal's anterior end; **c**, cephalothorax is free as is major cheliped, animal struggles to free rest of legs; **d**, using legs braced against old exoskeleton animal extracts abdominal segments.

REFERENCES

Bennett, I. 1968 The Mud-lobster. *Australian Natural History* **16** (1): 22-25.

Dammerman, K.W. 1929 *Agricultural Zoology of the Malay Archipelago. The Animals injurious and beneficial to Agriculture Horticulture and Forestry in the Malay Peninsula, The Dutch East Indies and the Philippines*. De Bussy: Paris.

De Man, J.G. 1928 The Decapoda of the Siboga-Expedition. Part VII. The Thalassinidae and Callianassidae collected by the Siboga-Expedition, with some remarks on the Laomediidae. *Siboga-Expeditie* **39^a**(b): 1-87.

Etheridge, R. Jr., and McCulloch, A.R. 1916 Sub-Fossil Crustaceans from the Coasts of Australia. *Records of the Australian Museum* **11** (1): 1-14.

Gillies, M.M. 1951 *The Ecology of Mangrove Faunas*. Honours Thesis University of Queensland: Brisbane.

Herbst, J.F.W. 1799 *Versuch einer Naturgeschichte der Krabben und Krebse Volume 3*. Lange: Berlin.

Johnson, D.S. 1961 The Food and Feeding of the Mud-Lobster, *Thalassina anomala* (Herbst). *Crustaceana* **2**: 325-326.

MacNae, W. 1966 Mangroves in eastern and southern Australia. *Australian Journal of Botany* **14** (1): 67-104.

——— 1968 A general account of the fauna and flora of mangrove swamps and forests in the Indo-West Pacific region. *Advances in Marine Biology* **6**: 73-270.

Man, J.G. de 1928 see De Man, J.G.

Pearse, A.S. 1911 On the Habits of *Thalassina anomala* (Herbst). *The Philippine Journal of Science, D.* **6** (4): 213-218.

Pillai, G. 1985 The Mana, or Mangrove-lobster. *Domodomo* **3** (1): 2-10.

Rollet, B. 1981 *Bibliography on Mangrove Research* 1600-1975. UNESCO: Paris.

Sankolli, S.N. 1963 On the occurrence of *Thalassina anomala* (Herbst), a burrowing Crustacea, in Bombay waters, and its burrowing methods, *Bombay Natural History Society Journal* **60**: 600-605.

Woodroffe, C.D., Thom, B.G. and Chappell, J. 1985 Delopment of widespread mangrove swamps in mid-Holocene times in northern Australia. *Nature* **317**: 711-713.

Accepted 8 July 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 71-79

THE DENTARY OF *WAKALEO VANDERLEUERI* (THYLACOLEONIDAE: MARSUPIALIA)

D. MEGIRIAN
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

A well preserved left dentary of the thylacoleonid *Wakaleo vanderleueri* Clemens and Plane was recovered from the mid Miocene Camfield Beds (Bullock Creek local fauna) of the Northern Territory, Australia. *W. vanderleueri* is distinguished from the slightly older *W. oldfieldi* Clemens and Plane by the size of the dentary and morphology of M_2 (= M_1 in Clemens and Plane (1974)), though these differences are not extreme. These features, by analogy with the well represented Pleistocene thylacoleonid *Thylacoleo carnifex* Owen, may be too variable for distinguishing species. The enlargement of P_3 relative to M_2 suggested as a possibly diagnostic character of *W. vanderleueri* by Clemens and Plane (1974) is confirmed. Additional diagnostic features in the posterior region of the dentary are present in the new specimen and are believed to reflect a refinement in the jaw musculature for a shearing function in the cheek teeth and a modification for an increased gape in the jaws.

KEYWORDS: Miocene, Thylacoleonidae, *Wakaleo*, dentary, functional morphology, taxonomy.

INTRODUCTION

The Thylacoleonidae, with their unusual dentitions, have fascinated palaeontologists since the discovery of *Thylacoleo carnifex* Owen in the 1830's (Finch 1982). The function of the teeth, diet and behaviour of *T. carnifex* were the subject of, at times, vigorous debate in the years following discovery. The various interpretations have been reviewed by Finch (1982) and Wells *et al.* (1982). More detailed studies (e.g. Wells and Nichol (1977), Finch and Freedman (1982), Wells *et al.* (1982), Archer and Dawson (1982)) were not possible until the accumulation of sufficient cranial and post-cranial elements.

Two genera and eight species of thylacoleonids are now recognized (Archer and Dawson 1982). *Thylacoleo* Gervais is known from the Pliocene and Pleistocene, though *T. hilli* Pledge may have occurred in the late Miocene (Pledge 1975), while *Wakaleo* Clemens and Plane is known from the middle and late Miocene. Clemens and Plane (1974) and Archer and Rich (1982) do not consider *Wakaleo* to be directly ancestral to *Thylacoleo* and the phylogenetic relationships of the family are obscure.

Two species of *Wakaleo* are known from the mid Miocene of Australia. *W. vanderleueri* Clemens and Plane was collected from the Camfield Beds (Bullock Creek local fauna) of the Northern Territory and *W. oldfieldi* Clemens and Plane was recovered from the slightly older Wipajiri Formation (Kutjamarpu local fauna) of South Australia. *W. vanderleueri* is thought to be a direct descendant of *W. oldfieldi*. (See Woodburne *et al.* (1985) for a recent review of the continental mammal record of Australia). Both species were described from their incomplete lower dentitions and are distinguished primarily by size of the dentary and morphology of M_2 (= M_1 in Clemens and Plane (1974), Archer (1978)). These differences are not extreme. There are too few data available to demonstrate whether or not the diagnostic characters of the two species overlap due to intraspecific variability.

A well preserved left dentary of *W. vanderleueri* was recovered from the type locality during the joint Northern Territory Museum/Museum of Victoria field expedition of 1985. The skull of *W. vanderleueri* recovered from Bullock Creek by M. Plane (description in prep; P.F. Murray pers. comm.) and the dentary fit closely when articulated suggesting the two elements represent the same individual. The M_2 of the new specimen is too worn and poorly preserved to add substantially to our knowledge of this tooth. Clemens and Plane (1974)

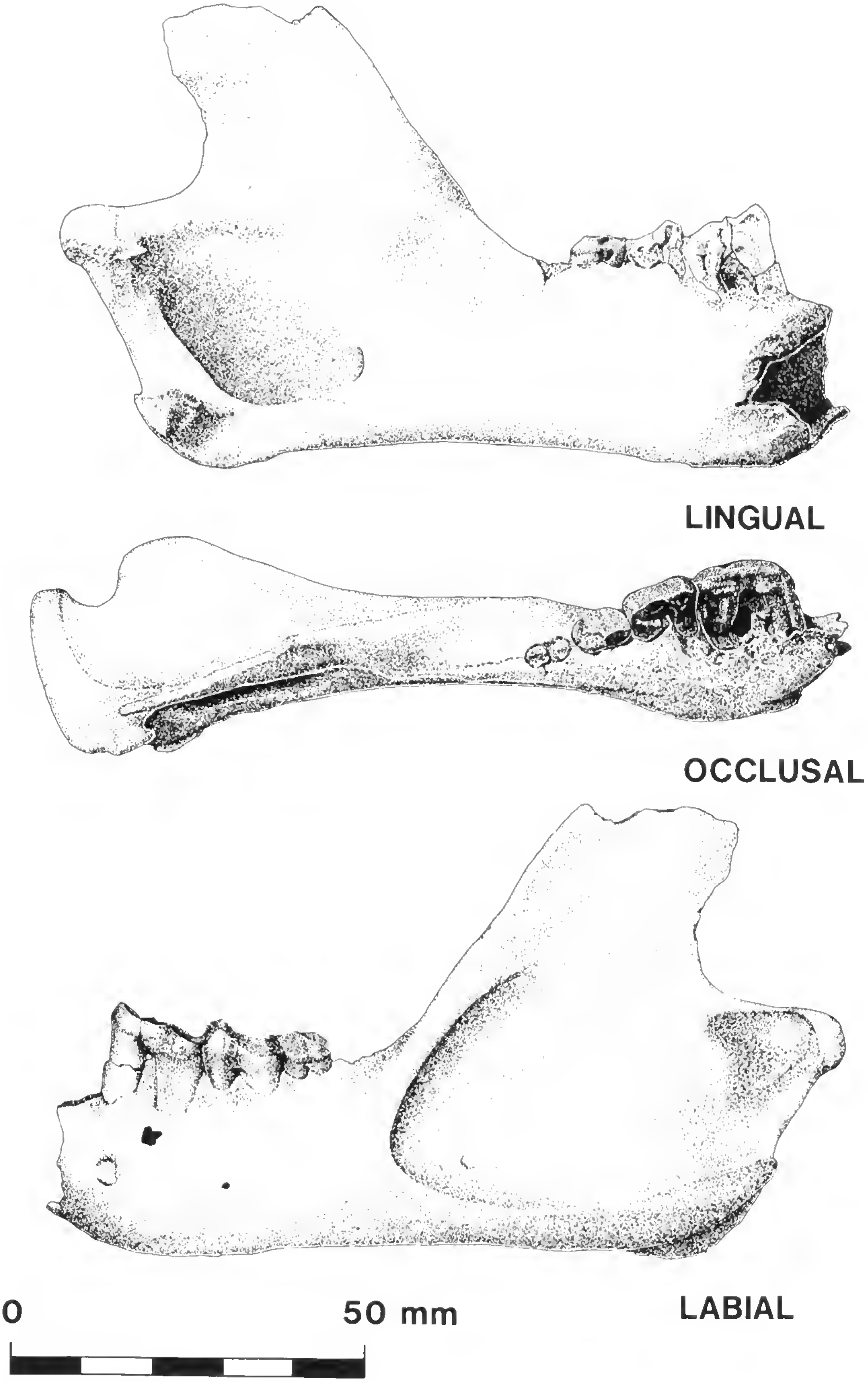


Fig. 1. Lingual, occlusal and labial views of the dentary of *Wakaleo vanderleueri* (NTM P85553-4).

suggested the absolute enlargement of P_3 and its enlargement relative to M_2 in *W. vanderleuri* as a possible diagnostic character. The enlargement relative to M_2 is confirmed in the new specimen but it is not certain with so few data whether the absolute size of P_3 differs significantly between the species. Additional diagnostic differences in the posterior region of the dentary are present on the new specimen.

W. alcootaensis Archer and Rich from the late Miocene Waite Formation (Alcoota local fauna) of the Northern Territory is the only other *Wakaleo* described and is known from a maxillary fragment.

Woodburne *et al.* (1985) drew attention to a growing chronologic utility of thylacoleonids but descriptions of few specimens from the Miocene have been published. Accordingly a description of the new fossil is presented here.

Table 1 contains brief descriptions and catalogue numbers of comparable specimens studied by Clemens and Plane (1974). Prefixes to catalogue numbers are as follows: CPC Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra; NTM Northern Territory Museum; SAM South Australian Museum; UCMP Museum of Paleontology, University of California, Berkely.

DESCRIPTION AND COMPARISONS

The new dentary (NTM P85553-4) was recovered from a limestone block using acetic acid. The teeth and the lingual side of the horizontal ramus lay on the exposed surface of the block and were damaged by weathering (Fig. 1). Alveoli only are present for I_1 and a small single rooted tooth between I_1 and P_3; P_3 and M_2 have split vertically along their midline leaving only their labial halves intact; M_3 is undamaged while only the roots of M_4 are present. The buccal side and posterior region of the dentary were protected by limestone. Slight damage to the angular process and the extremity of the coronoid process may be attributed to post-mortem breakage before preservation.

The dentary (excluding the teeth) is described relative to that of *W. oldfieldi* (SAM P17925). The NTM specimen is slightly larger and more robust (Fig. 2). The masseteric fossa is shallower and rather than having a simple labially concave area of insertion for the deep masseter, the posterior region is flexed lingually, confluent with a deep antecondylar fossa. A small (2 mm diameter) masseteric foramen near the anterior angle of the masseteric fossa has no apparent homologue in a cast of SAM P17925, nor does it appear in Clemens and Plane (1974). The pterygoid fossa is proportionally larger and is partially enclosed in the posterior region by a strut linking the base of the angular process to the base of the condyle. The reinforcement provides a robust base for the strongly inflected angular process. The restored coronoid process sweeps posteriorly to form a relatively deep mandibular notch. The thickened anterior edge of the ascending ramus expresses a slightly convex lateral profile in contrast to the slightly concave anterior coronoid profile of *W. oldfieldi* . The gonial angle of the new specimen (Fig. 2) is greater and consequently the condyle is positioned more posteriorly than that of *W. oldfieldi*. A prominent fossa inferior to the posterior margin of the condyle accomodated the postglenoid process when the jaws were at full gape. This subcondylar fossa is poorly developed in *W. oldfieldi* and its presence in NTM P85553-4 reflects a functional modification in the dentary for an increased gape. The horizontal ramus is deeper and more robust in cross section than *W. oldfieldi*, with a thicker, straighter inferior border and more clearly defined digastric fossa. The post alveolar shelf is terminated posteriorly by a prominent swelling on the lingual side of the coronoid process.

When the skull of *W. vanderleueri* and the new dentary are articulated it is evident that I_1 must have significantly longer than that of *W. oldfieldi* for the incisors to occlude. The inferred proportions of I_1 are shown in Fig. 2. A plan of the cheek teeth of NTM P85553-4 and measurements are shown in Fig. 3. Comparisons of crown morphology are made difficult by the very advanced stage of wear in the new fossil and the generally poor overlap in material. NTM P85553-4 appears to retain a small alveolus for a single rooted premolar immediately distal to I_1 alveolus. The tooth was probably button-like and protected the gum between I_1 and P_3. Only the labial half of P_3 is preserved. Two ventrolabially sloping wear facets are pre-

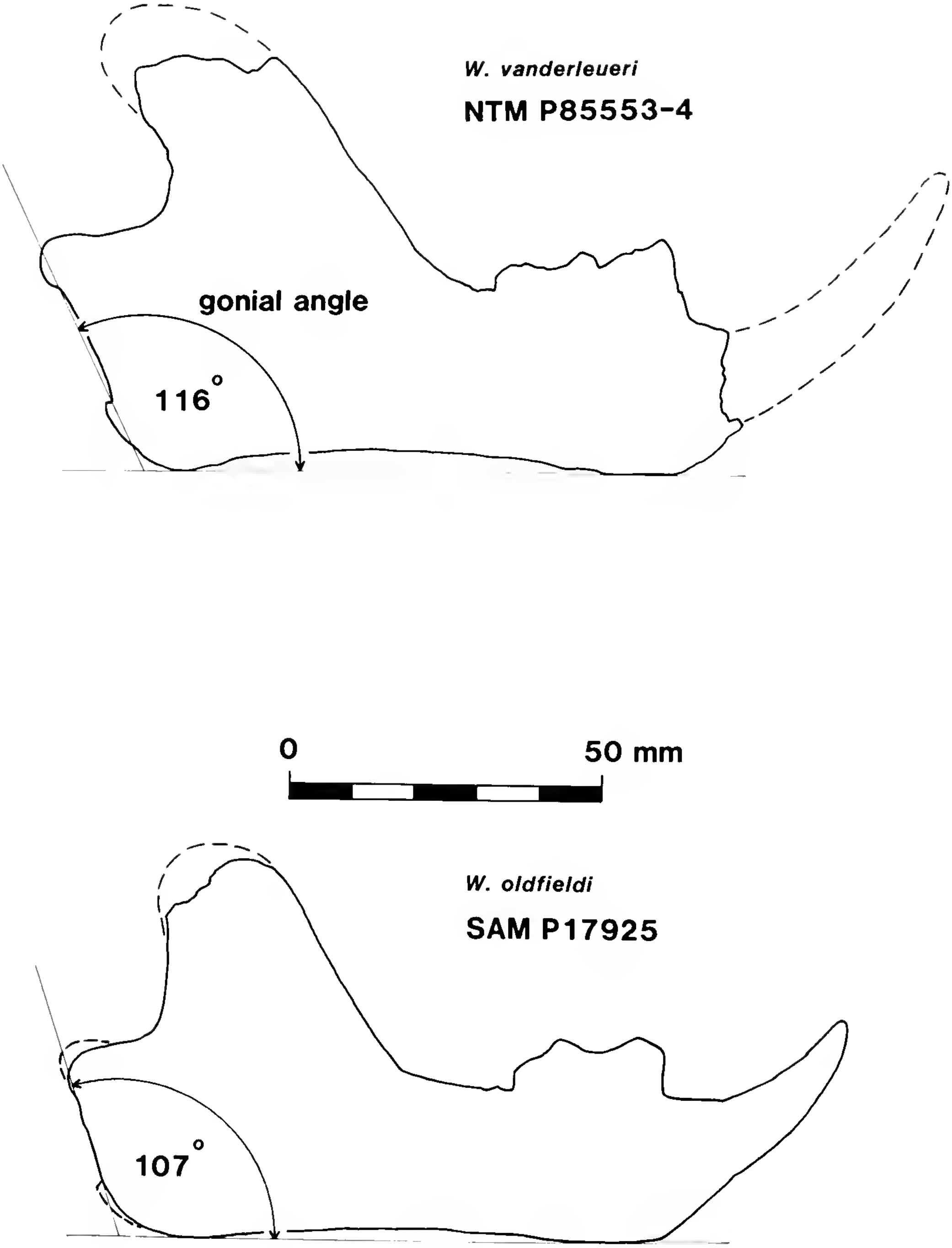


Fig. 2. Partially restored lingual silhouettes of *Wakaleo vanderleueri* (NTM P85553-4) and *W. oldfieldi* (SAM P17925).

sent. The anterior facet, extending from the anterior cusp to a point over the middle of the posterior root, is gently arcuate when viewed from the labial side. Distally a notch-like facet extends posteriorly from the middle of the posterior root across the posterior margin of P_3 and continues onto the anterior portion of M_2. A single elongated arcuate facet is developed on the P_3 of *W. oldfieldi*. The notch-like facet of NTM P85553-4 accomodated the posterior cusp of P^3 and is probably only present in aged individuals. Apart from age-related wear facet development and proportional differences discussed elsewhere, the P_3 crown morphology does not appear to differ significantly from that of *W. oldfieldi*.

In the NTM specimen the lingual half of M_2 has broken away and tooth wear is far more advanced than in SAM P17925 and CPC 13527. The relative development of the anterior and labial ridges descending from the apical cusp (metaconid) were cited by Clemens and Plane (1974) as diagnostic characters separating *W. oldfieldi* and *W. vanderleueri*. The M_2 has split on or near the anterior ridge and the labial ridge is completely worn away. Slight irregularities on the labial side of the crown are the only indications that a labial ridge may have been present. The talonid basin is also largely worn away with only a remnant near the posterior margin of the tooth remaining. Four wear facets are present. The anterior one is a continuation of the posterior facet on P_3. A small concave facet occupies the antero-labial side of the trigonid while the dominant facet extending postero-labially from the apical cusp swings posteriorly across the labial side of the talonid, almost to the posterior margin of the tooth. A small facet bridges M_2 and M_3. All facets are directed ventro-labially.

The M_3 crown is more worn than UCMP 102677. The elevation of the apical cusp has been markedly reduced by wear and there is no sign of an apical basin. The talonid basin is reduced to a small area lingual of the midline of the talonid. As a result of wear, a ridge runs anteroposteriorly across the trigonid close to the lingual margin. It is continued posteriorly by the lingual rim of the talonid basin. Two small cuspids are developed on the ridge over the trigonid. A single wear facet is present lingual to the ridge. It plunges postero-lingually from the anterior margin of the tooth to a point over the anterior edge of the posterior root. The remaining facets slope ventrolabially. One covers the labial slope of the trigonid and three smaller ones cover the talonid. The most posterior facet was probably continued on M_4.

The overall pattern of facets along the tooth tow is reminiscent of a blade from a set of pinking shears. The facets and their contacts comprise a series of ridges and troughs, sub-parallel and sloping ventrolabially. This pattern was probably continued on M_4, in which case the entire molar row and P_3 were involved in shearing. The tooth row has a marked torsion so that the angle of the facets decreases posteriorly relative to a vertical antero-posterior plane through the dentary. However, the angle relative to the vertical axes of the roots is fairly constant at about 65°.

Comparisons of tooth dimensions are given in Table 2 though proportional differences are clearer in plans of the various tooth rows (Fig. 3). NTM P85553-4 is most likely a smaller individual than CPC 13527, and differs from *W. oldfieldi* in a proportional reduction in the width of the tooth row and the relatively greater length of P_3.

DISCUSSION

Clemens and Plane (1974) distinguished *W. oldfieldi* and *W. vanderleueri* by the size of the molars and dentary bones, morphological differences in M_2 and the possible proportional enlargement of P_3 in *W. vanderleueri*. These differences are not extreme. The geographical separation of the type localities and the apparent difference in age were cited as further justification for the recognition of two species.

The Pleistocene *T. carnifex* is the only thylacoleonid sufficiently represented to allow a statistical analysis of tooth, skull and mandible measurements. Archer and Dawson (1982) found large differences in the size of skulls and mandibles but a uniformity in tooth size. Skull and mandible size was not attributable to allometric changes with increased age of individuals. Finch and Freedman (1982) found no evidence from measurements of P_3 of sexual dimorphism. The morphology of P_3 was one feature used to distinguish the early to middle Pliocene *T. crassidentatus* Bartholomai from *T. carnifex* (Bartholomai 1962). Apparently significant features on P_3 in small samples of *T. crassidentatus* appear to be variably expressed in large samples of *T. carnifex* (Archer and Dawson 1982). These include the extent of mid-crown thickening, the width of the posterior part of the tooth and the extent of vertical transverse crest development leading away from the main cusp.

If *Thylacoleo* is a valid analogue of *Wakaleo* the diagnostic features used by Clemens and Plane (1974) may be too variable for distinguishing the known mid Miocene species, particularly from isolated teeth. The new dentary has dental measurements that differ in some respects from both the holotypes and referred specimens of *W. oldfieldi* and *W. vanderleueri* and damage to the M_2 and advanced tooth wear preclude the recognition of diagnostic morphological features. It does, however, show a proportional increase in the length of P_3 relative to M_2. It is not yet possible to determine whether the absolute size of P_3 differs significantly between *W. oldfieldi* and *W. vanderleueri*. Substantial differences in the posterior region of the dentary and the reduced width of M_3 indicate it does not represent *W. oldfieldi* but conspecificity with *W. vanderleueri* is harder to demonstrate. The NTM specimen is assigned to *W. vanderleueri* on the basis of the relative enlargement of P_3 and its recovery from the type locality. There is no clear stratigraphic evidence of a temporal range at the type locality so CPC 13527 and NTM P85553-4 are, geologically speaking, considered contemporaneous. The erection of a new species is not justified.

It is apparent in the new dentary that evolutionary changes from *W. oldfieldi* to *W. vanderleueri* are more marked in the morphology of the posterior region of the dentary than they are in the cheek teeth. The differences in this region may best be explained as a reflection of a refinement in the jaw musculature for a shearing function in the teeth and an anisometric modification to compensate for the probably greater length of I_1.

Wells *et al.* (1982) found that *T. carnifex* retained essentially phalangerid jaw mechanics in association with a sectorial dentition. In *T. carnifex* the incisors are adapted for stabbing or piercing food and require a simple, though powerful, hinge-like closure of the jaws over a wide range of angles. The shearing cheek teeth begin to function when the jaws are almost closed. Shearing requires continuous unilateral pressure on the occluding teeth and hence some lateral movement at the hinge and a corresponding medial shift of the mandible. The shearing teeth on one side are thought to have been brought into occlusion by contraction of the deep masseter and the pterygoid complex on the balancing side. Lateral pressure on the shearing teeth may have been provided by a labial longitudinal rotation of the dentary produced by contraction of the superficial pterygoid on the occluding side. This motion requires a flexible symphysis otherwise disarticulation of the balancing dentary would occur. *T. carnifex* has an exceptionally well developed angular process which would provide a substantial base for the insertion of the superficial pterygoid. Wells *et al.* (1982) showed that the shearing blade in *T. carnifex* was positioned within the zone of the maximum bite force of Greaves (1978) for an animal using both occluding and balancing side articulation and musculature for application of the force.

The dentaries of *W. oldfieldi* and *W. vanderleueri* are similar enough to that of *T. carnifex* to indicate a stabbing and shearing function in the teeth.

The robust dentary of *W. vanderleueri* indicates a proportional increase in the masticatory musculature in its evolution from *W. oldfieldi*. The larger angular process and

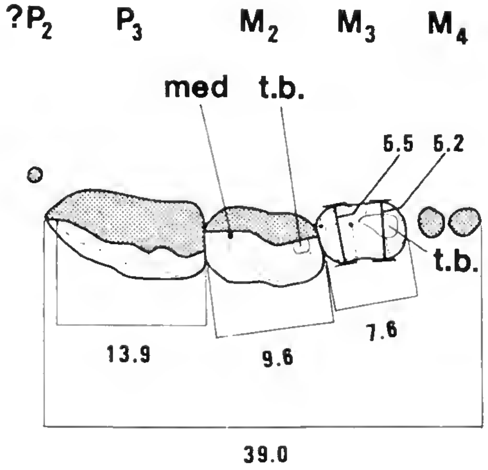


Fig. 3. Plan on the tooth row of NTM P85553-4. Dimensions in mm. Abbreviations: **med**, metaconid; **t.b.**, talonid basin.

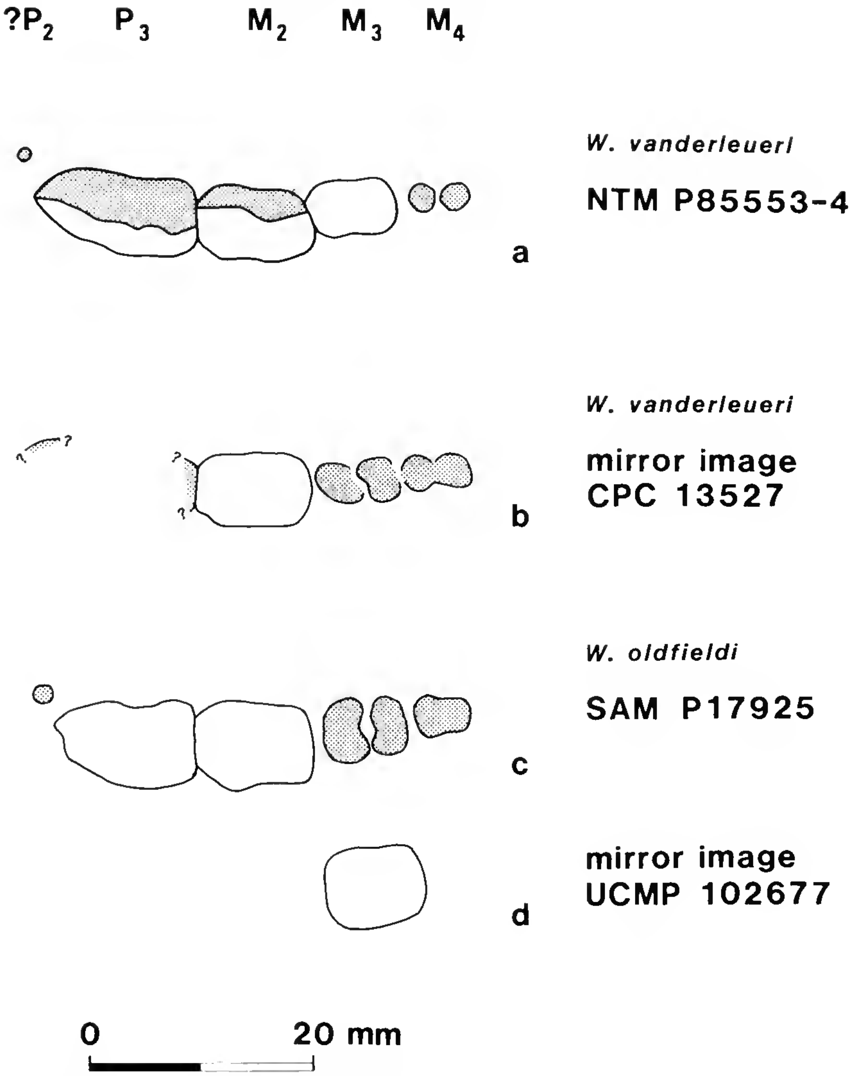


Fig. 4. Comparison of the tooth rows of various speeimens of *Wakaleo*: **a**, prepared from original; **b**, **d**, after Clemens and Plane (1974); **c**, prepared from cast.

modified pterygoid fossa may reflect modification of the pterygoid complex in *W. vanderleueri* for more effective labial rotation of the occluding dentary and medial shift of the mandible during shearing. Additional control may have been provided by insertion of part of the masseter into the ante-condylar fossa. Posterior displacement of the dentary during shearing of a resistant substrate (Wells *et al.* 1982) may also have been resisted by this fibre group, particularly if its line of action had an antero-posterior component.

By articulating the new dentary with the skull of *W. vanderleueri* it is evident that the incisors could only have occluded if I_1 was significantly longer than that of *W. oldfieldi*. An increased length of I_1 without a compensatory modification for increasing the angle of the jaws at full gape would result in reduced clearance between the upper and lower incisors. In *W. vanderleueri* an increased gape in the jaws has been achieved by an increase in the gonial angle and the development of a subcondylar fossa which accommodated the postglenoid process at full gape. Reduction of the width of the tooth row and relative enlargement of P_3 in *W. vanderleueri* can be interpreted as the evolutionary trend in thylacoleonids for a shearing function in the teeth derived from a presumed quadritubercular ancestor (Archer and Rich 1982) with grinding molars. Using the geometrical model of Greaves (1978) the area of maximum bite force in *W. oldfieldi* and *W. vanderleueri* includes both P_3 and M_2.

Archer and Rich (1982) identify the specialized loss of the two upper and lower anterior premolars as a diagnostic character state for *Wakaleo*. *W. alcootaensis* shows no evidence for P^{1-2} but the available specimens indicate that in the mid Miocene at least, *Wakaleo* retained one of the lower two premolars. The presence of absence of this tooth does not alter the current understanding, as outlined by Archer and Rich (1982), of the phylogenetic separation of *Wakaleo* and *Thylacoleo*.

CONCLUSIONS

Additional diagnostic characters for *W. vanderleueri* are recognized in the posterior region of the new dentary. They are the presence of a deep antecondylar fossa which is an elaboration of the masseteric fossa; a prominent fossa ventral to the posterior margin of the condyle; reinforcing of the base of the condyle and angular process by a strut resulting in the partial enclosure of the posterior part of the pterygoid fossa. These features are believed to reflect the specialization of the jaw musculature for a shearing function in the teeth and a modification in the dentary to compensate for the inferred greater length of I_1 relative to that of *W. oldfieldi*. Specimens described so far indicate morphological and proportional differences in

Table 1. Comparable material described by Clemens and Plane (1974)

Taxon	*Catalogue Number*	*Description*
W. oldfieldi	SAM P17925	Left dentary retaining I_1, P_3, M_2 alveoli for M_3, M_4 and a single rooted tooth between I_1 and P_3. I_1, P_3 and M_2 show early stages of wear
	UCMP 102678	Isolated fragment of anterior half, right P_3.
	UCMP 102677	Isolated right M_3 showing advanced stages of wear and post-mortem breakage.
W. vanderleueri	CPC 13527	Right dentary fragment retaining M_2, alveoli for M_3 and M_4 and part of the alveolus of I_1. M_2 shows only the earliest stages of wear.

Dental terminology follows Archer (1978). M_2, M_3 and M_4 are referred to as M_1, M_2 and M_3 respectively in Clemens and Plane (1974).

Table 2. Dental dimensions (in mm) of speciments of *Wakaleo*.

	W. vanderleueri		*W. oldfieldi*	
	NTM P85553-4	CPC 13527 (After Clemens and Plane 1974)	SAM P17925	UCMP 102677 (After Clemens and Plane 1974)
P_3 Length	13.9+	13.5-15.3	12.4	
Width (over anterior root)	—	—	6.2	
Width (over posterior root)	—	—	7.8	
M_2 Length	9.6	11.7	10.4	
Width (Trigonid)	—	7.9+	8.7	
Width (Talonid)	—	7.7	7.2	
M_3 Length	7.6			7.5
Width (Trigonid)	5.5			6.3
Width (Talonid)	5.2			6.1
$M_{3\text{-}4}$				
Total length of alveoli	13.9	14.5	13.7	

the cheek teeth between *W. oldfieldi* and *W. vanderleuri* are subtle. The relative to M_2 enlargement of P_3 in *W. vanderleueri* is confirmed in NTM P85553-4 but it is not yet possible to determine whether the absolute size of P_3 differs significantly between *W. oldfieldi* and *W. vanderleueri*. This was cited as a possibly diagnostic feature by Clemens and Plane (1974). The cheek teeth of *W. vanderleueri* are proportionally narrower than those of *W. oldfieldi*. This follows the evolutionary trend of a shearing specialization in the teeth of thylacoleonids and was derived from a presumed quadritubercular ancestor (Archer and Rich 1982) with grinding molars.

ACKNOWLEDGEMENTS

This work was supported by a National Estate Program Grant. I am indebted to Peter Murray for valuable discussions and for useful criticism of an early draft of this paper. Michael Archer kindly loaned casts of relevant material and Karl Roth, Ian Archibald and Jens Pederson of the Northern Territory Museum provided valuable assistance in the field.

REFERENCES

Archer, M. 1978 The nature of the molar-premolar boundary in marsupials and a reinterpretation of the homology of marsupial cheekteeth. *Memoirs of the Queensland Museum* **18**: 157-164.

Archer, M. and Dawson, L. 1982 Revision of marsupial lions of the genus *Thylacoleo* Gervais (Thylacoleonidae, Marsupialia) and thylacoleonid evolution in the late Cainozoic. In: M. Archer (ed) *Carnivorous Marsupials*. Royal Zoological Society of New South Wales: Sydney.

Archer, M. and Rich, T.H. 1982 Results of the Ray E. Lemley expeditions. *Wakaleo alcootaensis* n.sp. (Thylacoleonidae, Marsupialia). A new marsupial from the Miocene of the Northern Territory with a consideration of early radiation in the family. In: M. Archer (ed) *Carnivorous Marsupials*. Royal Zoological Society of New South Wales: Sydney.

Bartholomai, A. 1962 A new species of *Thylacoleo* and notes on some caudal vertebrae of *Palorchestes azeal*. *Memoirs of the Queensland Museum* **14**: 33-46.

Clemens, W.A. and Plane, M. 1974 Mid-Tertiary Thylacoleonidae (Marsupialia, Mammalia). *Journal of Paleontology* **48**(4): 652-600.

Finch, M.E. 1982 The discovery and interpretation of *Thylacoleo carnifex* (Thylacoleonidae, Marsupialia). In: M. Archer (ed) *Carnivorous Marsupials*. Royal Zoological Society of New South Wales: Sydney.

Finch, M.E. and Freedman, L. 1982 An odontometric study of the species of *Thylacoleo* (Thylacoleonidae Marsupialia). In: M. Archer (ed) *Carnivorous Marsupials*. Royal Zoological Society of New South Wales: Sydney.

Greaves, W.S. 1978 The jaw lever system in ungulates: a new model. *Journal of Zoology, London* **184**: 271-285.

Pledge, Neville. S. 1975 A new species of *Thylacoleo* (Marsupialia: Thylacoleonidae) with notes on the occurrences and distribution of Thylacoleonidae in South Australia. *Records of the South Australian Museum* **17**(6): 261-267.

Wells, R.T. and Nichol, B. 1977 On the manus and pes of *Thylacoleo carnifex* Owen (Marsupialia). *Transactions of the Royal Society of South Australia* **101**: 139-46.

Wells, R.T., Horton, D.R. and Rogers, P. 1982 *Thylacoleo carnifex* Owen (Thylacoleonidae, Marsupialia): marsupial carnivore? In: M. Archer (ed) *Carnivorous marsupials* Royal Zoological Society of New South Wales: Sydney.

Woodburne, M.O., Tedford, R.H., Archer, M., Turnbull, W.D., Plane, M.D. and Lundelius, E.L. 1985 Biochronology of the continental mammal record of Australia and New Guinea. *Special Publication of the South Australian Department of Mines and Energy* **5**: 347-363.

Accepted 11 July 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 81-93

AN UNUSUAL LEAF-LIKE GORGONIAN (COELENTERATA: OCTOCORALLIA) FROM THE GREAT BARRIER REEF, AUSTRALIA

PHILIP ALDERSLADE
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

A leaf-like gorgonian, *Hicksonella expansa* sp. nov. from the family Gorgoniidae is described and illustrated, and a comparison made with *H. princeps* Nutting, 1910, the only other known species of the genus. *H. expansa* has a very variable colony morphology and is the first leaf-like gorgonian known from the Indo-Pacific Region.

KEYWORDS: Gorgonian, Hicksonella, Coelenterata, Octocorallia, Australia.

INTRODUCTION

There are only a few species of holaxonia with more-or -less expanded coenenchyme, and they have been found only within the family Gorgoniidae. *Phycogorgia* Milne Edwards and Haime, 1850, *Phyllogorgia* Milne Edwards and Haime, 1850, and to a lesser extent *Pseudopterogorgia* Kukenthal, 1919, show this feature (Bayer 1956, 1961). These genera are reported from Chile, Brazil and the West Indies-Florida area respectively. There are very few Gorgoniidae known from waters other than those of the Americas and the West Indies. Those that are known are Indo-Pacific taxa. Species of *Rumphella* Bayer, 1955, and *Hicksonella* Nutting, 1910, previously classified with the Plexauridae but assigned to the Gorgoniidae by Bayer (1981), and some species of *Pseudopterogorgia* make up the group. *Hicksonella expansa* sp.nov., described below, adds another species to this short list and is the first leaf-like gorgonian known from this area.

The species was first discovered by Dr Zena Dinesen whilst on the staff of the Australian Institute of Marine Sciences, Townsville. Requests to Dr Dinesen and another colleague, Dr John Coll, Chemistry Department, James Cook University, Townsville, to look out for more material resulted in 6 more specimens being located. A seventh, amongst a collection of unidentified sponges in the Queensland Museum, was brought to my attention by Mr John Hooper of the Northern Territory Museum.

Abbreviations: NTM Northern Territory Museum of Arts and Sciences, Darwin; QM Queensland Museum, Brisbane.

SYSTEMATICS

Hicksonella expansa sp.nov.
(Figs 1-11)

Type material. All material was collected from the Great Barrier Reef, Australia. HOLOTYPE - NTM C4170, Flinders Reef (South), 17°37'S 148°31'E, 21 November 1981, 30 m depth, Z. Dinesen. PARATYPES - USNM 76294, NTM C4174, same data as for holotype; NTM C4168, Lizard Island, 14°40'S, 145°28'E, 18 August 1981, 7 m depth, J. Coll; NTM C4171, NTM C4172, Davies Reef, 18°55'S, 147°39'E, 3 March 1982, 12 m depth, Z. Dinesen; NTM C4173, John Brewer Reef, 18°37'S, 147°04'E, 8 February 1981, 10 m depth, Z. Dinesen; QM GL2742, Stanley Reef, 19°17'S, 148°08'E, 15 October 1981, 10-15 m depth, A. Kay.

Diagnosis. Colonies flabellate. Axis with a narrow core and no loculation. Coenenchyme discontinuously expanded over irregular pinnate ramifications producing laciniated leaf-like specimens. Sclerites of the surface layer, occasionally heavily warted and occasionally poorly differentiated, are predominantly wart clubs with a central wart and a whorl of 3 large warts in the club head. Sclerites of the subsurface layer are mostly warty spindles, sometimes with a waist, sometimes densely sculptured, sometimes with thorny warts. Amongst these sclerites

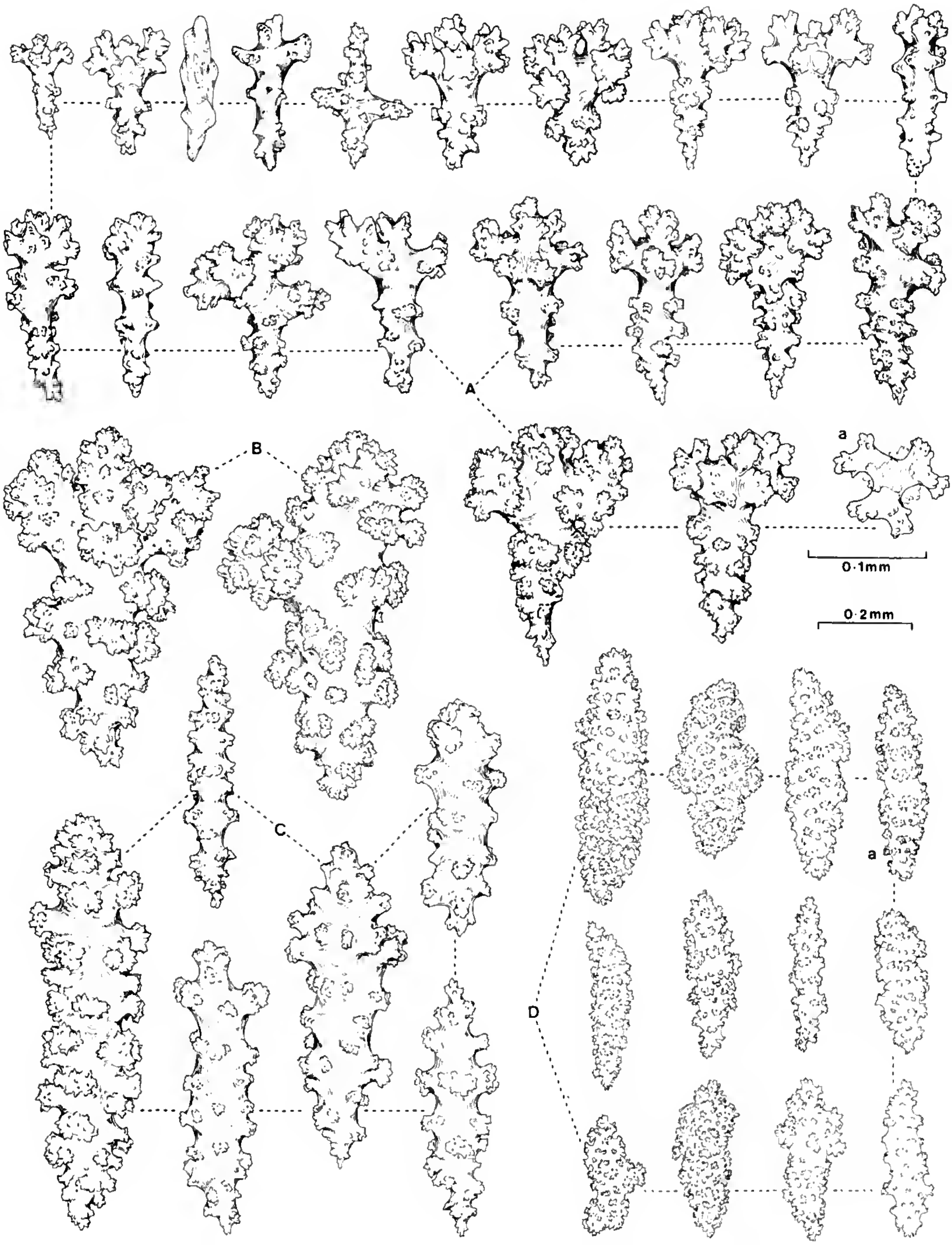


Fig. 1. *Hicksonella expansa* holotype: **A**, sclerites from the surface layer; **B-D**, sclerites from the subsurface layer. **A-C**, 0.1 mm scale; **D**, 0.2 mm scale.

are scattered large smooth-shafted rods with warty handles, characteristic of the genus. Coenenchyme next to the axis with small rods and spindles often with warts in whorls. Polyps armed with flattened, sometimes scale - like, rodlets, and totally retractile into the general coenenchyme.

Description. The flabellate holotype (Fig. 7A) is ramified in one plane producing a laciniated leaf-like appearance. The purely horny axis is circular in section with a narrow cross chambered core and no loculation. The mode of axial branching is irregularly pinnate with occasional anastomoses. Branching occurs to the 6th order. The nature of the branching is partly masked by the expanded coenenchyme which grows web-like between the branches. The web is not continuous and is perforated by a number of irregularly shaped holes. Figure 11 shows the holotype and several paratypes photographed using back-lighting to silhouette the axial ramifications. The general aspect of the colony resembles that of the Brazilian gorgoniid *Phyllogorgia dilatata* (Esper) (see Bayer 1961).

The colony is 27.5 cms high and 26 cms across, and has a small holdfast 24 mm across. The coenenchyme is variable in thickness. It covers the larger branches to a depth of about 0.7 mm. In the thinnest web areas the total thickness is still of this order. In terminal twigs, however, where the axis may only be 0.15 mm in diameter the total branch width may be 3 mm.

The polyps are completely retracted, very small, and irregularly distributed over both faces of the colony. For the most part the

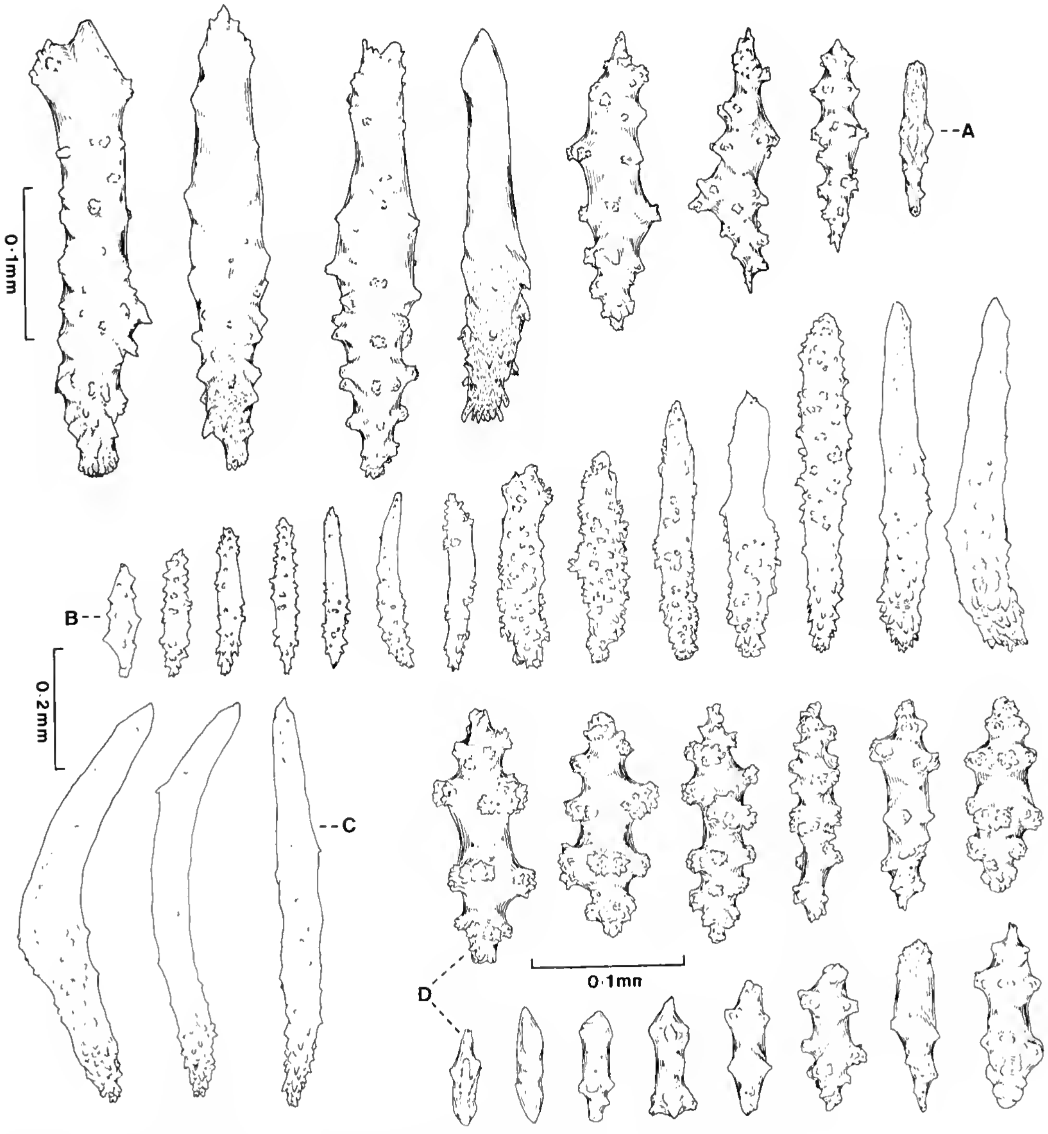


Fig. 2. *Hicksonella expansa* holotype: **A-B**, coenenchymal rods and probable developmental stages; **C**, coenenchymal rods; **D**, sclerites from the coenenchyme next to the axis.

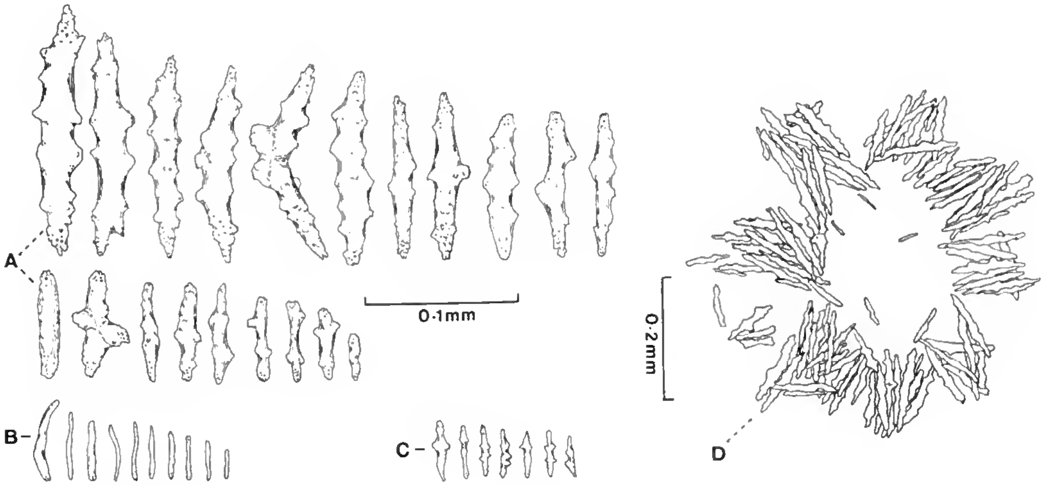


Fig. 3. *Hicksonella expansa* holotype: **A**, anthocodial sclerites; **B-C**, sclerites from the tentacles; **D**, arrangement of anthocodial sclerites.

polyps appear as minute apertures in the coenenchyme 0.18 mm to 0.42 mm in diameter. However, a number of polyp apertures are raised on small calicular domes which may be 1 mm high. These domes are usually restricted to areas of the coenenchyme covering the larger branches and branchlets and seem correlated with the depth of the coenchyme in these zones. The polyps on one face of the colony are spaced approximately 0.8 mm to 2.1 mm apart. On the opposing face the density is somewhat less with polyps being up to 6 mm apart on the larger branches. Apart from polyp domes, where no specialised calicular sclerites occur, and the rounded ridges above the axial ramifications, the coenenchyme is quite flat and smooth. The colour of the colony in spirit is pale yellowish white.

The sclerites of the surface layer (Fig. 1A) are predominantly wart clubs, up to 0.08 mm in length, occasionally larger, with a central apical wart. Characteristically there is a whorl of 3 large warts, somewhat bifurcated, in the club head. One such club has been drawn viewed end-on from the handle (Fig. 1Aa). A few crosses and some clubs with poorly differentiated heads also occur.

Below the layer of clubs the sclerites are warty spindles up to 0.55 mm in length (Fig. 1C,D). There is little regularity is size or density of warting or in overall sclerite shape as can be seen in the small scale drawings Fig. 1D. Occasionally club-like forms (Fig. 1B) and crosses are also found. Some of the spindles have a waist, as in Fig. 1Da.

The layer of coenenchyme immediately next to the axis contains small rods and spindles 0.05 mm to 0.15 mm long, often with warts in girdles (Fig. 2D).

Peculiar to the genus is the presence of large, straight or curved, rod-shaped to spindle-shaped sclerites with a characteristic short warty or thorny handle and a long, predominantly smooth, shaft (Fig. 2C). The distribution of these forms in the holotype follows no detectable pattern. They are not common and many sclerite samples will fail to detect them. If the colony surface is viewed under a low power microscope, areas will be found where the surface sclerite layer is thin and clubs are scarce. The spindles of the lower layer predominate here showing up as glassy bodies in the sugary looking surface. Sampling of these areas occasionally revealed this unusual sclerite type as did the calyces. Associated with the more classical form of the sclerite, which reaches 0.6 mm in length, there are also found numerous variations and smaller probable developmental stages (Fig. 2A, B) which are recognisably different from the warty spindles typical of this layer.

The spiculation of the polyps is typical of the family with the tentacle bases being armoured with numerous flattened rodlets 0.026 to 0.150 mm in length (Fig. 3A). Nearly all of the polyps are tightly contracted measuring only 0.3 mm in diameter. The arrangement of the sclerites is far from obvious in these forms and a rare more expanded polyp, 0.5 mm across, was used for Fig. 3D. The tentacles contain minute rodlets 0.017 mm to 0.035 mm in length (occasionally larger) which maybe smooth (Fig. 3B) or possess proturberances (Fig. 3C). Polyps may have either form or a combination of the two.

Etymology. The specific epithet refers to the expanded nature of the coenchyme.

Variability. In addition to the uncommon occurrence of the large smooth shafted rods,

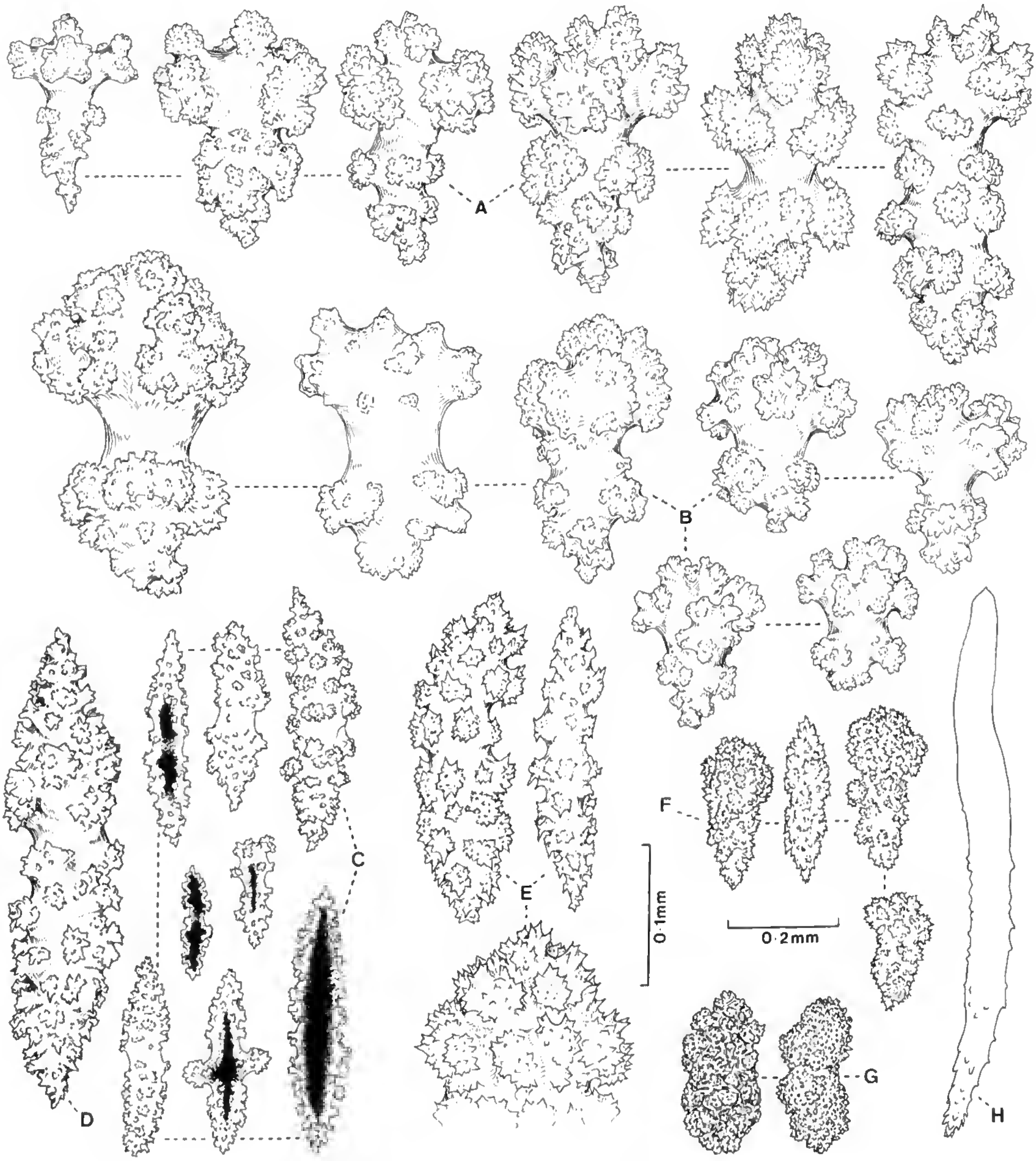


Fig. 4. *Hicksonella expansa* paratypes: **A**, clubs and spindles from NTM C4168; **B**, clubs from the calyces of USNM 76294; **C-D**, subsurface sclerites from NTM C4171; **E-F**, thorny warted spindles from QM GL2742; **G**, densely warted spindles from NTM C4173; **H**, coenenchymal rod from NTM C4174. **A, B, D, E,** 0.1 mm scale; **C, F, G, H,** 0.2 mm scale.

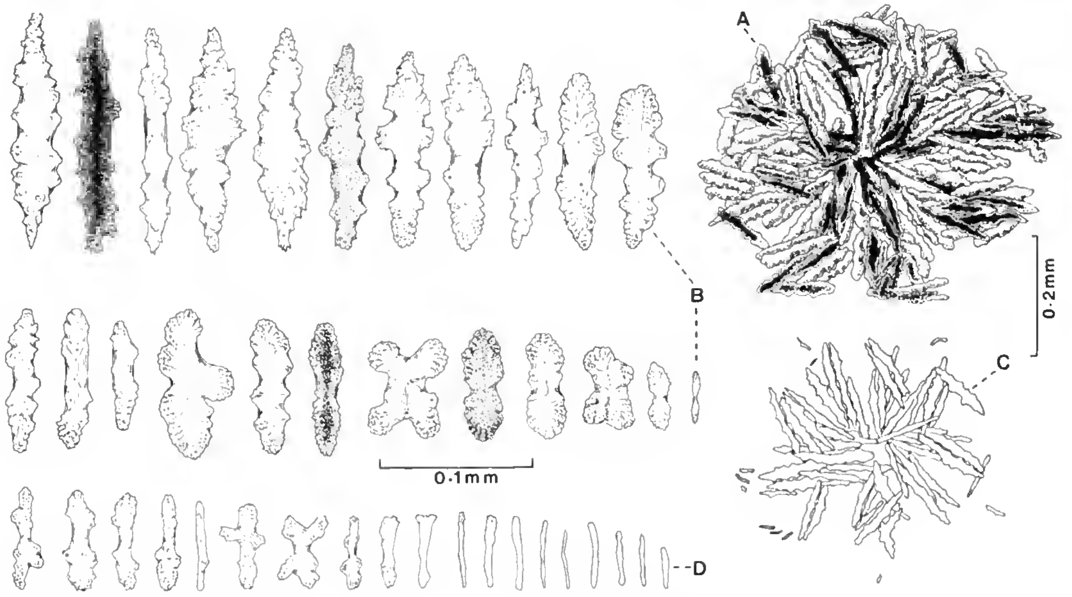


Fig. 5. *Hicksonella expansa* paratypes: **A**, anthocodial sclerite arrangement in NTM C4171 and NTM C4172; **B**, anthocodial sclerites (lower row from tentacles) in NTM C4171 and NTM C4172; **C**, anthocodial sclerite arrangement in QM GL2742; **D**, tentacle sclerites from USNM 76294.

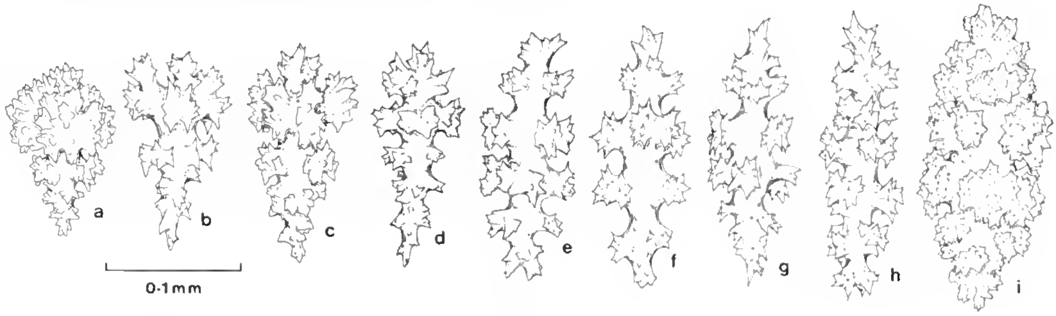


Fig. 6. *Hicksonella princeps*, NTM C3312, coenenchymal sclerites.

sclerite samples from the holotype may show a preponderance of clubs, a larger percentage of waisted spindles or, rarely, sclerites with large, high, tuberculate warts (Fig. 4A).

Seven colonies studied with the holotype are designated as paratypes. Variation within the whole suite of specimens is considerable.

With respect to colony form 3 of the paratypes have marked reduction in the extent of webbing with a number of branches showing no coenenchymal extensions at all. These are USNM 76294 (Fig. 8B), NTM C4173 (Fig. 7B), and NTM C4174 (Fig. 9A).

The extent of webbing is greatest in QM GL2742 (Fig. 9B), which has grown as several close lamellae with the spaces between the axial ramifications of each lamella almost completely filled in with expanded coenenchyme. This specimen, more than any other, has obvious differences between the two faces of the colony. Most noticeably, over the thick main branches the coenenchyme is thicker on one face leaving higher branch ridges on that side. Numerous polyp calyces, and a number of small twigs growing erect from the surface, give this face of the colony a rugose appearance.

With regard to the depth of the coenenchyme, in specimen USNM 76294 it appears greater than in any other colony. This is especially noticeable in the clavate ends of the branches where the axis is hair-like but the total branch diameter is up to 5 mm. Contrastingly NTM C4173 (Fig. 7B) has

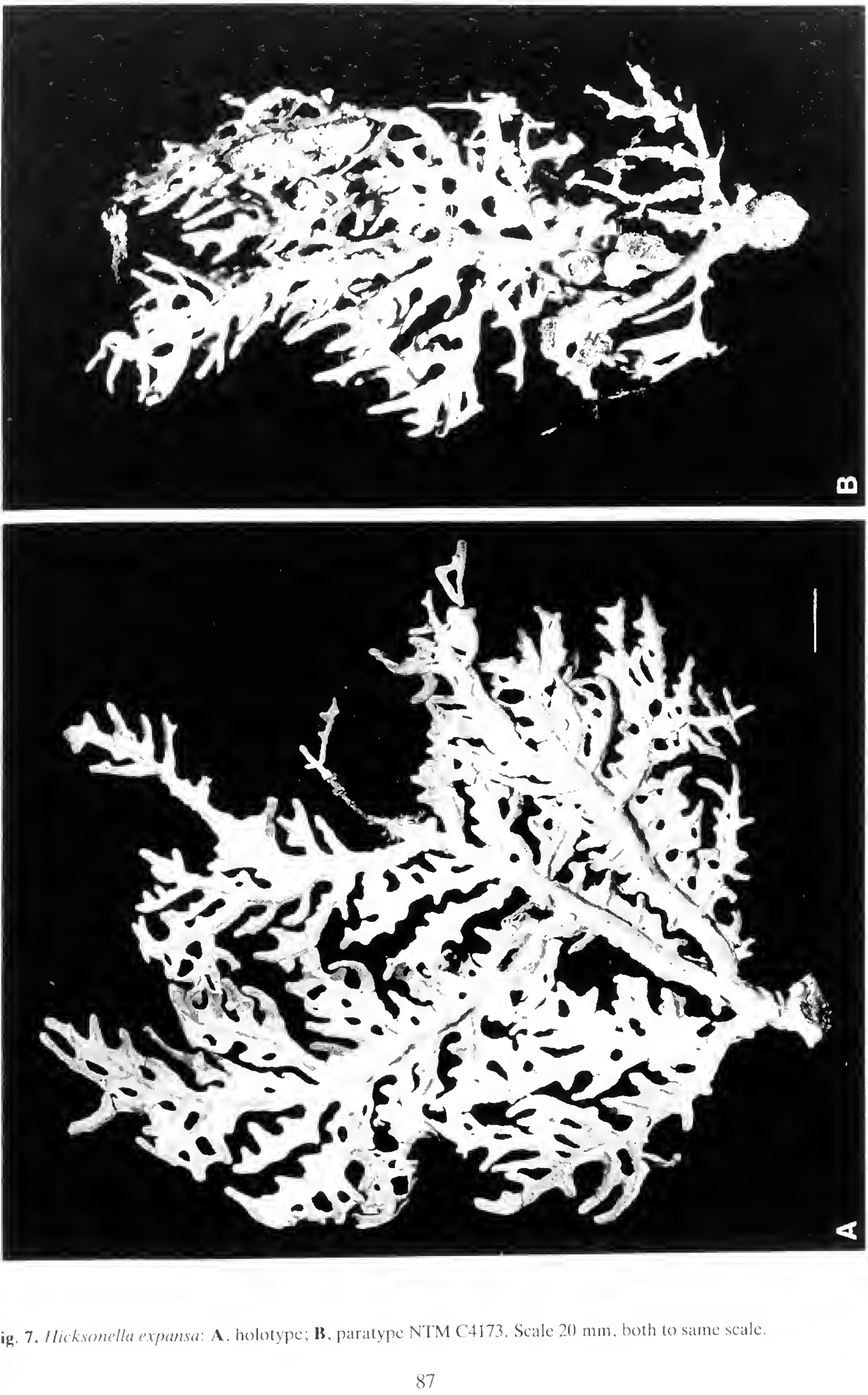


Fig. 7. *Hicksonella expansa*: **A**, holotype; **B**, paratype NTM C4173. Scale 20 mm, both to same scale.

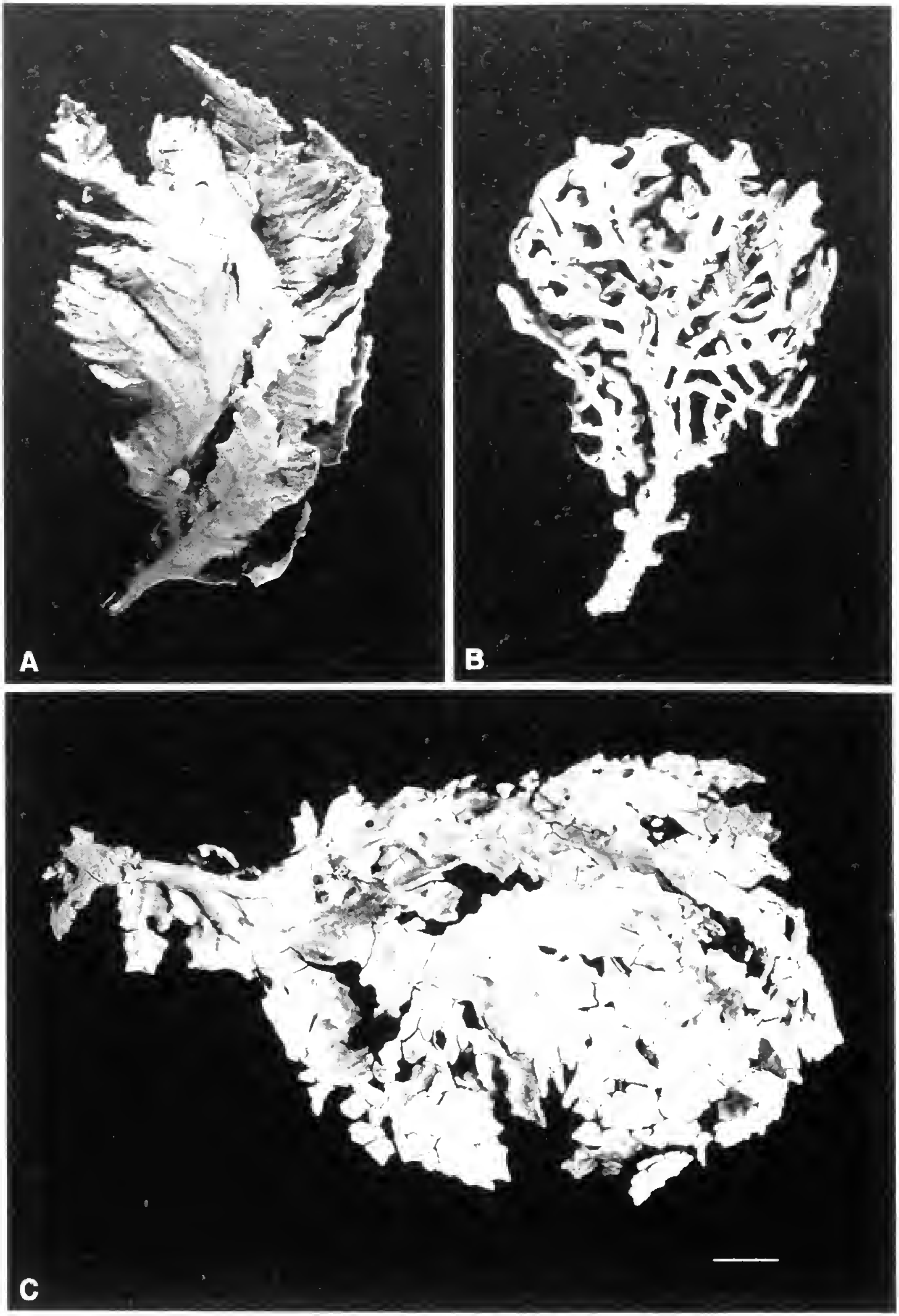


Fig. 8. *Hicksonella expansa* paratype: **A**, NTM C4168; **B**, USNM 76294; **C**, NTM C4171. Scale 20 mm, all to same scale.

Hicksonella expansa sp.nov.

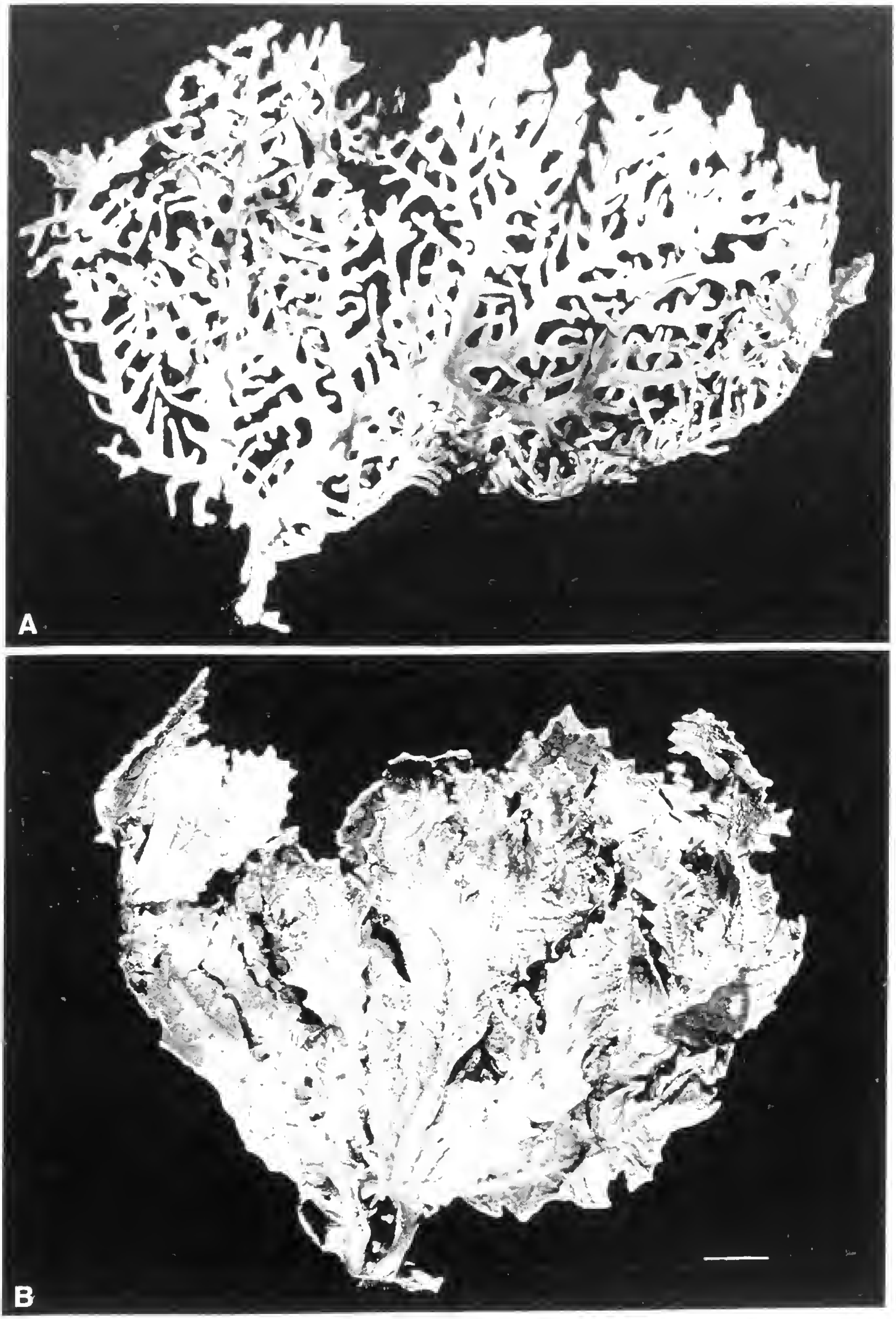


Fig. 9. *Hicksonella expansa* paratype: **A**, NTM C4174; **B**, QM GL2742. Scale 20 mm, both to same scale.

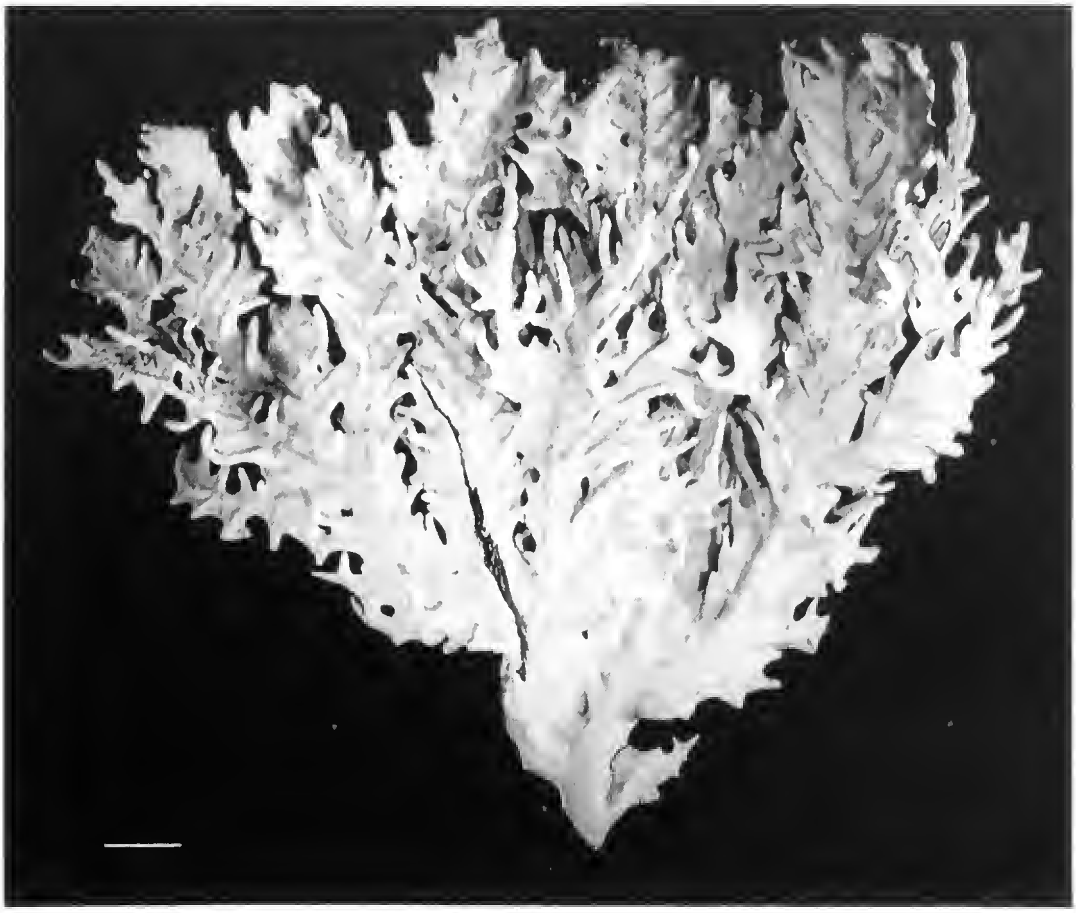


Fig. 10. *Hicksonella expansa* paratype, NTM C4172. Scale 20 mm.

extremely thin coenenchyme with the dark axis showing through the very pale and translucent tissue.

Specimen NTM C4168, a piece of which is shown in Fig. 8A, is 2 portions of a larger colony which may have resembled QM GL2742.

Colony NTM C4172 (Fig. 10) also shows considerable expansion of the coenenchyme. The several lamellae which make up the colony are in places anastomosed. This specimen has numerous terminal twigs, many of which arise from the lamellae at an acute angle.

Specimen NTM C4171 (Fig. 8C) is a single lamella with only a few angled twigs. There is little difference between the faces of this colony.

Apart from QM GL2742, colony colour in all paratypes is similar to that of the holotype. The light brown colouration of Queensland Museum specimen may be a result of its initial preservation with other organisms.

As in the holotype, NTM C4172 and USNM 76294 also have numerous large sclerites visible in the surface layer of clubs. This trend is taken to an extreme in NTM C4173 where the surface layer of clubs is so reduced that sclerite samples are predominantly spindles. In the remaining colonies the surface layer of clubs is more or less entire.

With respect to the long smooth-shafted rods, NTM C4173 is like the holotype and samples of sclerites may not include this form. When present they are usually very small (less than 0.3 mm) although they can be up to 0.55 mm in length. In all other specimens this type of sclerite is fairly common and averages larger. It is especially frequent in the calyces and tips of branches. USNM

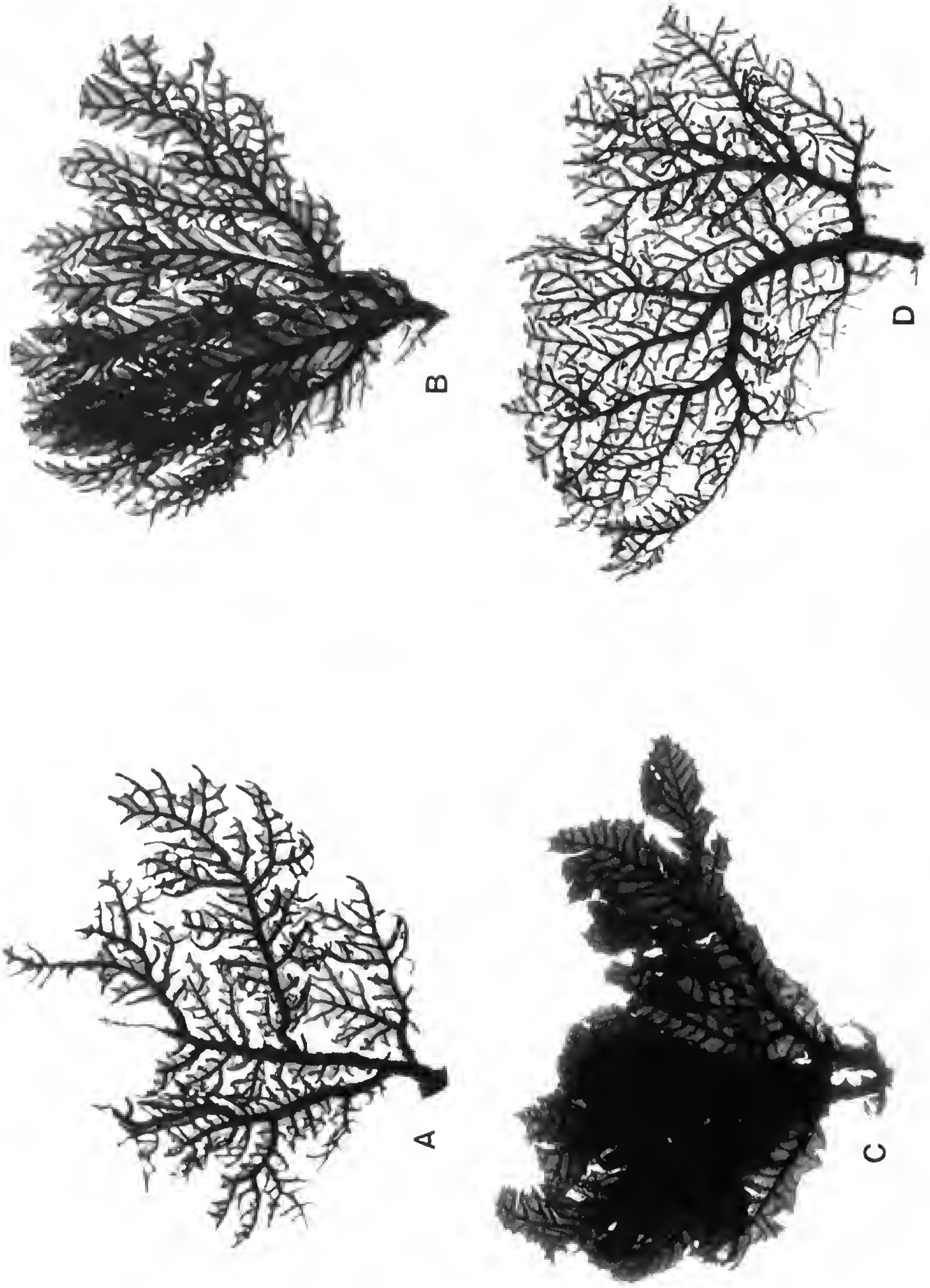


Fig. 11. *Hicksonella expansa* silhouettes: **A**, holotype NTM C4170; **B**, NTM C4172; **C**, QM GL 2742; **D**, NTM C4174. Not to scale.

76294 is quite remarkable in this regard with unusual large concentrations occurring in branch tips. Here, and in other areas of the colony, occasional smooth shafts visibly protrude from the coenenchyme. The largest rod encountered, 1.0 mm in length, came from NTM C4174 (Fig. 4,H).

Other sclerite variations also occur throughout the series. Although examples of most of the forms shown in Fig. 4 may occur in the majority of colonies, individual specimens appear to have higher concentrations of a particular type. The clubs and spindles with large complex warts (Fig. 4A) are from NTM C4168. The calyces of USNM 76294 contain clubs (Fig. 4B) where the handles are poorly differentiated. Spindles with thorny warts (Fig. 4E) sometimes very dense (Fig. 4F) are common in QM GL2742. Specimen NTM C4171 has large numbers of spindles with a central waist and the occasional cross (Fig. 4C,D). The 2 plump sclerites with extremely dense sculpture (Fig. 4G) are from NTM C4173.

A feature of the spiculation of all specimens is the presence of coenenchymal sclerites that exhibit a darkly coloured interior when viewed with transmitted light (Fig. 4C). The density of colouration is usually quite variable as is the percentage of sclerites in which it is observed. The phenomenon is extremely marked in NTM C4171 and NTM C4172 where it is also seen in the polyp sclerites. When viewed with incident illumination sclerites of this form appear to have a dense white core.

Polyp armature is also variable and two further examples are illustrated. In Fig. 5 colonies NTM C4171 and NTM C4172 are represented by diagram A. Both of these col-

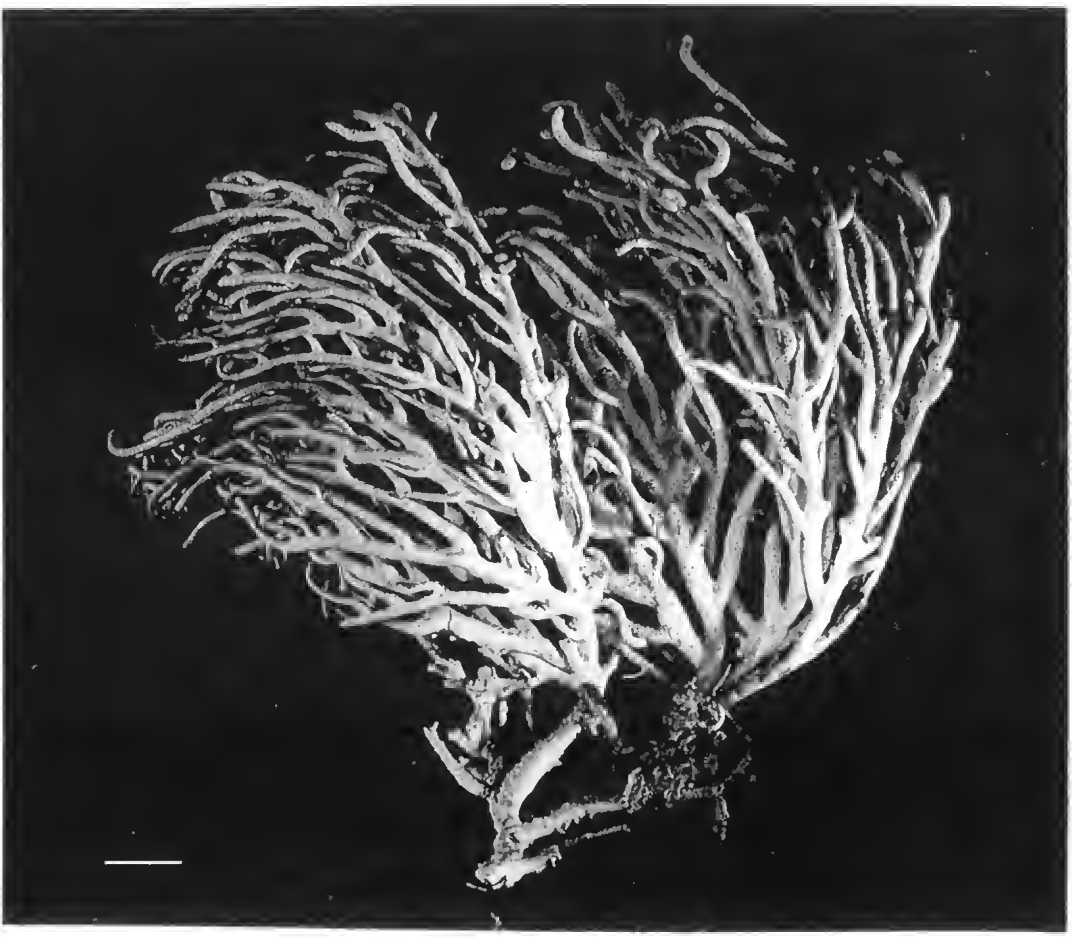


Fig. 12. *Hicksonella princeps*, NTM C3312. Scale 20 mm.

onies have somewhat robust polyp sclerites (Fig. 5B, top row) and a few unusually large and scale-like ones in the tentacles (Fig. 5B, lower row). In contrast the polyp armature of colony QM GL2742 is very slight (Fig. 5C). The tentacles of USNM 76294 have unusually large numbers of minute sclerites, a range of which is shown in Fig. 5D.

Systematic position. *H. princeps* Nutting, 1910, is the only other known member of the genus. On the present evidence little difficulty should be encountered in distinguishing between the two. As can be seen from Fig. 12, *H. princeps* has a dense bushy growth form with cylindrical branches. In this colony (NTM C3312) virtually all the polyps have calyces, (this is not so in other specimens), and they are evenly distributed around the branches. A number of anastomoses and small coenenchymal expansions are present. There are a number of areas where several branches are united at their bases by a web of coenenchyme. Some of these areas can be seen near the centre of the photograph of the colony. All colonies in the N.T.M. collection are light brown. Although heavily warted clubs and spindles (Fig. 6a,i) are found in *H. princeps*, particularly in older parts of the colony, very large numbers of the kind of clubs and girdled spindles shown in Fig. 6b-h also occur. These latter forms, with high thorny warts, should, along with colony shape, serve to differentiate between the two species.

It is to be noted that the same colony form and the same thorny clubs and spindles found in *H. princeps* are also found in specimens *Rumphella*. Apart from the occurrence of calyces and large smooth shafted sclerites in the former, both of which are variable characters, there seems little to distinguish the two taxa, but a close examination of *Rumphella* needs to be made.

ACKNOWLEDGEMENTS

It is with great pleasure that I acknowledge Dr Zena Dinesen and Dr John Coll for collecting the material and donating it to the Northern Territory Museum. Their continued support in this area is greatly appreciated. My thanks to John Hooper for his serendipitous discovery of the Queensland Museum specimen and to Dr Lester Cannon of that Museum for making the specimen available for investigation. I am extremely grateful to Dr Frederick Bayer, whose respected advice and criticism of the manuscript is valued as always, (Dr Dinesen's original find was first shown to Dr Bayer who gave me the opportunity of investigating the species). The efforts of Jody Baxter and Rex Williams, who assisted with the figures, and Jenny Newman, who typed the manuscript, are greatly appreciated.

REFERENCES

Bayer, F.M. 1955 Contributions to the nomenclature, systematics, and morphology of the Octocorallia. *Proceedings of the United States National Museum* 105:207-220.

——— 1956 Octocorallia. In: R.C. Moore (ed) *Treatise on Invertebrate Paleontology. Part F. Coelenterata*:166-231. Geological Society of America and University of Kansas Press: Lawrence.

——— 1961 The Shallow-water Octocorallia of the West Indian region. A manual for marine biologists. *Studies on the Fauna of Curacao and other Caribbean Islands* **2**:1-373.

——— 1981 Key to the genera of Octocorallia exclusive of Pennatulacea (Coelenterata: Anthozoa), with diagnoses of new taxa. *Proceedings of the Biological Society of Washington* **94**(3):902;947.

Kükenthal, W. 1919 Gorgonaria. *Wissenchaftliche Ergebnisse der Duetschen Tiefsee-Expedition auf dem Dampfer Valvidia 1898-1899* **13**(2):854.

Milne Edwards, H. and Haime, J. 1850 *A monograph of the British Fossil Corals. Part I. Introduction; corals from the Tertiary and Cretaceous Formations*. Palaeontographical Society: London.

Nutting, C.C. 1910 The Gorgonacea of the *Siboga* Expedition IV. The Plexauridae. *Siboga-Expeditie* **13b**^{1}: 14-15.

Accepted 5 August 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 95-122

NEW SPECIES OF THE GORGONIAN GENUS *PLUMIGORGIA* (COELENTERATA: OCTOCORALLIA) WITH A REVIEW OF THE FAMILY IFALUKELLIDAE

PHILIP ALDERSLADE
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Three new species of the gorgonian genus *Plumigorgia* Nutting, 1910, are described and illustrated by scanning electron micrography. *P. terminosclera* sp.nov., *P. schuboti* sp.nov., and *P. astroplethes* sp.nov. were all collected on the Australian Great Barrier Reef. The family Ifalukellidae is summarised and a taxonomic key is given. All other known species of the family are also illustrated.

KEYWORDS: Gorgonian, Plumigorgia, Coelenterata, Octocorallia, Australia.

INTRODUCTION

The family Ifalukellidae Bayer, contains only 2 genera. The monobasic *Ifalukella* Bayer, 1955, and *Plumigorgia* Nutting, 1910, which contains 2 known species. Three more species of Plumigorgia are described below from a total of thirty-four specimens gathered together over a period of seven years with the valuable assistance of several people who are acknowledged later in this paper. Two of the species, *P. schuboti* sp.nov., and *P. astroplethes* sp.nov., have sclerites which are extremely unusual, appearing somewhat reminiscent of mineral specimens. The third species, *P. terminosclera* sp.nov., has sclerites of a form similar to those of P. hydroides Nutting, 1910, and *P. wellsi* Bayer, 1955, the two previously known species. Unlike those species, however, *P. terminosclera* has very few sclerites and sometimes none at all. When sclerites are present they are predominantly located on the terminal twigs in the younger parts of the colony.

The sclerites of all known members of the family are extremely small and scanning electron micrography has been used to illustrate them. Many of the photographs were taken recently by Heather Winsor at James Cook University, Townsville, others some time ago by Sue Doyle at Macquarie University, Sydney, and a few were taken by myself. The resulting images differ somewhat in their representation of the sclerite surface structure mainly as a result of being taken on microscopes of different vintage and employing different accelerating voltages in those machines. An attempt has been made to be consistent in choosing illustrations but in some instances different types of images have been mixed in order to display as great a range as possible of sclerite shapes. A series of photographs taken by Sue Doyle to illustrate the effect of varying the accelerating voltage on the images of both the object and the background are shown in Fig. 21.

There is a paucity of up to date keys for most groups within the Octocorallia. There may never be many species assigned to the family Ifalukellidae, however, the vast Indo-Pacific to West Pacific regions throughout which the known occurrances are scattered have seen little scientific exploration. With the introduction of three new species it is timely to summarise the group, with illustrations to supplement previous descriptions, and to include a taxonomic key which can be progressively updated and altered should new species, or further examples of described species, be found.

Abbreviations: NTM Northern Territory Museum of Arts and Sciences, Darwin; USNM United States National Museum, Washington; ZMA Zoological Museum, Amsterdam.

SYSTEMATICS

Plumigorgia terminosclera sp.nov.
(Figs 1-5)

Type material. All material except C2881 was collected from the Great Barrier Reef, Australia. HOLOTYPE - NTM C 5378, Davies Reef, 18°50'S 147°39'E, 15-20 m depth, July 1982, C. Wilkinson.

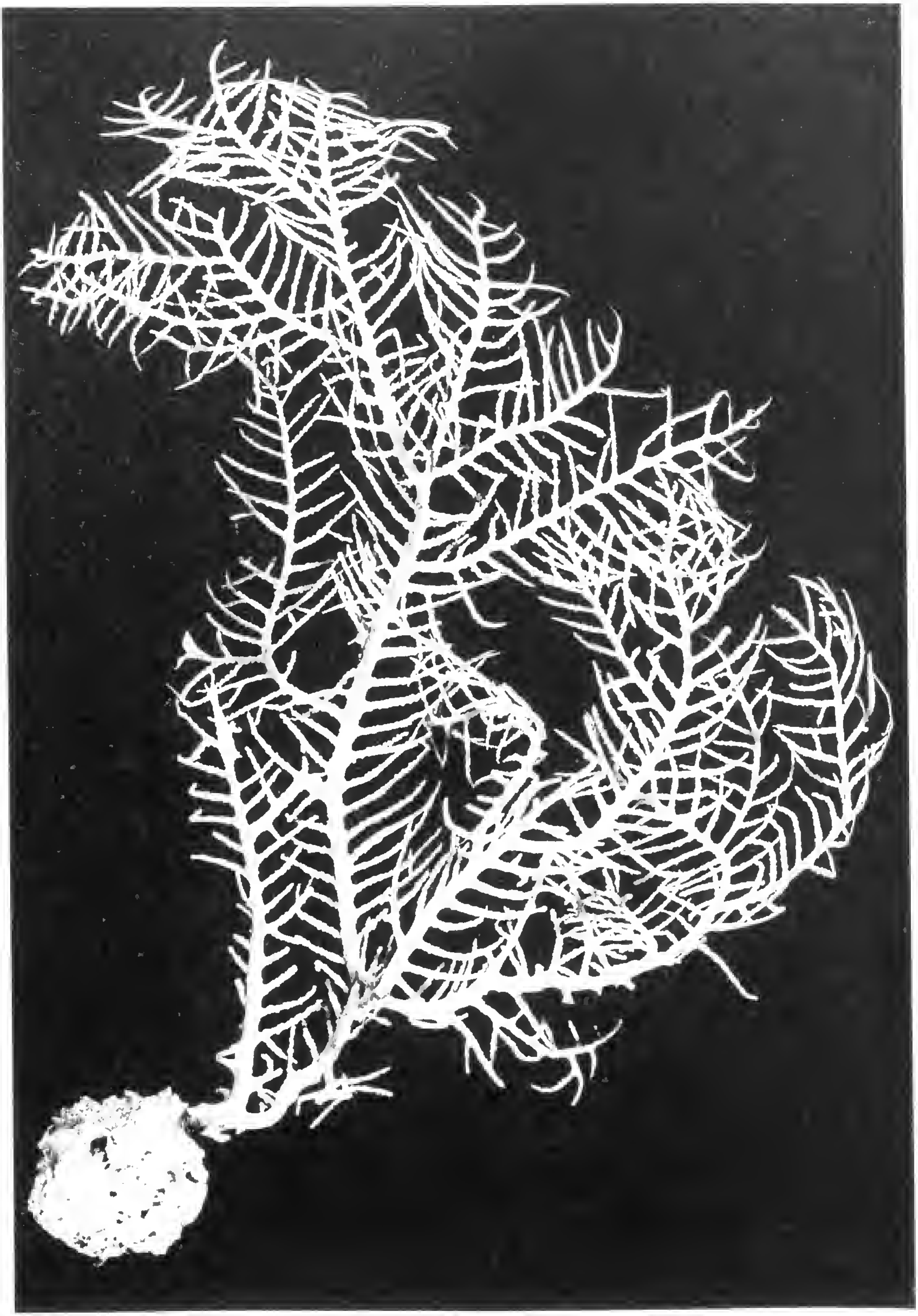


Fig. 1. *Plumigorgia terminosclera* holotype. Natural size.

PARATYPES - NTM C4175, NTM C5379, NTM C5380, NTM C5381, USNM 76295, data as for holotype; NTM C4995, same data but August 1981, 25-30 m depth, Z. Dinesen; NTM C4998, same data but 8-10 m depth; NTM C4497, NTM C4493, Broadhurst Reef, 18°58′S 147°41′E, 22 August 1981, 25-30 m depth, Z. Dinesen; NTM C4496, same data but 6-9 m depth; NTM C5382, Rib Reef, 18°30′S 146°52′E, 6 March 1981, Z. Dinesen; USNM 76296, Briggs Reef, 16°56′S 146°13′E, 1 December 1976, 5 m depth, P. Alderslade; NTM C2881, Marion Reef, 19°10′S 152°17′E, August 1977, 10 m depth, N. Coleman; NTM C4994, John Brewer Reef, 18°37′S 147°04′E, 15 February 1974, 6 m depth, P. Alderslade; NTM C5383, same data but 8 m depth, N. Coleman; NTM C2452, NTM C2486, Sanctuary Reef, Swain Reefs Complex, 22°04′S 152°41′E, 13 November 1980, 4-6 m depth, P. Alderslade; NTM C1259, Central Reef, Swain Reefs complex, 21°55′S 152°31′E, 6 November 1980, 27 m depth, K. Harada; NTM C2880, Swain Reefs complex, 9 September 1974, 25 m depth, N. Coleman.

Diagnosis. *Plumigorgia* colonies with a planar growth form, main branches slightly flattened, a stem that may be unusually long in large colonies and a small spreading holdfast. Terminal branching is alternate pinnate with the coenenchyme often slightly expanded at the base of the twigs. Axis highly calcified and often protruding from the tips of the twigs. Polyps most abundant on the twigs, where they are distributed all around, and totally retractile into the general coenenchyme or into low calyces. Sclerites not abundant and sometimes absent altogether. Oval to cylindrical in shape, with slight median constrictions, sclerites occur primarily on the tips of the terminal twigs in the younger parts of the colonies. Colonies slimy when alive and grey-brown with some violet-brown hues in the twigs.

Description. The pale yellowish-white holotype is a planar colony 195 mm in width and height (Fig. 1). A short main stem of approximately 4 mm in diameter extends from a small 15 x 7 mm spreading holdfast attached to a piece of coral rock. Branching commences 8 mm up from the base where the stub of a twig remains. The first major branch occurs 4 mm above this and is 2 x 2.7 mm in cross section just above its point of commencement. The majority of branches show some flattening due to a slight lateral expansion of the coenenchyne. The terminal twigs are up to 20 mm long but most are less than 15 mm. They arise from the main branches 2-3 mm apart in an alternating pinnate mode. The coenenchyme is slightly expanded at the twigs' base of attachment. Twigs in the older parts of the colony are up to 1.2 mm in diameter, while younger ones are 0.6 mm and less. The diameter of a twig remains roughly constant throughout most of its length except for the last few millimeters which taper to a fine point. It is not uncommon for a portion of naked axis to protrude from the tip of a twig. A few twigs bear small twiglets but most are unbranched.

Within the fan occasional anastomes occur, some of which consist of coenenchyme only.

Polyps occur scattered all around on the terminal twigs with 0.5-1.0 mm between polyp centres. On the branches polyps are few and irregularly distributed, being very scarce in older parts of the colony and more common in newer growths. On the twigs in some areas of the colony the polyps are retracted and occur as low domes about 0.60 mm across and 0.15 mm high. More commonly the polyps on the twigs are exert up to 0.53-0.72 mm across and 0.24 mm high. The short tentacles are often folded inward longitudinally down their midline. Tentacles are up to about 0.3 mm long and each has 1 row of 7 pinnules along each edge. Many of the polyps on the main branches are totally retracted and more or less flush with the surface. They appear very small and measure only 0.17-0.34 mm in diameter. The fine tapering extremities of the twigs are for the most part devoid of polyps.

The axis of the main stem is longitudinally ridged and has a golden-brown sheen. The axes of the main branches are smooth and have a golden yellow sheen. Tissue on the main stem is about 0.72 mm thick. Tissue on the twigs is of similar thickness but here the axes are very fine, 0.14 mm diameter, and whitish in colour with a satin-like lustre.

Sclerites, which only occur in the superficial layer of the coenchyme, are minute and mostly ovals and cylinders (Fig. 2A). Some are nearly circular in outline and a few have 4 lobes, but the majority are elongate and most of these are narrower across their centres and appear somewhat peanut shaped in plan view. A number of sclerites have small cavities which appear as less dense patches when examined under a light microscope. The smallest sclerites are about 0.022 x 0.011 mm but most are longer than 0.029 mm with some of the larger measuring 0.051 x 0.026, 0.051 x 0.016, 0.045 x 0.022, 0.035 x 0.026 mm. One sclerite laying on its edge measured 0.034 x 0.008 mm.

Distribution of the sclerites with the colony is unusual as their occurrence is primarily restricted to the terminal twigs, with the greatest concentration being at the ends of the twigs. Twigs lower down within the colony tend to have fewer sclerites and many of them seem to have none at all. The main stem is devoid of sclerites as are the middle to lower regions of the branches. In areas where sclerites are present they can be seen in the surface tissue as minute white corpuscles. The distribution density varies between twigs. At their most compact they appear to be more or less touching but tissue is still visible amongst the mass. In other regions they are quite separate. In areas of the branches

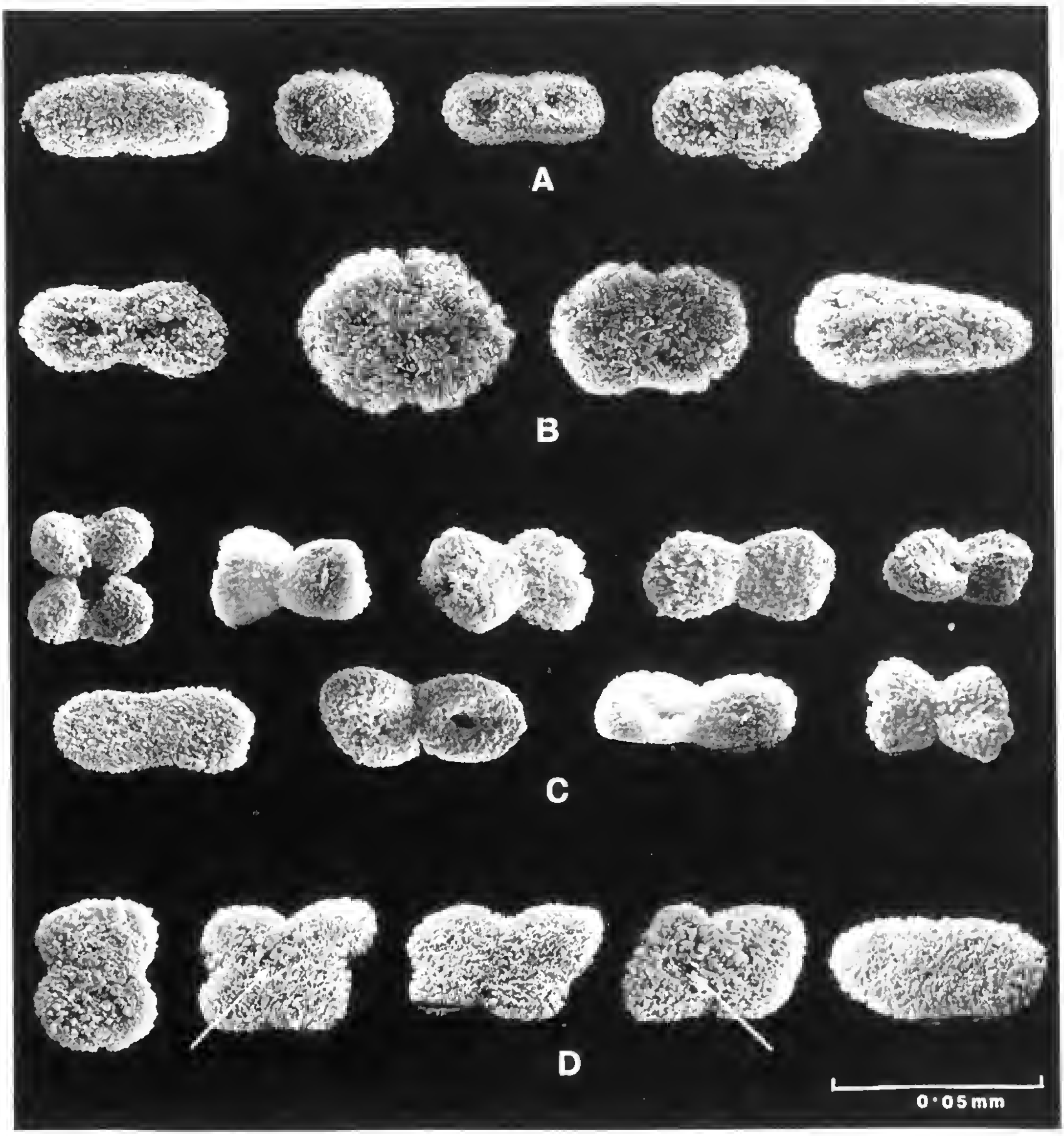


Fig. 2. Sclerites : **A**, *Plumigorgia terminosclera* holotype; **B**, *P. terminosclera*, paratype, NTM C2881; **C**, *P. wellsi* holotype; **D**, *P. hydroides*, USNM 59811.

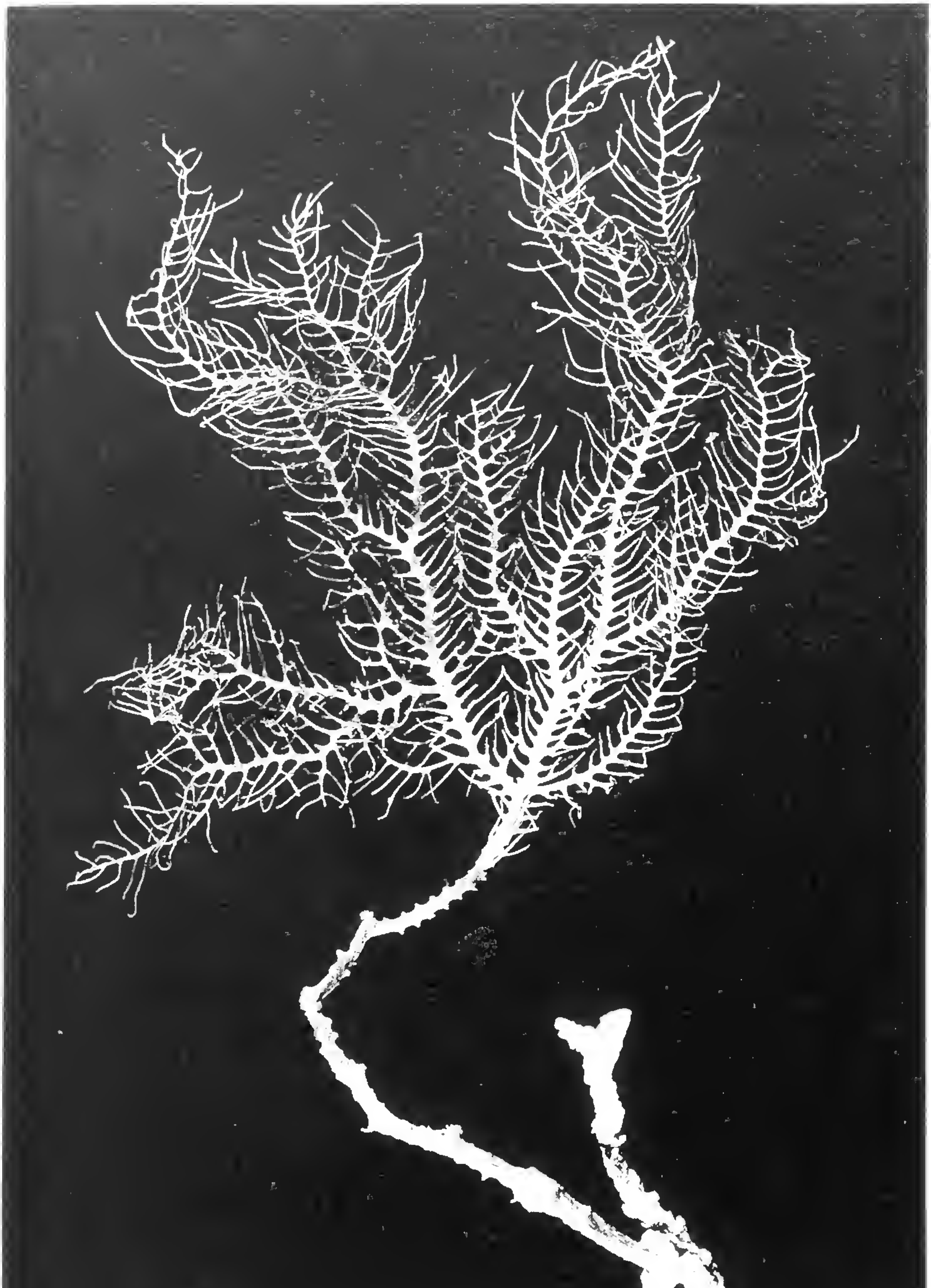


Fig. 3. *Plumigorgia terminosclera* paratype, NTM C2486. Scale 20 mm.

where sclerites are absent, particularly in places where some surface tissue appears to have been rubbed off, an intricate subsurface canal system is visible in the transluscent coenenchyme.

Etymology. The specific epithet refers to the accumulation of sclerites at the ends of the twigs and utilises the Latin "termino" meaning to set limits or mark off boundaries.

Variability. Apart from one specimen the general colonial form of the paratypes compares very well with that of the holotype. There is some variation in the density of terminal branching and some differences in length and thickness of these branches, with 2 specimens each having several extra long twigs 25 mm in length. The shape of the twig tips also differs among colonies with some specimens having bluntly rounded tips, unlike the holotype. It is still common, however, for portions of axis to protrude from twig ends.

There is variation in the length of the main stem. On many of the colonies the lower branches have broken away or been shed from the stem with their positions being indicated by small remaining stumps. In many cases at least half the height of the colony is attributable to a branch-free stem which is virtually devoid of polyps (Figs. 3 and 4). In many colonies shallow longitudinal grooves can be seen on the stems where the stem canals have collapsed.

Most specimens have a few anastomoses. In the majority of cases these appear to be circumstantial where, either the colony architecture modified by local conditions had caused two twigs from neighbouring branches to attempt to grow through the same point in space, or the colony has been damaged and one portion of the fan has been caused to lay over another. Anastomoses do not always involve the axes. Presumably soft tissue fusing would occur initially with the axes coalcseing with time or possibly only if the junction was subject to overmuch compression.

Regarding colour the type series can be split into 2 groups. The holotype together with 7 other specimens, 6 from the same population, were frozen after collection and subsequently preserved in 70% ethanol. All of these colonies are pale yellowish-white with polyps and tissue preserved in a relatively expanded state. Most of the other specimens were placed directly in 70% ethanol after collection, a couple were dried. All of these colonies are brownish-orange and the coenenchyme and, for the most part, the polyps have been preserved in a much more contracted and shrunken state.

Specimen NTM C5382 (Fig. 5B) deserves special mention as it has an abberrant growth form. The specimen consists of a portion of the main stem with some branches and two portions of the fan. The terminal twigs are placed quite close together and, curiously, curve towards the apex of the colony. The twigs are also unusual in that they gradually taper throughout their length to long fine tips. Many of the twigs have initially grown away from the plane of the main fan. Several small pinnately branched parts have also grown out of the main fan, but turned parallel to it, giving the specimen a slightly bushy appearance.

Specimen NTM C2881 (Fig. 5A) is a dry colony that has been rehydrated and, unlike the majority of the series, does not suffer the curvature gained from jar storage. In comparison with the previous specimen this colony's growth form is at the other extreme. It has grown strictly in one plane and has consistently short twigs, an unusually high percentage of which branch again into 1 or 2 small twiglets.

Amongst the paratypes most variability occurs in the distribution of the sclerites. The aforementioned specimen, NTM C2881, has the greatest amount of sclerites. As with the holotype, they are primarily concentrated in the twigs, being densest at the tips. They are so densely clustered that the terminal half of each twig was nearly white when the colony was dry. In many of the paratypes sclerites are difficult to locate and only a few twigs are found to have them, and often then they may be restricted to the last millimeter or two. Four of the paratypes NTM C5383, NTM C4993, NTM C4493, NTM C1259, do not appear to have any sclerites at all.

In general, with respect to size and shape, the fewer sclerites a colony has the smaller and less well developed they tend to be. In several colonies from the same population as the holotype the sclerites are very scarce and they are < 0.30 mm in length. In such colonies as these the sclerites are often poorly formed. Many are narrow and elongate while others have very thin waists. Their outlines

Fig. 4. *Plumigorgia terminosclera* paratype, USNM 76295. Scale 20 mm.

tend to be uneven and often pieces appear to be missing from the ends. Specimen NTM C2881 which has the most sclerites also has by far the largest which have been measured up to 0.072 x 0.029 mm. The smallest are about 0.030 x 0.011 mm while the majority are between 0.042 and 0.070 in length. Some are shown in Fig. 2B.

Field notes made for USNM 76296, C2452, C2486, C4994 and NTM C5383 indicate the live colonies were slimy.

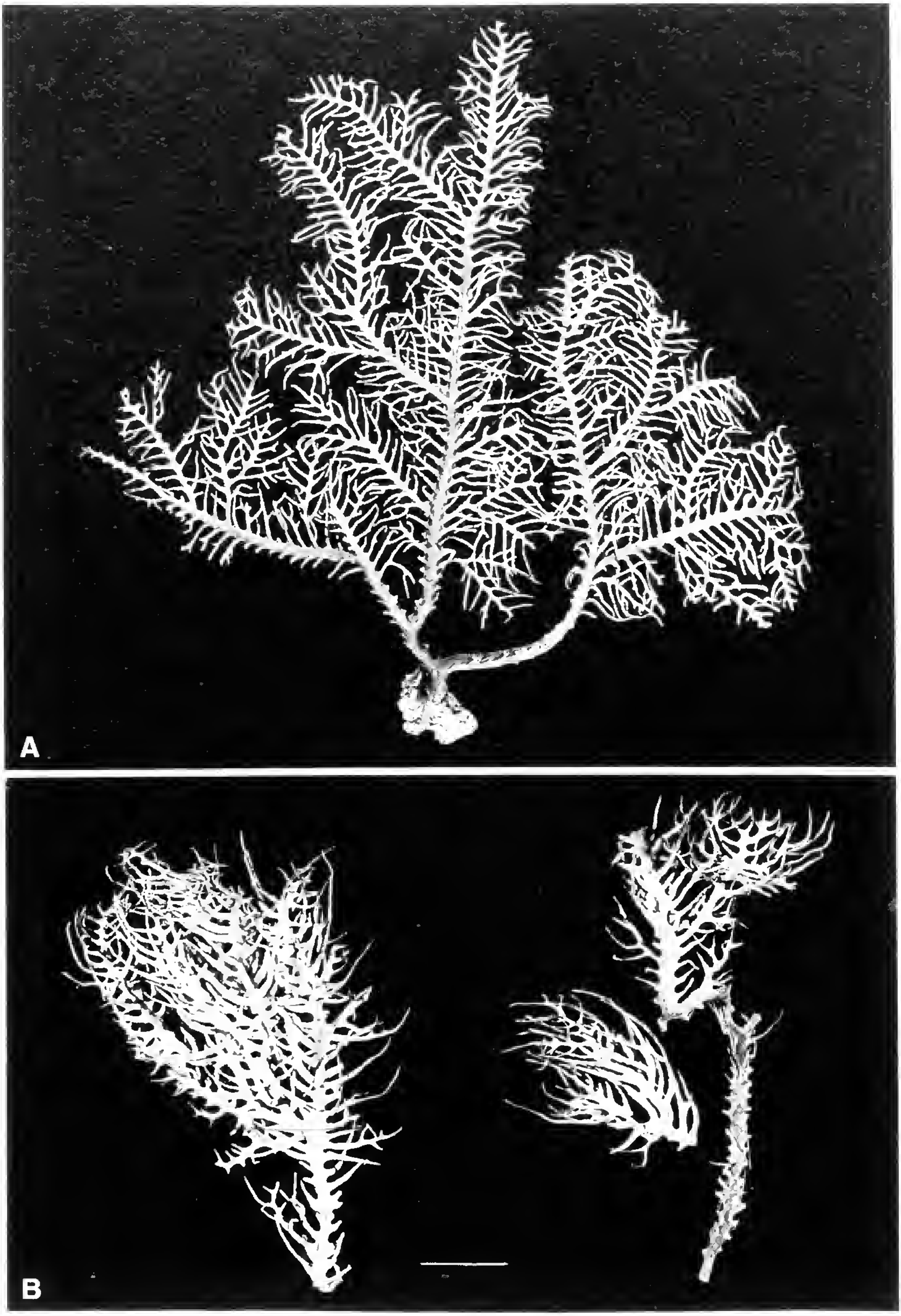


Fig. 5. *Plumigorgia terminosclera* paratypes: **A**, NTM C2880; **B**, NTM C5382. Scale 20 mm, both to same scale.

Plumigorgia schuboti sp.nov.

(Figs 6-12)

Type material. All material collected on the Great Barrier Reef, Australia. HOLOTYPE - NTM C767, Elford Reef, 16°55′S 147°17′E, March 1978, 3 m depth, R. Schubot. PARATYPES - NTM C766, NTM C5384, same data as holotype; NTM C349, Milln Reef, 16°47′S 146°17′E, February 1978, 10 m depth, R. Schubot; NTM C495, same data but 2 December 1976, 5 m depth, P. Alderslade; NTM C816, same data but March 1978, 7 m depth, R. Schubot; NTM C969, Moore Reef, 16°52′S 146°14′E, November 1978, 7 m depth, R. Schubot; USNM 76297, Briggs Reef, 16°56′S 146°13′E, March 1978, P. Alderslade.

Diagnosis. *Plumigorgia* colonies with a planar growth form, main branches slightly flattened, short main stem and a small holdfast. Terminal branching alternate pinnate with the coenenchyme slightly expanded at the base of the twigs. Axis highly calcified and often protruding from the tips of the twigs. Polyps all around on twigs and branches and totally retractile into the general coenenchyme or into low calyces. Sclerites are rodlets, ovals and crosses, often with a highly crystalline appearance and angular projections, forming a dense meshwork in the surface layers of the coenenchyme. Colour in life grey with violet hues.

Description. The blonde coloured holotype (Fig. 6) is 135 mm high by 130 mm

Fig. 6. *Plumigorgia schuboti* holotype. Natural size.

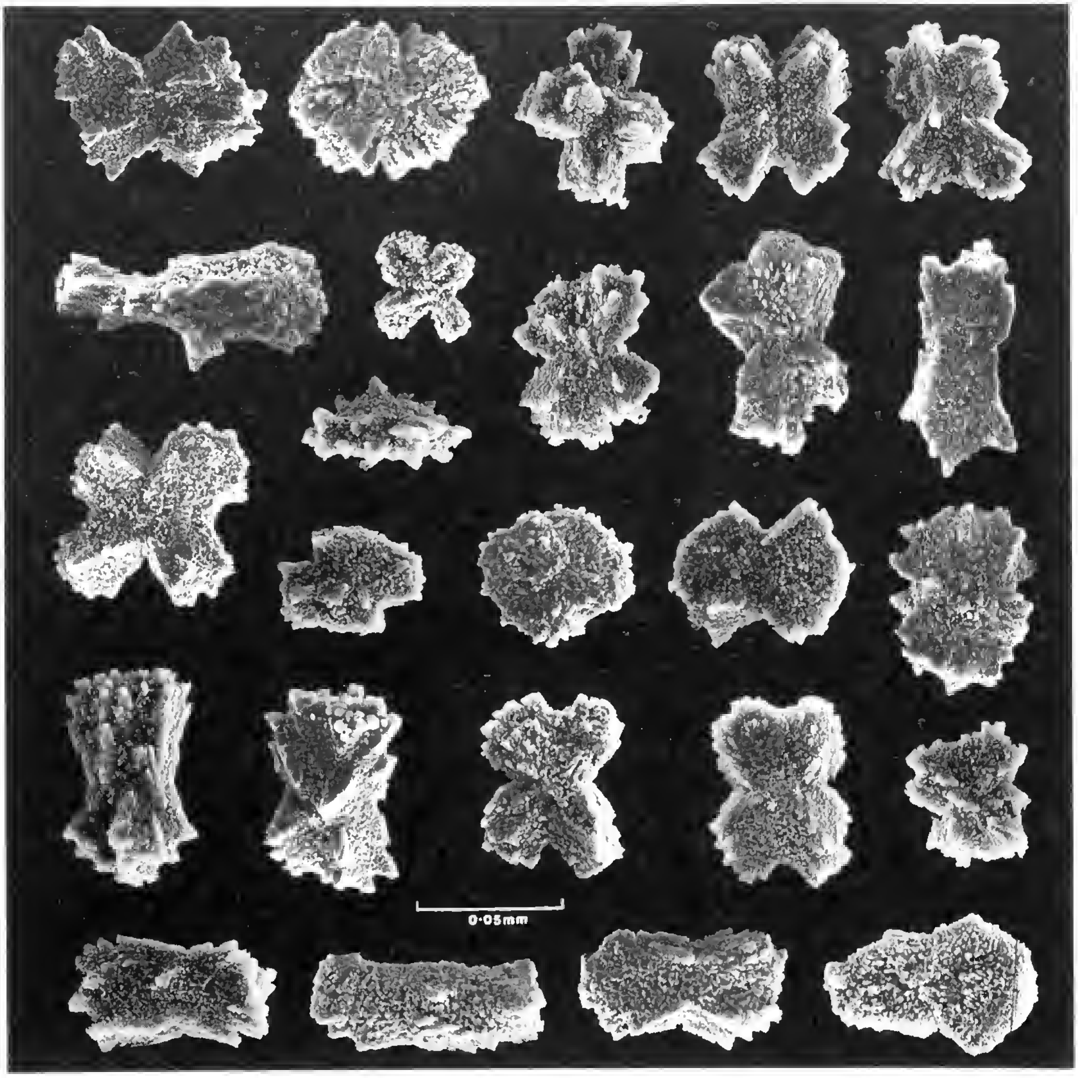


Fig. 7. *Plumigorgia schuboti* holotype, sclerites.

broad, quite stiff, and profusely branched in one plane. At the base of the colony there is a strongly calcified holdfast. Branching commences within 10 mm of the place of attachment and some anastomosing has occurred in this area.

The main branches are slightly flattened, 2-2.5 mm wide and roughly oval in cross section. This ellipsoid section is due solely to a bilateral thickening of the coenenchyme as the axis is roughly circular in section.

The terminal twigs are up to 15 mm in length but most are less than 8 mm. They arise 2-3 mm apart in an alternating pinnate mode from the main branches and branchlets. Occasionally pinnate twigs bear small twiglets 1-3 mm in length, but usually they are unbranched. At their base of attachment the coenenchyme of the twigs is slightly expanded. Above this the twigs are 0.7-0.9 mm thick and taper to a tip which may be rounded or acutely pointed. It is not uncommon to find a short portion of the axis protruding from the end of a twig. The axis in the stem and main branches is grooved longitudinally and has a golden sheen. The coenenchyme on the main stem is about 0.4 mm thick. In the terminal twigs the axis is white to yellowish-white with a satin-like lustre and its diameter is approximately 1/3 that of the twig. Most of the polyps are retracted. Those on the larger branches and twigs are flush with

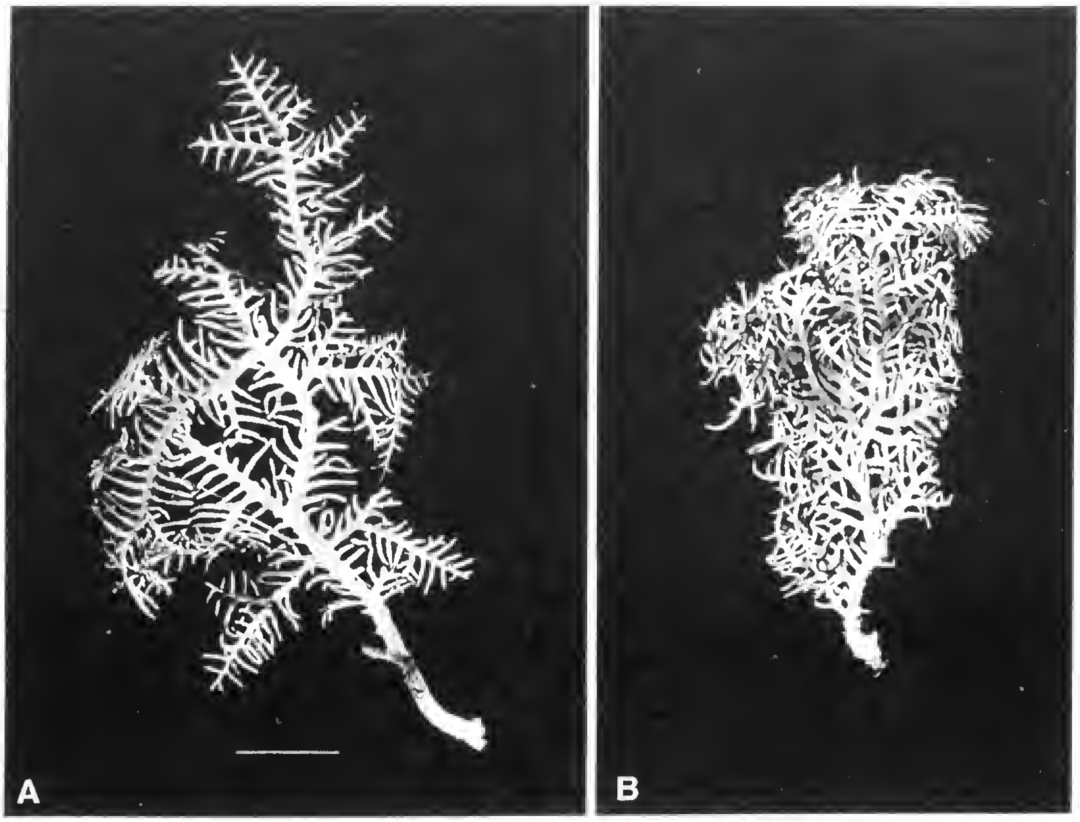


Fig. 8. *Plumigorgia schuboti* paratypes: **A**, NTM C816; **B**, NTM C5384. Scale 20 mm, both to same scale.

the surface and appear as sclerite-free yellowish grey patches approximately 0.2 mm in diameter. Those on the branches are commonly slightly swollen and appear as low mounds. A small number of polyps are partially expanded showing a flattened oval disc surrounded by 8 very contracted tentacles. These polyps are about 0.29-0.48 mm high and 0.12-0.24 mm in diameter. On the terminal twigs the polyps are distributed all round with 1-2 polyp diameters separating them. On the main branches however, the distribution is quite erratic. They occur sparingly in the lower parts increasing in numbers distally and about 0.5-5 mm separate individuals.

Sclerites are distributed over the whole of the colony surface, with the exception of the polyps. Under a low power microscope the sclerites on the twigs appear as small white rodlets amassed densely but haphazardly on the surface. On the main branches closer examination of many areas reveals the sclerites aggregated into a loose mesh-like arrangement with the terminal sacs of an intricate subsurface canal system appearing as minute whitish to clear patches within the mesh.

The sclerites occur in the outer layer of the coenenchyme and appear to be derived from basic rod shapes which are often present as a form of interpenetration twins at various angles The resulting shapes (Fig. 7) with their gross crystalline surface sculpture are unlike the sclerites of any gorgonacean described until now. Vaguely reminiscent of the sclerites of some pennatulaceans and the crystal-like bodies found in *Clavularia ochracea* Von Koch, 1878, by Weinberg (1978), they are more like mineral specimens of non-biogenic origin. A notable feature of the sclerites is that virtually all of them possess prominent angular projections. Most sclerites have many of these projections while others possess only a few larger ones. These somewhat ridge-like, pyramidal or block-like prominences do not have the coarse crystalline sub-unit architecture seen on the rest of the sclerite surface. In mineralogy such an occurrence might be attributed to primary crystallisation with the smaller crystals in-filling secondarily. If, however, the process of biomineralisation resembles that described by Kingsley and Watabe (1982) the projections may be precipitated last and are finer due to a denser organic matrix. Although there is no evidence to support the idea of a secondary crystallisation occurring I shall refer to the material deposited between the prominences, which varies between specimens, as "in-filling", purely to assist in describing their visual appearance.

The majority of sclerites are >0.053 mm in the longest axis. The largest crosses are about 0.081 x 0.065 mm but most are smaller. The largest rod-like forms are rarely larger than 0.081 x 0.041 mm, while shorter ones maybe fatter. There are many sclerites 0.049-0.069 mm in length and the occasional oval form about 0.037 x 0.016 mm with a median constriction resembling the sclerites of *P. terminosclera*.

Etymology. This species is named after Mr Richard Schubot who collected most of the material.

Variability. Among the specimens of the type series there is considerable variation, particularly in colony morphology.

Specimen NTM C816 (Fig. 8A) is yellowish brown and darker than any of the others. It is also conspicuous because of the very strong flattening of the main branch, which is 4 mm wide. The colony also has an unusual aspect because the main branches ramify at right angles. The twigs are thicker than those of the holotype and the whole colony is quite flexible. The sclerites (Fig. 9A) have more pronounced ridges than the holotype and the "in-filling" is of a much finer structure.

Specimen NTM C349 is a stiff wiry colony and morphologically similar to the holotype although the terminal twigs are slightly closer together. An unusual amount of shrinkage

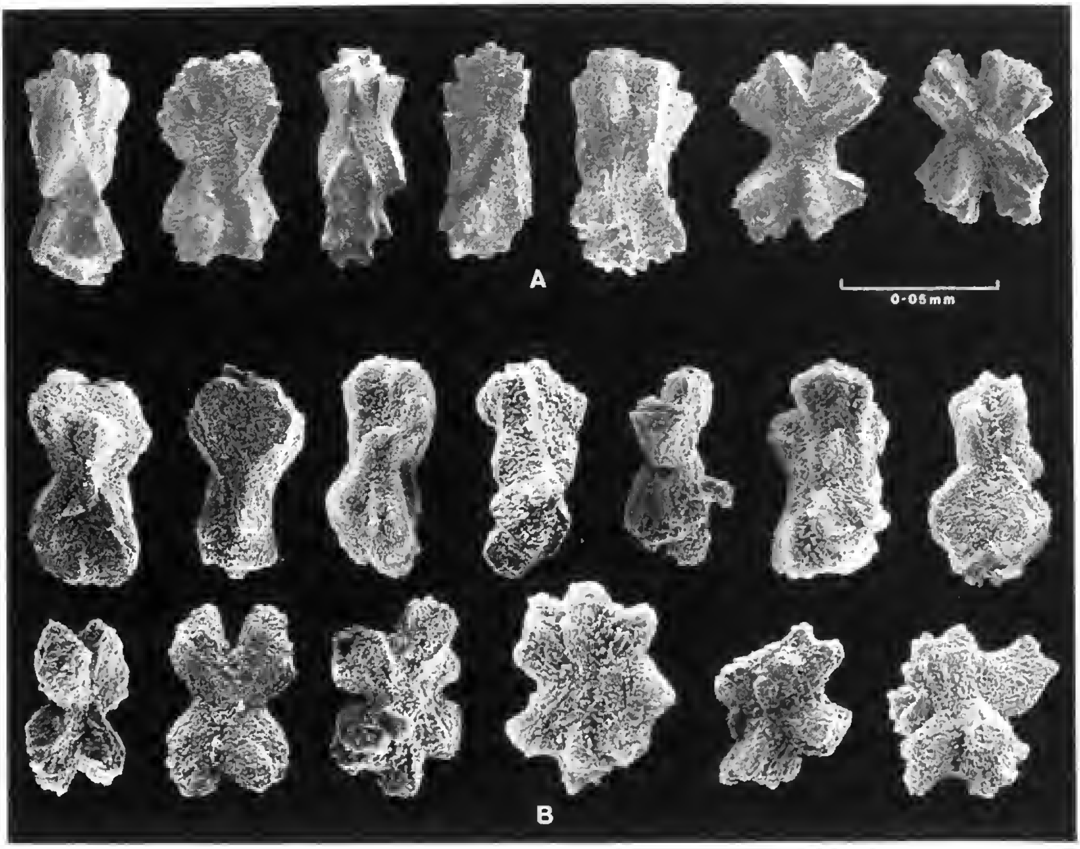


Fig. 9. *Plumigorgia schuboti* paratypes: **A**, sclerites from NTM C816; **B**, sclerites from NTM C969.

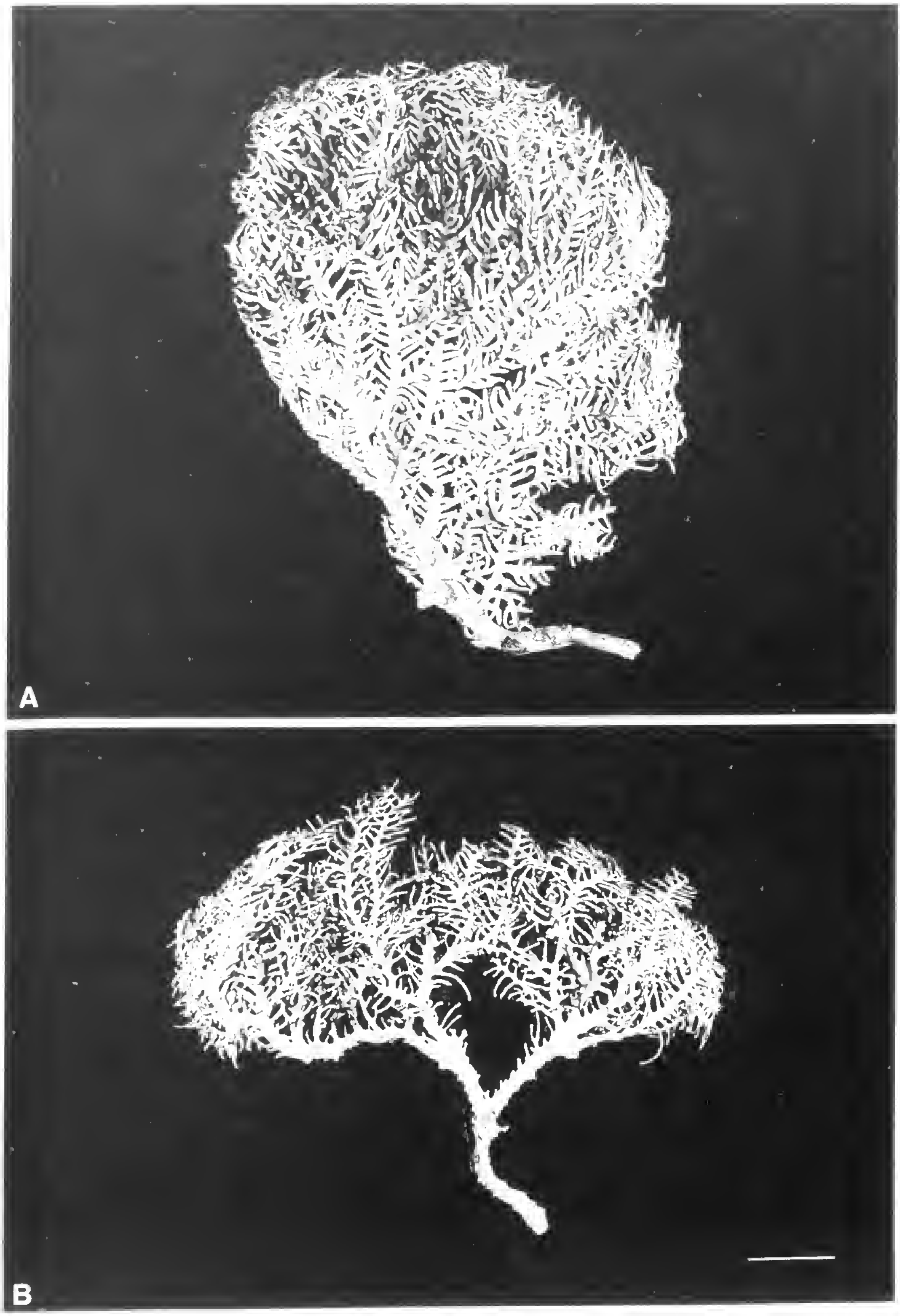


Fig. 10. *Plumigorgia schuboti* paratypes. **A**, NTM C766; **B**, USNM 76297. Scale 20 mm, both to same scale.

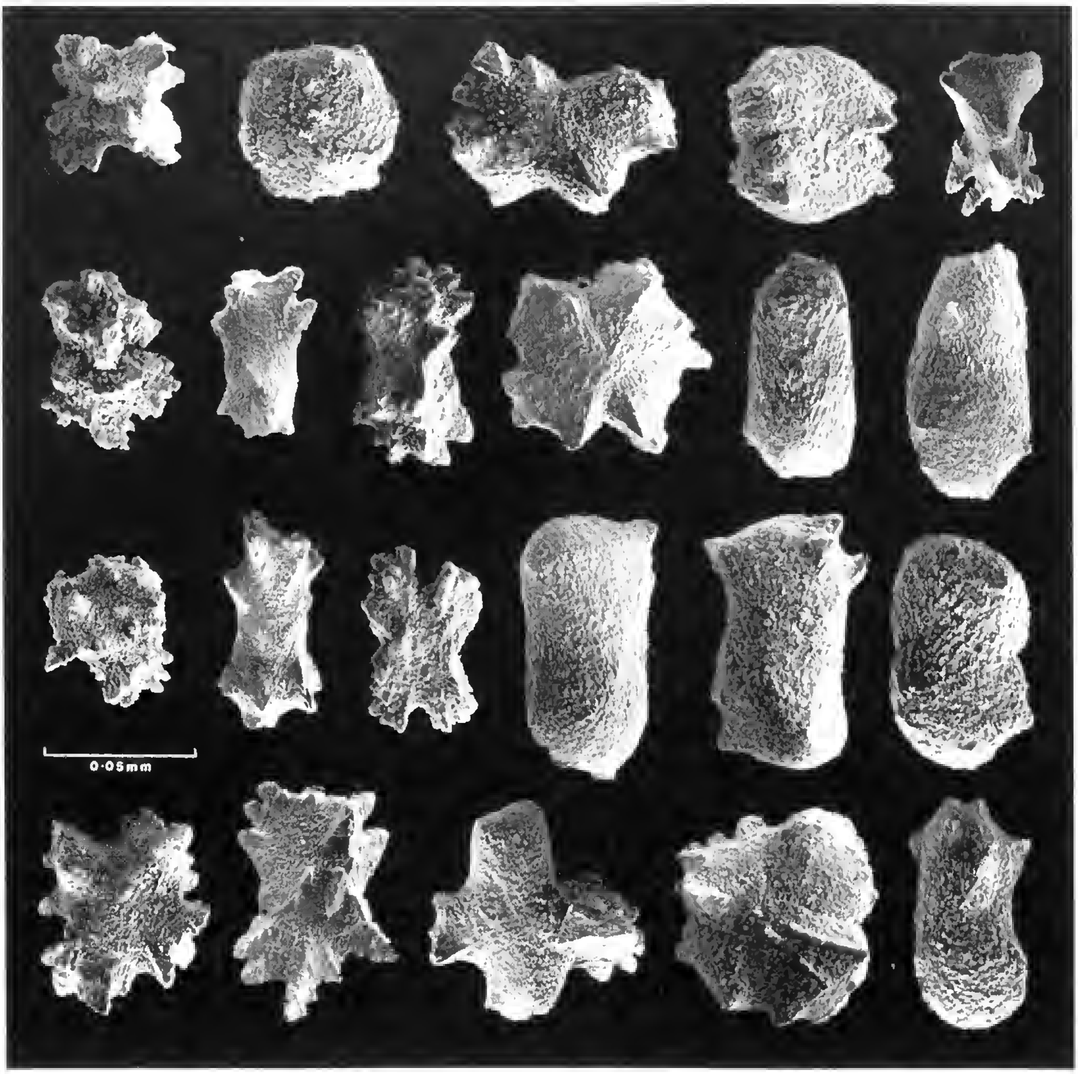


Fig. 11. *Plumigorgia schuboti* paratype, NTM C766, sclerites.

appears to have taken place during preservation as a result of which a ridge of tissue runs above the axis along the flatter faces of the branches. The small web of coenenchyme at the base of the twigs is quite obvious and on the branches the loose meshwork of the sclerites is easily observed. Most of the polyps are contracted flush with the surface or into shallow pits. The sclerites are less angular than those of the holotype, there is more "in-filling" and some of the rods are slightly bulbous.

Specimen USNM 76297 (Fig. 10B) differs very little from the holotype in specific characters. The colony is broader, lacks a base and the lower 70mm has the secondary branches missing.

Colony NTM C766 (Fig. 10A) is quite remarkable for its luxuriant growth form. The specimen is stiff and has extremely dense branching with a number of anastomoses. The terminal twigs are relatively thick, being up to 1.8 mm wide at the base. They arise very close together, sometimes nearly touching. Numerous twigs arise more or less at right angles to the growth plane on one side of the colony and curve upwards. The majority of the polyps on both twigs and main branches are retracted into low calyces while some appear as small pits. The sclerite meshwork is visible but not obvious in the surface tissue. The sclerites (Fig. 11) reflect the robust growth form of this colony. They are noticeably larger than those of the holotype, being up to 0.098 mm in length. A few have well defined ridges and processes as seen in specimen C816, but many are "in-filled" to such a degree that these processes are all but obliterated and quite bulbous forms have resulted. Of particular interest are the unusual and uncommon forms shown in Fig. 12 where the "in-filling" is profoundly asymmetrical.

The apparent overcalcification of the sclerites of this specimen may have solely been due to its genetic make up. It is however tempting to theorise along the lines of Simkiss (1980) who postulates that calcium carbonate deposition may wholly or partially occur as a result of a detoxification process lowering excessive concentrations of calcium ions through biomineralisation. There is a small amount of evidence (Kingsley and Watabe 1982) that some extracellular precipitation may even be possible. It is certainly not difficult to envisage specimens growing in an optimal environment producing luxurious growth and becoming encumbered with an excessive build-up of minerals. *P. schuboti* could prove an interesting study in this field.

Specimen NTM C5384 (Fig. 8B) is smaller than NTM C766 but similar to it in most respects.

Specimen NTM C969, which is only a portion of a colony, is quite lax. The terminal twigs average >10 mm in length with the largest measuring 17 mm. On the main branches there is a slight furrow along the centre of the flattened faces, the loose sclerite meshwork is quite visible and most of the polyps are retracted flush with the surface. On the twigs the majority of the polyps are either exert or expanded sufficiently to rise above the surface as truncated cones. Sclerites from this colony (Fig. 9B) bear similarities to those of the species whose description follows this one. The percentage of crosses is higher than in the holotype and the angular processes are reduced in number and prominence. Although some bulbous forms are present, sclerites with gross in-filling are rare and the overall surface architecture is course.

Plumigorgia astroplethes **sp.nov.**

(Figs 13-15)

Type material. All material was collected from the Great Barrier Reef, Australia. HOLOTYPE - NTM C5001, Milln Reef, 16°147'S 146°17'E, 2 December 1976, 3-5 m depth, P. Alderslade. PARATYPES - USNM 76298, NTM C5000, NTM C5376, NTM C5377, same data as holotype; NTM C811, Moore Reef, 16°52'S 146°14'E, March 1978, 7 m depth, R. Schubot.

Diagnosis. *Plumigorgia* colonies with a bushy growth form, slightly flattened branches and a short main stem. Terminal branching alternate pinnate with thick coenenchyme often slightly expanded between the bases of the twigs. Axis highly calcified and often protruding from the tips of the twigs. Polyps evenly distributed over the whole of the colony and totally rectractile into the general coenenchyme. All but the innermost layers of the coenenchyme packed with multiradiate sclerites. Colour violet-grey when alive.

Description. The profusely branched colony (Fig. 13) is yellowish white. Terminal branching is pinnate and the pinnately branched sections are all more or less facing

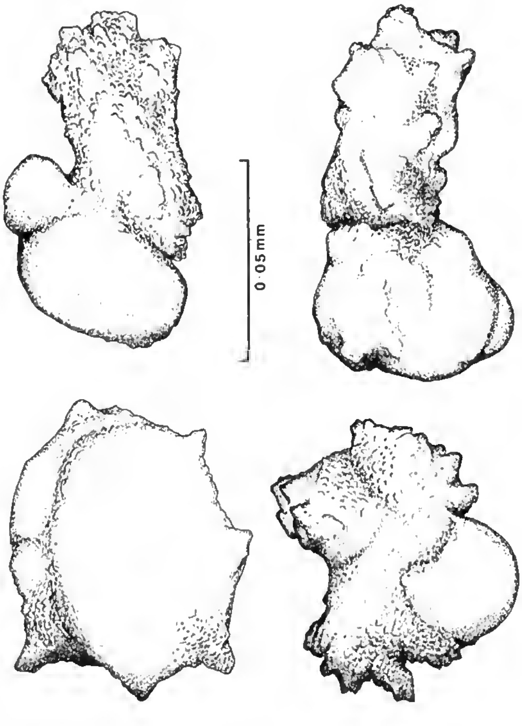


Fig. 12. *Plumigorgia schuboti* paratype, NTM C766, sclerites with marked asymmetrical development.

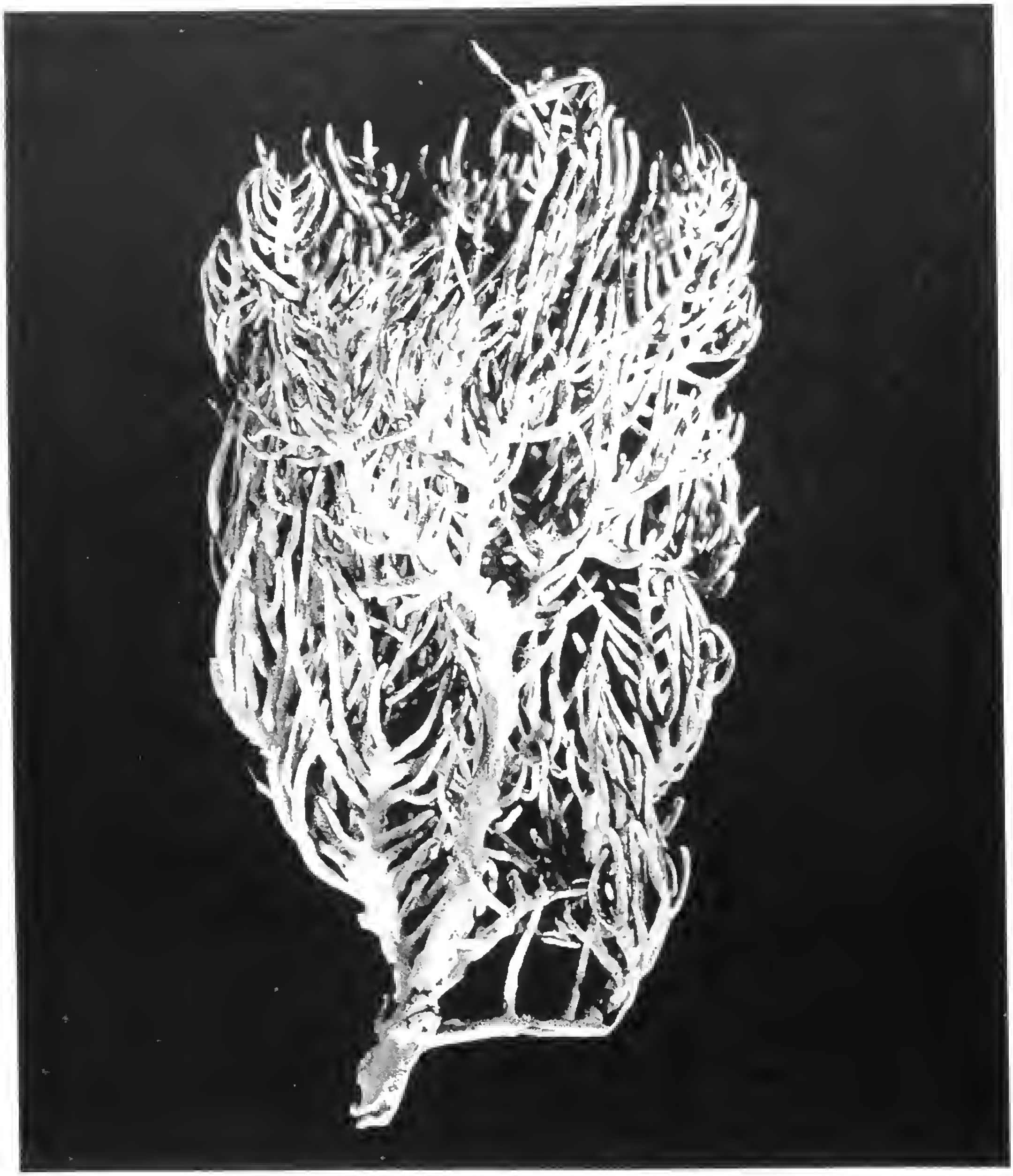


Fig. 13. *Plumigorgia astroplethes* holotype. Natural size.

the same way. These sections are not, however, in the same plane and the resultant growth form is markedly bushy. The colony is 180 mm high, 85 mm wide and 70 mm deep.

The pinnate branching is alternate and the twigs are 1-2 mm, and occasionally 3 mm, apart. The length, thickness and orientation of these twigs is not regular. Regardless of the direction of growth of a branch the majority of twigs on it have curved and attempted to grow towards the apex of the colony. The twigs are round in cross section and taper slightly. Some have developed 1 or 2 twiglets. Most twigs are between 10 and 20 mm long. Some are only a few millimeters in length while others are extremely elongate and measure up to 50 mm.

The diameter of most twigs at their base is between 1.6 and 2.4 mm with the largest

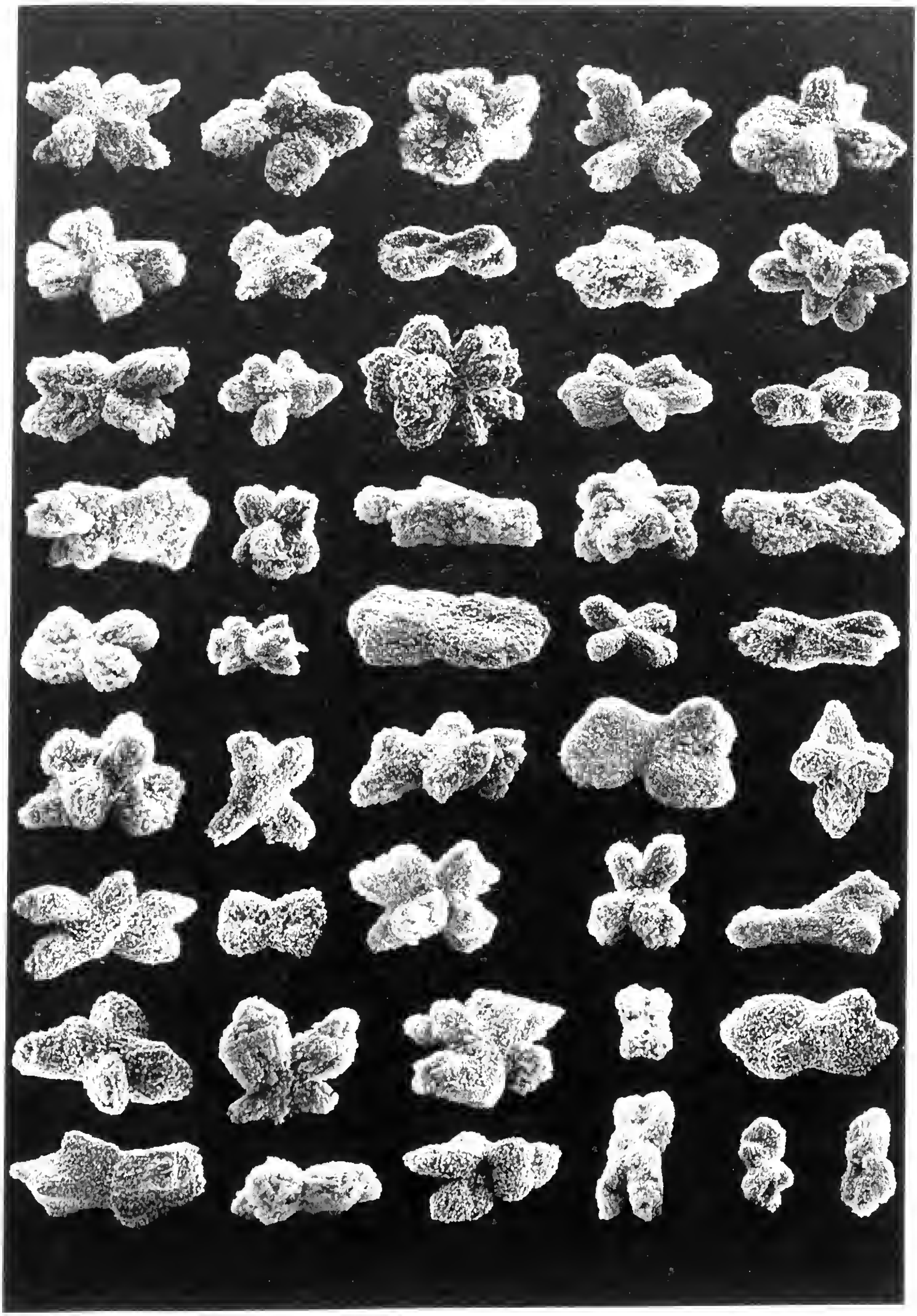


Fig. 14. *Plumigorgia astroplethes* holotype, sclerites

being 2.7 mm. The coenchyme on the twigs is relatively thick. One twig with a diameter of 2 mm has a pale brown cylindrical axis measuring only 0.4 mm thick. The tips of the twigs can be bluntly rounded or conical. The latter often have a minute transluscent portion of the axis protruding from the end. Some of the twigs have up to 10 mm of white hair-like axis projecting from the tip.

The main stem is somewhat oval in cross section with one side slightly flattened and diameters of 7 mm and 5 mm. The axis is brown, longitudinally ridged, and covered with coenechyme about 0.6 mm thick. Most of the major branches are 4-5 mm thick and appear slightly flattened due to some expansion of the coenenchyme between the twigs. Except for the lower portions of the colony the axes of the branches are not ridged. They are mainly smooth with occasional lumps and rough patches.

The polyps are more or less evenly distributed over the whole of the colony, apart from the lower 25 mm, giving the specimen a faint speckled appearance. The polyps are fully retracted and appear as minute pale grey patches, sometimes star shaped, 0.05-0.17 mm across. Each is situated at the centre of a slight depression in the surface. The distances between polyps, both on the twigs and on the main branches, ranges from 0.35-0.70 mm. Those on the twigs, however, average closer together. In the area between the polyps numerous minute clear patches of

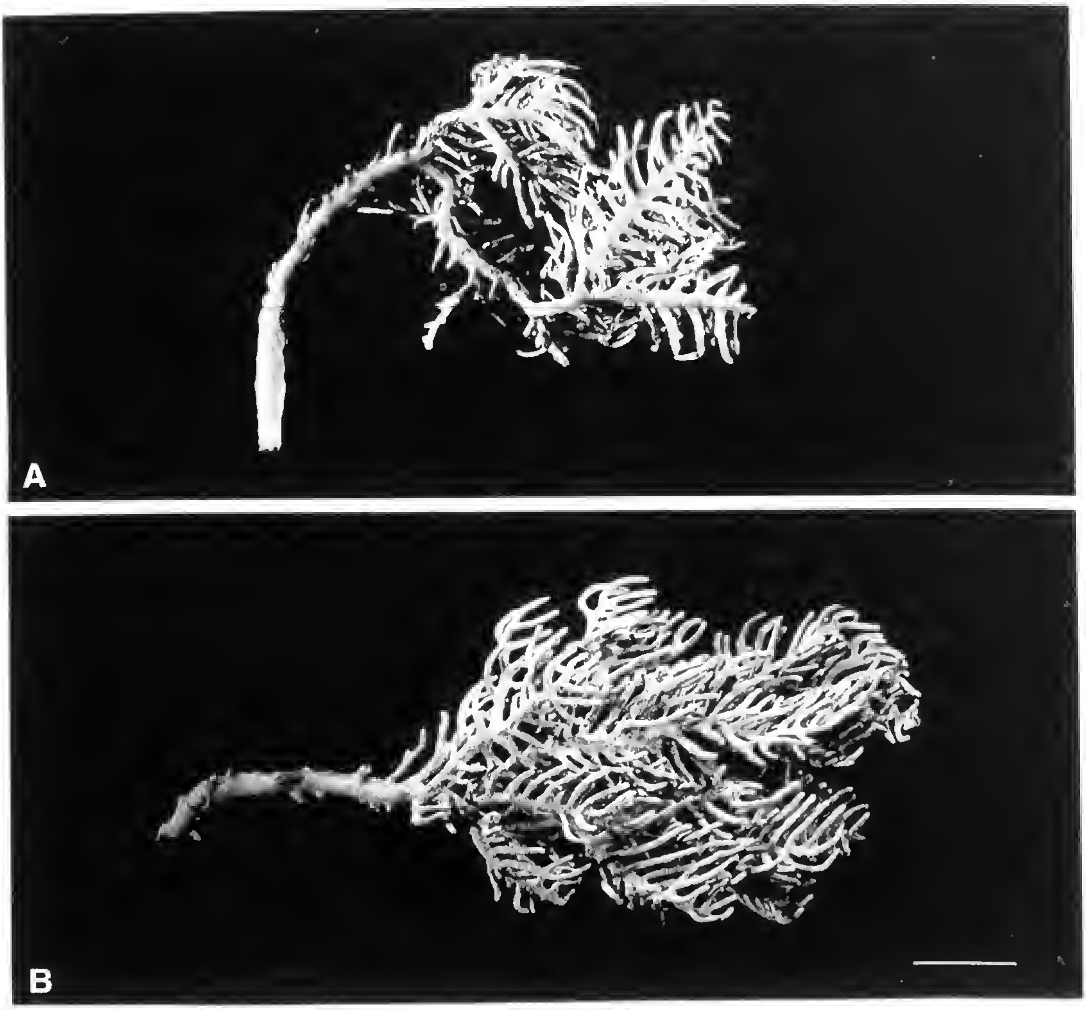


Fig. 15. *Plumigorgia astroplethes* paratypes: **A**, USNM 76298; **B**, NTM C5376. Scale 20 mm, both to same scale.

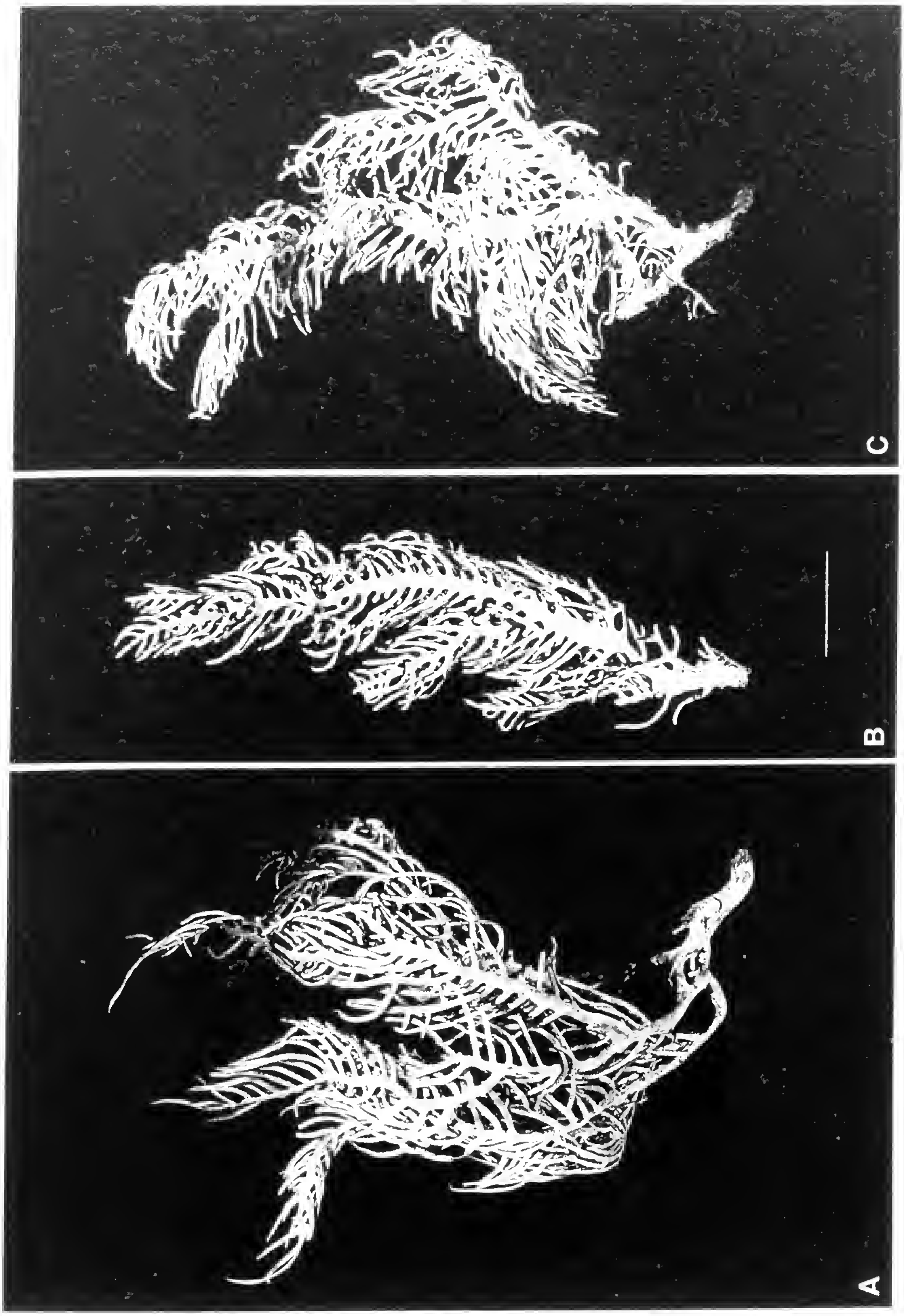


Fig. 16. *Plumigorgia astroplethes* paratypes: **A**, NTM C811; **B**, NTM C5377; **C**, NTM C5000. Scale 20 mm, all to same scale.

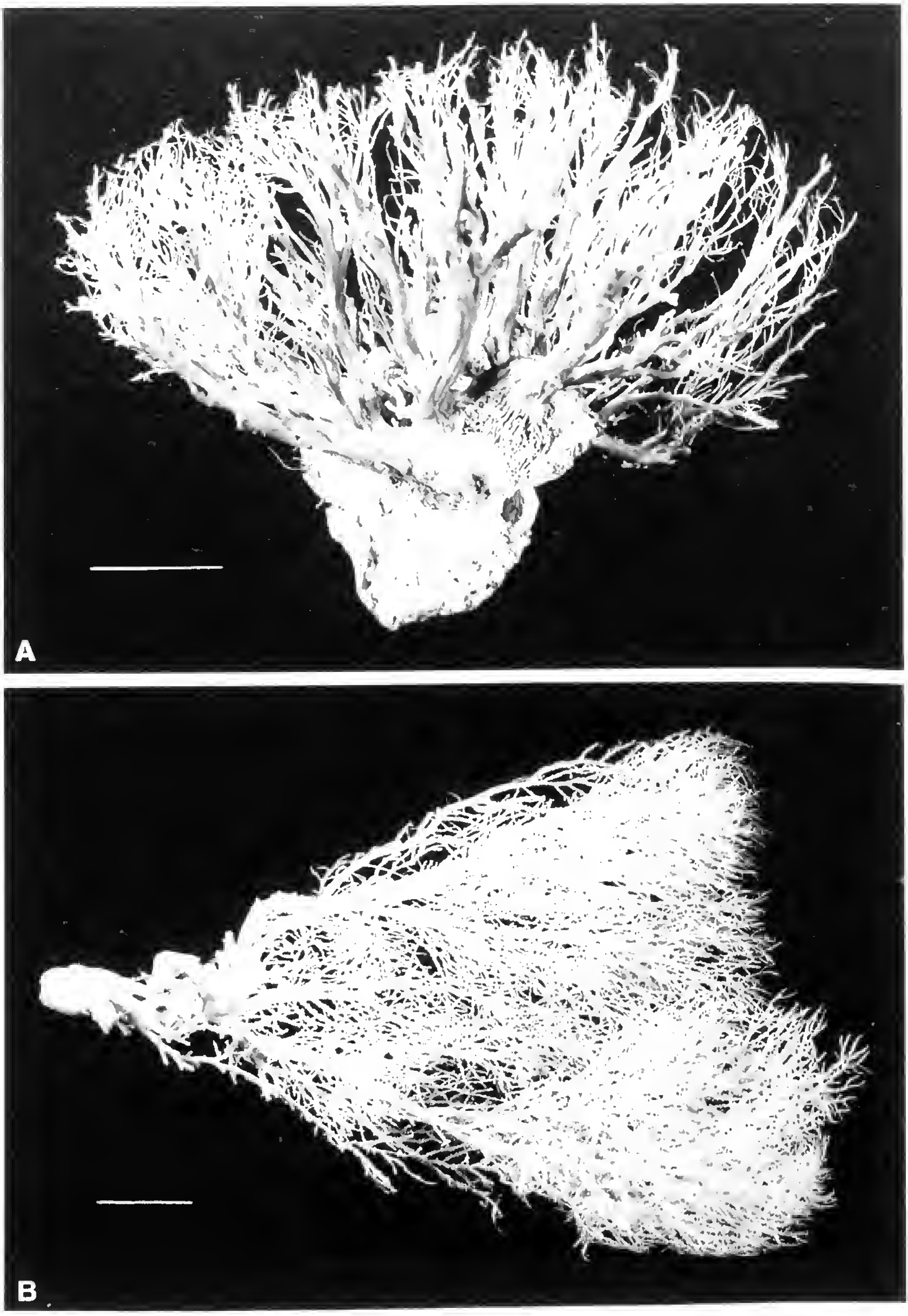


Fig. 17. *Ifalukella yanii*: **A**, paratype, USNM 51527; **B**, holotype. Scale 20 mm.

tissue 0.024-0.048 mm across are visible within the mass of sclerites.

The layer of coenenchyme outside the axial sheath and longitudinal stem canals is packed with minute sclerites. The sclerites (Fig. 14) are of a similar nature to the unusual crystal-like forms of the previous species. However, there is a marked lack of sharp angular ridges and projections, and forms exactly like those in Fig. 7 are absent. Most noticeable are the large numbers of crosses and multiradiates. Scattered among the multiradiates but not very common are sclerites similar to those of *P. terminosclera*, with a median constriction and commonly with a cavity in each half. The gross surface sculpture of the sclerites is different from that of the previous species and the sclerites appear darker under a light microscope. The longest sclerites are the rod-like forms which are up to 0.077 x 0.037 mm. The widest are the multiradiates which are up to 0.069 x 0.057 mm. The smallest measured was 0.033 x 0.016 mm.

Variability. Within the type series there is noticeable variation in the stoutness of the colonies. The holotype and two paratypes (Fig. 15) are markedly stouter than the other 3 specimens (Fig. 16). The former 2 specimens compare very well with the holotype but lack the few extraordinarily long terminal twigs. One of the slighter colonies, NTM C811, does have several very long twigs. All the twigs of this colony are very much slimmer than those of the holotype and taper much more rapidly to long thin tips. The coenenchyme of this specimen appears not to have undergone the same extent of shrinkage or contraction as that of the holotype as the clear tissue patches above the totally retracted polyps are wider and they are not in depressions on the surface. The surface of the branches has a more coarse appearance due partly to the sclerites being packed less tightly and partly to the sclerites being on the average larger than those of the holotype. The darker colour of the colony is a storage artefact. The remaining 2 slighter specimens NTM C5000 and NTM C5377 both have short, thin, twigs. The main branches appear markedly flattened due to extensive expansion of the coenenchyme along their edges. Specimen NTM C5377 is only a branch of a larger colony and in some areas of the expanded tissue the polyps appear in short distinct lines.

Sclerites do not vary greatly within the series. The sclerites of NTM C811 average larger, and those of NTM C5377 and NTM C5000 average smaller, than those of the holotype, but the size range is much the same. Sclerites from the latter 2 specimens also tend to be more angular.

Etymology. The specific epithet *astroplethes* is a direct use of the greek word which means "full of stars".

REVIEW OF THE FAMILY

In 1910 Nutting erected a new genus for several plumose gorgonian specimens collected by the *"Siboga"* expedition. He named the material *Plumigorgia hydroides* and placed his new genus in the family Gorgonellidae (now Ellisellidae). *P. hydroides* was characterised as pinnately branched and resembling a plumularian hydroid. The colonies had small calcified holdfasts attached to irregular calcareous masses and exceedingly fine branch axes. The polyps were very small and disposed bilaterally on the branches, and the sclerites were described as lenticular or disc-shaped and often having median constrictions. The genus did not appear in the literature again until 1940 when Stiasny identified specimens from the *"Snellius"* expedition as *P. hydroides*. Stiasny made the following reference to the sclerites: "Manche tragen ein oder zwei flache scheibenförmige warzen". He was almost certainly referring to the patches of lower density which are visible in some sclerites of this form and which show up as cavities in electron micrographs of chemically cleaned sclerites (Fig. 2A,C). Nutting, however, did not mention this phenomenon and an examination of his material showed only slight cavities similar to those in Fig. 2D, arrowed (not from Nutting's specimen). Stiasny's colonies exhibited a stouter growth form than Nutting's specimens and the biserial polyps were closer together.

The family Ifalukellidae was established by Bayer (1955) for a new genus and species of gorgonian from the Caroline Islands, *Ifalukella yanii* (Figs 17-18). In the same account Bayer erected a new species *Plumigorgia wellsi*, from the Marshall Islands, and reassigned *Plumigorgia* to the new family based on the characters of the

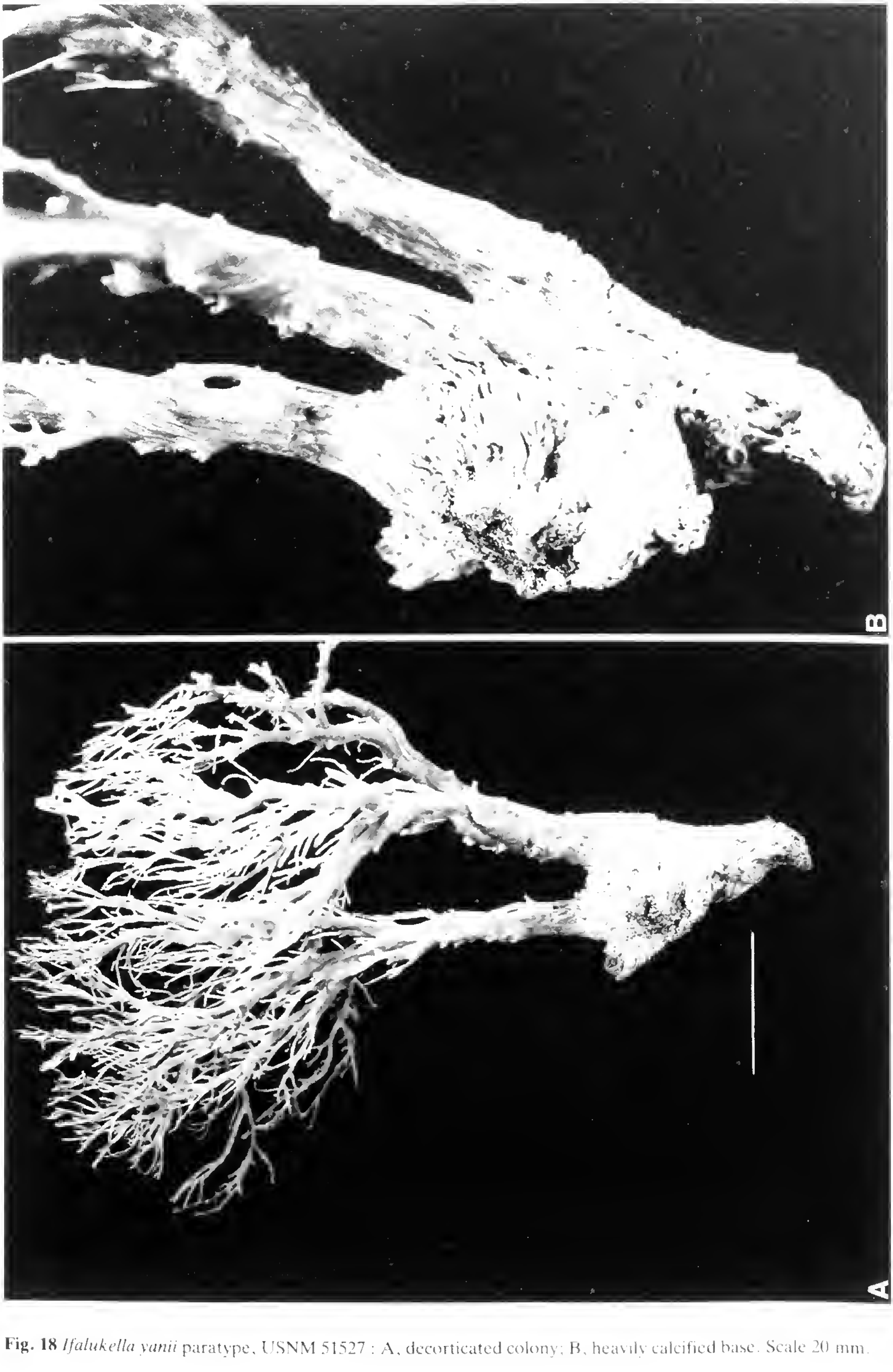


Fig. 18 *Ifalukella yanii* paratype, USNM 51527 : A, decorticated colony; B, heavily calcified base. Scale 20 mm.

axial calcification as well as the form of the sclerites. Specimens of *P. hydroides* from the China Sea were also referred to in the paper. Colonies of *Ifalukella* have very few sclerites. They are distinguished from *Plumigorgia* by their bushy non-pinnate growth form and massive calcareous base of attachment (Figs 17A,18B). *P. wellsi* is a stouter species than *P. hydroides*. The polyps are not biserial and the pinnate twigs branch at such shallow angles that the colonies do not have the feather or fish-bone-like appearance of *P. hydroides*. The sclerites of *P. wellsi* are also smaller with median constrictions being more pronounced, fewer flattened forms and the cavites shown in electron micrographs are far more common and far more distinct. Photographs of some of the type specimens of *I. yanii*, the holotype of *P. wellsi* and a large colony of *P. hydroides*, along with electron micrographs of the sclerites of the latter 2 species, are shown here for the first time (Figs 17-19), (an electron micrograph of a sclerite of *I. yanii* appears in Bayer et al. 1983, pl. 19 fig. 186). The photographs of the colonies are those of F.M. Bayer who also made it possible for me to examine fragments of the specimens. The colony of *P. hydroides* is a most luxurious specimen compared to Nutting's figured specimen and there are virtually no gaps between the polyps in the biserial rows. Dr Rob van Soest of the Instituut vour Taxonomische Zoologie, Amsterdam, made it possible for me to examine Nutting's material and, in contrast to his illustrated specimen, many of his syntypes have crowded polyps. It should also be noted here that the specimen illustrated by Nutting and that described by him in the text are not one and the same. In a bottle labelled "type" there are four colonies and some fragments (plus a small hydroid). The largest of these colonies, which is in very poor condition, has a main stem 2 mm wide at the base, branches 2-3 mm from the base and is approximately 135 mm high. It is attached to some dead coral and appears to be the colony referred to by Nutting in the text of his report. One of the smaller specimens corresponds to the bottom half of Nutting's illustration of a whole colony. By comparison the original colony must have been approximately 80-90 mm high when photographed. Because Nutting did not correctly specify a holotype I will designate this figured specimen, from Siboga Station 123, as the lectotype of the species. Although the specimen is incomplete it is in good condition and still has abundant sclerites. It is not clear whether this specimen and the other 2 small colonies were ever attached the base of the larger specimen. The specimens from Siboga station 96 are in another jar labelled "cotype". Six of these colonies are shown here in Fig. 20. The fine hair-like nature of the axes of the terminal branches is quite evident. As indicated by Nutting, it is extremely difficult to find any sclerites in the material from this station.

The definitions of the family Ifalukellidae and the genus *Plumigorgia* given by Bayer (1955, 1956) need only be slightly augmented to include the new species described in this paper.

Family Ifalukellidae Bayer

Diagnosis. Arborescent holaxonia with strongly calcified axes made up of gently undulating concentric lamellae; calcareous material not oriented in radial sectors; central chord not soft and cross chambered. Sclerites minute and of several forms; calcareous ovals, cylinders and platelets, some twin forms and some with median constrictions; angular rodlets and multiradiates, some with a highly crystalline appearance and prominent processes and ridges; surface structure irregularly granular; length 0.025-0.098 mm.

Genus *Plumigorgia* Nutting

Plumigorgia Nutting, 1910:32 (type species, *Plumigorgia hydroides* Nutting, 1910, by monotypy).

Diagnosis. Colonies pinnately branched, bushy or planar with a small calcified holdfast. Axis calcified but flexible. Polyps forming calyces or completely retractile within the general coenenchyme and may have sclerites. Coenenchyme maybe relatively thick. Sclerites absent to prolific, of all forms characteristic of the family.

Bayer's definition of *Ifalukella* (with a minor change) is given here for completeness;

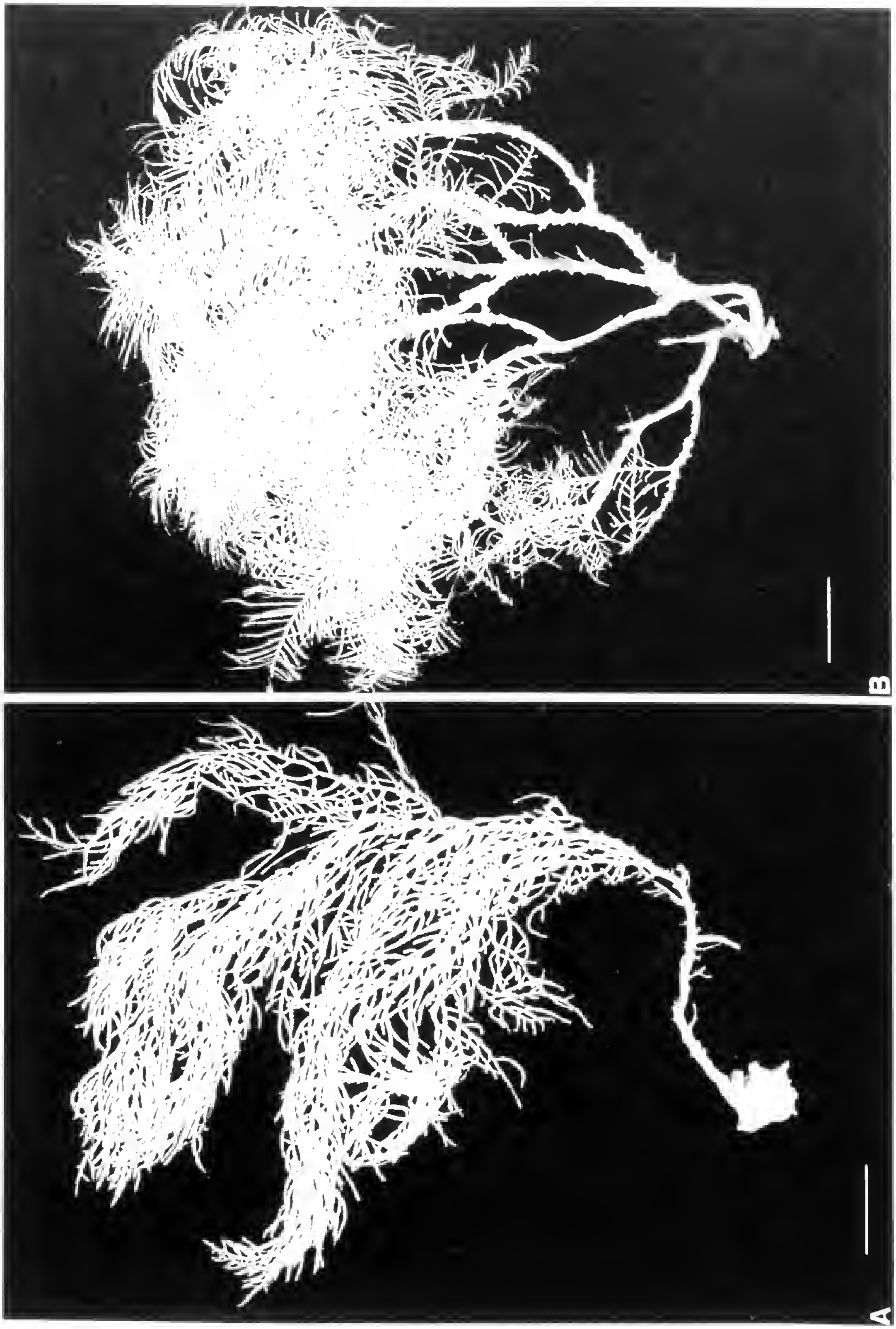


Fig. 19. **A**, *Plumigorgia wellsi* holotype; **B**, *Plumigorgia hydroides*, USNM 59811. Scale 20 mm.

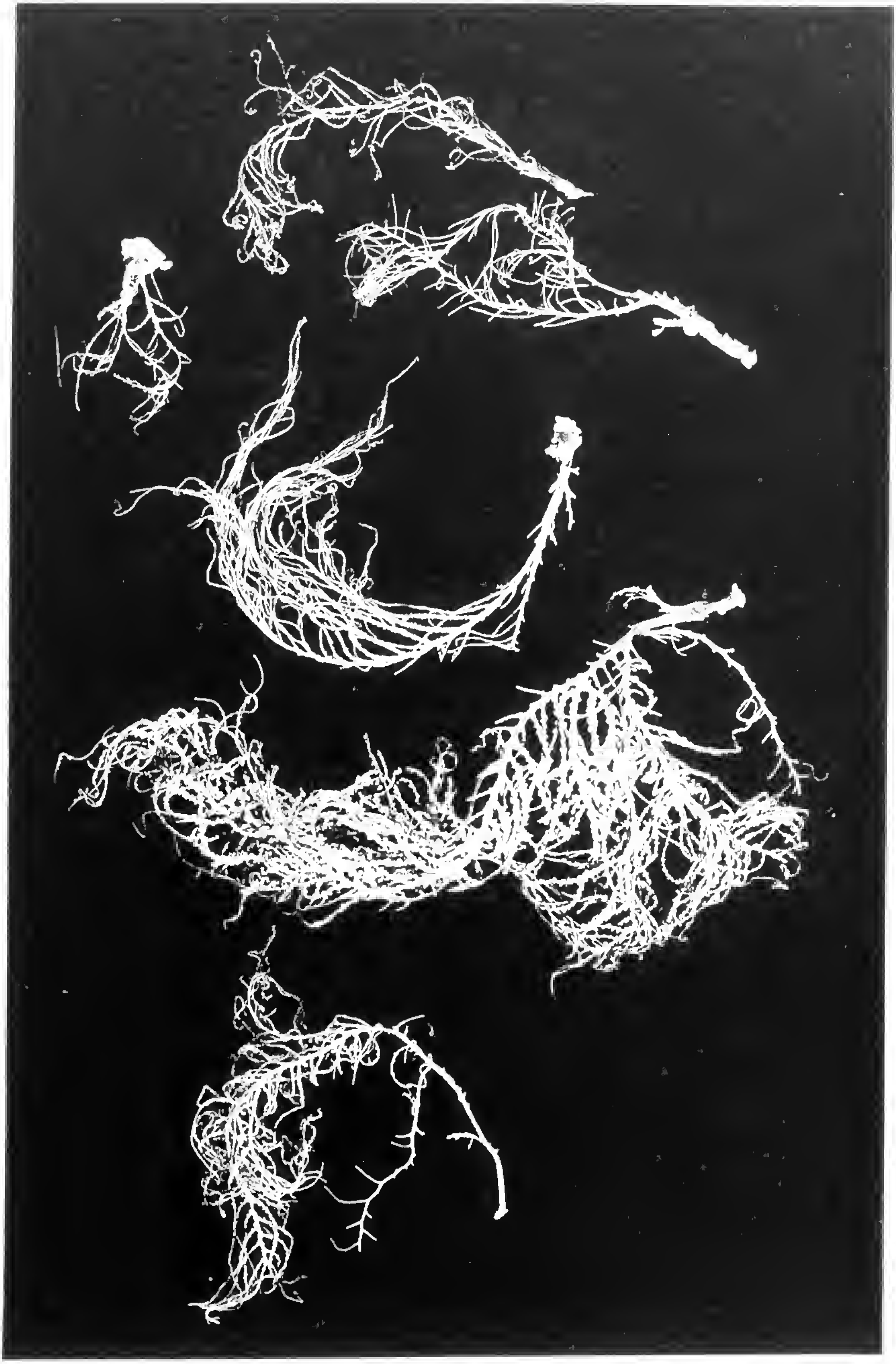


Fig. 20. *Plumigorgia hydroides* paratypes, ZM Coel 3083. Natural size.

Genus *Ifalukella* Bayer

Ifalukella Bayer, 1955:213 (type species, *Ifalukella yanii* Bayer, 1955, by original designation and monotypy).

Diagnosis. Colonies low, arborescent, finely branched in an irregular, lateral pattern. Axis calcareous, brittle, spirally ridged, arising from a massive calcareous base on to which ridges extend as high crests with lobed or strongly laciniated edges that may produce small twigs, some of which may develop into full-sized colonies. Coenenchyme thin, polyps unarmed. Spicules very small, up to 0.035 mm in length, oval or elongate platelets of characteristic outline.

A key to the known species of the family is given below. Some comment is necessary on the usage of overall colony shape as one of the distinguishing factors between species. A number of workers have clearly demonstrated the effect of water movement on the growth form of octocoral colonies and, to a lesser extent, on sclerite morphology (e.g. Theodor 1963; Rees 1972; Grigg 1972). Grigg has necessarily pointed out that "Classification of gorgonian corals has depended heavily on the general form of the entire colony and the size and shape of the spicules. Because of the ecotypic variation of these characters, it is likely that many nominal species are not valid." It appears that for many species both planar and non-planar forms will increasingly be encountered. The last word, however, is still be said as there are a number of extremely common taxa which are often collected, such as the bushy *Rumphella aggregata* (Nutting, 1910) and the flabellate *Subergorgia mollis* (Nutting, 1910), that appear to never greatly diverge from their classical forms. Nevertheless, in view of the findings of Grigg and others one must be wary of placing too much weight on colony shape as a taxonomic character. But, in instances where deviation from a particular colony form is known only from a few cases, there is still an argument for the use of that species' common shape where, in a practical sense and providing possible divergence is pointed out, it can simplify a matter such as a taxonomic key.

A case to point is *P. hydroides*. In the original description of the species Nutting did not accurately detail colony form. He figured one small specimen and made no mention of the shapes of other syntypes. Stiasny, however, indicated that his material ramified more or less in one plane and in Bayer's key to the octocorallia (1981) the genus *Plumigorgia* is defined as "branching in one plane". An examination of Nutting's colonies, some of which are shown in Fig. 20, has revealed that a small degree of bushyness could be attributed to this species. A number of the smaller colonies branch considerably from, or just above, the holdfast and a number have branches that diverge "out of plane". Although some of these "out of plane" branches are broken others turn vertical and ramify more or less parallel to the main plane. In one colony an "out of plane" branch begins to ramify pinnately at right angles to the main plane, but the plume has twisted during growth to lie parallel to this plane. The specimen in Fig 19B, although stouter and more luxurious than any of Nutting's syntypes, shows a typical branching strategy in the lower half of the colony. The bushyness in this colony, however, is exaggerated by bottle storage and the terminal plumes lay more or less in one plane. Therefore, to avoid the item "Colonies planar but sometimes bushy" from making the key unnecessarily complex, *P. hydroides* is considered as planar.

Key to the genera and species

1. Family Ifalukellidae,
   a. Colonies pinnately branched, bushy or planar, holdfast small and calcified: Genus *Plumigorgia* 2
   b. Colonies laterally branched, bushy, with massive calcareous holdfast. Sclerites scarce, oval or elongate platelets: Genus *Ifalukella* .... *I. yanii* Bayer
2. Colonies pinnate, Genus *Plumigorgia*,
   a. Colonies bushy. Polyps not biserial. Sclerites mainly multiradiates: .... *P. astroplethes* sp. nov.
   b. Colonies planar: 3
3. Colonies planar,
   a. Polyps not biserial. Sclerites highly crystalline rodlets, ovals and crosses, with angular prominences: .... *P. schuboti* sp.nov.
   b. Sclerites ovals, cylinders and platelets, often with median constrictions: 4

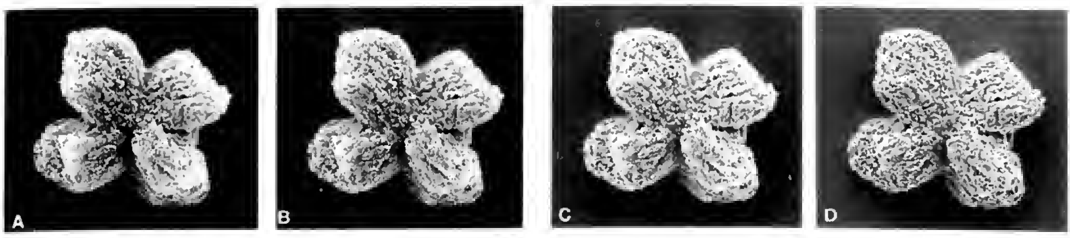


Fig. 21. Scanning electron micrographs at different accelerating voltages : **A**, 25 kv; **B**, 20 kv; **C**, 15 kv; **D**, 10 kv.

4. Sclerites ovals, cylinders and platelets,
    a. Polyps not biserial. Sclerites ovals, and cylinders, scarce (sometimes absent) and clustered primarily at the ends of the twigs: ... *P. terminosclera* sp.nov.
    b. Polyps not biserial. Sclerites ovals, cylinders and platelets, often with pronounced median constrictions, densely aggregated over whole colony: .... *P. wellsi* Bayer
    c. Polyps biserial: 5
5. Polyps biserial,
    a. .... *P. hydroides* Nutting

The key is so designed that entry is possible at any point, 2-5, after the first couplet.

GEOGRAPHIC DISTRIBUTION

The distribution of the group is only known from 6 isolated occurrences. The apparent range extends from north eastern Australia through central Indonesia to the northern Philippines and out into the central West Pacific. The only collection of *Ifalukella* was from quite shallow water. *Plumigorgia* has been obtained from a similar depth down to 20 fathoms.

ACKNOWLEDGEMENTS

I offer my sincere thanks to Dr Zena Dinesen, of the Queensland National Parks and Wildlife Service, and to Dr Clive Wilkinson, of the Australian Institute of Marine Sciences, who made special efforts to secure more specimens for this project. Without their help this study would have been restricted to a much smaller suite of gorgonians. I also welcome the opportunity to acknowledge the contribution made by Richard Schubot to the study of Australian octocorals. On several occasions I was a guest on board Mr Schubot's vessel for collecting trips that he not only personally organised and financed but during which he spent countless hours collecting and photographing specimens which now reside in the Northern Territory Museum. The naming of *P. schuboti* is but a small gesture of appreciation.

I am much indebted to Heather Winsor, Sue Doyle and Jim Darley for their excellent work and assistance with the scanning electron microscopy, and to Dr Frederick Bayer for making available material for study and photographs for publication as well as for his comments and criticism of the manuscript. I am also grateful to Neville Coleman, whose donated collection of octocorals contained *Plumigorgia* specimens, and to Dr Rob van Soest for the loan of Nutting's types.

This paper benefited from discussion with Helen Larson and Charlotte Russell and from the persistence and patience of Rex Williams who helped set up the illustrations. My thanks to Jenny Newman for typing the manuscript.

REFERENCES

Bayer, F.M. 1955 Contributions to the Nomenclature, Systematics, and Morphology of the Octocorallia. *Proceedings of the United States National Museum* **105**:207-220.

——— 1956 Octocorallia. In: R.C. Moore (ed) *Treatise on Invertebrate Paleontology. Part F. Coelenterata*:166-231. *Geological Society of America and University of Kansas Press*: Lawrence.

——— 1981 Key to the genera of Octocorallia exclusive of Pennatulacea (Coelenterata : Anthozoa), with diagnoses of new taxa. *Proceedings of the Biological Society of Washington* **94**(3):902-947.

Bayer, F.M., Grasshoff, M. and Verseveldt, J. 1983 *Illustrated trilingual glossary of morphological and anatomical terms applied to Octocorallia.* E.J. Leiden Brill: Leiden.

Grigg, R.W. 1972 Orientation and growth form of sea fans. *Limnology and Oceanography* **17**(2):185-192.

Kingsley, R.J. and Watabe, N. 1982 Ultrastructure investigation of spicule formation in the gorgonian *Leptogorgia virgulata* (Lamark) (Coelenterata: Gorgonacea). *Cell and tissue Research* **223**:325-334.

Nutting, C.C. 1910 The Gorgonacea of the Siboga Expedition IV. The Plexauridae. *Siboga-Expeditie* **13**b^1:1-20.

——— 1910a Ibid. VI. The Gorgonellidae. *Siboga-Expeditie* **13**b^3:1-39.

Rees, J.T. 1972 The effect of current on growth form in an Octocoral. *Journal of Experimental Marine Biology and Ecology* **10**:115-123.

Simkiss, K. 1980 Detoxification, calcification and the intracellular storage of ions. In: M. Omori, and N. Watabe (eds) *The Mechanism of biomineralisation in animals and plants*. Tokai University Press: Tokyo.

Stiasny, G. 1940 Die Gorgonarien - Sammlung der *Snellius* - Expedition. *Temminckia* **5**:191-256.

Theodor, J. 1963 Contribution a l'étude des Gorgones. III. Trois formes adaptives d'*Eunicella stricta* en fonction de la turbulence et du courant. *Vie Milieu* **14**:815-818.

Weinberg, S. 1977 Revision of the Common Octocorallia of the Mediterranean circalittoral. III. Stolonifera. *Beaufortia* **27**:139-176.

Accepted 6 August 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 123-130

A REVISED CHRONOLOGY FOR INTIRTEKWERLE (JAMES RANGE EAST) ROCKSHELTER, CENTRAL AUSTRALIA

M.A. SMITH
Northern Territory Museum of Arts and Sciences,
GPO Box 2109, Alice Springs, NT 5750, Australia.

ABSTRACT

A revision to the chronology of Intirtekwerle (James Range East) rockshelter is proposed. A review of the depositional history is supported with fresh radiocarbon dates and it is concluded that major occupation at the site post-dates 1000 yrs BP.

KEYWORDS: Intirtekwerle, James Range East rockshelter, arid zone prehistory, Central Australia.

INTRODUCTION

The purpose of this paper is to propose a revision to the chronology of Intirtekwerle rockshelter in Central Australia. This is a prerequisite for integrating the results of the 1973-4 excavations by R. A. Gould (1978) with the sequence of late holocene changes in landuse suggested by other archaeological work in the region (Smith 1986, 1983; Napton and Greathouse 1985; Stockton 1971). Using Gould's chronology the major period of occupation at Intirtekwerle begins at about 5000 yrs BP and artefacts in the underlying levels date back to about 10,000 yrs BP. Thus the sequence is seen to be one of the longest from the Central Australian ranges and directly comparable to that of Puntutjarpa (Saggers 1982; Gould and Saggers 1985). However further excavation at Intirtekwerle in 1983 and 1985 shows that major occupation at the site began much later, at around 850 years BP, and that the underlying layers need not be older than 5000 years BP.

NOMENCLATURE

Intirtekwerle rockshelter, formerly known as the James Range East site, is situated in the James Range approximately 100 km southeast of Alice Springs. A rockhole near the shelter is called Intirtekwerle by Arrernte-speaking Aborigines (cf. Intitagula, Strehlow 1971: xxxvii, 765; Intitjikula, Gould 1978:94) and the shelter itself is referred to as Intirtekwerle intiye (Intirtekwerle cave). As this name clearly has precedence I propose that future references to the site should be in the form - Intirtekwerle (James Range East) rockshelter. This nomenclature will minimise confusion in the archaeological literature while making the search for associated ethnographic information easier. My spelling follows the standard orthography now used for Arrernte (Aranda).

STRATIGRAPHY

The deposits at Intirtekwerle are part of the sand sheet which forms the floor of the valley in front of the shelter (Fig. 1). Occupation debris extends out from the shelter on the surface of this sand sheet for 20-30 metres. The stratigraphy of the site reflects both the accumulation of the sand sheet and weathering and progressive collapse and retreat of the shelter.

Deposits outside the dripline

The deposits outside of the present dripline consist of a fine red aeolian sand containing varying amounts of occupational debris, sandstone rubble and rockfall. Unit I (see Fig. 2) contains a large amount of finely divided charcoal giving the deposit a dark grey or black colour. This unit also contains the bulk of the occupational debris such as burnt bone. chipped stone artefacts and grindstones (Fig. 3). A comparison of unit 1 with the underlying layers shows that it contains approximately ten times the density of chipped stone artefacts (Table 1) suggesting that signifcantly more intensive use of the site occurred at this time. This layer grades into the uniform red sand which comprises unit II. The latter contains little charcoal and very few artefacts (Fig. 3). Unit III is a layer of sandstone rubble in a matrix of red sand (Fig. 3). Figure 2 shows that on the slope outside the dripline the rubble interdigitates with aeolian sand (see c in Fig. 2). Chipped stone artefacts are present throughout unit III in small numbers but there is a minor peak near the top of the unit (Fig. 3).

Deposits in the shelter

Gould (1978:98) notes that the deposits within the shelter are slightly different in texture and colour to those outside the dripline. This is presumably due to a greater proportion of fine white sand derived from weathering of the shelter walls (Mereenie sandstone). Thus the sediments at the eastern end of trench 1 are observed to be redder in colour and slightly coarser in texture than those at the western end. Within the shelter unit I is also noted to contain more fine ash and charcoal.

Unit III rubble

The rubble in unit III consists of poorly sorted sub-angular pieces of sandstone (the term rubble is used for rocks 5-50 mm in size, which loosely approximates the Wentworth size class for pebbles). Larger rocks up to 100 mm are common but the modal size for rocks is about 30-40 mm (excluding large boulders).

The rubble is distributed within a matrix of red sand which is identical in colour and texture to that forming unit II (see Fig. 4). Particle-size analysis of the matrix shows that both unit II and III are made up of predominantly fine to very fine sand (approximately 80% wt.) with a small silt/clay fraction (approximately 10% wt.).

Both the composition of unit III and the presence of artefacts throughout the layer suggests that it was not formed by a single large rockfall or debris flow. Gould interpreted it as a layer of rockfall that had progressively accumulated over some time (1978:99). Slopewash is another process which could have contributed material to this unit and it is likely that some of the sediment and pebbles derive from the small cone of debris at the foot of the scarp on the north side of the shelter.

Despite the obvious change in the proportion of rubble and sand from unit III to unit II the sequence appears to be essentially a continuous record of deposition. There is little to suggest a disconformity between these units. Figure 4 shows the boundary between the units. There is no evidence of erosion, reworking or sorting of the sediment nor of epimorphic processes such as weathering, leaching, or induration. However without local information about the rate of such processes I cannot entirely dismiss the possibility that there is a period of elapsed time between the accumulation of the two units.

PROBLEMS WITH THE CHRONOLOGY

Gould presented seven radiocarbon dates to support his chronological framework (Table 2). The main problems with it are that the dates from different trenches do not agree on the age of unit I, the key date (I-7599) for the framework diverges markedly from the age/depth relationship of the other dates and there are no dates from units II and III.

The existing framework

Gould accepted the oldest of his dates as reliable and inferred that the basal age of unit I was approximately 5,000 years B.P. Extrapolating from this he suggested that the basal levels of the site may date to 10,000 years BP (Gould 1978:105,1979:32). Thus the assemblage of stone artefacts was divided into two phases: *James Range II* from unit I dating back to 5,000 years BP and *James Range I* from the underlying sediments, of possible pleistocene age. Changes in the assemblage from phase I to phase II appeared to corroborate this scheme. For instance backed blades first appear in levels dated to about 5,000 years BP. This is in line with the age of similar technological changes in southern and eastern Australia.

Problems

Age of unit I. The uncertaintly over the the age of unit I is evident in Table 2. To accomodate these divergent dates one could argue that the rate at which the deposit accumulated varied markedly in different parts of the site. For instance, on the flat in front of the shelter the unit would appear to have accumulated between 1800-1500 years BP. In the shelter it accumulated at about 4600 years BP and then from 700 years BP onward. However, this interpretation is not consistent either with Gould's description of the stratigraphic relationships across the site nor with his section drawings which show unit I as a continuous layer. Furthermore Gould attributes his dates of 715+/−80 and 4640+/−260 to the same subunit of unit I which implies that he saw no evidence of any break in the depositional sequence at this point. My own field observations suggest that the sandsheet in the area has built up at a steady, though not necessarily constant, rate and that it is unlikely that unit I could vary so much in its age across a distance of only 5-10 m.

Reliability of I-7599. A prima-facie case can be made that the key date of 4640+/−260 (I-7599) does not accurately reflect the age of unit I. Figure 5 shows the extent to which it diverges from the age/depth relationship of

Table 1. Comparative density of chipped stone artefacts.

1974 trench 1.			
Unit	*Volume*	*No. artefacts*	*Density*
I	7.2 m^3	17,742	2464/m^3
II/III	15.7 m^3	3,219	205/m^3
Total	22.9 m^3	20,961	915/m^3
1983/5 square L11			
I	0.9 m^3	1,449	1610/m^3
II/III	1.7 m^3	194	114/m^3
Total	2.6 m^3	1,643	632/m^3

Table 2. Radiocarbon dates. Depths (cm) are below ground surface.

Unit I				
Trench 1.	I-7600	195+/−80	8 cm	hearth
	I-8308	285+/−80	42 cm	hearth
	I-8306	715+/−80	50 cm	hearth
	I-7599	4640+/−260	70 cm	dispersed charcoal
Trench 2.	I-8307	1840+/−105	57 cm	dispersed charcoal
Trench 3.	I-8643	1525+/−80	17 cm	hearth
1983.	SUA2247	670+/−100	34-40 cm	dispersed charcoal
Unit II				
1983.	SUA2125	1460+/−210	120-160 cm	dispersed charcoal
Uncertain context				
Trench 2.	I-7601	2495+/−85		dispersed charcoal from feature interpreted as a pit

Fig. 1. The sandplain at Intirtekwerle. The position of the rockshelter is shown by the arrows. The staff held by the person is 4 m long.

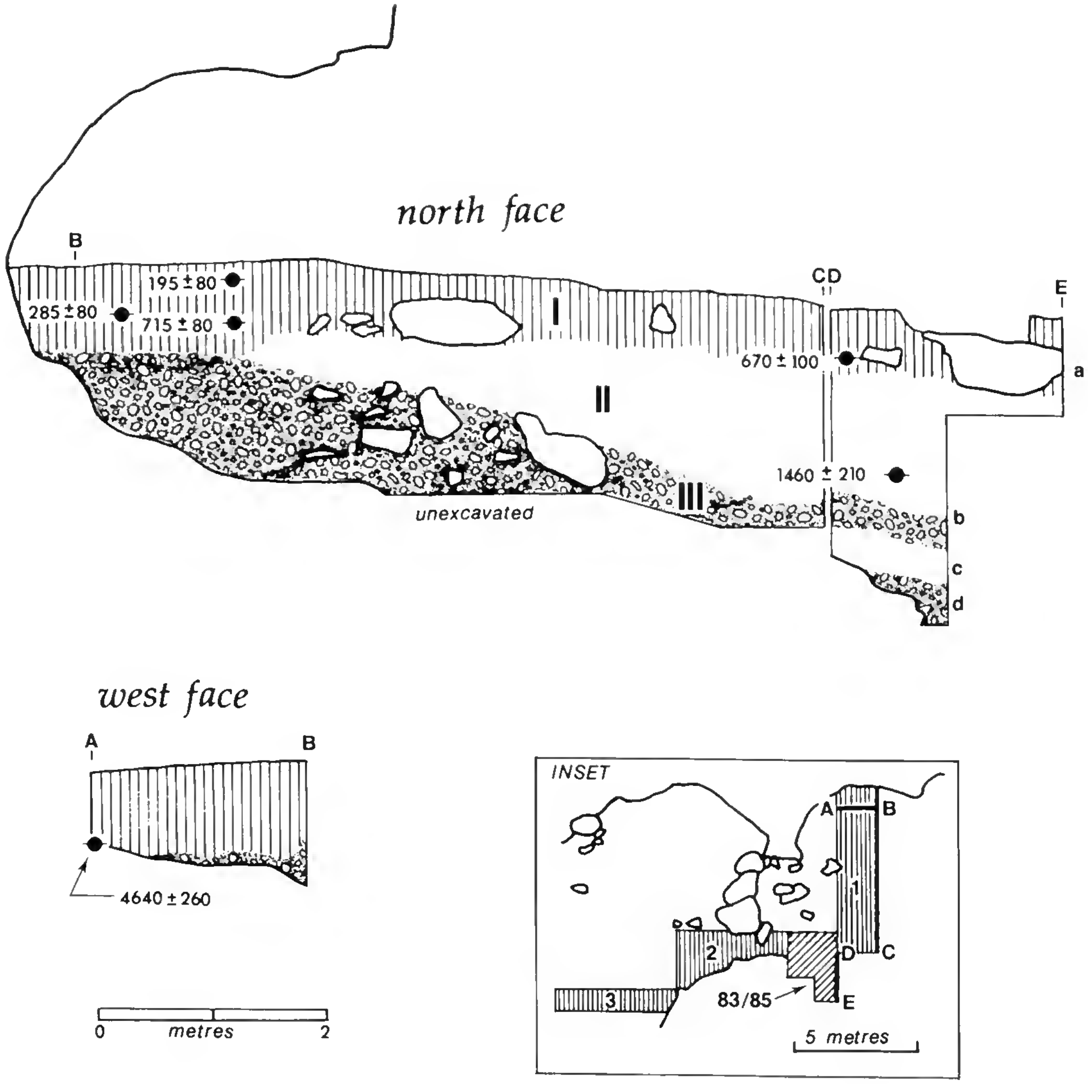


Fig. 2. Stratigraphic section. Redrawn from Gould (1978) with additions from 1983/85 excavations at right. The lower case letters in the right margin key the section into Figure 3.

the other dates for trench 1. Of Gould's four dates from adjacent squares in this trench, three form a consistent sequence back to 715+/−80 years BP and date charcoal from features interpreted as hearths. There is only 20 cm difference in level between this date and the fourth date, that of 4640+/−260. As both are attributed to the same part of unit I by the excavator I suggest that I-7599 is anomalous.

Provenance of I-7599. The provenance of I-7599 is open to question because the sample has come from a stratigraphically complex part of the site which has been disturbed by burrowing animals. The sample consisted of scattered charcoal pieces collected from the south face of trench 1 just above bedrock. Gould's section (1978, Fig. 5) shows that this part of the site has been disturbed by burrowing animals and an independent study by Webster (1982) confirmed that the deposits within the shelter are extensively disturbed by *Bettongia lesueur*, a small macropod. It is possible therefore that I-7599 could be either charcoal disloged from unit III (which directly underlies unit I in the northern part of the shelter) or charcoal from a pocket on the shelter floor possibly predating unit III.

Changes in the assemblage. The changes in the type of stone artefacts between unit I and units II/III cannot be used to corroborate the present chronological framework. Firstly, the age of small-tool tradition assemblages in Central Australia and surrounding regions is not well established (see Johnson 1979:133). Secondly, the first appearance of artefacts such as backed blades, adzes and seedgrinders may be masked by the sampling problems that accompany changes in the intensity of site use and assemblage size. For instance, although a backed blade was associated with a date of 3210+/−90 years BP at Ilarari kulpi (Smith 1983:31-2), the first appearance of assemblages containing these artefacts at the three Kuyunpe sites (Smith 1983; Napton and Greathouse 1985) and at Keringke (Stockton 1971; Smith 1983:38) took place at different times within the last 1000 years and in each case is associated with the main occupation at the site.

Tula adzes in unit II. Although the chronology of these artefacts is not known in any detail the presence of two tula adze slugs in unit II at depths of 69-76 cm and 91-99 cm respectively suggests that this layer is not older than 5000 years BP.

FURTHER RADIOCARBON DATES

In 1983 and 1985 I re-excavated Intirtekwerle to examine the depositional history of the site. Further samples for radiocarbon dating were collected to test the hypothesis that the basal age of unit I was less than 5000 years BP.

Five square metres were excavated at the eastern end of trench 1 (Fig. 2 inset) where I expected that the deposit would be less disturbed than that in the shelter. The deposit was excavated using 5-10 cm spits and sieved using 3 mm and 6 mm mesh. The sieve residues were retained and later wet sieved. Charcoal was recovered by flotation.

Unit III was found to contain very little charcoal and the amount recovered was too small to directly date this unit. From a cubic metre of deposit only 1.2 of charcoal was recovered by flotation.

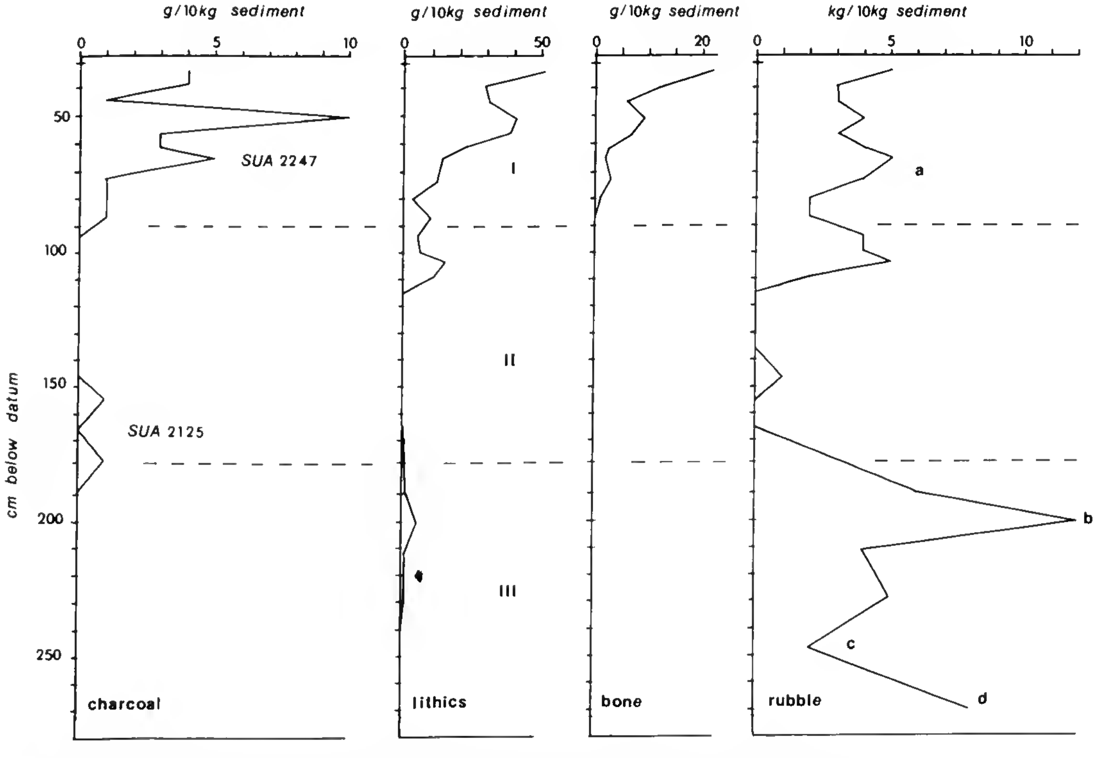


Fig. 3. The distribution of charcoal, chipped stone artefacts, bone and rubble (rocks from 5-50 mm) in square L11 (1983/85). Lower case letters key the graphs into Figure 2. Depths are cm below site datum.

Fig. 4. North face of square L11 (1983/85). The interface of unit II and III is shown by the arrow. The fill of Gould's trench is visible on the left.

From the base of unit II a date of 1460+/−210 BP (SUA2125) was obtained on finely divided charcoal. Care was taken to ensure that the sample was not contaminated by recent material. The sandy matrix in this part of the site was uniform and there was no sign of root penetration, burrows or insect casts. Figure 3 shows the minor peak in charcoal at the base of this unit.

A second sample, of scattered charcoal pieces, was submitted from the lower part of unit I as a cross-check on SUA2125. This sample gave a date of 670+/−100 BP (SUA2247).

These dates appear to be internally consistent and except for I-7599 they agree well with the dates obtained for trench 1. Together the five dates now form a consistent chronological sequence for the site.

REVISED CHRONOLOGY

The balance of the evidence suggests that the date of 4640+/−260 years BP (I-7599) does not accurately reflect the age of unit I. Since this date is the cornerstone of the present chronology it follows that significant revisions are warranted.

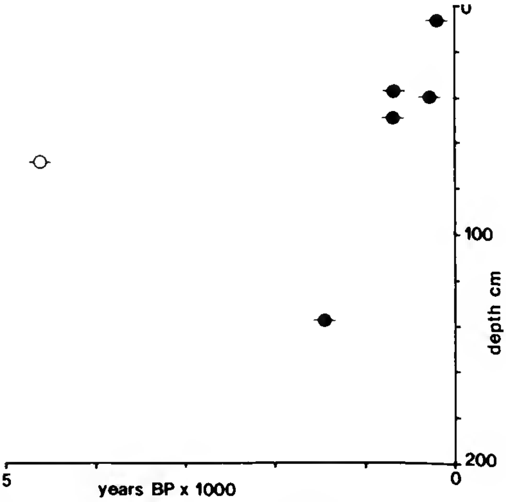


Fig. 5. Age/Depth graph for radiocarbon dates from trench 1 and the 1983/85 excavations. Depths are in cm below ground surface. I-7599 is shown by the open symbol at the far left.

A sequence of five dates, from trench 1 and the 1983/85 excavations show that the basal age of unit I is about 850 years BP (interpolated date) and of unit II about 1500 years BP.

The date of 1460+/−210 forms a *terminus ante quem* for unit III. As I see no evidence to suggest a major disconformity here I suggest that the top of unit III dates to about 1500-2000 years BP. This is in line with Gould's date of 2495+/−85 (I-7601) obtained from a deep pit or burrow which from its depth (2.13 m) must have penetrated well into unit III. If the rapid rate of deposition evident in unit II is extrapolated this would give a basal age of approximately 3000-3500 years BP for unit III. However if the rate of accumulation of unit III was slower, as seems likely, this figure would represent a minimum basal age for the unit. If one accepts my interpretation of the provenance of I-7599 then the maximum age of the unit need not be greater than about 5000 years BP. Without direct radiocarbon dating it is difficult to further refine these estimates.

If Intirtekwerle is considered in its regional context the above revisions to the chronology remove an anomaly. For instance, other sites bordering the sandplains such as Ilarari kulpi, Kuyunpe and Keringke show rapid rates of deposition of the order of 50-60 mm/100yr (Smith 1983). It seems unlikely that the much lower rates implied by Gould's chronology would have prevailed on the sandsheet at Intirtekwerle.

Similar changes in site use also occurred at other prehistoric sites across Central Australia. In each case an ephemeral use of the site is followed by more intensive occupation represented by a dark grey layer with burnt bone and a high density of chipped stone artefacts and grindstones. Table 3 lists radiocarbon dates for the lower part of this late holocene occupation horizon at various sites. The nature, timing and possible causes of the change are currently being investigated by the author and are beyond the scope of this paper. However it is worth noting that major late holocene occupation begins in Central Australia after 1000 years BP and that the revised chronology brings the changes at Intirtekwerle into line with the regional sequence.

Table 3. Radiocarbon dates for the lower part of the late holocene occupation horizon at sites in Central Australia.

Site	*Type*	*Radiocarbon age*	
Rainbow Valley 1	open site	980+/−80	Beta-16306
Wanmara	open site	970+/−70	Beta-16307
Tjungkupu 2	open site	940+/−70	Beta-16305
Keringke	open site	920+/−130	ANU-426
Tjungkupu 1	rockshelter	840+/−80	Beta-16303
Intirtekwerle	*rockshelter*	*670+/−100*	SUA-2247
Kuyunpe 6	rockshelter	590+/−80	SUA-2096
Therrerrete	open site	400+/−50	SUA-2520
Kuyunpe 1	rockshelter	265+/−75	Beta-4895

ACKNOWLEDGEMENTS

I wish to thank Mr and Mrs W. Hayes of Deep Well Station for their cooperation in this research, E. Chaloupka, B.J. Cundy, J. Kaye, K.T. Roth and S. Sutton who assisted with the 1983 and 1985 excavations, Edward and Gregory Johnson, George Breaden, and Alan Drover who gave their consent for the work at Intirtekwerle, and the late A. Blackwell who assisted with the processing of the excavated material. I also wish to acknowledge the assistance of R. A Gould who made available plans and section drawings of his 1973/74 excavations at Intirtekwerle and who commented at length upon several drafts of this paper. SUA2125 was funded by the Northern Territory Museum and SUA2247 by a Northern Territory University Planning Authority research award.

REFERENCES

Gould, R. A. 1978 James Range East Rockshelter, Northern Territory, Australia: A summary of the 1973 and 1974 Investigations. *Asian Perspectives* **21** (1): 85-126.

——— 1979 Exotic stones and Battered bones: Ethnoarchaeology in the Australian Desert. *Archaeology* **32** (2): 28-37.

Gould, R.A. and Saggers, S. 1985 Lithic procurement in Central Australia: a closer look at Binford's idea of embeddedness in Archaeology. *American Antiquity* **50** (1): 117-136.

Johnson, I. 1979 *The Getting of Data: A case study from the recent industries of Australia* Ph.D. Thesis, Australian National University: Canberra.

Napton, L. K. and Greathouse, E. A. 1985 Archaeological investigations at Pine Gap (Kuyunba), Northern Territory. *Australian Archaeology* **20**: 90-108.

Saggers, S. 1982 Comparative analysis of adzes from Puntutjarpa rockshelter and the James Range East site complex, Australia. *Archaeology in Oceania* **17**: 122-126.

Smith, M. A. 1983 Central Australia: Preliminary archaeological investigations. *Australian Archaeology* **16**: 27-38.

——— 1986 The antiquity of seedgrinding in arid Australia. *Archaeology in Oceania* **21**: 29-39.

Stockton, E. D. 1971 Investigations at Santa Teresa, Central Australia. *Archaeology and Physical Anthropology in Oceania* **6**: 44-61.

Strehlow, T. G. H. 1971 *Songs of Central Australia* Angus and Robertson: Sydney.

Webster, J. 1982 *Faunal Analysis and the James Range East Site* B.A. Honours Thesis, University of Sydney.

Accepted 14 August 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 131-136

PHYLLOGOBIUS, A NEW GENERIC NAME FOR *COTTOGOBIUS PLATYCEPHALOPS* SMITH (PISCES: GOBIIDAE), AND A REDESCRIPTION OF THE SPECIES

HELEN K. LARSON
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

A new genus, *Phyllogobius* gen. nov., is proposed for *Cottogobius platycephalops* Smith, a species of commensal goby which does not belong in *Pleurosicya* Weber, the senior synonym of *Cottogobius* Koumans. The genus is characterised by an unrestricted gill opening forming a broad free fold across the isthmus, at least half the first gill arch bound by membrane to the opercular wall, and the premaxilla with ascending and articular processes broadly fused together. *P. platycephalops* is a rare species, commensal on flat upright sponges.

KEYWORDS: Gobiidae, taxonomy, *Cottogobius platycephalops*, new genus, *Phyllogobius*, commensal, sponge, *Phyllospongia*.

INTRODUCTION

In 1964, Smith described the Flathead Sponge Goby, *Cottogobius platycephalops* from Pinda, Mozambique. *Cottogobius* Koumans was shown by Larson and Hoese (1980) to be a synonym of *Pleurosicya* Weber, a widespread genus of small gobies commensal with invertebrates. *C. platycephalops* does not fit in *Pleurosicya* or related genera, differing by its unrestricted gill opening with membranes forming a broad fold across the isthmus, wide interorbital with a pair of anterior interorbital pores, and at least half of the first gill arch bound by membrane. A new generic name is required to separate *C. platycephalops* from its, albeit, close relatives. Recent collections on the Great Barrier Reef and the Philippines have produced a few additional specimens of this uncommon goby. All were living commensally on flat-bladed sponges tentatively identified as *Phyllospongia* sp. The fish is redescribed and figured below in the light of the new material although Smith's description is quite comprehensive. Methods of counting and measuring follow those of Larson and Hoese (1980). Counts of the holotype are marked by an asterisk. Type specimens from Rhodes University Institue of Ichthyology, Grahamstown (RUSI) were examined, as were specimens from the Australian Museum, Sydney (AMS), the Northern Territory Museum, Darwin (NTM), and the Royal Ontario Museum, Toronto (ROM).

SYSTEMATICS

Phyllogobius gen. nov.

Type species: *Cottogobius platycephalops* Smith, 1964.

Type material: HOLOTYPE - RUSI 212, 19 mm SL, Pinda, Mozambique. PARATYPES - RUSI 5441, 5 specimens, 17-22 mm SL, collected with holotype.

Additional material. AMS I.21916-001, 3 specimens, 14-18 mm SL, Caban Island, Batangas Province, Philippines; ROM 42636, 11 mm SL, Solomon Islands; AMS I.24847-001, 23.5 mm SL, west face of No Name Reef, NE of Dunk Island, Queensland; NTM S.11404-001, 2 specimens, 17.5-18 mm SL, Rib Reef, Queensland; AMS I.24846-001, 19.5 mm SL, same locality as preceding; NTM S.11962-001, 2 specimens, 15-18 mm SL, Ashmore Reef.

Diagnosis. A small goby with the following combination of characters: fleshy lobes around pelvic spines, and pelvic frenum folded forward into pocket; head and anterior half of body extremely depressed; eyes largely dorsally-placed; interorbital wide, with two anterior interorbital pores present, and thin ridges of bone on either side of interorbital canals; scales 28-37 in lateral series and nape scaled up to behind eyes; gill opening unrestricted, a broad free fold across isthmus; at least half of first gill arch bound to opercle by membrane; outermost fine teeth at sides of lower jaw straight and horizintally-directed in contrast to outer row of upper jaw teeth which are large, pointed and backwardly-directed.

Osteological characters (based on one specimen only) include: five branchiostegal rays; no dorsal post-cleithrum; ventral post-cleithrum a very small oval; metapterygoid expanded, barely separate from quadrate; sphenotic with narrow pointed flange forming part of posterior edge of orbit; frontal short, with rounded posterior wings and low angled ridge around dorsal and posterior part of orbit with very low ridge running parallel on either side of frontal to accommodate interorbital canal; supraoccipital narrow anteriorly, with short median wings, very low crest posteriorly; premaxilla with ascending and articular processes indistinguishable, fused into single very broad process; maxilla thin, lateral process expanded anterolaterally; glossohyal expanded, spatulate; scapula unossified; vertebrae 10+16 (including urostyle) = 26; dorsal ribs on first ten vertebrae; ventral ribs on vertebrae three to eight; elongate ventral processes of pelvic bones diverge at roughly T-shaped tips; single epural with poorly ossified dorsal flange; upper hypural splint-like; parahypural free, somewhat curved anteriorly.

***Phyllogobius platycephalops* (Smith), comb. nov.**

(Figs 1-3, Table 1)

Cottogobius platycephalops Smith, 1964: 174-176, pl. IV.

Description. First dorsal rays VI*; second dorsal rays I, 8* (I, 7 in 2 specimens); anal rays I, 8*; pectoral rays usually 19* (16 to 20, 18 in holotype); longitudinal scale counts 28-37 (30-35? in holotype, many scales lost posteriorly) transverse scale count backward 9*-13; 10-13 predorsal scales; gillrakers on first arch 2+1+2 or 3; segmented caudal rays 16-17*; branched caudal rays 11*.

Head extremely flattened, increasing in height posteriorly. Body slender, roughly triangular in cross-section anteriorly, compressed posteriorly. Snout long, broad, rounded in dorsal view. Mouth subterminal, upper lip overlapping lower jaw (Fig. 1). Nostrils close together, posterior nearly touching anterior rim of eye. Anterior nostril with short tube. Tongue rounded to blunt. Jaws end at point below mid-eye. Eye moderate, 20-30% of head length (21% in holotype), dorsolaterally oriented. Supraorbital ridge present (enhanced by preservation in holotype), as is low interorbital ridge running longitudinally on side of each interorbital canal. Interorbital width about twice eye diameter. Gill opening unrestricted, membranes somewhat pointed posteriorly, fused together across isthmus and free of it. Membranes attached anterior to eye. At least half of first gill arch bound by membrane to opercle, and about a quarter of second arch bound to first arch. Gill rakers on front of first arch very low stubs without spines, rakers on back of arch with fine spines. Rakers on front of second arch somewhat larger, more numerous, with fine forwardly-directed spines. Scales ctenoid, absent from sides of head, pectoral base, breast, and midline of belly (in 3 specimens, including largest, belly scaled in front of anus). Predorsal scales smaller than body scales, covering nape fully, extending up to behind eyes at a level above or little forward of preopercular edge (Fig. 2). Most nape scales lost in holotype (its rather dehydrated condition made accurate check of scale pockets impossible).

First dorsal fin triangular in outline, height greater than body depth. Second and third spines longest, subequal. Second dorsal about equal to first in height anteriorly, lower posteriorly. Anal fin very low, little over half height of second dorsal. All anal rays unbranched. Pectorals rather pointed, reaching to just above anus, with 7 (6 to 9) lowermost rays unbranched and somewhat thickened distally, as are tips of lowermost branched ray. Pectoral base oriented diagonally so that lowermost pectoral rays are considerably anterior to uppermost rays. Caudal roughly rectangular, margin slightly rounded. Lowermost 5 or 6 caudal rays slightly thickened along ventral margin. Pelvic fin flattened, broad and round, does not reach anus (Fig. 3). Fifth pelvic ray with slender base (not broad, flattened) and branching 5-6 times. Pelvic spines slightly curved inward. Pelvic spine lobes short, flat, not folded or dissected. Frenum folded forward into an anteriorly-facing pocket. Lobes and frenum mostly smooth, with low rounded papillae often present on edges of frenum, spines or surface of lobes.

Three preopercular pores present along deep groove behind preopercle, 2 lowermost

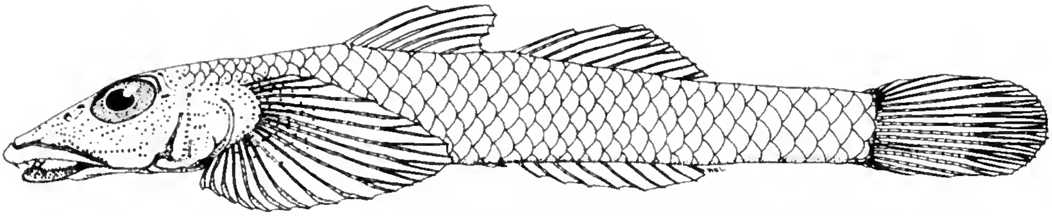


Fig. 1. *Phyllogobius platycephalops*, AMS I.24846-001, from Rib Reef, Queensland, lateral view, 19.5 mm SL.

close together by preopercular angle. Opercle sculptured around groove, with anteriorly-directed lower lobe variably developed (Fig. 1), and shallow groove running up behind vertical opercular papillae row. A nasal pore close to dorsal side of each posterior nostril. Two separate interorbital canals, each with an anterior and posterior interorbital pore (posterior pore just above hind margin of eye). In several specimens, posterior pores united into one median pore linked to the interorbital canal by short canal. A postocular pore behind each eye, an infraorbital pore on each side of head below mid-eye level and a pore just above preopercular canal. All pores connected by lateral line canals.

Sensory papillae on head as in Figs 1 and 2. In all specimens (except those from Philippines and several types) many fine papillae present, scattered evenly over top, sides and underneath head, pectoral base, and lower half of pectoral fin (remainder of types dehydrated). These papillae (which, for clarity, are not shown in Figs 2 and 3) usually slightly smaller than major sensory papillae, and obscure pattern in some specimens.

Teeth in lower jaw with outermost row of uniserial horizontally-directed straight fine teeth (tips slightly curved posteriorly); teeth absent from jaw symphysis. Outermost row separated from inner rows by very narrow gap. One to three irregular inner rows of small curved pointed teeth present, with

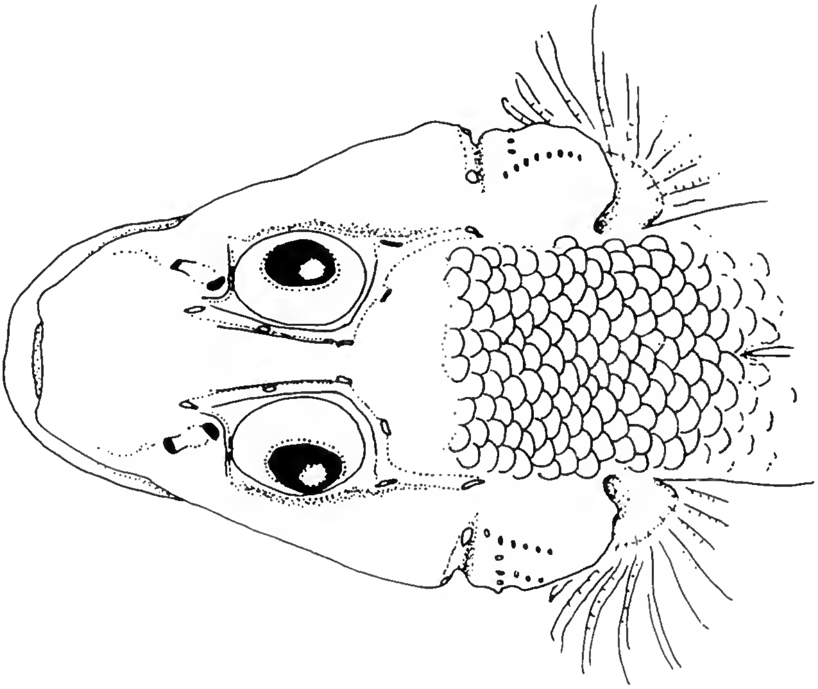


Fig. 2. *Phyllogobius platycephalops*, AMS I.24846-001, dorsal view of head showing headpore pattern and scalation.

innermost even row of slightly larger pointed teeth. On either side of symphysis of jaw, large sharp curved caniniform tooth present, occasionally with smaller such tooth beside it.

Upper jaw with outermost row of about 14 large strongly recurved pointed teeth across front and anterior half of sides of jaw. Points of teeth protrude past upper lip and over lower jaw when mouth closed. Single row of small curved sharp teeth along posterior half of sides of upper jaw. Innermost band of one to three rows of small sharp fine conical teeth around sides and front of jaw. Vomer without teeth, does not protrude from roof of mouth.

Colour in life. Smith's account (1964) states: "In life milky green, the occiput with shiny green spots on an orange red background, similar markings around snout, eyes bright blue". The Rib Reef, Queensland, material was noted as being transparent pink, but no further description was kept. One specimen was transparent with fine crimson chromatophores scattered over head and body, intensified along dorsal fin bases (from a slide of largest Philippines specimen). The pectoral rays and caudal fin rays and membrane are tinged with the same colour. The chromatophores are most dense around the cranium and brain, and also form two curved lines from front of eye to tip of snout, following the contours of the maxilla. The front of the upper lip is densely speckled with fine crimson. Irises are silvery, with crimson and red speckling overlaying most of silver surface, leaving a narrow silver ring around the pupil. No green or blue pigments are observable (Smith's specimens may have come from a very differently-coloured host).

Colour in alcohol. No pigment pattern visible. All preserved specimens are various shades of brownish to creamy-white, depending on preservation.

Comparisons. The five commensal goby genera with lobed pelvic spines are closely related and generally similar in appearance. *Phyllogobius* shares three characters with *Pleurosicya*, the most speciose genus. These are the fine horizontal moveable lower jaw teeth, the scaled nape, and the diverging tips of the pelvic bone anterior processes (the latter is variable in *Pleurosicya*). The head-pore pattern with two separate canals and two anterior interorbital pores present is a character shared by *Phyllogobius, Bryaninops* Smith and *Lobulogobius* Koumans.

Phyllogobius has five unique characters not possessed by members of the other four genera. These are: the premaxilla with only one broad low process, the gill membranes joined together forming a fold across the isthmus and free of it, at least half of the lower limb of the first gill arch joined to the opercular wall, low interorbital ridges present on each side of each interorbital canal, and the scattered papillae on the head and pectoral base. None of the other fishes in this group are shaped in such an exaggerated manner. Although this fish shows similarities to several genera, it appears to be most closely related to *Pleurosicya*.

Remarks. The type specimens came from "sandy coral pools at Pinda, Mozambique"; no depth was given. The Queensland and Philippine specimens were collected by hand from foliaceous, flattened, thin, digitate purplish-brown sponges identified as *Phyllospongia/Carteriospongia*, of which a revision of the genus and species are in preparation by P. Bergquist (Hooper, pers. comm.). The present species most resembles *P. papyracea* (Esper) sensu Lendenfeld, 1889, plate 4, figure 2. The sponges are upright, with overlapping flat leaflike blades, growing on sand and rubble bottoms, near rich coral areas at depths of 15 m. *P. platycephalops* has not been found associated with any other invertebrate group so far, and does not seem to be common. *Luposicya lupus* Smith, another commensal goby restricted to sponges, has been collected from the same type of sponge (and locality) as *Phyllogobius*, but the two fish have not been observed on the same individual sponge. *Phyllogobius* has become known as the "Flathead Sponge Goby". Smith (1964) remarked upon its similarity to a juvenile platycephalid.

Etymology. From the Greek "phyllon", meaning leaf, referring to the extremely depressed head and body of the type species. This also echoes the name of the host sponge.

ACKNOWLEDGEMENTS

Mrs M. Smith and Dr P. Heemstra, of RUSI, very kindly made available to me the

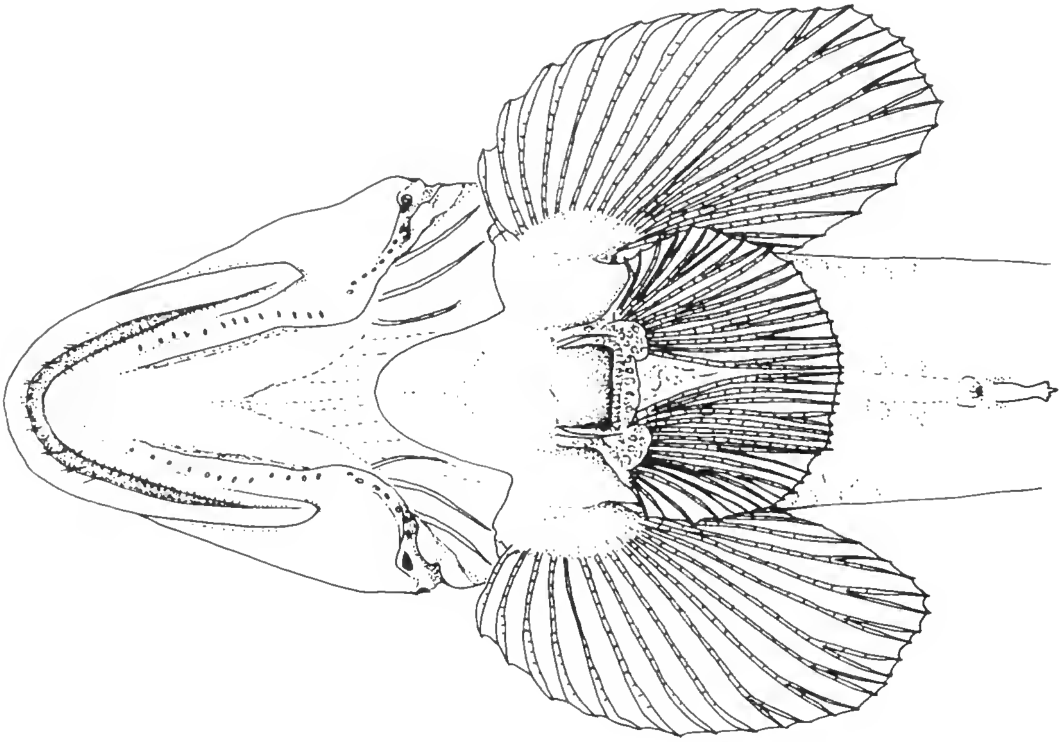


Fig. 3. *Phyllogobius platycephalops*, AMS I.24846-001, ventral view of head showing pelvic fin structure, main sensory papillae and gill membrane shape.

Table 1. Counts and measurements (in mm) of *Phyllogobius platycephalops*

	Holotype RUSI 212			*Paratypes RUSI 5441*			*AMS I.24847-001*	*NTM S.11404-001*		*AMS I.24846-001*		*AMS I.21016-001*	
	♂	♂	♂	♂	♀	♂	♂	♂	♀	♂	♂	♀	♀
Standard length	19	22	20	20	19.5	17	23.5	18	17.5	19.5	18	14	14
First dorsal	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI
Second dorsal	1,8	1,7	1,8	1,8	1,8	1,8	1,7	1,8	1,8	1,8	1,8	1,8	1,8
Anal	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8
Pectoral	18	16	19	19	19	19	19	19	18	19	18	20	18
Longitudinal scales	30-35?	35	37	—	—	34?	36?	28	29	28	—	—	—
Transverse scale backward	9	9	13	11?	10?	10?	9?	9	10	9	—	—	—
Head length	6.6	6.5	6.0	5.9	5.8	5.3	7.7	5.6	5.8	6.3	6.1	5.0	4.9
Head depth	2.1	3.0	2.6	2.3	2.7	1.9	3.0	2.0	2.0	2.2	2.0	1.9	1.8
Head width	4.3	5.2	4.7	4.3	4.5	3.3	5.3	4.0	4.0	4.9	4.4	3.2	3.4
Body depth at anus	3.7	3.2	2.8	2.8	2.7	1.8	3.1	2.1	2.1	2.2	2.0	1.8	1.8
Caudal length	3.7	—	—	4.1	4.4	3.7	5.2	4.0	4.0	4.0	4.0	3.2	3.4
Pectoral length	4.0	4.6	4.1	4.1	4.1	3.3	5.0	3.3	3.0	3.8	3.2	2.9	3.0
Pelvic length	3.9	4.3	3.8	3.7	3.8	3.2	4.0	3.2	2.8	3.2	3.0	2.8	3.0
Caudal peduncle length	3.9	4.7	4.3	4.8	4.3	3.6	4.9	3.8	3.5	4.2	3.7	3.4	2.8
Caudal peduncle depth	1.5	1.9	1.7	1.5	1.5	1.4	2.1	1.7	1.7	1.8	1.6	1.0	1.0
Snout length	2.4	2.3	2.3	2.3	2.3	2.1	3.1	2.5	2.5	2.7	2.3	2.1	2.0
Eye width	1.4	1.5	1.5	1.3	1.3	1.2	1.6	1.4	1.5	1.6	1.6	1.0	1.0
Mouth length	3.3	3.4	3.3	3.3	3.3	2.9	4.2	3.0	3.0	3.6	3.1	2.6	2.8
Interorbital width	0.7	0.8	0.8	0.8	0.7	0.7	0.9	0.9	0.8	0.9	0.9	0.8	0.6

types of *Cottogobius platycephalops*. Dr Doug Hoese of AMS collected the specimens from the Philippines and No Name Reef, Queensland. Doug also lent me his photographs of the Philippine specimens, without which there would have been no fresh colour description. Mr John Hooper of NTM provided information on sponges and their taxonomic problems.

REFERENCES

Larson, H.K. and Hoese, D.F. 1980 Fische des Indischen Ozeans. *"Meteor" Forschung-Ergebnisse* **32:** 33-43.

Lendenfeld, R. von. 1889 *A monograph of the horny sponges*. Royal Society: London.

Smith, J.L.B. 1964 A new gobiid fish of unusual type from Mozambique. *Annals and Magazine of Natural History* (12)**7**: 173-176.

Accepted 15 August 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 137-142

TWO NEW SPECIES OF *PARASCOLOPSIS* (PISCES: NEMIPTERIDAE) FROM NORTH-WESTERN AUSTRALIA, INDONESIA AND THE PHILIPPINES

B.C. RUSSELL
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Two new species of dwarf monocle-breams of the genus *Parascolopsis* Boulenger are described. *P. rufomaculatus* sp. nov. is characterised by having a prominent red spot between the eighth and tenth dorsal spines. The colour pattern of *P. rufomaculatus* closely resembles that of *P. boesemani* (Manikyala Rao and Srinivasa Rao), but is separable from the latter in having a slightly deeper body and shorter pectoral and pelvic fins (not reaching beyond level of vent). *P. rufomaculatus* occurs in depths of 210-320 m and is known thus far only from specimens collected from north-western Australia. *P. tanyactis* sp. nov. is distinguished from all other species of *Parascolopsis* by having the 4th or 5th dorsal rays notably elongated, at least in larger specimens. *P. tanyactis* appears close to *P. inermis* (Schlegel) but differs in the aforementioned character and also in having a dusky band across the snout joining the eyes through the nostrils. *P. tanyactis* occurs in depths of 45-180 m and is described from specimens collected from north-western Australia, Indonesia and the Philippines.

KEYWORDS: taxonomy, Nemipteridae, *Parascolopsis*, north-western Australia, Indonesia, Philippines, new species.

INTRODUCTION

The dwarf monocle-breams of the genus *Parascolopsis* Boulenger are widely distributed throughout the tropical Indo-West Pacific region. The group comprises some 7 nominal species, most of which are small (<20 cm SL) bottom-living fishes, and inhabit mid to outer-shelf waters, usually in depths of 40-400 m. The genus can be distinguished from the closely related *Scolopsis* Cuvier by having a very reduced suborbital spine (absent in some species), and by differences in jaw structure, development of the infraorbital bones, number of epipleural ribs, and degree of development of the second anal spine (Russell and Gloerfelt-Tarp 1984).

Recent exploratory trawling surveys .on the continental shelf of north-western Australia carried out by the Commonwealth Scientific and Industrial Research Oganisation (CSIRO) have yielded two new species of *Parascolopsis*. These undescribed species, included by Sainsbury *et al.* (1985) in their illustrated guide to the continental shelf fishes of northern and north-western Australia, are described herein as new. One of the new species is known only from specimens collected from north-western Australia; the other is known from specimens from north-western Australia, Indonesia and the Philippines.

The terminology used in the descriptions follows that of Russell and Gloerfelt-Tarp (1984). Where different from the holotype, measurements for the paratypes are indicated in parentheses following the data for the holotype. Type-specimens have been deposited in the following institutions: Australian Museum, Sydney (AMS); British Museum (Natural History), London (BMNH); CSIRO Division of Fisheries Research, Hobart (CSIRO); Lembaga Oseanologi Nasional, Jakarta (LON); Northern Territory Museum, Darwin (NTM); National Museum of Natural History, Smithsonian Institution, Washington D.C. (USNM); Western Australian Museum, Perth (WAM).

SYSTEMATICS

Parascolopsis rufomaculatus sp. nov.
(Figs 1, 2)

Parascolopsis sp. 1 — Sainsbury *et al.* 1985:208, 209,341.

Type material. HOLOTYPE - WAM P.28105-001, 153.0 mm SL, ♂, Australia, N.W. Shelf, 18°10′S 118°16′E, FV 'Soela', bottom trawl, 276-278 m, N. Sinclair and P. Berry, 24 August 1983. PARATYPES - NTM S.11211-001, 8:83.4-110.7 mm SL, 4 ♂ and 4 ♀, Australia, Arafura Sea, N. of Melville I., 10°02′S 130°03′E–10°02′S 130°01′E, FV 'Soela', bottom trawl, CSIRO AS 5/80/58, 216 m, 8 July 1980. WAM P.25394-010, 101.0 mm SL, Australia, N.W. Shelf, off Rowley Shoals, 17°27′S 119°43′E, 'Umitaka Maru', bottom trawl, 317 m, J.B. Hutchins, 30 December 1969. WAM P.26207-003, 5: 114.7-121.3 mm SL, Australia, N.W. Shelf, 15°30′S 120°58′E, FV 'Courageous;' bottom trawl, shot 0751, 280-320 m, P. Brown and party, 28 June 1978. WAM P. 28106-001, 146.3 mm SL, ♀, Australia, N.W. Shelf, 100 km S.W. of Rowley Shoals, 18°07′S 118°09′E, FV 'Soela', bottom trawl, 301-302 m, N. Sinclair and P. Berry, 24 August 1983.

Diagnosis. A species of *Parascolopsis* with the following combination of characters: pectoral-fin rays ii,13-15; pectoral fins moderately long, reaching to or just short of level of vent; pelvic fins short, not reaching to level of vent; gill rakers on first arch 9-12; scales on top of head reaching forward to about level of middle of eye; suborbital naked; posterior and anteroventral margin of suborbital finely denticulate; lower limb of preopercle naked; bright red spot on dorsal fin between eighth and tenth spines.

Description. Dorsal rays X,9; anal rays III,7; pectoral rays ii,14 (13-14/15); lateral-line scales 36 (35-37); transverse scale rows 5/15 (4/13-5/15); gill rakers 9 (9-12).

Body moderately deep, 2.4 (2.4-2.7) in SL; head 2.8 (2.7-2.8) in SL; head shorter than body depth, depth 0.9 (0.9-1.0) in head; snout short, bluntly rounded, 3.5 (3.3-4.5) in head; eye 3.4 (2.6-3.5) in head; diameter of eye greater than or equal to snout length, 1.0 (0.7-1.0) in snout; interorbital width 1.0 (1.0-1.3) in eye; suborbital shallow, least depth 3.0 (3.0-5.1) in eye; dorsal-fin base length 1.9 (1.9-2.2) in SL; fourth through to sixth dorsal spines longest, 1.5 (1.6-1.9) times length of first dorsal spine; third through to fifth soft dorsal rays usually longest, 0.8 (0.8-1.0)

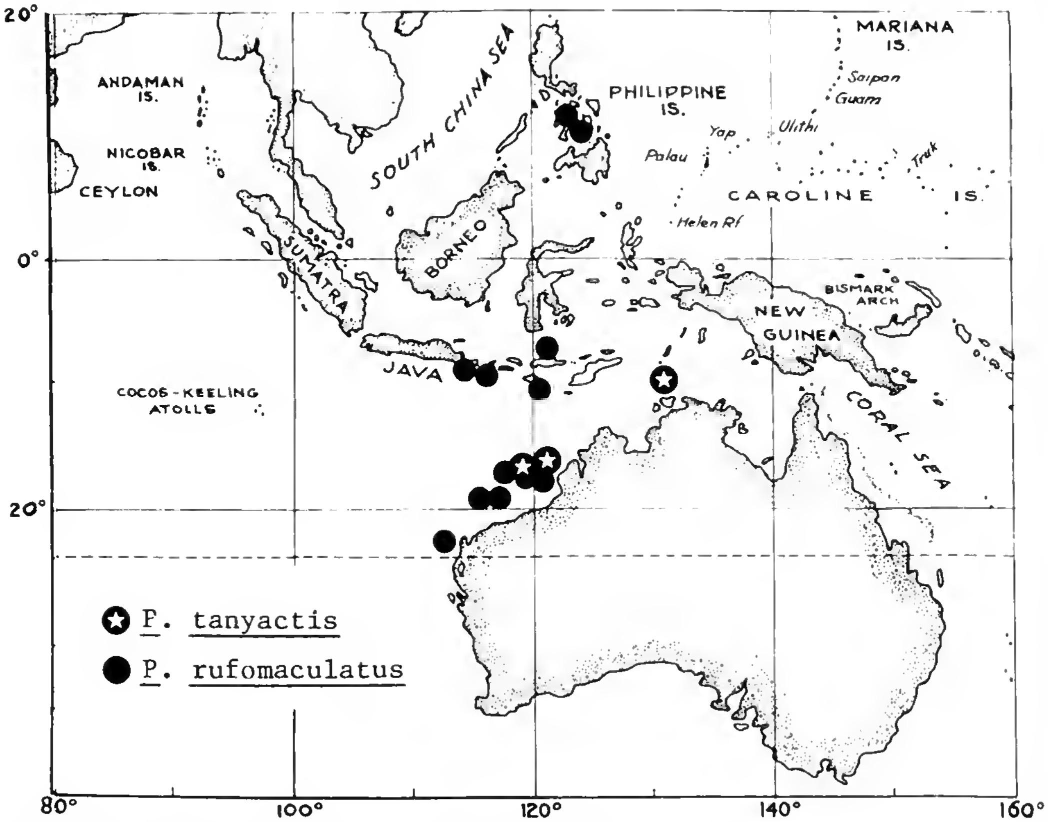


Fig. 1. Distribution map of *Parascolopsis rufomaculatus* and *P. tanyactis*.

Fig. 2. *Parascolopsis rufomaculatus* holotype, WAM P.28105-001, 153 mm SL.

times length of longest spine; anal-fin base length 6.2 (5.0-6.1) in SL; first anal spine 1.4 (1.3-1.6) in second; second anal spine 1.0 (0.9-1.1) in third; pectoral fins moderately long, reaching to or just short of level of vent, 1.4 (1.4-1.6) in head; pelvic fins short, not reaching to level of vent, 1.6 (1.6-1.9) in head; pectorals 0.9 (0.8-0.9) in pelvics.

Mouth small, maxillary reaching to or just behind anterior margin of eye; jaw teeth villiform, in narrow tapering bands in both jaws; upper jaw with about 6-8 pair of slightly enlarged, recurved teeth anteriorly. Scales on top of head extending forward between eyes to about level of middle of eye; snout naked; suborbital naked; suborbital with fine denticulations on posterior edge and on anteroventral margin; preopercle scaly, lower limb naked; posterior margin of preopercle finely denticulate; dorsal fin emarginate; caudal fin slightly forked.

Colour when fresh (from colour transparencies). Body pinkish, darker above and becoming pearly white below; broad, pale golden band below lateral line from upper margin of opercle to caudal peduncle; broad, pale pinkish midlateral band and faint golden band below this; dorsal fin with yellowish tinge; bright red spot between eighth and tenth dorsal spines; soft part of dorsal and other fins pale translucent whitish; pectoral-fin base yellowish. This species is illustrated in colour by Sainsbury *et al.* (1985:209).

Colour in alcohol. Pale overall; silvery white midlateral band from behind opercle to caudal peduncle; thorax and abdomen silvery white; traces of silvery white on opercle; dorsal fin with traces of grey along membranous margin.

Remarks. This species is identical in colour pattern to *P. boesemani* (Manikyala Rao and Srinivasa Rao 1981), both species being characterised by a prominent red spot between the eighth and tenth dorsal spines. However, *P. rufomaculatus* differs from *P. boesemani* in having the body depth greater than or equal to head length (versus depth less than head length) and in having relatively shorter pectoral and pelvic fins (reaching to or short of level of vent, versus reaching to beyond level of vent).

P. rufomaculatus is a moderately deep-water species, trawled in depths of 210-320 m, and is known thus far only from north-western Australia.

Etymology. The specific name *rufomaculatus* is a combination of the Latin *rufus*, red, and *maculatus*, spot, in reference to the distinctive red spot on the dorsal fin of fresh specimens.

Parascolopsis tanyactis sp. nov.

(Figs 1, 3)

Parascolopsis sp. 1 — Gloerfelt-Tarp and Kailola 1984:190, 191.

Parascolopsis sp. 2 — Sainsbury *et al.* 1985:210, 211, 341

Type Material. HOLOTYPE - WAM P.26263-001, 147.0 mm SL, ♂?, Western Australia, 250 km NNE of Larrey Point, 17°56′S 119°56′E, bottom trawl, 150-160 m, FV 'Courageous', shot 0762, D. Sheridan and party, 3 June 1978. PARATYPES - AMS I.24278-001, 92.3 mm SL, ♂, Indonesia, northern Flores I., T. Gloerfelt-Tarp, July 1981; BMNH 1984.6.25.7, 152.0 mm SL, ♀, Indonesia, Bali Strait, 8°26′S 114°29′E, bottom trawl, 71-82 m, RV 'Jurong' Cruise 16, T. Gloerfelt-Tarp, 21 August 1980; CSIRO CA2917, 193.5 mm SL, ♂, Western Australia, northwest of Port Hedland, 19°43′S 116°12′E, bottom trawl, 45-50 m, FV 'Soela', CSIRO AS 4/80/18, 16 June 1980; LON NCIP unreg., 82.0 mm SL, ♂? Indonesia, Bali, Singaraja market, 8°05′S 115°05′E, B.C. Russell, 13 April 1984; NTM S.10739-002, 142.0 mm SL, ♀, Indonesia, southern Lombok, 9°00′S 116°30′E, bottom trawl, 100-130 m, T. Gloerfelt-Tarp, July 1981; NTM S.10747-005, 154.2 mm SL, ♂, Indonesia, Sumba I., 10°30′S 120°15′E, bottom trawl, 60-80 m, T. Gloerfelt-Tarp, August 1981. NTM S.10781-001, 3:77.0-103.3 mm SL, largest a ♀, Philippines, Visayan Sea between northern Negros I. and Masbate I., southwest of Caduruan Point, 11°24′38″N 123°54′E, 98.7 m, L. Knapp and party, 7 June 1978; NTM S.11046-001, 116.2 mm SL, ♂ ?, Western Australia, northwest of Port Hedland, 19°40′S 116°12′E – 19°41′S 116°16′E, bottom trawl, 65-92 m, FV 'Soela', CSIRO AS 4/80/16, 1 June 1980; NTM S.11168-004, 104.4 mm SL, ♂ ?, Indonesia, Bali, Singaraja market, 8°05′S 115°05′E, B.C. Russell, 13 April 1984; USNM 231473, 154.0 mm SL, ♂, Philippines, Visayen Sea between northwestern Negros I. and Masbate I., southwest of Caduruan Point, 11°37′07″N 123°54′45′E, 91.4 m, L. Alcata and party, 6 June 1978; USNM 231480, 144.7 mm SL, ♂, Philippines, Samar Sea, Carigara Bay, 11°27′N 124°25′06″E – 12°07′N 124°47′36″E, C. Ferraris, April-May 1980; WAM P.26187-003, 166.0 mm SL, Western Australia, Monte Bello Is., 50 km northwest of North West I., 19°57′S 115°13′E, bottom trawl, 150-180 m, FV 'Courageous', Shot 0673, B. Hutchins, 10 May 1978; WAM P.26212-001, 12:186.2-187.6, ♂ and ♀, Western Australia, 125 km NNW of Port Headland, 10°14′S 118°22′E, bottom trawl, 88-90 m, FV 'Courageous', shot 0698, B. Hutchins, 27 May 1978; WAM P.26888-001, 190.2 mm SL, Western Australia, off Rowley Shoals, 17°30′S 118°20′E, bottom trawl, 'Dong Bang', 1979; WAM P.26889-001, 206.0 mm SL, ♀?, Western Australia, north of Carnarvon, 23°36′S 113°18′E, bottom trawl, 'Taiyo Maru 71', M. Walker, 12 August 1979.

Diagnosis. A species of *Parascolopsis* with the following combination of characters: pectoral-fin rays ii,14-15; pectoral fins moderately long, reaching to or just short of level of vent; pelvic fins moderately long, reaching to about level of vent; gill rakers on first gill arch 8-10; scales on top of head reaching forward to or almost to anterior margin of eye; suborbital naked; suborbital usually with 1-2 tiny spines at upper corner, its margin smooth or with a few tiny spines posteriorly; lower limb of preopercle naked; greyish band across snout joining eyes through nostrils; fourth or fifth dorsal rays elongate, at least in larger specimens.

Description. Dorsal rays X,9; anal rays III,7; pectoral rays ii,14 (14-15); lateral-line scales 36 (35-38); transverse scale rows 3/10 (11-14); gill rakers 9 (8-10).

Body moderately deep, depth 3.0 (2.6-3.0) in SL; head 3.1 (2.9-3.1) in SL; head about equal to or a little less than body depth, head length 1.0 (1.0-1.2) in body depth; snout short, rounded, 3.6 (3.3-4.4) in head; eye 3.0 (2.3-3.7) in head; diameter of eye subequal to or greater than snout length, 0.8 (0.6-1.1) in snout; interorbital width 5.2 (4.3-5.4) in head; suborbital shallow, least depth 7.5 (6.4-11.6) in head; least depth of suborbital 2.5 (1.7-5.0) in eye; dorsal-fin base length 1.8 (1.8-1.9) in SL; third through to sixth dorsal spines longest, 2.1 (1.7-2.1) times length of first dorsal spine; fourth or fifth dorsal ray longest (more notably elongated in larger specimens), 1.6 (1.5-2.1) times length of longest spine; anal-fin base length 5.9 (5.5-6.4) in SL; first anal spine 1.7 (1.5-2.1) in second; second 1.0 (0.9-1.2) in third anal spine; pectoral fins moderately long, reaching to or just short of level of vent, 1.3 (1.2-1.4) in

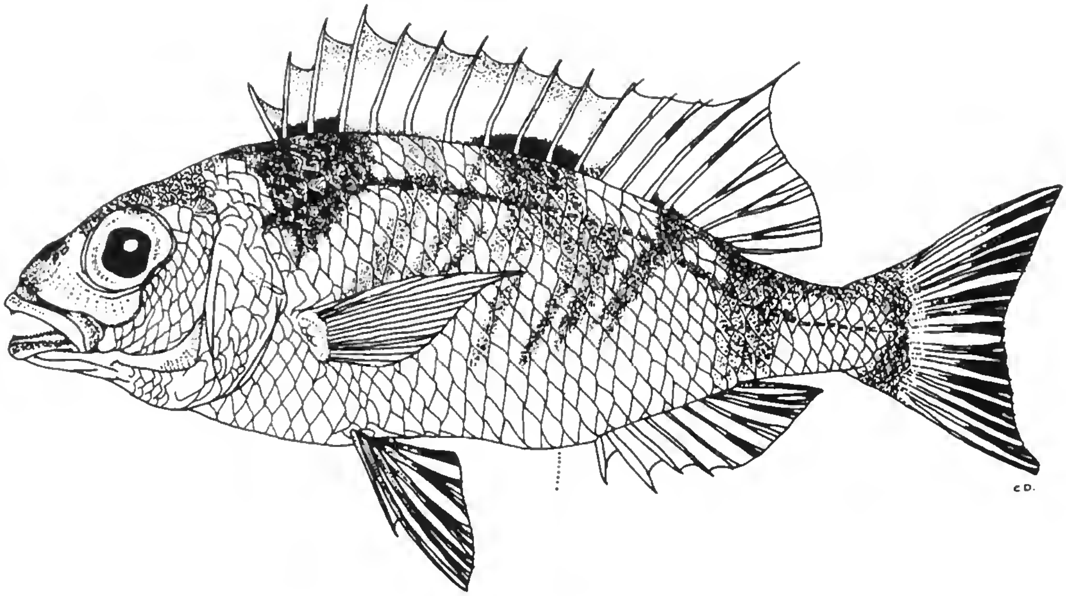


Fig. 3. *Parascolopsis tanyactis* paratype, NTM S.10747-005, 154.2 mm SL.

head; pelvic fins moderately long, reaching to about level of vent, 1.4 (1.2-1.5) in head.

Mouth moderate, maxillary reaching to below level of anterior margin of eye; jaw teeth villiform, in narrow tapering bands in both jaws; upper jaw with 3-4 pair of slightly enlarged, recurved teeth anteriorly. Scales on top of head reaching to or almost to anterior margin of eye; snout and suborbital naked; suborbital with 1-2 tiny spines (sometimes absent) at upper corner, its posterior edge smooth or with a few tiny spines; preopercle scaly, lower limb naked; posterior margin of preopercle finely denticulate; dorsal fin emarginate; caudal fin slightly forked.

Colour when fresh (from colour transparencies). Body pinkish, darker on back and paling below, becoming silvery on ventral surface; four dark pinkish brown saddles or bars on back; first saddle from nape to fifth dorsal spine and extending down to upper edge of opercle; second saddle between eighth dorsal spine and second dorsal ray, and extending down almost to ventral surface; third saddle on peduncle immediately behind dorsal fin and extending down almost to ventral surface; fourth saddle extending down base of caudal fin; interspaces between these saddles and bars with less distinct bars; pale lemon-yellow band on either side of midventral line from base of pelvic fins to base of caudal fin; area between eyes yellowish green; snout pink; pale mauve band joining eyes through nostrils; dorsal fin pink with dusky reticulated markings; basal part of dorsal fin above three main saddles on body dark pinkish brown; pectoral fins pale pink; pelvic fins whitish, inner rays yellowish. This species is illustrated in colour by Gloerfelt-Tarp and Kailola (1984:190), and Sainsbury *et al.* (1985:211).

Colour in alcohol. Body pale brownish, with dusky oblique markings on back and sides; top of head dusky; greyish band across snout joining eyes through nostrils; base of dorsal fin with three black blotches, first between anteriormost four spines, second between last three spines and first ray, third between posteriormost five rays; fins otherwise transparent.

Remarks. This species is similar to *P. inermis* (Schlegel in Temminck and Schlegel, 1843) but differs in having a dusky band across the snout joining the eyes through the nostrils and in having the fourth or fifth dorsal ray notably elongate.

P. tanyactis is known from north-western Australia, Indonesia and the Philippines. It occurs in depths of 45-180 m.

Etymology. The specific name *tanyactis* is from the Greek *tanyo*, meaning stretched out, and *aktis*, ray, in reference to the elongate fourth or fifth dorsal ray present in adult specimens.

ACKNOWLEDGEMENTS

Thanks are due to the following people who provided specimens, photographs and other information: Guy G. Leyland (CSIRO), Patrica J. Kailola (University of Adelaide), Peter J.P. Whitehead (BMNH),Thomas Gloerfelt-Tarp (F.A.O./ Jetindofish). Special thanks are due to Clinton Duffey for his illustration of *P. tanyactis*. Part of this work was undertaken during tenure of a CSIRO Postdoctoral Fellowship at the National Museum of Natural History, Smithsonian Institution, and I am grateful to Victor G. Springer for making available to me the fish collection and facilities at the USNM.

REFERENCES

Gloerfelt-Tarp, T. and Kailola, P. 1984 *Trawled fishes of southern Indonesia and northwestern Australia*. Australian Development Assistance Bureau; Directorate General of Fisheries, Indonesia; German Agency for Technical Cooperation: Jakarta.

Manikyala Rao, D. and Srinivasa Rao, K. 1981 A revision of the genus *Scolopsis* Cuvier (Pisces: Nemipteridae) with descriptions of two new species from Indian waters. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*. ser. c, **84**: 131-141.

Russell, B.C. and Gloerfelt-Tarp, T. 1984 A new species of *Parascolopsis* (Pisces: Nemipteridae) from Indonesia. *The Beagle, Occasional papers of the Northern Territory Museum of Arts and Sciences* **1**: 111-114.

Sainsbury, K. J., Kailola, P.J. and Leyland, G.G. 1985 *Continental shelf fishes of northern and northwestern Australia. An illustrated guide*. Cloustan & Hall and Peter Pownall Fisheries Information Service: Canberra.

Temminck, C.J. and Schlegel, H. 1843 Pisces. In: P.F. von Siebold (ed) *Fauna Japonica*. Pt 2: 21-72. Lugduni Batavorum : Leyde.

Accepted 22 August 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 143-166

THREE NEW SPECIES OF COMMENSAL SHRIMPS FROM PORT ESSINGTON, ARNHEM LAND, NORTHERN AUSTRALIA (CRUSTACEA: DECAPODA: PALAEMONIDAE)

A.J. BRUCE
Northern Territory Museum of Art and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Three new species of commensal caridean shrimps from Port Essington, Cobourg Peninsula Marine Park, Arnhem Land, are described and illustrated. *Periclimenes alegrias* sp.nov. is associated with the crinoids *Stephanometra spicata* Carpenter, *Lamprometra palmata* Müller and *Comanthina variabilis* Bell; *Periclimenaeus orontes* sp.nov. with the sponge *Jaspis stellifera* Carter and *Hamopontonia essingtoni* sp.nov. with the scleractinian coral *Stylophora pistillata* (Esper).

KEYWORDS: Taxonomy, Crustacea, Palaemonidae, new species, commensals, Northern Australia.

INTRODUCTION

The caridean shrimp fauna of northern Australia has been little studied. In the course of a study carried out by the Northern Territory Museum of the marine fauna of Port Essington, in the Cobourg Peninsula Marine Park, three undescribed species of commensal palaemonid shrimps were discovered. These three species are described and illustrated in the following paper. The study of the Port Essington marine fauna was funded by the Australian Heritage Commission. I am most grateful to the following for the identifications of host animals; J.N.A. Hooper, L. Vail and Dr J.E.N. Veron, and the Master and crew of the F.V. "*Alegrias*", for the facilities provided at sea.

SYSTEMATICS

Periclimenes alegrias sp.nov.

(Figs 1A, 2-5, 15A-C)

Type material. HOLOTYPE - ♀ (ovigerous), Northern Territory Museum (NTM) Cr. 004071, Coral Bay, Port Essington, 11°11.2'S 132°02.8'E, Stn. CP/76, 2-4 m, 12 September 1985, coll. L Vail. PARATYPES - 1 ♀ (ovigerous), NTM Cr. 003223, same locality as holotype, Stn. CP/70, 3-6 m, 12 September 1985, coll. L Vail; 1 ♂, 1 ♀ (ovigerous), NTM Cr.000286, North West Vernon Island, 12°02.6'S 131°04.6'E, Stn. AJB/9, 15 m, 27 September 1982, coll. P Horner.

Description. Small sized shrimps, of robust smooth, sub-cylindrical body form, with male smaller and more slender than female.

Carapace smooth, glabrous. Rostrum moderately deep, horizontal and straight, about 0.7 of postorbital carapace length, slightly exceeding antennular peduncle; dorsal lamina with six or seven small acute teeth, first situated well in advance of postorbital margin, interspaces setose; ventral carina well developed, convex, unarmed and non-setose, lateral carinae feebly developed distally, expanded posteriorly over orbital region; supraorbital teeth and tubercles absent; orbit feebly developed dorsally; inferior orbital angle slightly produced, subacute; antennal spine well developed, acute, marginal and upwardly directed; hepatic spine more robust than antennal, situated at slightly lower and more posterior level, only slightly posterior to postorbital margin; branchiostegite normal, with anteroventral angle feebly produced, broadly rounded.

Abdominal segments smooth, glabrous; third segment not posterodorsally produced, fifth segment about 0.6 times length of sixth, sixth about 1.25 times longer than deep, with acute posterolateral and posteroventral angles; pleura all broadly rounded, first to third broadly expanded in female, fourth and fifth relatively small and feebly produced. Telson nearly 1.5 times sixth segment length, about 3.0 times longer than anterior width, sides straight, convergent to transverse posterior border, equal to about 0.36 of anterior width, slightly produced centrally, without median point; two pairs of small submarginal dorsal spines at about 0.66 and 0.8 of telson length; three pairs of posterior spines present, lateral spines small, subequal to dorsal spines, inter-

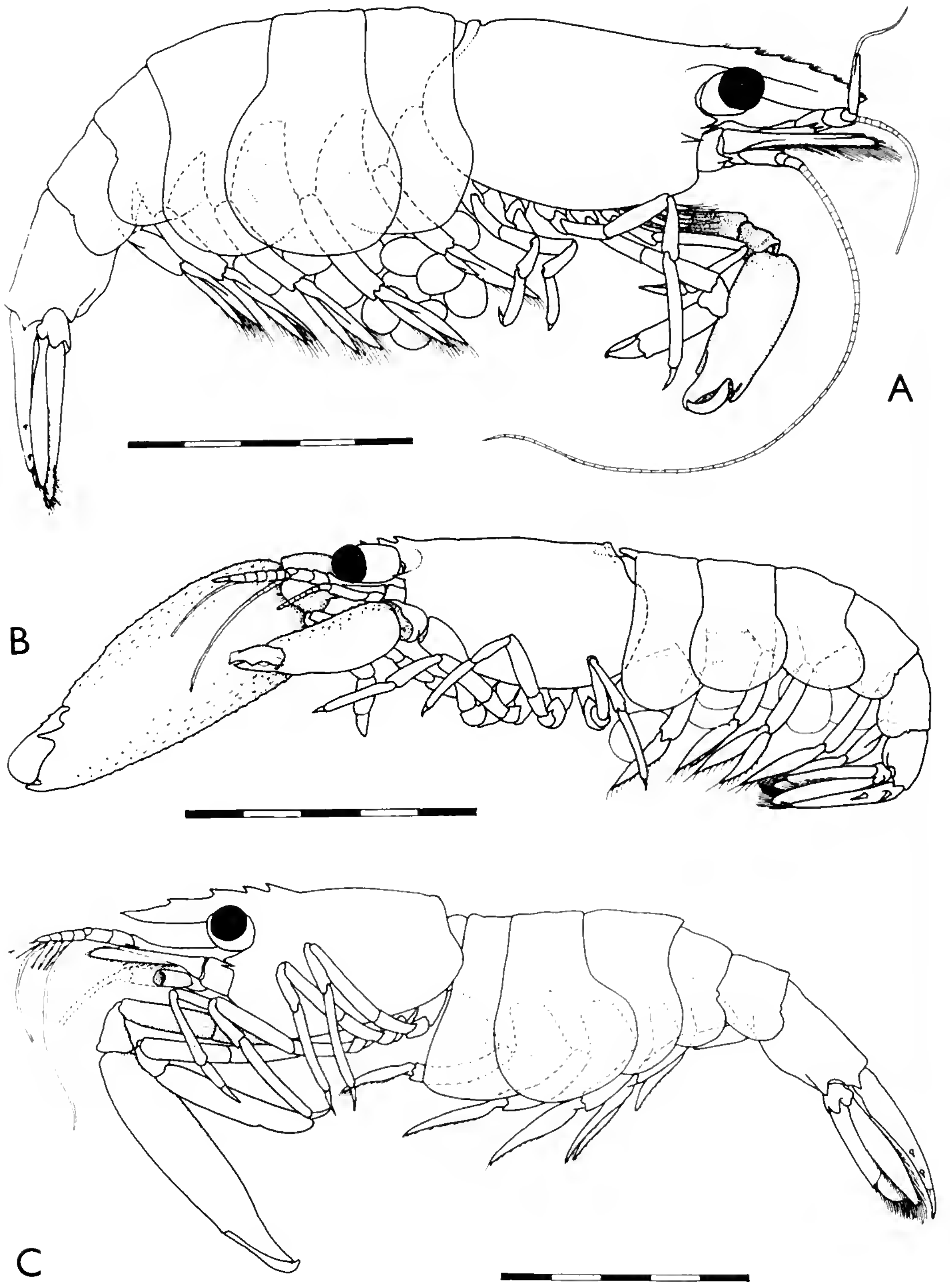


Fig. 1. A, *Periclimenes alegrias* holotype ♀ (ovigerous); **B**, *Periclimenaeus orontes* holotype ♀ (ovigerous); **C**, *Hamopontonia essingtoni* holotype ♀ (ovigerous). Scales 0.5 mm.

mediate spines large, about 0.13 of dorsal telson length, submedian spines about half length of intermediate spines, densely setulose medially and laterally.

Antennules with proximal segment broad, about 1.5 times longer than width distal to statocyst, stylocerite well developed, acute, exceeding half segment length; distolateral margin strongly produced, with acute tooth distinctly exceeding strong tooth at distal end of lateral margin; medial margin with acute tooth ventrally at half length; statocyst normally developed with circular non-granular statolith, intermediate and distal segments short, intermediate slightly longer than distal, together equal to about 0.85 of proximal segment length; upper flagellum short, about 0.6 of postorbital carapace length, biramous with proximal three segments of rami fused, shorter ramus with three free segments, longer with about 12, about six groups of aesthetascs present.

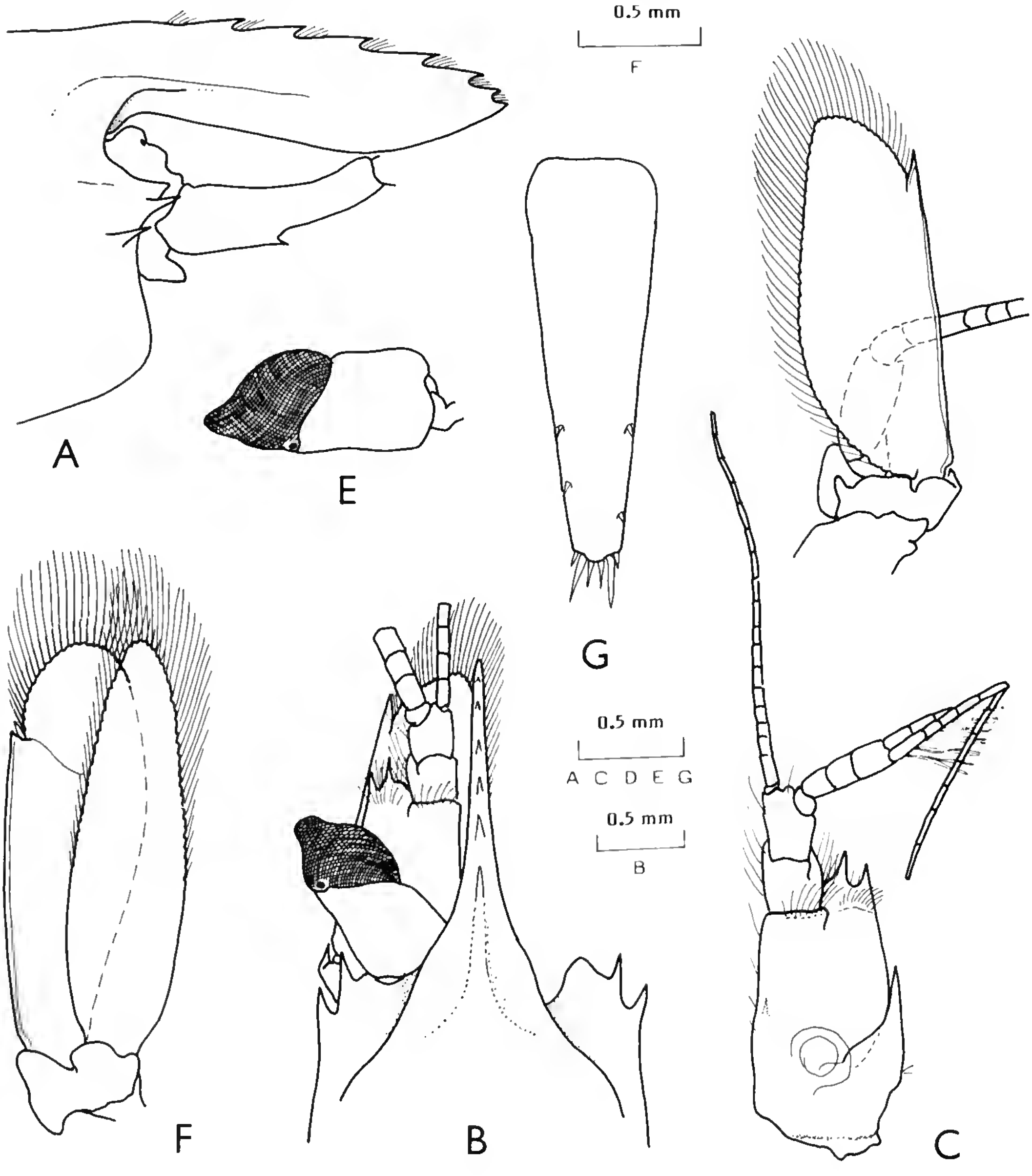


Fig. 2. *Periclimenes alegrias* holotype ♀ : **A**, anterior carapace and rostrum, lateral; **B**, same, dorsal; **C**, antennule; **D**, antenna; **E**, eye; **F**, uropod; **G**, tenson.

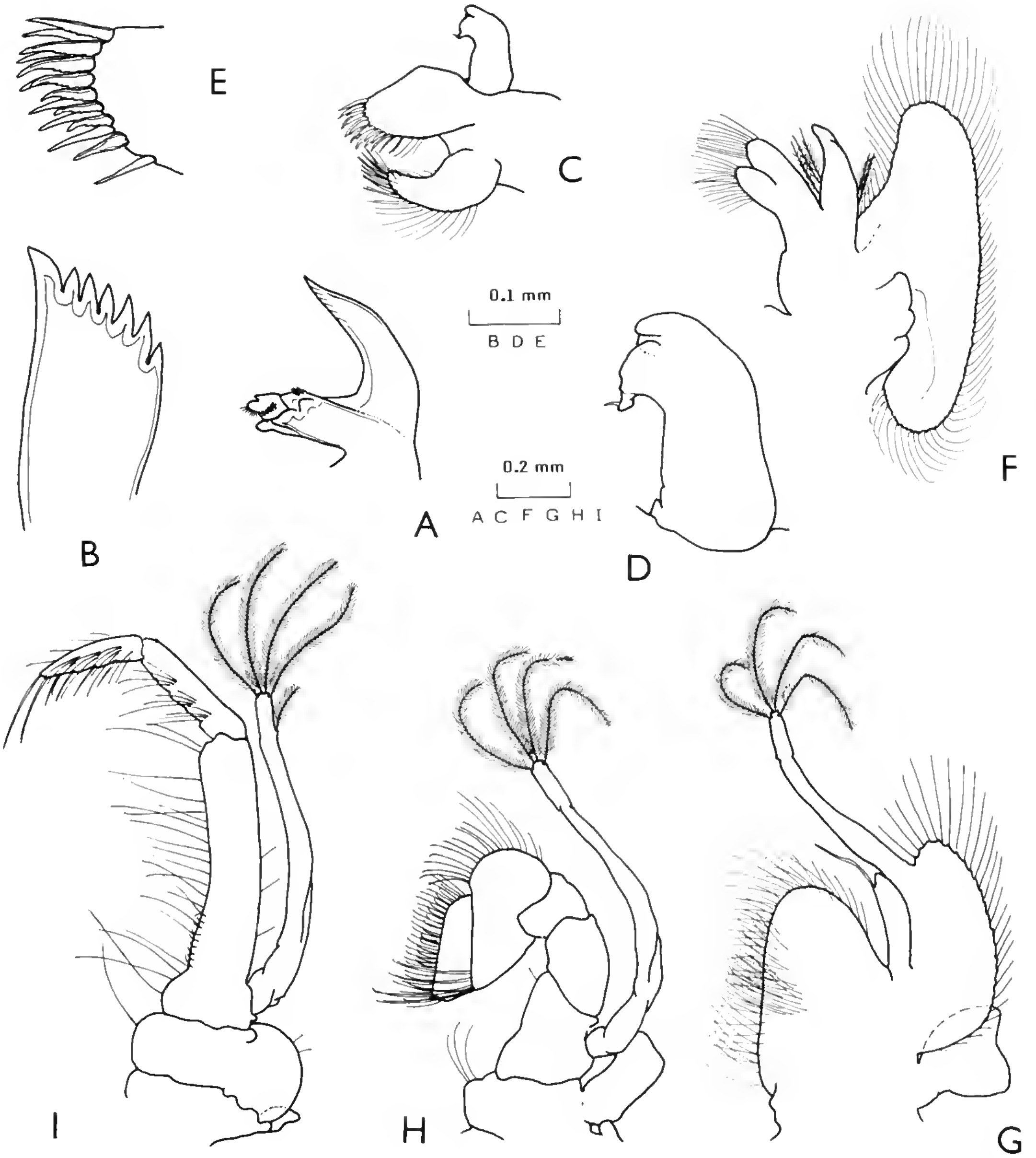


Fig. 3. *Periclimenes alegrias* holotype ♀ ; **A**, mandible (damaged); **B**, same, incisor process; **C**, maxillula; **D**, same, palp; **E**, same, distal upper lacinia; **F**, maxilla; **G**, first maxilliped; **H**, second maxilliped; **I**, third maxilliped.

Antenna with robust basicerite, with strong, acute distolateral tooth, antennal gland opening produced medially, ischiocerite and merocerite normal, carpocerite short, about twice as long as wide, extending to about 0.3 of lateral border of scaphocerite, flagellum well developed, about 3.0 times postorbital carapace length; scaphocerite exceeding antennular peduncle, about 2.6 times longer than greatest width, tapering slightly distally, anterior margin bluntly angular, far overreaching strong distolateral tooth on straight lateral margin.

Eye well developed, cornea globular, conoidally produced posterodistally, obliquely attached to stalk, with distinct posterior accessory pigment spot; stalk subcylindral, about as broad as average length.

Mandible robust, without palp, molar process (right) obliquely truncated distally with five large blunt teeth and patches of short stout setae; incisor process well developed, broadened distally, cutting edge oblique with seven acute teeth, with distolateral tooth enlarged and laterally directed. Maxillula normal, with feebly bilobed palp, lower lobe with ventral process bearing short simple setae, upper lacinia feebly broadened, distal margin rounded with 13-14 spines, robust spines serrated, more slender spines simple;

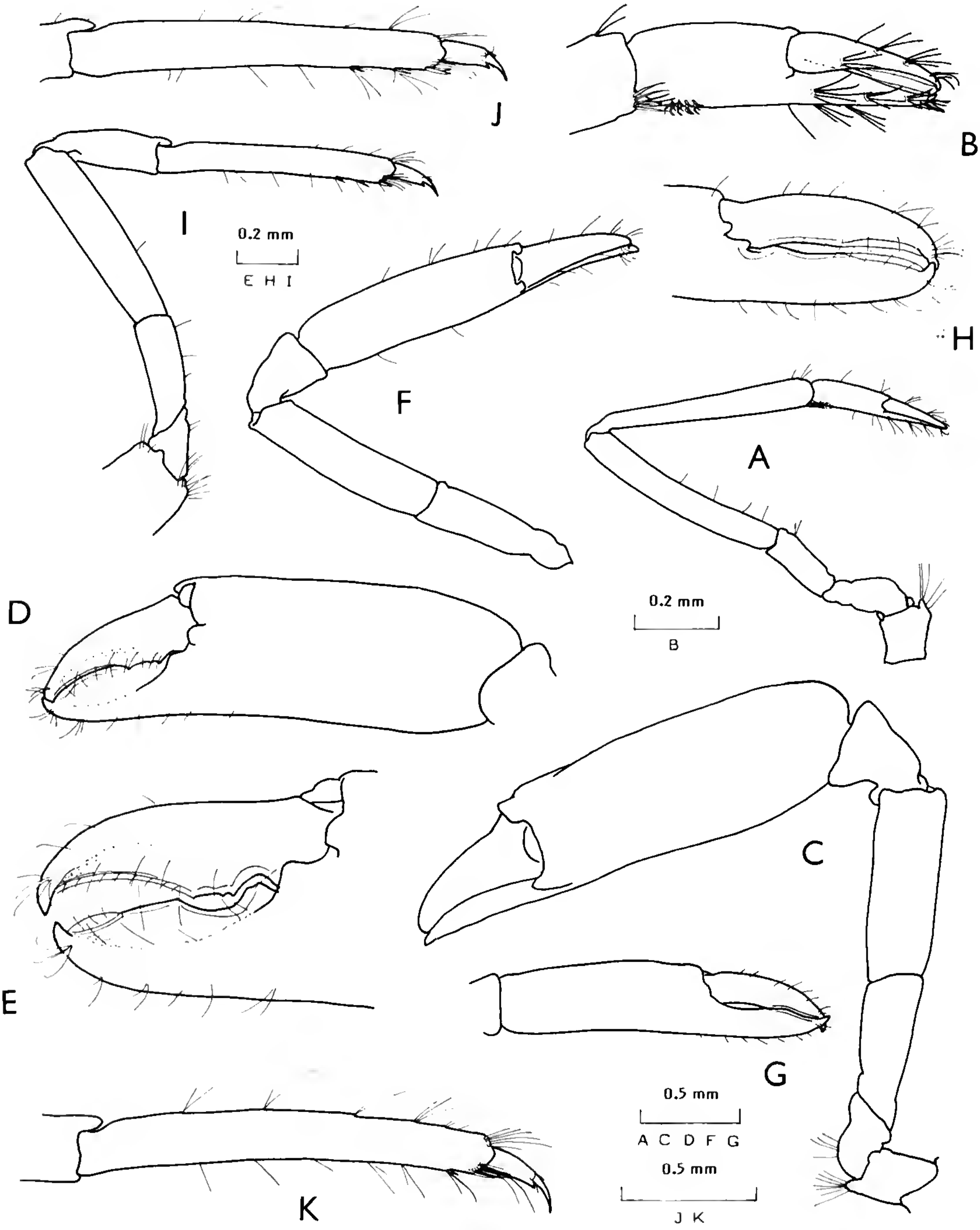


Fig. 4. *Periclimenes alegrias* holotype ♀ : **A**, first pereiopod; **B**, same, chela; **C**, major second pereiopod; **D**, same, chela; **E**, same, fingers; **F**, minor second pereiopod; **G**, same chela; **H**, same fingers; **I**, third pereiopod; **J**, same propod and dactyl; **K**, fifth pereiopod, propod and dactyl.

lower lacinia tapering with numerous sparsely serrulate setae ventrally, becoming spiniform distally. Maxilla with short tapering palp bearing setulose setae medially and laterally proximally, basal endite deeply bilobed, lobes subequal, distal lobe with about 11 simple setae distally, proximal lobe with about 15; coxal endite obsolete, medial border feebly convex; scaphognathite well developed, about 2.6 times longer than broad, anterior lobe broad, medial margin concave, posterior lobe large, subequal to length of anterior lobe. First maxilliped with subcylindrical palp bearing preterminal plumose seta, basal endite broadly rounded, sparsely setose medially with simple setae, separated by small notch from obsolete non-setose coxal endite; exopod with well developed flagellum with four plumose distal setae, caridean lobe large, epipod small, triangular, feebly bilobed. Second maxilliped with dactylar segment moderately broad, medial border densely armed with serrulate spines, propodal segment broadly rounded distally with numerous slender setae, setulose medially and simple laterally, carpal, ischiomeral and basal segments normal, exopod with well developed flagellum with four plumose distal setae; coxa feebly produced medially with three simple setae, small subrectangular epipod without podobranch laterally. Third maxilliped with short endopod, reaching to about proximal end of carpocerite, ischiomerus and basis completely fused, combined segment about 5.7 times longer than central width, ischiomeral portion subuniform, 4.5 times longer than wide, slightly expanded proximomedially with submarginal row of six short curved spines, medial border with sparse simple setae; penultimate segment about half length of antepenultimate segment, about 4.5 times longer than wide, uniform, with groups of short spiniform setae; terminal segment tapering distally, about 0.75 times length of penultimate segment, 4.0 times longer than proximal width, with long simple spiniform seta distally and numerous groups serrulate setae; basal region medially convex with three long setae, exopod with well developed flagellum with four terminal and one short preterminal plumose setae distally; coxal region medially convex with single simple seta, with low round lateral plate and rudimentary arthrobranch.

Epistome with anterolateral angles bluntly produced. Fourth thoracic sternite without fingerlike median process. Fifth to eighth sternites moderately broad, unarmed.

First pereiopods moderately slender, extending to near distal border of scaphocerite; chela with palm subcylindrical, slightly compressed, about 2.1 times longer than deep; fingers slender, subequal to palm length, about 4.0 times longer than proximal depth, with small acute hooked tips, entire lateral cutting edges and numerous groups of setae; palm with five rows of short serrulate cleaning setae proximally; carpus about 1.6 times length of chela, about 8.0 times longer than distal width, slightly tapering proximally, with several long serrulate cleaning setae distally; merus slightly shorter than carpus, feebly bowed, about 7.4 times longer than wide, uniform; ischium 0.36 of meral length, about 2.6 times longer than central width; basis subequal to ischial length, coxa with small setose distoventral process.

Second pereipods robust, unequal, chelae smooth. Major second pereiopod chela with palm subcylindrical, compressed, about 2.3 times longer than central depth, chela slightly longer than postorbital carapace length; dactyl about 3.0 times longer than proximal depth, robust, about 0.5 of palm length, with stout acute hooked tip, distal half of cutting edge laterally situated, sharp, entire, proximal half blunt with small distal tooth and two small proximal teeth opposing diastema on fixed finger; fixed finger generally similar, distal sharp cutting edge only one fourth of whole length, blunt proximal edge with small obtuse tooth distally separated by diastema from two small blunt teeth opposing diastema on proximal dactylus; carpus short, stout, unarmed, distally expanded, about 0.28 of palm length; merus robust, about 3.0 times longer than wide, 0.55 of palm length, smooth, distoventral angle unarmed;ischium about 0.8 of merus length, about 2.9 times longer than distal width, slightly tapered proximally, unarmed; basis and coxa without special features. Minor second pereiopod chela subequal to palm length of major chela, about 0.7 of postorbital carapace length; palm subcylindrical, slightly compressed, about 3.0 times longer central depth, slightly deeper distally than proximally; dactyl about 0.6 of palm length, about 4.4 times longer than proximal

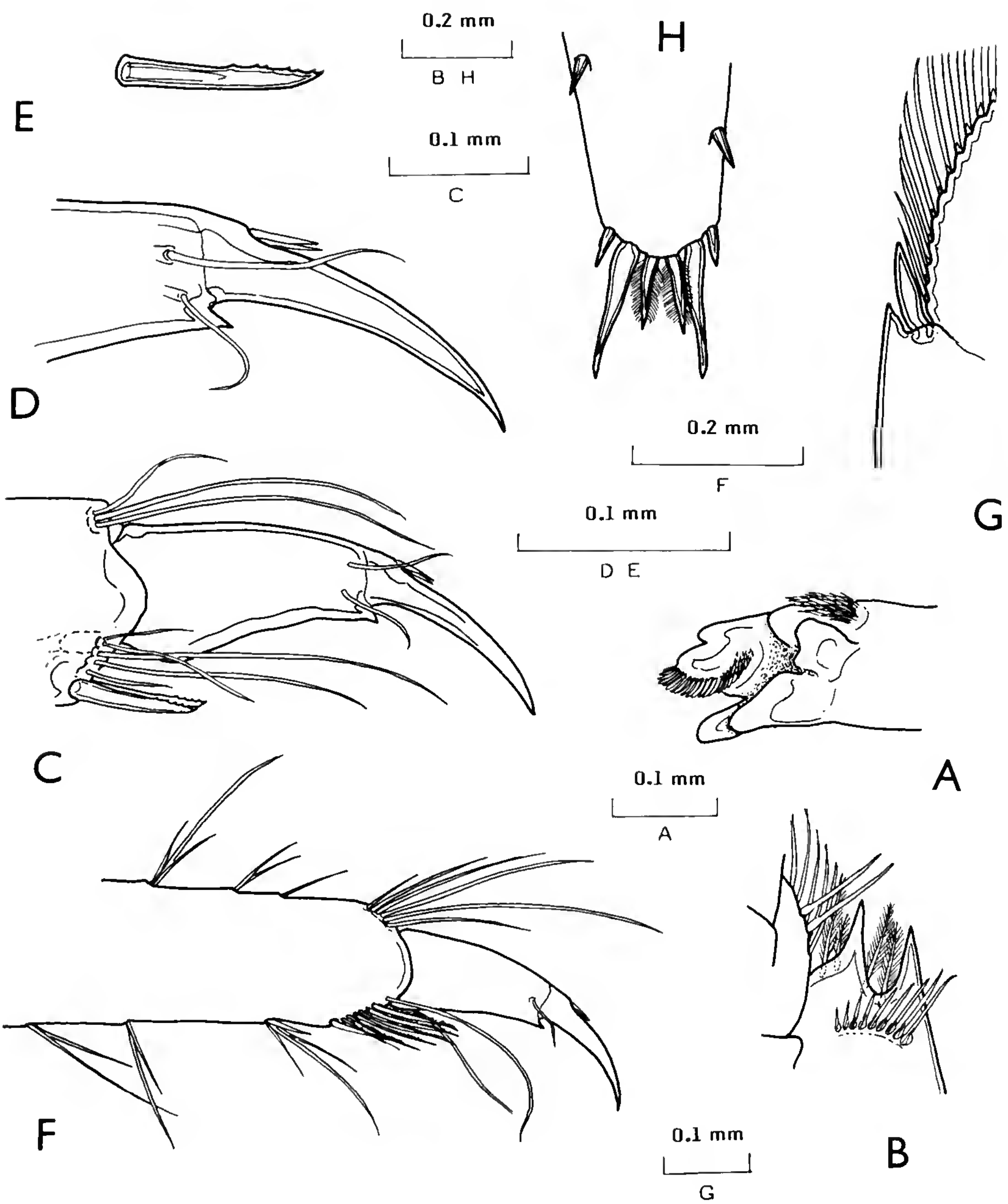


Fig. 5. *Periclimenes alegrias* holotype ♀ : **A**, molar process of right mandible; **B**, distolateral angle of proximal segment ofn antennular peduncle; **C**, third pereiopod, distal propod and dactyl; **D**, same unguis; **E**, same, distoventral spine of propod; **F**, fifth pereiopod, distal propod and dactyl; **G**, uropod, distolateral angle of exopod; **H**, telson posterior spines and posterior dorsal spines.

depth, with small acute hooked tip; fixed finger similar, cutting edges with distal halves sharp and closing, proximal halves blunt, gaping; carpus about 0.38 of palm length, unarmed; merus about 0.8 of palm length, 4.0 times longer than wide, unarmed, subequal to major pereiopod merus length; proximal segments similar to major pereiopod but less robust.

Ambulatory pereiopods moderately slender. Third pereiopod extending anteriorly to slightly exceed distal border of scaphocerite, dactylus strongly compressed, corpus about 1.8 times longer than proximal depth, distal depth half of proximal, with single small acute distoventral tooth with two short sensory setae distolaterally and one distomedially; unguis slender, curved, subequal to dorsal length of carpus, with pair of short spiniform setae proximodorsally; propod about 4.8 times dactylar length, about 7.6 times longer than proximal depth, slightly tapering distally, distoventral angle with pair of strong dorsally serrulate spines, ventral border with two single similar spines on distal fourth; carpus about half length of propod, about 3.2 times longer than central width, unarmed; merus about 0.9 of propod length, about 4.4 times longer than central width, uniform and unarmed; ischium about 0.6 of merus length, about 3.1 times longer than distal width, slightly narrowed proximally; basis and coxa without special features. Fourth and fifth pereiopods similar to third. Propod of fifth pereiopod about 1.1 times length of third, 8.0 times longer than proximal width, with single densely serrulate distoventral spine, and single ventral spine only, with numerous serrulate setae distoventrally.

Endopod of male first pleopod about 1.6 times longer than greatest width, distal two thirds expanded, subcircular, with single simple seta medially, proximal medial border with three short curved spines. Endopod of male second pleopod with corpus of appendix masculina slightly exceeding half segment length, about 3.0 times longer than wide, subcylindrical, with pair of slender simple distal spines, about equal to corpus length, and shorter preterminal ventromedial spine; appendix interna slightly exceeding corpus of appendix masculina, with few distal concinnnuli only.

Uropod with protopodite with blunt posterolateral lobe; exopod distinctly exceeding telson, about 3.1 times longer than wide, lateral margin feebly convex, entire, with small distolateral tooth, with larger mobile spine medially; endopod subequal to exopod, about 3.6 times longer than wide.

Ova about 50, of normal length.

Colouration. Body with median dorsal creamy longitudinal band, bordered by dark brown, becoming orange on dorsal rostral lamina; carapace with broad dorsolateral and ventrolateral creamy bands, separated by narrow band of brown; abdomen laterally transparent, pleura with upper and lower creamy longitudinal bands bordered dorsally by dark brown; telson mainly dark brown, uropods largely orange, especially distolaterally; scaphocerite bright orange laterally, dark brown medially; second pereiopods medially orangish, laterally dark brown, first pereiopods similar, less intense, ambulatory pereiopods pallid.

Host. The specimens were all found in association with crinoid hosts. The holotype was found on *Stephanometra spicata* (Carpenter), the Coral Bay paratype on *Lamprometra palmata* (Müller) (Mariametridae) and the Vernon Island specimens were found on *Comanthina variabilis* (Bell) (Comasteridae).

Systematic Position. *P. alegrias* is most closely related to *P. cornutus* Borradaile, 1915, and to a lesser degree to *P. ceratophthalmus* Borradaile, 1915 and *P. amboinensis* (De Man, 1887) These three species are all crinoid associates (Bruce 1982) and were at one time placed together in the subgenus *Corniger* Borradaile, 1915. This subgenus was characterized by the presence of a conoidally produced cornea, a feature not found in other species of the genus *Periclimenes* Costa, 1844. *P. alegrias* may immediately be distinguished from all three species by its lack of supraorbital teeth, which are conspicuously developed in the other three species, together with a relatively

Measurements (mm)	*Holotype* ♀ *CP/76*	*Paratype* ♀ *CP/70*	*Paratype* ♀ *AJB/9*	*Paratype* ♂ *AJB/9*
Total length (approx).	13.0	11.5	15.5	11.0
Carapace length (incl. rostrum)	4.75	4.0	5.4	3.5
Postorbital carapace	2.6	2.2	2.9	1.75
Major chela	2.7	2.4	2.75	2.25
Minor chela	1.8	1.85	2.5	1.6
Length of ova	0.6	0.6	0.6	—

better degree of development of the orbit. *P. ceratophthalmus* and *P. amboinensis* have relatively much more slender chelae on the second pereiopods, but robust chelae are present in *P. cornutus* although less so than in *P. alegrias* (Bruce 1978a). *P. cornatus* and *P. ceratophthalmus* also lack the acute tooth present on the anterolateral lobe of the first segment of the antennular peduncle as in *P. alegrias*.

Key to the *Periclimenes ceratophthalmus* Species Group

1. Cornea with conspicuous elongated terminal papilla; rostral dentition 3-5/0-2 .... *P. ceratophthalmus* Borradaile

— Cornea conoidally produced, without elongated papilla; rostral dentition 3-4/0-1 2

2. Supraorbital teeth absent; rostral dentition 6/0 .... *P. alegrias* sp.nov.

— Supraorbital teeth present 3

3. Rostrum exceeding antennular peduncle, rostral dentition 1+6-7/1; chelae of second pereiopod long and slender .... *P. amboinensis* (De Man)

— Rostrum not exceeding antennular peduncle, rostral dentition 1+6/1; chelae of second pereiopod short and stout .... *P. cornutus* Borradaile

Remarks. *P. alegrias* and the closely related species are found in association with a variety of crinoid hosts belonging to three families. These associations are summarized in the following table, the hosts names, largely from Bruce (1983), are updated in accordance with Rowe, *et al.* (1986).

	Periclimenes alegrias	*Periclimenes ceratophthalmus*	*Periclimenes cornutus*	*Periclimenes amboinensis*
COMASTERIDAE				
Capillaster multiradiatus	—	—	—	—
Comanthus briareus	+	—	—	+
Comanthus parvicirrus	—	—	—	+
Comanthus wahlbergii	—	—	—	+
Oxycomanthus bennetti	—	—	—	+
HIMEROMETRIDAE				
Himerometra robustipinna	—	+	+	—
MARIAMETRIDAE				
Dichrometra afra		+	—	—
Lamprometra klunzingeri	—	+	—	—
Lamprometra palmata	+	—	—	—
Stephanometra indica	+	+	—	—
Stephanometra spicata	—	+	—	—

Periclimenaeus orontes sp.nov.

(Figs 1B, 6-10)

Type material. HOLOTYPE - ♀ (ovigerous), NTM Cr. 000272, Orontes Reef, Port Essington, 11°03.6′S 132°05.0′E, Stn. CP/40, 3 m, 5 May 1982, coll. J.N.A. Hooper.

Description. A small sized shrimp of subcylindrical body form.

Carapace smooth, glabrous, with short, straight, horizontal, acute rostrum reaching to level of distal end of proximal segment antennular peduncle and distal corneal margin of anteroverted eye; equal to about 0.3 of postorbital carapace length; dorsal carina with six acute teeth, all situated distally to level of orbital notch, with size decreasing anteriorly, ventral border straight, non-setose, unarmed; lateral carinae feebly developed; orbit feebly developed, supraorbital teeth or tubercles lacking, antennal spine well developed; inferior orbital angle feebly produced; hepatic spine absent; anterolateral angle of carapace not produced, bluntly rounded.

Abdominal segments smooth and glabrous; first segment with anterior margin of posterior part of tergite produced as robust broad median lobe that fits beneath the posterior margin of carapace; third segment not posterodorsally produced, fifth segment subequal to sixth, sixth about 1.2 times longer than deep, depressed, with posterolateral and posteroventral angles feebly produced, blunt; pleura broadly rounded, first three feebly enlarged, fourth and fifth small, feebly produced. Telson equal to 2.0 times sixth abdominal segment length, about 2.1 times longer than anterior width, sides feebly concave, converging to rounded posterior margin, about 0.5 of anterior width; two pairs of large, robust subequal dorsal spines at 0.09 and 0.28 of telson length, spines about 0.14 of telson length; three pairs of posterior spines, lateral spines small, slender, subdorsal; intermediate spines well developed, about 0.18 of telson length; submedian spines long and slender, densely setulose, well exceeding tips of intermediate spines, about 0.21 of telson length.

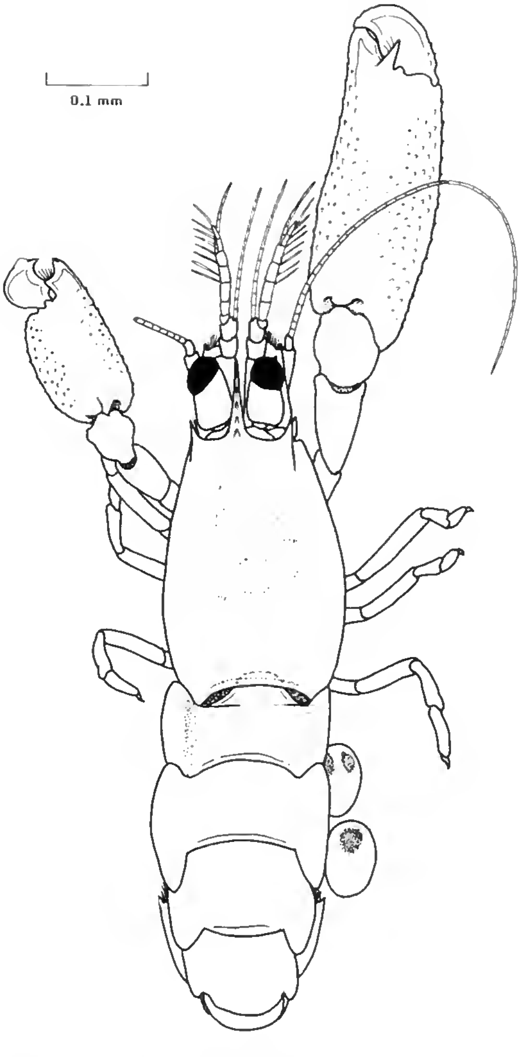


Fig. 6. *Periclimenes orontes* holotype ♀ (ovigerous), dorsal.

Antennule small and feebly developed, peduncle exceeding rostrum by intermediate and distal segments; proximal segment broad, about 1.8 times, longer than wide, proximal lateral border strongly produced laterally, distal part strongly concave, distolateral margin strongly produced with stout distolateral tooth, medial margin with strong ventral tooth; stylocerite short and stout, phylliform, distally acute, not reaching half segment length, laterally with plumose setae, and gaping from lateral margin of segment; statocyst normal, with granular statolith; intermediate segment short and stout, about 0.22 of proximal segment length, with feeble lateral lamella; distal segment about 1.5 times intermediate segment length, 1.4 times longer than wide; upper flagellum biramous with four proximal segments of rami fused, shorter free ramus with single free segment only, larger ramus with 8 segments; about 8 groups of aesthetascs present.

Antenna with short stout basicerite with small acute lateral tooth; carpocerite about 3.6 times longer than broad, compressed, slightly broadened distally, flagellum about 2.0 times postorbital carapace length; scaphocerite distinctly exceeding rostrum and carpocerite, about 2.6 times longer than wide, greatest width at half length, anterior margin of lamella broadly rounded, distinctly exceeding small acute distolateral tooth of straight lateral margin.

Eye with oblique hemispherical cornea, without acessory pigment spot; stalk subcylindrical, slightly tapered distally, greatest length about 1.5 times proximal width.

Mandible (right) with robust corpus, without palp; molar process stout, obliquely truncated distally, dorsal and ventral margins with elongated low carinae separated by dense tuft of short setae laterally and small blunt tooth with adjacent setae medially; incisor process feebly developed, slender, tapered distally, truncate with three small subequal acute teeth. Maxillula with small, feebly bilobed palp, lower lobe with small simple setae, upper lacinia slightly broadened, distally truncate with 10 stout simple spines and few setae; lower lacinia slender, distally tapered, with setulose setae distally. Maxilla with tapering, subcylindrical non-setose palp; basal endite bilobed, proximal lobe distinctly smaller than distal, with 5 and 9 simple distal setae respectively; coxal

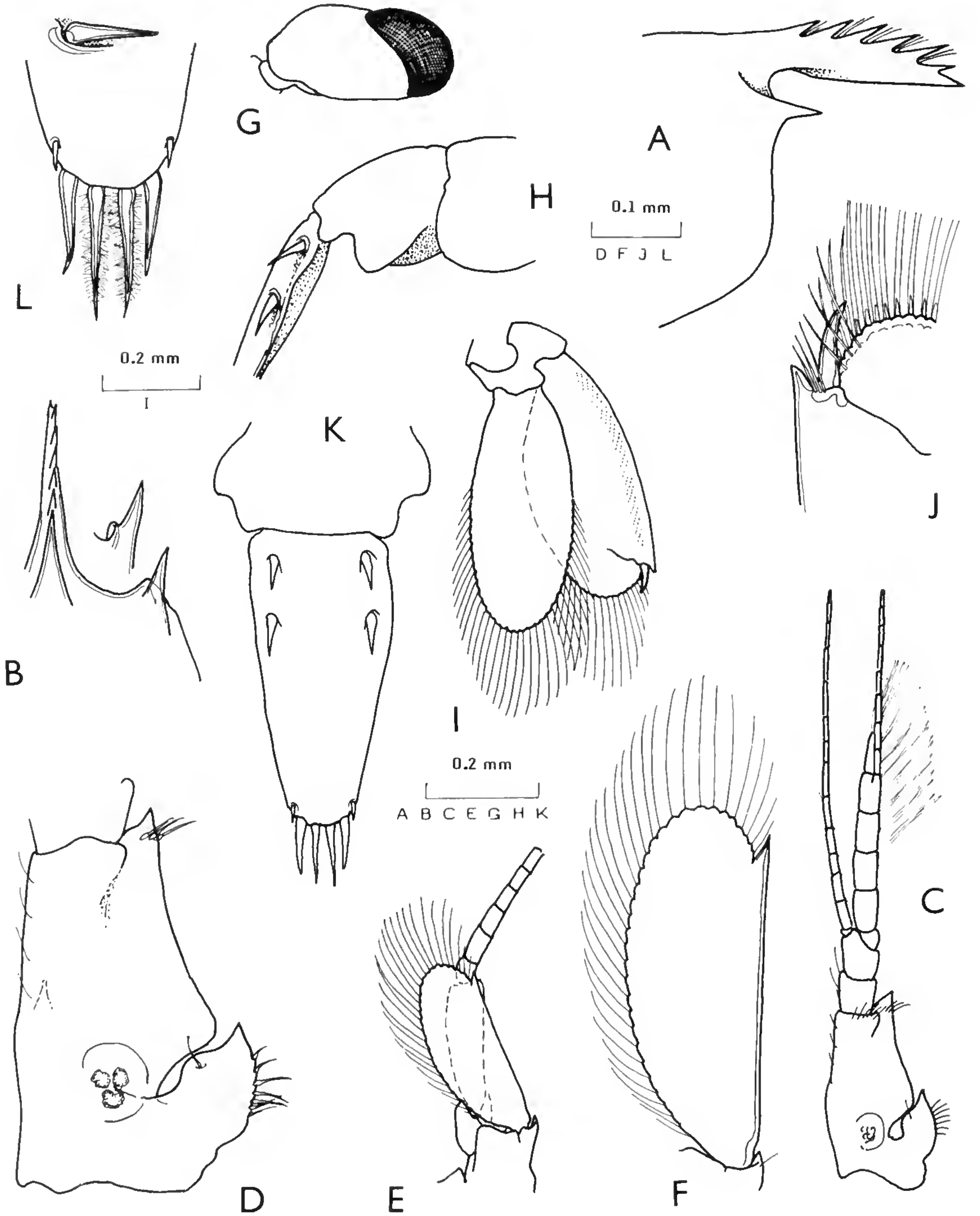


Fig. 7. *Periclimenes orontes* holotype ♀ : **A**, anterior carapace and rostrum, lateral; **B**, right orbital region; **C**, antennule; **D**, same, proximal pedunacular segment; **E**, antenna; **F**, scaphocerite; **G**, eye, dorsal; **H**, posterior abdomen, lateral; **I**, uropod; **J**, same, distolateral angle; **K**, telson; **L**, and same, posterior spines.

endite obsolete, median margin convex, non-setose, scaphognathite well developed, about 3.2 times longer than broad, anterior lobe narrowing distally, medial margin concave, posterior lobe well developed. First maxilliped with slender, subcylindrical palp with preterminal simple medial seta; basal endite broadly rounded, sparsely provided with simple setae medially, exopod with well developed flagellum with four distal and one preterminal plumose setae, caridean lobe large and broad; coxal endite obsolete, small, convex, non-setose; epipod well developed, triangular, deeply bilobed. Second maxilliped endopod of normal form, dactylar segment sparsely setose with slender

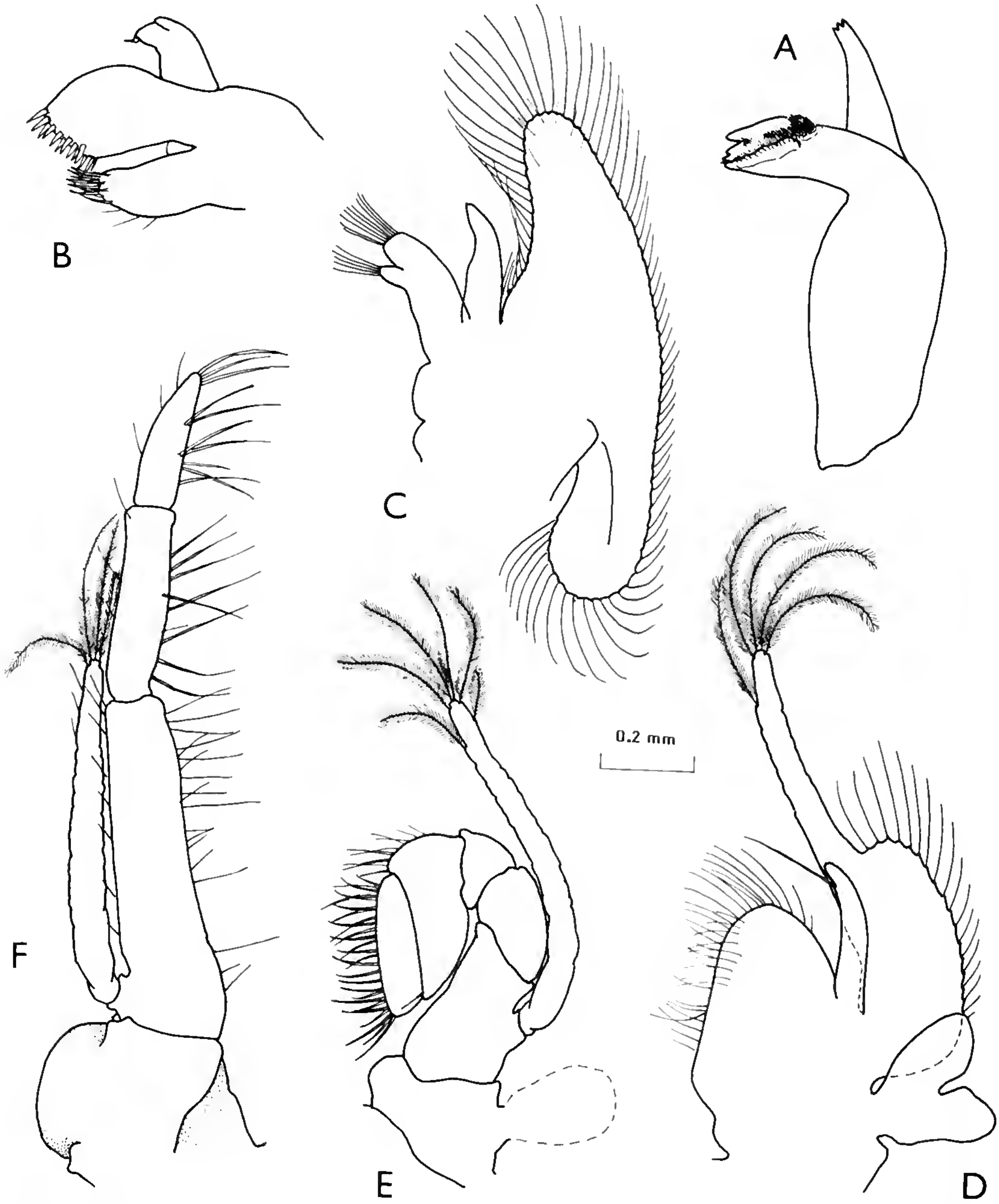


Fig. 8. *Periclimenes orontes* holotype ♀: **A**, mandible; **B**, maxillula; **C**, maxilla; **D**, first maxilliped; **E**, second maxilliped; **F**, third maxilliped.

spines; exopod well developed, with four terminal and two preterminal plumose setae distally; coxa slightly produced medially, non-setose, with small oval epipod without podobranch laterally. Third maxilliped with endopod extending anteriorly to level of ventromedial tooth of proximal segment of antennular peduncle; ischiomerus and basis fused, combined segment abuut 4.0 times longer than broad, uniform, about 0.57 of antepenultimate segment length, with sparse stouter setae medially; terminal segment about 3.5 times longer than proximal width, about 0.4 of antepenultimate segment length, sparsely setose; exopod slightly exceeding distal end of antipenultimate segment, with four plumose setae distally; coxa stout, medially excavate, with broad low lateral plate, without arthrobranch.

First pereiopod moderately robust, distal merus slightly exceeding carpocerite; chela stout, palm slightly swollen and compressed, about 1.3 times longer than greatest depth; dactylus subequal to palm length, about 3.0 times longer than distal width, tapering proximally; carpus about 1.2 times length of chela; merus bowed, about 4.2 times longer than wide, uniform, about 1.1 times carpal length; ischium, basis and coxa normal, without special features.

Second pereiopods well developed, markedly unequal and dissimilar. Major chela about 1.6 times postorbital carapace length, palm swollen, subcylindrical, slightly compressed and tapering distally, dorsally tuberculate, with small acute tubercles; about 2.0 times longer than greatest depth; dactylus about twice as long as deep, semicircular, compressed, with stout blunt hooked tip distally and large molar process on cutting edge; fixed finger about as long as deep, with feeble hooked tip, cutting edge with large fossa for dactylar molar process, with conspicuous acute process on dorsal margin, carpus about 0.28 of palm length, about 1.3 times longer than broad, distally expanded, unarmed, non-tuberculate; merus robust, about 1.5 times longer than central width, 0.3 of palm length, ventrally tuberculate, without distoventral tooth; ischium about 0.8 of merus length, 1.4 times longer than distal width, compressed, tapered proximally, with single acute ventral tubercle; basis and coxa robust, without special features. Minor chela about 0.5 of major chela length, strongly compressed, with acute tubercles dorsally, about 1.5 times longer than deep, slightly tapered distally; dactylus strongly compressed, about 1.6 times longer than deep, dorsal margin thickened over posterior three fourths but sharply carinate over distal fourth, tip acute, hooked, cutting edge sinuous, concave anteriorly, non-denticulate posterior part produced into stout recurved tooth; fixed finger much shorter than dactylus, about as long as deep, with small blunt tip, cutting edge with deep fossa for dactylar edge, with large triangular process on dorsal margin bearing numerous long simple setae distally; carpus about 0.4 of palm length, expanded distally, unarmed, non-tuberculate; merus about 1.2 of carpal length, 0.5 of palm length, about 1.8 times longer than broad, ventrally tuberculate, without distoventral tooth; ischium about 1.1 times meral length, about 2.0 times longer than distal width, tapered proximally, without ventral tubercles; basis and coxa as in major pereiopod but less robust.

Ambulatory pereiopods moderately robust, third pereiopod exceeding carpocerite by length of dactylus. Dactylus of third pereiopod strongly compressed, corpus about 1.5 times longer than deep, with pair of setae distolaterally and single seta distomedially, dorsal margin strongly convex, ventral border sharp with small acute preterminal distal tooth, otherwise unarmed, convex proximally with medial ventral flange; unguis simple, feebly distinct from corpus, curved, acute, about 2.0 times longer than basal width, about 0.45 of corpus length; propod about 4.0 times length of dactyus and 4.6 times longer than deep, slightly tapering distally, sparsely setose, with pair of strong distoventral spines and four smaller single ventral spines; carpus about 0.7 of propod length, about 3.0 times longer than distal width, unarmed; merus about 1.3 times propod length, 3.2 times longer than proximal width, slightly tapered distally, unarmed; ischium about 0.6 of meral length, tapering proximally, about 2.5 times longer than distal width, unarmed; basis slender, about 0.5 of meral length, coxa robust, both unarmed. Fourth and fifth pereiopods similar, fifth more slender.

Uropods with posterolateral angle of propod feebly produced, rounded; exopod about 2.25 times longer than broad, lateral

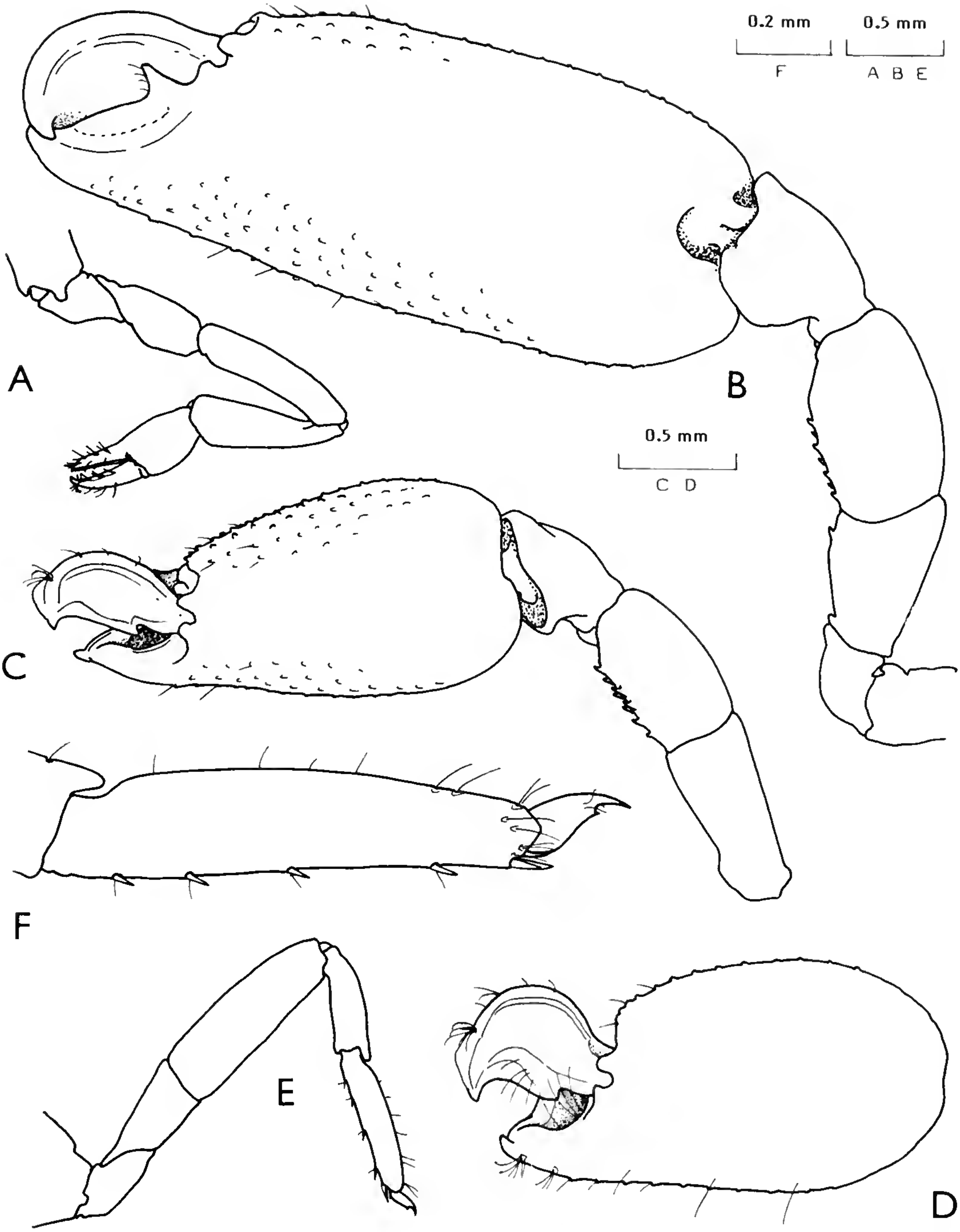


Fig. 9. *Periclimenes orontes* holotype ♀: **A**, molar process of right mandible; **B**, incisor process; **C**, maxillula, palp; **D**, same, distal upper lacinia; **E**, chela of first pereiopod; **F**, major second pereiopod, fingers of chela, ventral; **G**, minor second pereiopod, fingers of chela, dorsal; **H**, same, ventral; **I**, third pereiopod, dactylus; **J**, same, distal corpus and unguis.

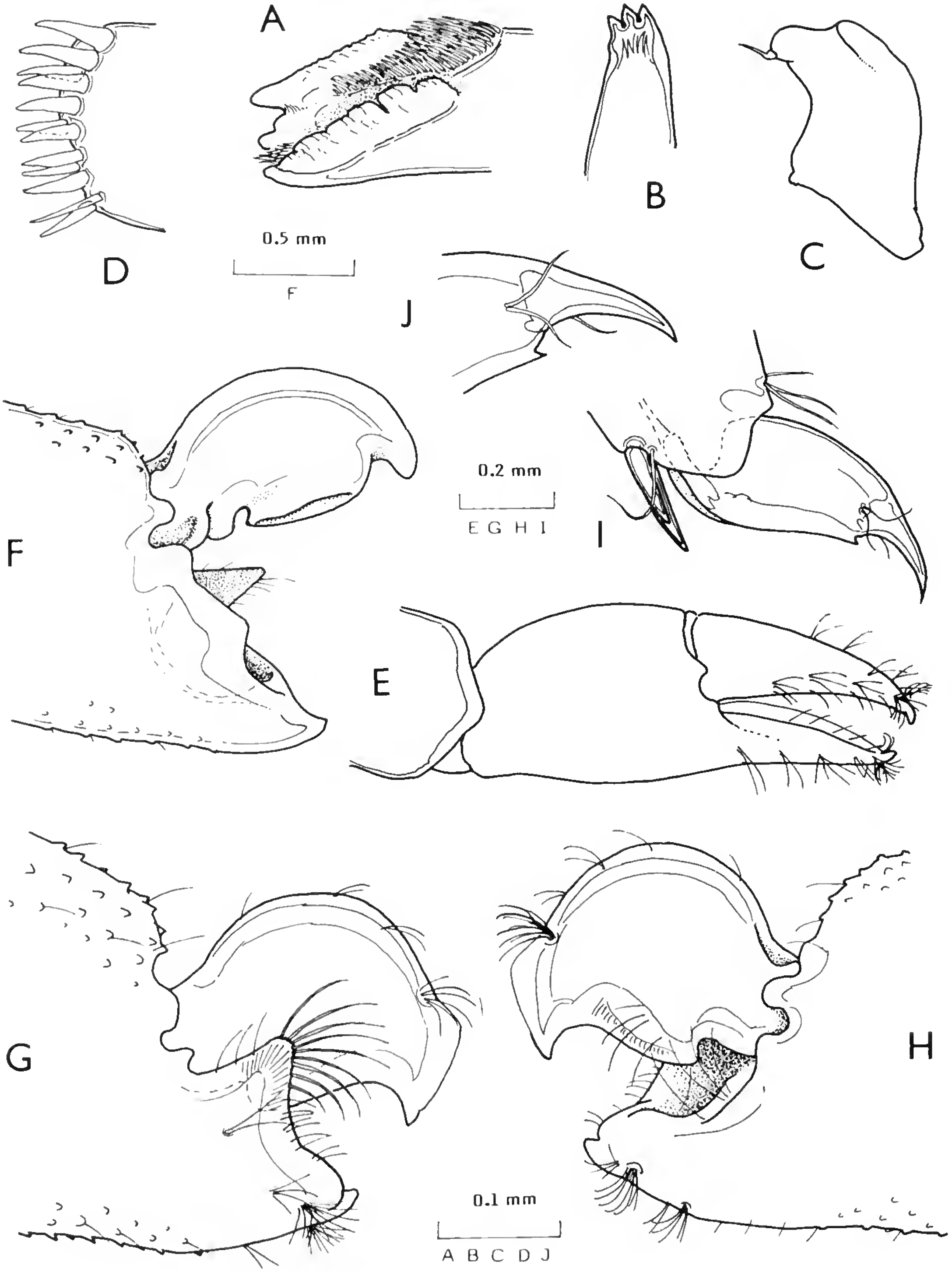


Fig. 10. *Periclimenes orontes* holotype ♀ : **A**, first pereiopod; **B**, major second pereiopod; **C**, minor second pereiopod; **D**, same, chela, ventral; **E**, third pereiopod; **F**, same, propod and dactyl.

border convex, without teeth or spines, with submarginal row of setae ventrally, distally with small acute tooth with single large curved mobile spine medially; endopod distinctly exceeding exopod, about 2.3 times longer than broad.

Ova few, about 20, of normal size.

Measurements (mm).	
Total length (approx.)	8.5
Carapace length (incl. rostrum)	3.0
Postorbital carapace length	2.4
Major chela	3.75
Minor chela	1.85
Ova length	0.6

Colouration. Transparent.

Host. *Jaspis stellifera* (Carter)(Jaspidae : Porifera).

Systematic position. The most remarkable features of *P. orontes* sp.nov., are the dorsal lobe on the first abdominal tergite and the chela of the minor second pereiopod. A dorsomedian projection of the posterior part of the tergum of the first abdominal segment, fitting beneath the posteromedian margin of the carapace, has been described in few species of the genus, although it may have been overlooked in some of the earlier described species that are still little known. The species in which it has been reported are *P. ardeae* Bruce, 1970 from the Australian Great Barrier Reef and *P. lobiferus* Bruce, 1978 from Madagascar (Bruce 1970, 1978).

P. orontes may be readily distinguished from *P. lobiferus* by the absence of denticulations along the ventral border, in addition to the distal accessory tooth, of the corpus of the dactylus of the ambulatory pereiopods. *P. lobiferus*, still known only from the holotype specimen, has nine dorsal rostral teeth, with a rostrum that far exceeds the anteroverted corneal margins and also lacks the characteristic chela of the minor second pereiopod found in *P. orontes*. This chela shows a marked reduction of the fixed finger, which is much shorter than the dactylus, with a deeply cannulate cutting edge that houses the sharp dactylar cutting edge when the fingers are closed. The sharply carinate distal outer margin of the dactylus and the sharply sinuous cutting edge with a recurved posterior tooth occluding into a deep fossa appear without parallel in other species of the genus. *P. ardeae* lacks denticulations along the ventral margin of the dactylar corpus and has eight dorsal rostral teeth, but is most easily distinguished from *P. orontes* and *P. lobiferus* by the chela of the first pereiopods in which the dactylus bears a conspicuous dense tuft of setae dorsally.

The species of the genus *Periclimenaeus* known to have a dorsomedian lobe on the first abdominal tergum may be readily separated by the following key:

1. Rostrum with 6 dorsal teeth; minor second pereiopod with distal outer margin of dactylus produced and carinate; cutting edge strongly sinuous with large proximal tooth, fitting into deep groove on fixed finger.................... *P. orontes* sp.nov.
— Rostrum with 8-9 dorsal teeth 2
2. Ambulatory pereiopods with ventral dactylar corpus denticulate; dactyl of first pereiopod without conspicuous dorsal tuft of setae .... *P. lobiferus* Bruce
Ambulatory pereiopods with ventral dactylar corpus non-denticulate; dactyl of first pereiopod chela with conspicuous dorsal tuft of setae ..... *P. ardeae* Bruce

P. palauensis Miyake and Fujino appears to be very closely related to *P ardeae* and may therefore belong to the above group of species (Miyake and Fujino 1986). However, the condition of the dorsum of the first abdominal segment in the only known specimen has not been described. *P. palauensis* may be readily distinguished from *P. ardeae* by the absence of spinulations on the chela of the major second pereiopod, but it shares with *P. ardeae* the presence of the very characteristic group of setae on the dactyl of the first pereiopods (Bruce 1978).

***Hamopontonia essingtoni* sp.nov.**

(Figs 1C, 11-14, 15 D-G)

Type material. HOLOTYPE - ♀ (ovigerous), NTM Cr. 004072A, Coral Bay, Port Essington, 11°11.05'S 132°03.4'E, Stn. CP/71, *ca.* 6 m, 13 September 1985. ALLOTYPE - ♂, NTM Cr.004072B, same data as holotype. PARATYPES - 11 specimens (6 ♀ ovigerous), NTM Cr. 004073, some data as holotype; 1 ♀ (ovigerous), Rijksmuseum van Natuurlijke Historie, Leiden RMNHD 36584, same data as holotype.

Description. Small sized shrimps of smooth, subcylindrical, slightly depressed body form, with males smaller and more slender than females.

Carapace smooth, glabrous. Rostrum slender, compressed, reaching to distal margin of intermediate segment of antennular peduncle, horizontal, slightly upturned distally, with apex acute, dorsal carina well developed, slightly elevated in male, with 4-6 acute teeth in female and 5-6 in males, first two teeth situated on carapace behind posterior orbital margin in female, first only in male, with setose interspaces; ventral carina obsolete, lower margin convex and non-setose; lateral carinae feebly developed. Supraorbital and hepatic spines absent; orbit undeveloped, inferior orbital angle produced, with small inner flange, antennal spine well developed, submarginal,

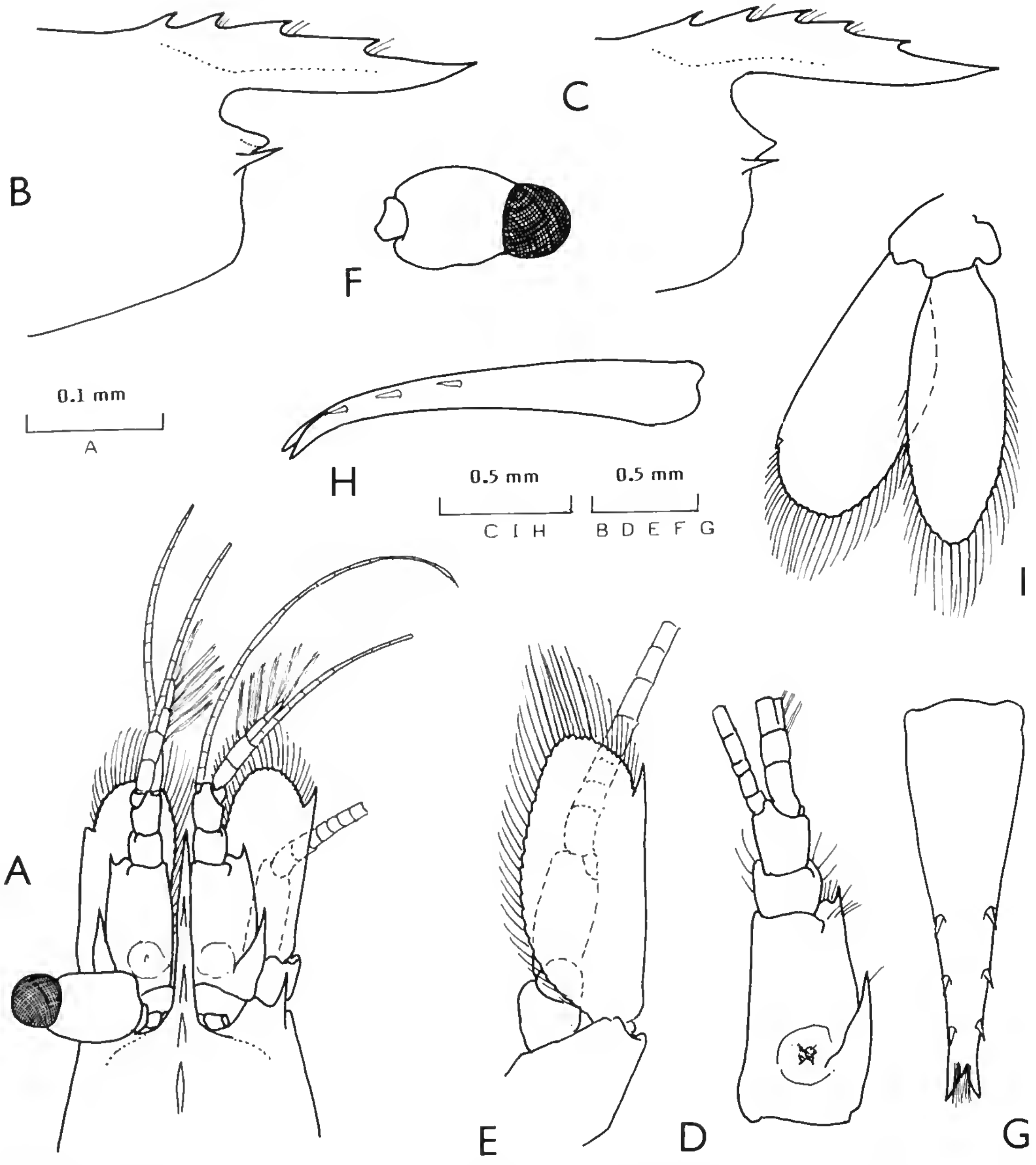


Fig. 11. *Homopontonia essingtoni* paratype ♀ except **A-C**: **A**, anterior carapace, rostrum and antennae, dorsal, holotype ♀ ; **B**, anterior carapace and rostrum, holotype ♀ : **C**, same, allotype ♂; **D**, antennule; **E**, antenna; **F**, eye; **G**, telson, dorsal; **H**, same, lateral; **I**, uropod.

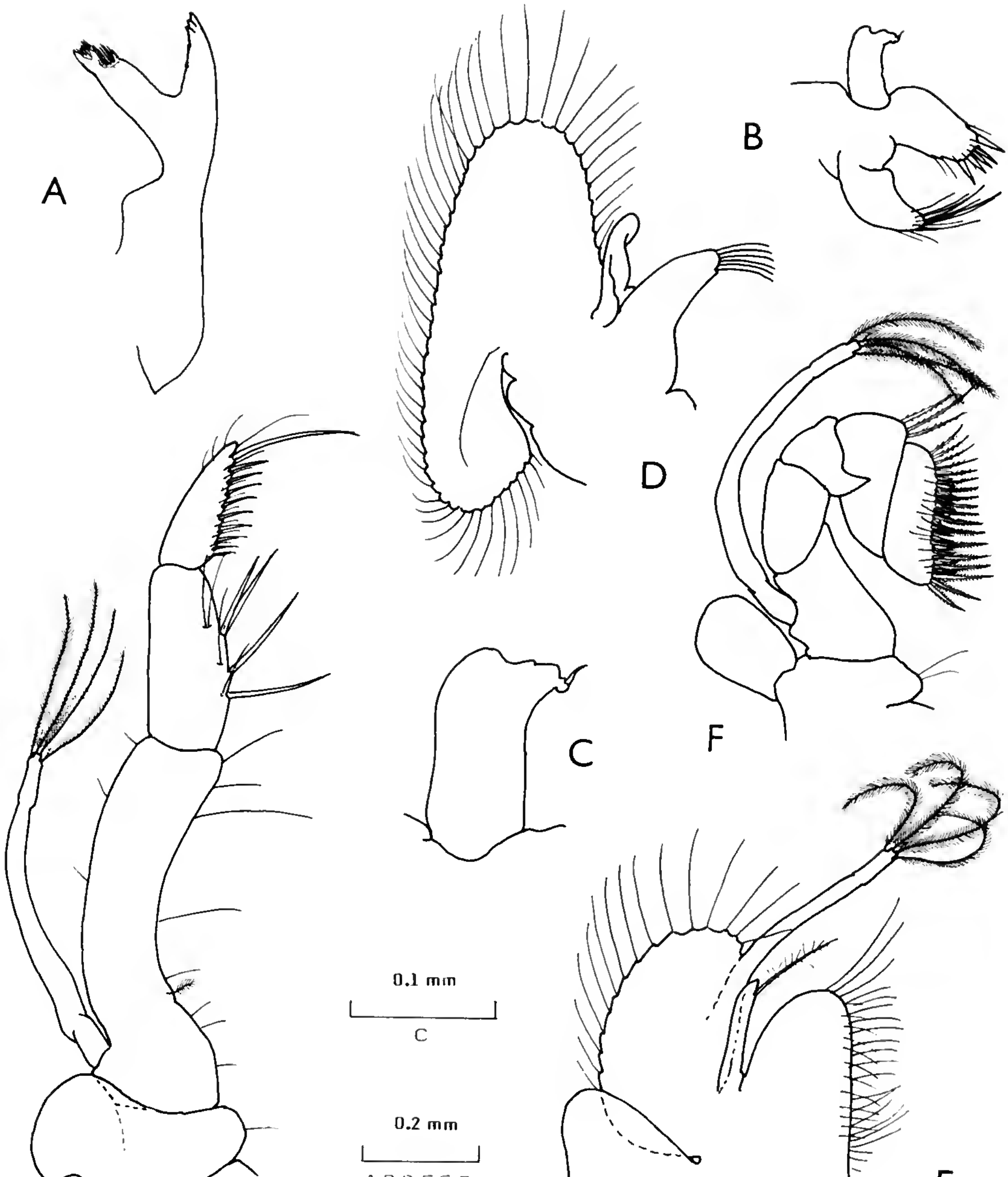


Fig. 12. *Hamopontonia essingtoni* holotype ♀: **A**, mandible; **B**, maxillula; **C**, same, palp; **D**, maxilla; **E**, first maxilliped; **F**, second maxilliped; **G**, third maxilliped.

upwardly directed in female, horizontal in male; branchiostegite normal with anteroventral angle broadly rounded, not produced.

Abdominal segments smooth, glabrous; third segment not posterodorsally produced, fifth segment about 0.6 times length of sixth, sixth about 1.5 times longer than deep, with acute posterolateral and posteroventral angles; pleura all broadly rounded, with first to third enlarged in adult females. Telson about 1.65 times length of sixth of abdominal segment, about 3.2 times longer than anterior width, tapering posteriorly and ventrally concave longitudinally, posterior surface with three pairs of small subequal spines at 0.6, 0.75 and 0.9 of telson length; posterior margin armed with paired lateral ventrally curved hooklike processes, equal to about 0.1 of telson length, separated by small rounded median process with adjacent long simple steae.

Antennules normally developed, proximal segment of peduncle about 1.8 times longer than central width; stylocerite slender, acute, exceeding half segment length, statocyst normal with granular statolith; distolateral margin produced with small rounded lobe medially and acute tooth laterally, reaching to about half intermediate segment length, medial border with small acute tooth ventrally at half length; intermediate and distal peduncular segments equal to about 0.8 of proximal segment length; intermediate segment shorter and broader than distal segment, with small lateral lobe; upper flagellum short, equal to about 0.8 of postorbital carapace length, biramous, with first two segments of rami fused; shorter ramus with two free segments, longer ramus with ten, about six groups of aesthetascs present; lower flagellum slender, slightly longer than postorbital carapace length, about 21 segments.

Antenna with robust basicerite, without distolateral tooth; ischiocerite and basicerite normal; carpocerite short, about 2.1 times longer than broad, exceeding half length of scaphocerite; flagellum well developed, about 3.5 times postorbital carapace length; scaphocerite well developed, exceeding antennular peduncle distally, about 2.4 times longer than greatest width, at about half length, distal lamella bluntly angular, far exceeding strong distolateral tooth on straight lateral margin.

Eye well developed with small globular cornea, lacking distinct assessory pigment spot, situated transversely on stalk; stalk slightly longer than central width, about 1.3 times corneal diameter.

Mandible (right) moderately slender, without palp; molar process slender, obliquely truncated distally, with three small acute teeth posteriorly, surrounded by dense groups of setae, some serrulate, with tuberculate carina anteroventrally; incisor process slender with three acute teeth distally, largest tooth medially, two small denticles on medial edge distally. Maxillula normal, palp feebly bilobed, lower lobe with small hooked seta; upper lacinia slender, with five acute simple spines distally and several slender setae; lower lacinia slender, sparsely setose, with several long slender setae distally. Maxilla with slender non-setiferous subcylindrical palp; basal endite simple, tapering distally with six slender simple distal setae; coxal endite absent, medially feebly convex; scaphognathite well developed, broad, about 2.3 times longer than width, anterior lobe with medial margin convex, not emarginate; posterior lobe large, slightly shorter than anterior lobe. First maxilliped with slender, subcylindrical palp with preterminal setulose setae, basal endite large, broadly rounded, medial margin sparsely setose with slender, feebly setulose setae, separated by small notch from reduced rounded non-setose coxal endite; exopod with well developed flagellum with four plumose distal setae, caridean lobe large and broad, epipod large and bluntly triangular. Second maxilliped of normal form, dactylar segment broad, with dense rows of long and short coarsely serrulate spines and setae medially; carpal segment acutely produced proximomedially, ischiomerus and basis normal, exopod well developed with four plumose distal setae, epipod oval, without podobranch. Third maxilliped with endopod reaching to middle of carpocerite; ischiomerus fused to basis, junction indicated by small median notch, ischiomeral portion of combined segment strongly bowed, broad, about 3.8 times longer than central width, very sparsely setose, few simple setae only; penultimate segment about 2.5 times longer than central width, tapering distally, about 0.6 of ischiomerus, with few long slender spines medially; distal segment about 0.75 of penultimate segment length, tapering strongly distally, about 3.0 times longer than proximal width, with numerous groups of short spines medially and single long slender preterminal spine; basis broadly convex medially, sparsely setose; exopod slender with four plumose terminal setae; coxa with small rounded lobe medially, not produced, and oval plate laterally, with (?) rudimentary arthrobranch.

Epistome unarmed. Fourth thoracic sternite without fingerlike median process, with

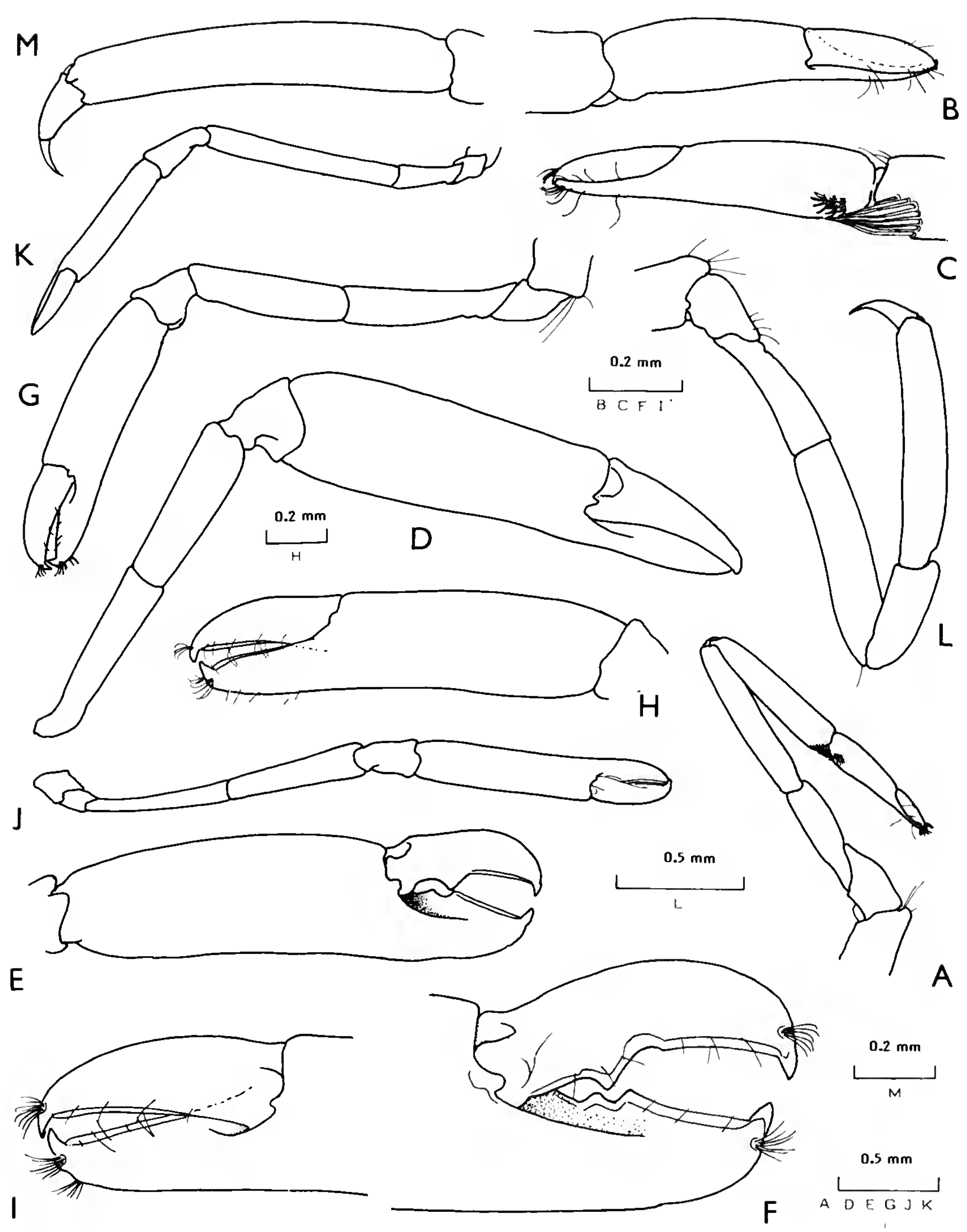


Fig. 13. *Hamopontonia essintoni* paratype ♀ except **J**, **K**: **A**, first pereiopod; **B**, same, chela, dorsal; **C**, same, ventral; **D**, major second pereiopod; **E**, same, chela; **F**, same, fingers; **G**, minor second pereiopod; **H**, same, chela; **I**, same, fingers; **J**, major second pereiopod, allotype ♂; **K**, minor second pereiopod, allotype ♂; **L**, third pereiopod; **M**, same, propod and dactyl.

pair of low plates posteriorly separated by small median notch. Fourth to eight sternites moderately broad.

First pereiopods slender, reaching anteriorly to distal end of antennular peduncle; chela slender, palm subcylindrical about 2.5 times longer than proximal width tapering slightly distally, fingers about 0.6 of palm length, compressed with laterally situated entire cutting edges, dactyl about 3.0 times longer than proximal width, with small hooked tip, fixed finger similar, with bidentate tip; palm with three transverse rows of short serrulate cleaning setae proximally; carpus about 1.25 times chela length, about 5.0 times longer than distal width, scarcely tapering, with transverse row of long cleaning setae distally; merus slightly longer than carpus, about 5.8 times longer than central width,ischium slightly shorter than chela, about 0.7 of merus length; basis about 0.5 of merus length; coxa slender, without medial process.

Second periopods robust, of moderate size, unequal, relatively smaller in males than females. In female, major second pereiopod with chela equal to about 1.6 times postorbital carapace length and minor about 0.9; male with major chela about 0.85 and minor 0.7. In female, major chela with palm smooth, subcylindrical, about 2.9 times longer than deep; dactylus compressed, about 0.5 of palm length, robust, about 3.5 times longer than central depth, dorsal border strongly convex, stout acute tooth distally, cutting edge with single large acute tooth proximally, distal half with sharp entire cutting edge; fixed finger about 2.0 times longer than proximal depth, cannulate proximally to house dactylus, distal cutting edge entire, proximal cutting edge with two small acute teeth, laterally to closed dactylus; carpus short and stout, unarmed, distally expanded, about 0.2 of palm length; merus about 0.55 of palm length, about 3.4 times longer than distal width, slightly narrowed proximally, unarmed; ischium about 1.12 of merus length and 0.6 of palm length, about 4.4 times longer than distal width, proximally tapering; basis and coxa robust, without special features. Minor chela about 0.6 of length of major chela, palm about 3.0 times longer than deep, fingers generally similar to major chela but less robust with unarmed cutting edge, dactyl about 2.6 times longer than proximal depth, 0.5 of palm length; other segments similar to major chela but smaller and less robust. In male, second pereiopods relatively small, major chela about 1.2 times length of minor chela; merus of minor chela much longer than ischium, subequal to length of chela; merus of major chela shorter than ischium, much shorter than palm length.

Ambulatory pereiopods moderately slender, third pereiopod exceeding antennular peduncle by 0.3 of propod; dactylus robust, slightly compressed, corpus about 2.1 times longer than proximal depth, dorsal margin convex, ventral border sinuous, unarmed, with pairs of sensory setae distolaterally, unguis distinct, curved, about 0.6 of corpus length, 3.0 times longer than proximal width, simple; propod about 6.0 times longer than deep, slightly curved, about 3.8 times length of dactyl, with few simple setae distally, devoid of spines; carpus about 0.45 of propod length, 2.5 times longer than distal width, tapering proximally, unarmed; merus 0.95 of propod length, 4.7 times longer than wide, uniform and unarmed;ischium about 0.6 of merus length, tapering proximally, about 3.6 times longer than distal width; basis and coxa normal. Fourth and fifth pereiopods similar, propod lengths subequal to third; coxa of fifth with transverse band of small spinules ventrally.

Male first pleopod with endopod about 2.5 times longer than distal width; feebly expanded distally, proximal half of medial margin with two simple setae proximally and four short hooked spines distally, distal lateral border with three short plumose setae only. Second pleopod with appendix masculina equal to about 0.3 of endopod length, corpus about 6.0 times longer than average width, with very long strong densely spinulose setae terminally, with similar shorter preterminal ventral seta and small simple distal lateral seta; appendix interna slender, overreaching corpus of appendix masculina, with few distomedial concinnuli only.

Uropod with protopodite posterolaterally unarmed; exopod broad, distally exceeded by posterior hooks of telson, about 2.2 times longer than wide, lateral margin almost straight, unarmed, with small distal mobile spine only; endopod slender, about 2.8 times longer than wide.

Ova about 25-30, of normal size.

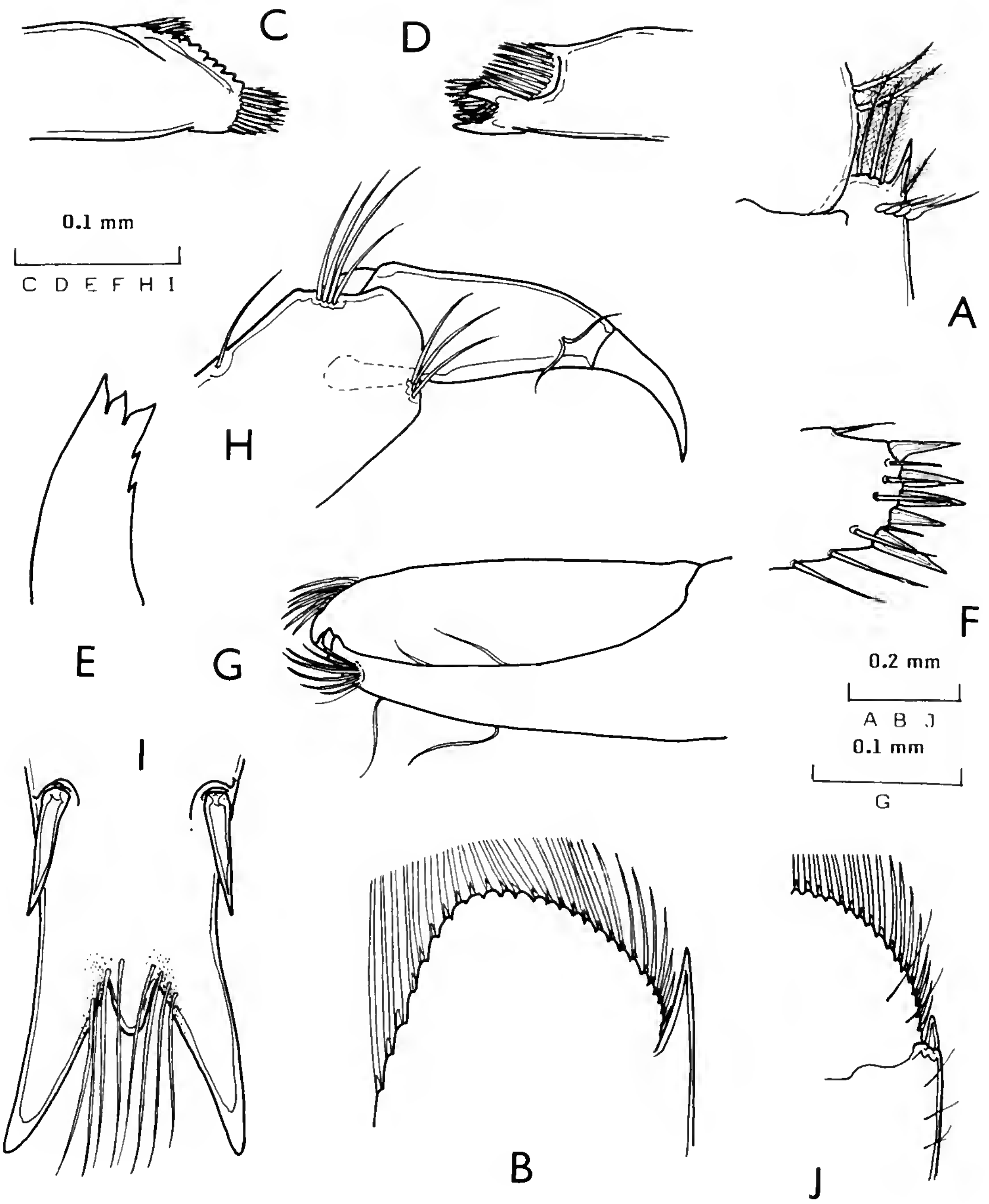


Fig. 14. *Hamopontonia essingtoni* paratype ♀ except **C-F**: **A**, distolateral angle of proximal segment of antennular peduncle; **B**, distal end of scaphocerite; **C**, **D**, molar process of mandible, dorsal and ventral aspects, holotype ♀; **E**, incisor process of mandible, holotype ♀; **F**, distal end of upper lacinia of maxillula, holotype ♀; **G**, fingers of chela of first pereiopod; **H**, dactyl and distal propod of third pereiopod; **I**, posterior margin of telson; **J**, posterior margin or telson distolateral angle of escopod.

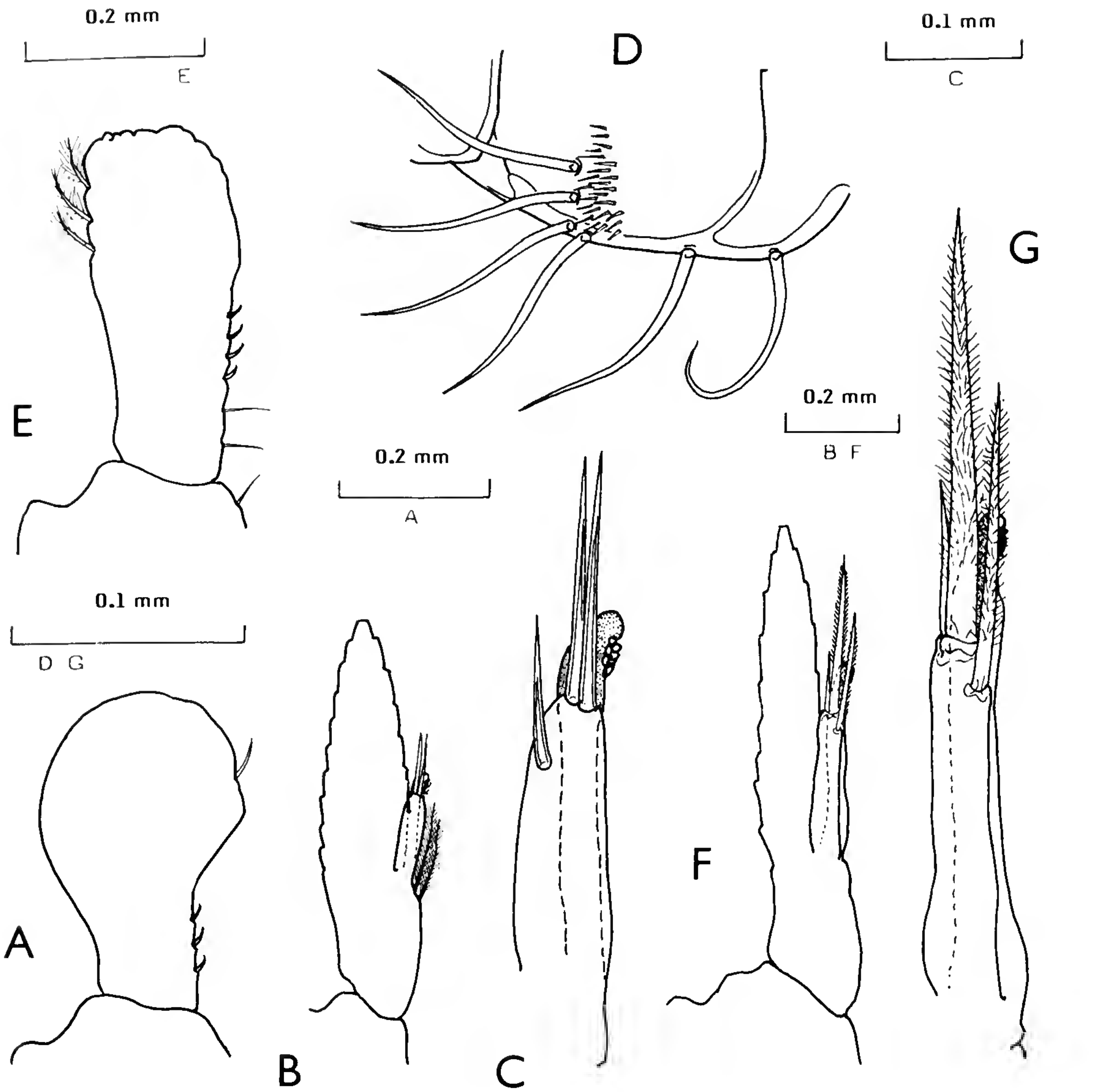


Fig. 15. *Periclimenes essingtoni* paratype ♂: **A**, first pleopod, endopod; **B**, second pleopod, endopod; **C**, appendices masculina and interna. *Hamopontonia essingtoni* paratype ♂ except **D**: **D**, fifth pereiopod, coxa, paratype ♀; **E**, first pleopod, endopod; **F**, second pleopod; **G**, same, appendices masculina and interna.

Measurements (mm).	Holotype ♀	Allotype ♂
Total length (approx.)	8.5	7.0
Carapace length (incl. rostrum)	3.2	2.6
Postorbital carapace length	2.1	1.5
Major chela	3.4	1.3
Minor chela	1.95	1.1
Ova length	0.6	—

Colouration. Details not noted in this field. The live specimens were largely transparent with numerous small white patches.

Host. Both lots of specimens were collected from *Stylophora pistillata* (Esper) (Coelenterata, Scleractinia).

Systematic Position. The present specimens are closely related to the only other known species of the genus, *H. corallicola* Bruce 1970, first reported from Hong Kong in association with *Goniopora stokesi* Milne-Edwards and Haime, (Bruce, 1970a). This species has since been found to be particularly common in association with the fungiid coral *Heliofungia actiniformis* Quoy and Gaimard and also to associate with the anemone *Entacmaea quadricolor* (Rüppell and Leuckart) (as *Parasicyonis actinostroides*) in Japanese waters (Suzuki and Hayashi 1977). *H. essingtoni* may be readily distinguished from *H. corallicola* by the presence of a small blunt median process between the two strong hooklike distal processes of the telson. In addition, *H. essingtoni* is of much smaller size than *H. corallicola* when adult, associates with a different host animal and possesses a distinctive colour pattern in life. This pattern, of numerous small white patches on a transparent animal, closely resembles that of *Fennera chacei* Holthuis, 1951, of similar size and associations (see Bruce 1986), for which the present specimens were unfortunately first mistaken when collected. *H. corallicola* usually shows a single large conspicuous oval white dorsal spot on the central carapace and another on the third abdominal segment. These spots closely resemble the size and appearance of the acrosomes of *H. actiniformis* and facilitate concealment of the shrimps among the hosts tentacles. A single specimen of *H. corallicola* was also found on *Heliofungia* at the same station as *H. essingtoni*.

REFERENCES

Borradaile, L.A. 1915 Notes on Carides. *Annals and Magazine of Natural History* (8) **15**:205-213.

Bruce, A.J. 1970 Further preliminary descriptions of new species of the genus *Periclimenaeus* Borradaile, 1915 (Crustacea, Decapoda Natantia, Pontoniinae). *Zoologisches Mededelingen, Leiden* **44**(21):305-315.

Bruce, A.J. 1970a Notes on some Indopacific Pontiniinae, XV. *Hamopontonia corallicola* gen.nov., sp.nov., a new pontoniine shrimp from Hong Kong. *Crustaceana* **18**:37-48.

Bruce, A.J. 1978 A report on a collection of pontoniine shrimps from Madagascar and adjacent seas. *Zoological Journal of the Linnean Society* **62**:205-290

Bruce, A.J. 1978a The re-examination of some pontoniine shrimp types first described by L.A. Borradaile (Decapoda, Palaemonidae). *Crustaceana* **34**(3):251-268.

Bruce, A.J. 1982 The shrimps associated with the Indo-west Pacific echinoderms, with the description of a new species in the genus *Periclimenes* Costa, 1884 (Crustacea: Pontoniinae). *Memoirs of the Australian Museum* **16**: 191-216.

Bruce, A.J. 1983 Expedition Rumphius II (1975). Crustacés parasites, commensaux, etc. (Th. Monod ed. IX Crustacés Décapodes (1 ere partie: Natantia Pontoniinae). *Bulletin du Museum nationale d'Histoire Naturelle, Paris* (4) **5**(A3):871-902.

Bruce, A.J. 1986 Logerende a koralrevet-rfmer i samliv med mange andre dyr. Naturens Verden:161-176.

Miyake, S. and Fujino, T. 1968 Pontoniinid shrimps from the Palau Islands (Crustacea, Decapoda, Palaemonidae). *Journal of the Faculty of Agriculture, Kyushu Imperial University* **10**(3):399-431.

Rowe, F.W.E., Hoggett, A.K., Birtles, R.A., and Vail, L.L., 1986. Revision of some comasterid genera from Australia (Echinodermata: Crinoidea), with descriptions of two new genera and nine new species. *Zoological Journal of the Linnean Society* **86**:197-277.

Suzuki, K. and Hayashi, K.I. 1977 Five caridean shrimps associated with sea anemones in Central Japan. *Publications of Seto Marine Biological Laboratory* **24**(1-3):193-208.

Accepted 10 September 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 167-189

REVISION OF THE MARINE SPONGE GENUS *AXOS* GRAY (DEMOSPONGIAE: AXINELLIDA) FROM NORTH-WEST AUSTRALIA

JOHN N.A. HOOPER
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

The Australian marine sponge genus *Axos* Gray (Hemiasterellidae) is revised. Two species are recognised, *A. cliftoni* Gray and *A. flabelliformis* Carter, and are differentiated on the morphology of euaster microscleres. Reproductive products of *A. cliftoni* are described. *A. spinipoculum* Carter is redescribed from the holotype and transferred to *Latrunculia* Bocage. The holotype of *A. anchorata* Carter, and recent specimens of *A. fibulata* Carter are described, and the species are retained in *Plumocolumella* Burton and *Gelliodes* Ridley, respectively, following Burton (1934). The family Hemiasterellidae is reviewed.

KEYWORDS: taxonomy, Porifera, Axinellida, Hemiasterellidae, *Axos*, north-west Australia.

INTRODUCTION

The genus *Axos* Gray is an aster bearing marine axinellid sponge, which has suspected Hadromerid affinities. The genus was revised in a footnote by Burton (1934: 549) presumably based on original material, but no descriptions or other evidence was presented by that author. Species are prevalent in northwest Australian waters, and indeed they appear to be restricted to this region. This paper revises *Axos* from type specimens and recent material from the Northern Territory and Western Australia, and discusses the family Hemiasterellidae.

Methods of preparation and examination are described elsewhere (Hooper 1984a, 1984b). Scanning electron micrographs of euasters were obtained from sponge sections dissolved directly onto microscope cover glasses, in nitric acid and heat. Cover glasses were mounted on stubs and vacuum plated in gold. Spicules were measured using a camera lucida and calibrated digitizer (computer graphics pad). Analyses of variance (Rx2 ANOV) and Student's t-tests were computed following the methods and models prescribed by Steele and Torrie (1960) and Zar (1974).

Abbreviations used in the text are as follows: AM Australian Museum, Sydney; BMNH British Museum (Natural History), London; LFM Merseyside County Museums (formerly Liverpool Free Museum), Liverpool; NMV Museum of Victoria (formerly National Museum of Victoria), Melbourne; NTM Northern Territory Museum, Darwin; WAM Western Australian Museum, Perth; ZMA Zoological Museum, Amsterdam.

SYSTEMATICS

Family Hemiasterellidae Lendenfeld

Hemiasterellinae Lendenfeld, 1889: 903.

Hemiasterellidae — Lévi 1973: 606; Bergquist 1978: 67; Wiedenmayer 1977a: 152; Hartman 1982: 647.

Astraxinellidae Dendy, 1905: 107; Stephens 1912: 59, 1915: 28; Topsent 1919: 6, 1928:38; Wilson 1925: 354; Lévi 1955: 79.

Diagnosis. Sponges incrusting, digitate, arborescent, flabelliform, cup-shaped or vasiform. Monactinal, occasionally quasi-diactinal or diactinal megascleres enclosed in spongin fibres or spicule tracts, with or without ectosomal specialization. Choanosomal fibres and tracts form a condensed or plumoreticulate extra-axial skeleton. Microscleres smooth or microspined euasters (Lendenfeld 1889; Lévi 1955; Hartman 1982).

Remarks on genera included in the family. Hemiasterellidae was established for *Hemiasterella* Carter and *Epallax* Sollas (not Gray; cf. de Laubenfels 1936; Wiedenmayer 1977a), with brief diagnosis "Axinellidae with stellate microsclera" (Lendenfeld 1889: 903). The possession of euaster microscleres is the principal feature differentiating Hemiasterellidae from other Axinellida. The presence of euasters in other tetractinomorph groups (orders Astrophorida (Choristida) and Hadromerida), probably represents the retention of an ancestral character, and all three groups may have arisen from a common ancestor (e.g. Astrotetraxonid stock (Reid 1970: 79)). Consequently, those taxa cannot be discriminated on that basis. Similarly, there is a paucity of other morphological (skeletal) characters, of known stability, available for classification of those taxa. It remains to be investigated whether shared morphological features (megasclere and microsclere spiculation, growth form, and skeletal architecture) are indicative of true affinities between groups (in preparation).

The present definition of Hemiasterellidae is unsatisfactory, as it relies upon the possession of an ancestral character to differentiate it from other Axinellida. No solution is presently available without a re-evaluation of all tetractinomorph orders. Hemiasterellidae presently comprises the following genera.

1. *Hemiasterella* (type species *H. typus* Carter, 1879: 146) contains a diverse group of taxa in which megascleres are monactinal, diactinal, or a combination of both; the architecture is more-or-less plumo-reticulate, and growth form is exclusively vasiform or cup-shaped (Topsent 1919: 6; Dendy 1922: 144). *Hemiasterella s.s* has monactinal megascleres, and as such shows affinities with *Axos* and *Timea*. *Hemiasterella s.l.* includes taxa bearing oxeas only (e.g. *H. affinis* Carter, 1879: 147), or both oxeas and styles (e.g. *H. complicata* Topsent, 1919: 7). In that respect, the taxon is diverse as *Raspailia* Nardo *s.l.*, and some species are morphologically very close to *Jaspis* Gray (type species *Vioa johnstoni* Schmidt, 1862: 78) of the Coppatiidae Topsent (syn. Jaspidae de Laubenfels) (e.g. Bergquist 1968: 33; Wiedenmayer 1977a: 173).

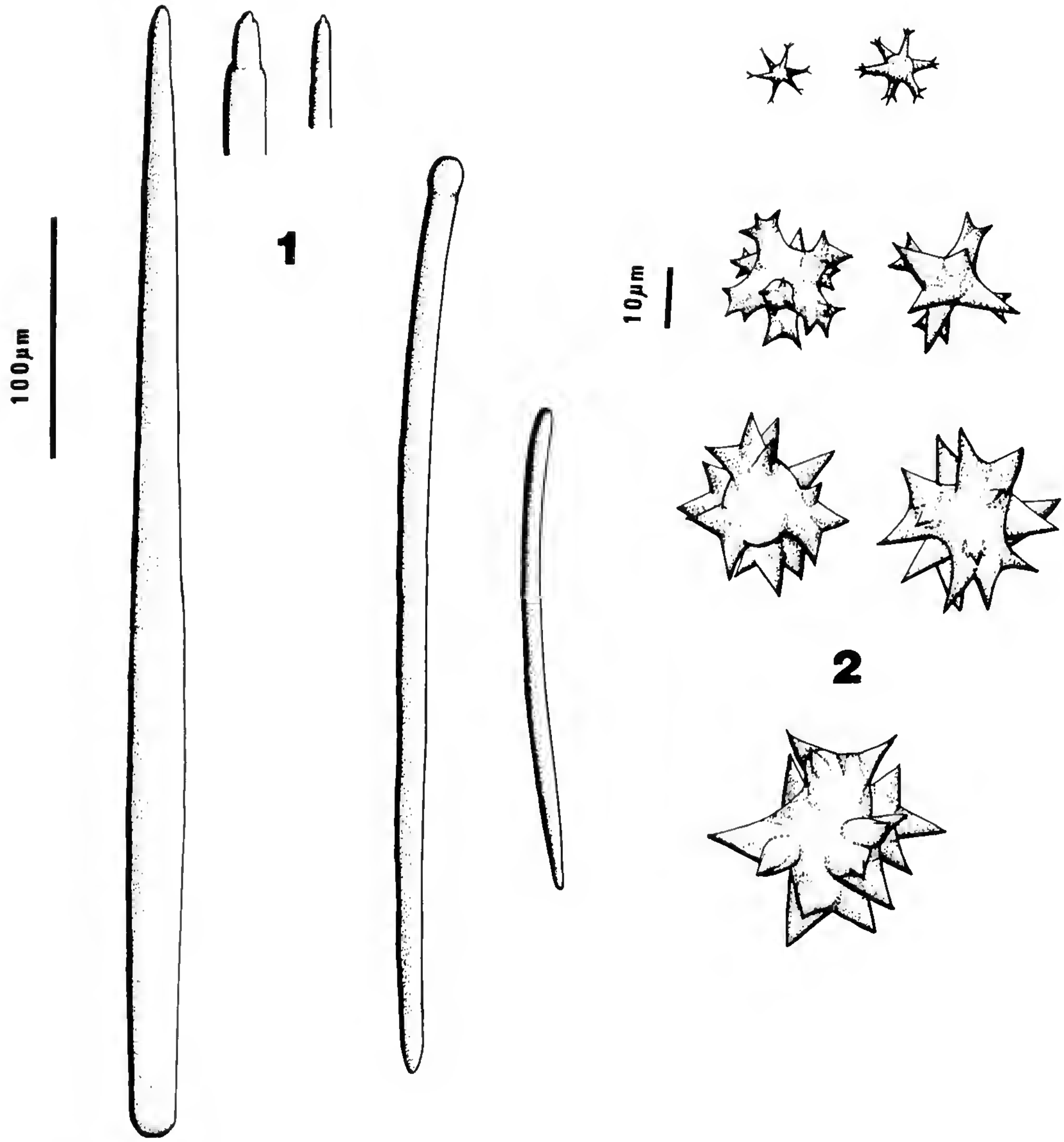
Indeed, de Laubenfels (1936) placed several Hemiasterellids with the Coppatiidae but Wiedenmayer (1977a: 152) suggests that despite apparent morphological congruence, such a system totally disregards characters such as architecture and growth form, and that affinities of those taxa are with the Axinellida. Although it remains to be demonstrated that those attributes are of primary importance at the ordinal level of classification, de Laubenfels system cannot be upheld. It is probable however, that several *Jaspis* (syn. *Coppatias* Sollas, type species *C. coriaceus* (Carter, 1886: 126)) will be transferred to hemiasterellid genera, particularly those species without obvious radial architecture, and modified oxeote megascleres (strongyles, stongyloxeas and quasi-monacts) (e.g. *Coppatias carteri* (Ridley, 1884).

2. *Epallax* Sollas (type species *E. callocyathus* Sollas, 1888: 423) is vasiform also, has diactinal megascleres, which are occasionally modified to quasi-monactinal styles or tylostyles, and an architecture consisting of longitudinal bundles of megascleres in a more-or-less radial arrangement. By those characters, *Epallax* is virtually identical to *Hemiasterella s.l.*, and as such Topsent (1919) and Dendy (1922) include the type and only species with *Hemiasterella*. *E. callocyathus* has, in addition to simple oxyasters common to other Hemiasterellids, calthrops-like asters, for which Sollas (1888) inferred parallels with the genus *Thenea* Gray (Order Astrophorida). Similarly, *Epallax* should be compared to *Timea*, in which several species have been erected on the sole basis of possessing calthrops-like asters (e.g. Pulitzer-Finali 1977, 1983), and *Jaspis* in having a tendency to modify oxeas to quasi-monactinal forms. *Jaspis s.s.* usually has oxyasters as microscleres only (de Laubenfels 1936; Wiedenmayer 1977a), and maintains a radial architecture.

3. Dendy (1905: 107) added *Vibulinus* Gray (type species *V. stuposus* (Montagu)) to his Astraxinellidae (=Hemiasterellidae; Astraxinellidae is *nomen nudum*; there is no genus "*Astraxinella*" (Wiedenmayer 1977a)). The growth form of *V. stuposus* is reminiscent of *Axos cliftoni* Gray (see below), *Raspailia* species, and many other Axinellids (Montagu 1814: 79; Stephens 1914; Pl. 3). *Vibulinus, sensu* Bowerbank, has monactinal to quasi-diactinal megascleres (cf. Gray 1867: 545), with a condensed axial skeleton and radial extra-axial skeleton (Bowerbank 1866; Gray 1867). The spiculation of Montagu's (1814) type specimen has not been described, and therefore it is only surmised that Bowerbank's (1866) specimen of *Dictyocylindrus stuposus* is conspecific with Montagu's species. That specimen must be re-examined to corroborate Gray's *Vibulinus s.s. Vibulinus s.l.* (e.g. *V. stuposus, sensu* Bowerbank 1866 and *V. mutilus* Topsent,

1928: 188) has both monactinal and diactinal megascleres; the former coring the axial skeleton, at right angles to it, and protruding beyond the ectosome, the latter occurring in the extra-axial, peripheral skeleton. In the disposition of its megascleres, *Vibulinus* shows close affinities with Raspailiidae (Axinellida), whereas the presence of oxyasters would suggest affinities with the Hadromerida. *Stelligera* Gray (type species *Raspailia stelligera* Schmidt, 1862: 60) is arborescent to lobodigitate, occasionally flabelliform, and has both oxeas and styles (or tylostyles) as megascleres and euasters as microscleres. It is probable that *Stelligera* is synonymous with *Vibulinus* (e.g. Topsent 1900: 112; Van Soest pers. comm.), in which case the former name has priority.

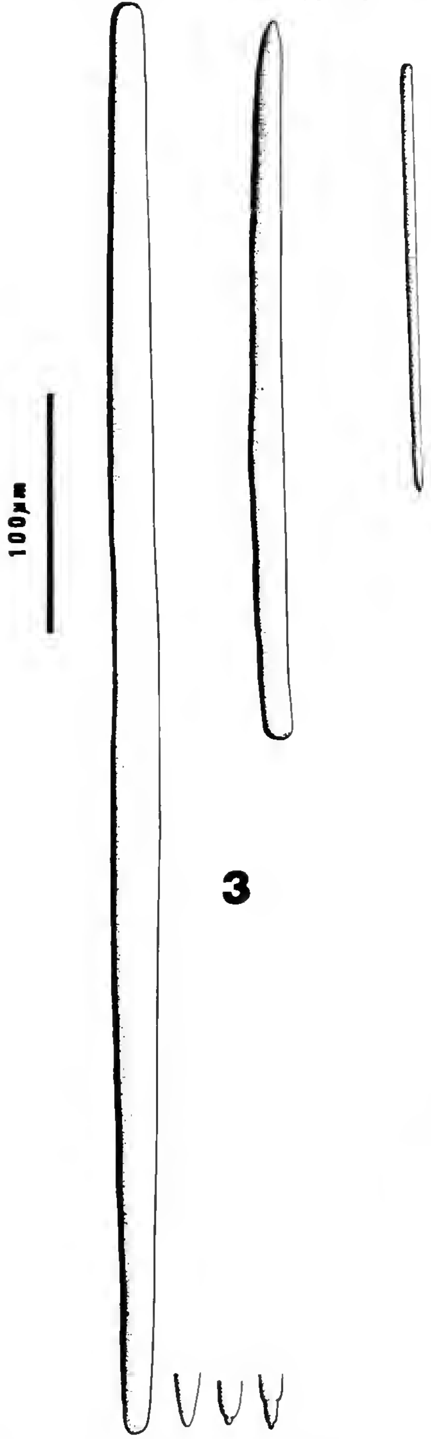
4. Topsent (1904: 137, 1919: 7) included *Adreus* Gray (type and only species *Adreus fascicularis* (Bowerbank, 1866: 110)) with the aster-bearing Axinellids. *Adreus* is arborescent, with monactinal megascleres occurring in bundles, ascending towards the periphery, and with apparent size differences between choanosomal and subectosomal megascleres (Bowerbank 1866: 110; Gray 1867: 545; Topsent 1928: 38). Euasters are not abundant, and occur mainly in the



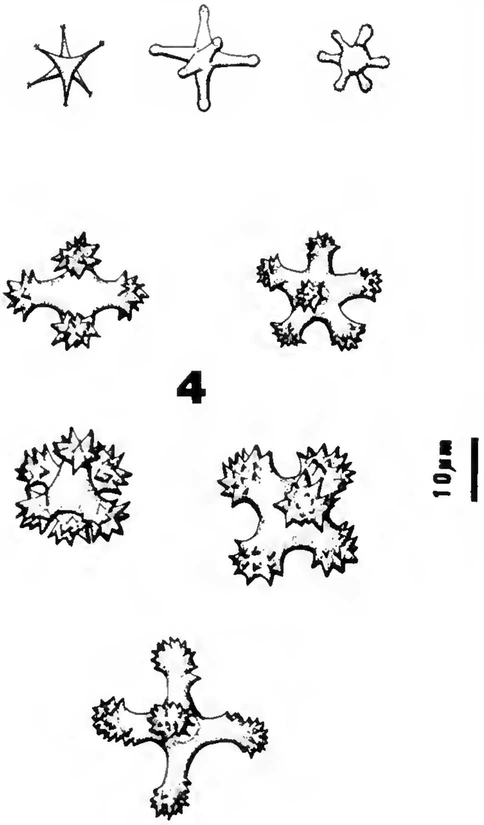
Figs 1-2. *Axos cliftoni* holotype: **1**, styles; **2**, euasters.

ectosomal region. Sexual reproduction has been reported, and larvae are oviparous (Brien 1973: 303). *Adreus* is closely related to *Axos* and *Stelligera* and possibly synonymous with *Axos* , but Bowerbank's type specimen must be re-examined to confirm such a combination.

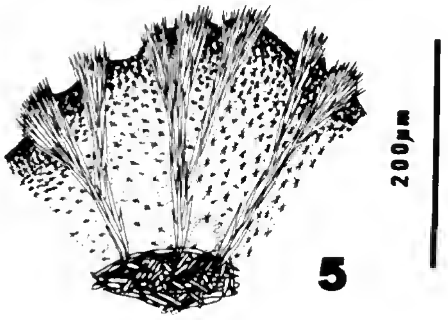
5. Kirkpatrick (1903) proposed the genus *Kalastrella* (type and only species *K. vasiformis* Kirkpatrick, 1903: 238), which is vase-



3



4



5

Figs 3-5. *Axos flabelliformis*: **3**, styles, holotype; **4**, euasters, holotype; **5**, section of peripheral skeleton, NTM Z1031.

shaped, has both monactinal and diactinal/quasi-diactinal megascleres, and microspined rays on euasters (similar to many *Timea* species, order Hadromerida). Skeletal architecture is more-or-less condensed, with interconnected lacunae, which bear extra-axial small bundles of oxeas and styles projecting at right angles to the ectosome (Kirkpatrick 1903). Topsent (1919: 6) and Dendy (1922: 144) consider that *Kalastrella* is a junior synonym of *Hemiasterella* , and is closely related to *H. complicata* Topsent.

6. Hallmann (1916: 673) combined the Desmoxyidae Hallmann (with acanthose or smooth microxeas) and the aster-bearing Axinellids; *Halicnemia* Bowerbank (type species *H. patera* Bowerbank, 1864: 184), *Laonoenia* Hallmann (for *Laothoe* Gray and *Noenia* Gray, both preoccupied; type species *Hymeraphia verticillata* Bowerbank, 1864: 268), and *Paratimea* Hallmann (type species *Bubaris constellata* Topsent, 1893: 33), all of which possess choanosomal tylostyles and ectosomal centrotylote oxeas. Topsent (1928: 38) rejects Hallmann's system and new genera, and retains *Halicnemia, sensu* Topsent, in a broad sense (=*Halicnemia* Bowerbank, + *Paratimea* Hallmann + *Laonoenia* Hallmann). *Halicnemia s.s.* (viz. *H. patera*, and including *H. gallica* (Topsent) and *H. geniculata* Sarà) has tylostyles, ectosomal oxeas, often polytylote, and acanthose microxeas (Bowerbank 1864: 363, 1866: 96; Topsent 1897: 235, Descatoire 1966: 238). By comparison, *Halicnemia s.l.* (*H. arbuscula* Topsent, 1928: 185; *H. duplex* Topsent, 1928: 182; *H. azorica* Topsent, 1904: 149; 1928: 181; *H. constellata* (Topsent, 1893: 33; 1897: 245); *H. verticillata* (Bowerbank); and *Paratimea galaxea* de Laubenfels, 1936: 146) has euasters, ectosomal centrotylote oxeas, and choanosomal tylostyles. *Halicnemia s.s.* is correctly assigned to the Desmoxyidae (Lévi 1973), and is close to the genus *Higginsia* Higgin, whereas other nominal species containing asters are better placed in *Stelligera s.l.*, which must be expanded to include incrusting forms.

7. By its skeletal architecture, *Axos* Gray is the most closely related of all the Hemiasterellidae to the Axinellida, and its spiculation is typical of the family (see below).

Of the recognizable Axinellid genera which bear asters, only four can be differentiated on the basis of morphological characters. Genera can be diagnosed as follows. (1) *Hemiasterella* (species examined — none) has a distinctive vasiform habit, without regional differentiation of monactinal and/or diactinal megascleres, and with only slightly condensed plumo-reticulate architecture. (2) *Stelligera* (species examined — *S. stuposa* (Montagu), ZMA POR 5945) has distinctive axial and extra-axial differentiation of megasclere type. The axis is condensed and cored by monactinal megascleres, whereas there are extra-axial plumose to plumo-reticulate columns of monactinal and/or diactinal megascleres. (3) *Adreus* (species examined — none) has monactinal megascleres only, a plumose to plumo-reticulate architecture, and distinctive differentiation in megasclere size between axial and extra-axial regions. Euasters are predominantly peripheral. (4) *Axos* (species examined — *A. cliftoni* Gray, holotype BMNH, *A. flabelliformis* Carter, holotype BMNH) is distinctively digitate, less commonly flabelliform, with prominent surface ornamentation. The skeleton is axially condensed and extra-axially plumo-reticulate, and there is no pronounced regional differentiation of monactinal megascleres.

Genus *Axos* Gray

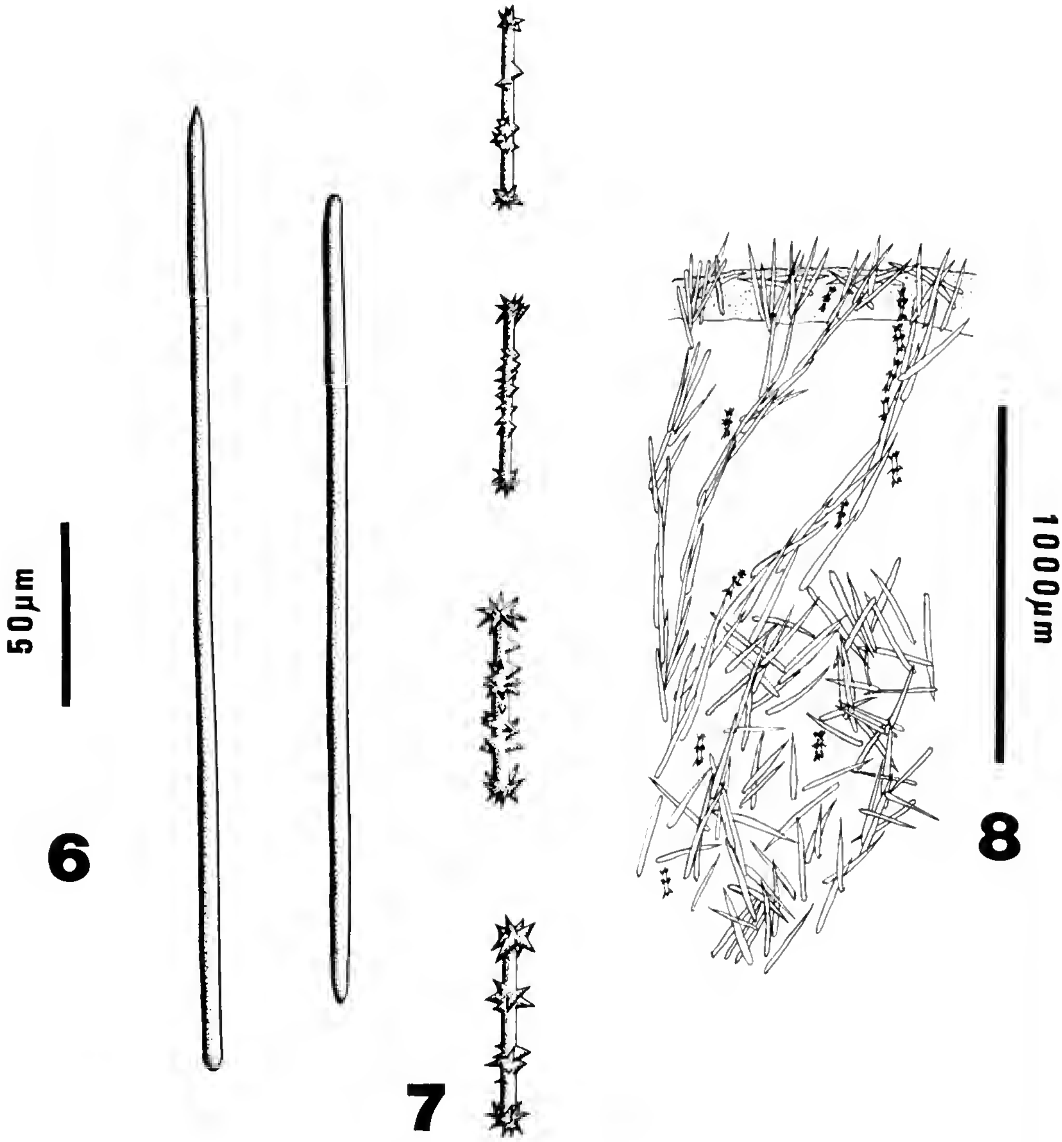
Axos Gray, 1867: 546 (type species *A. cliftoni* Gray, by monotypy).

Echinospongia Gray, 1870: 272 (type species *E. australis* Gray, 1870, by monotypy). Syn. by de Laubenfels 1936: 161.

Diagnosis. Digitate, anastomosing or dichotomously branched, to thinly flabelliform growth form. Surface raised into specialized conulose or micropapillose structures, formed by protruding extra-axial components of peripheral skeleton. Choanosomal skeletal architecture condensed, rarely plumo-reticulate. Extra-axial (subectosomal) architecture plumose to plumo-reticulate. Ectosome microscopically hispid, containing dense layers of euaster microscleres. Megascleres styles to subtylostyles. Reproductive pattern oviparous.

Remarks. *Axos* was established for *A. cliftoni* Gray, named for a single spicule depicted by Bowerbank (1864). From its description, *Echinospongia australis* is identical to *A. cliftoni*, and subject to confirmation from re-examination of the type specimen, *Echinospongia* becomes a junior synonym of *Axos* (de Laubenfels 1936).

De Laubenfels (1936: 161) suggests further that *Axos* and *Adreus* are closely related, with similar growth form and spiculation. He suggests that the genera are differentiated in having branched rays on the euasters, and a greater proportion of oxeas than styles (*Axos*). That observation is erroneous. *Axos cliftoni* (see below) has monactinal megascleres only, and furthermore in the description of *Dictyocylindrus fascicularis* (Bowerbank, 1866) it is reported that "acuates" (styles) are present only. The contention that *Adreus* and *Axos* can be differentiated by the presence or absence of a regional size differentiation of choanosomal megascleres between axial and extra-axial regions, respectively, is debatable. That character is also present in *A. cliftoni* and *A. flabelliformis*, although it is not pronounced or obvious. Similarly, the morphology of euasters in the two *Axos* species recognized here, is certainly unusual to either Hemiasterellidae or Timeidae species, but the uniqueness of that character is solely due to



Figs 6-8. *Latrunculia spinipoculum* holotype: **6**, styles; **7**, verticillate sanidasters; **8**, section of peripheral skeleton.

an emphasised microspination, rather than branching of aster rays as suggested by de Laubenfels (1936). Bowerbank's type species of *Adreus* requires redescription prior to a decision on the possible synonymy of *Axos* and *Adreus*; the latter genus has line/page priority over *Axos*. Notwithstanding the possible synonymy (*D. fascicularis* is from the English coast), *Axos* is indigenous to the northwest coast of Australia.

Axos cliftoni Gray

(Figs 1, 2, 13, 18-21, 25, Pl. 1A)

Unidentified sponge — Bowerbank 1864: 260, Pl. 10, Fig. 197.

Axos cliftoni Gray, 1867: 546-7; Ridley 1884: 454; Dendy 1921: 95, Burton 1934: 549.

Non *Axos cliftoni* — Carter 1879; 284, Pl. 26, Figs 5-7.

Dictyocylindrus dentatus Bowerbank, 1873: 321, Pl. 29.

Echinospongia australis Gray, 1870: 272.

Type material. HOLOTYPE - BMNH 1870.8.26.31 (dry: label "523. G. Clifton esq. E.h.21"); 1870.8.26.11 (spicule preparation; "No. 8A").

Additional material. BMNH 1930.12.1.10a (spicule preparation; label "Pres.Mrs B.Gray, Cape Boileau, NW Australia"); BMNH unreg (holotype of *Dictyocylindrus dentatus* Bow.; photograph NMV 41/8-10 sponge archives — F. Wiedenmayer); NTM Z1274, North of Bedout Island, NW Shelf, Western Australia, 19°33.1'S 118°43.8'E, 26 April 1983, 35 m depth, coll. J.N.A. Hooper, RV "Soela" SO2/83, trawl; NTM Z1424, Northeast of Port Hedland, NW Shelf, WA, 19°01'S 119°25'E, 19 April 1983, 80 m depth, coll. R.S. Williams, FV "Tung Mao 1", trawl; NTM Z1821, West of Port Hedland, NW Shelf, WA, 19°26.9'S 118°54.2'E, 30 August 1983, 50 m depth, coll. T. Ward, RV "Soela" SO4/83, stn.126, trawl.

Distribution. Type locality: Nickol Bay, Dampier Archipelago, NW Shelf, WA (20°30'S 117°00'E) (Bowerbank 1864; Gray 1867, 1870). In the present study the species was recorded only in the Port Hedland region, approximately 200 km from the type locality. The species appears to be extremely restricted in its distribution.

Ecology. Attached to dead coral, rock or shell grit conglomerate; basal portion partially burrowed into substrate. Bathymetric distribution 35-80 m depth.

Description of holotype. Fragment of branch, thickly cylindrical, with large surface conules. Original specimen probably digitate, anastomosing or dichotomously branched growth form. Texture firm, incompressible in dry state. Colour white-beige. Surface smooth between conules. Pores and oscula minute, inconspicuous.

Ectosome: contains dense deposits of euasters, with ascending plumose columns of choanosomal/subectosomal styles poking through surface at tips of conules. Ectosome dense, not opaque, and paper-like in dry state. Subectosomal region contains occasional plumose tracts of styles arising from choanosomal skeleton, associated with surface conules, and scattered euasters between tracts. Collagenous non-fibre spongin abundant, moderately heavy. Subdermal cavities and choanocyte chambers obscured by mega- and microscleres.

Choanosome: skeleton has a dense axial core of reticulated megascleres, mostly running longitudinally through branches, less often giving rise to extra-axial (subectosomal) plumose tracts of megascleres. Fibre component of axial skeleton not observed; if present, it is completely cored by styles.

Megascleres: Smooth, fusiform, rounded or stepped styles, mostly straight, occasionally slightly curved near basal end. (N=25) Length 517.68 μm (mean) (range 217-851 μm), width 9.04 μm (2-15 μm).

Microscleres: Euasters, variable in morphology, relatively large, hexaradiate to cruciform, often with asymmetrical spination. No or little tylote swelling on apices of rays. Spines large and distributed over tips of rays. (N=25) Maximum mean diameter 23.36 μm (12-29 μm).

Description of other specimens. BMNH 1930.12.1.10a.

Megascleres: identical to holotype. (N=25) Length 428 μm (mean) (range 208-670 μm), width 7.32 μm (2-12 μm).

Microscleres: identical to holotype. (N=25) Maximum mean diameter 17.16 μm (8-26 μm).

NTM specimens (N=3).

Colour. orange-red to red-brown alive (Munsell 2.5R 4-5/4-8-5R 6/12) (Pl. 1A). Pigment alcohol soluble, and preserved specimens grey to being in colour.

Shape: Dichotomously branched, occasionally digitate anastomosing, with basal stalk and holdfast attachment. Attachment rhizomous, adhering to shell and gravel particles. Branches thickly cylindrical, rubbery in appearance, with large, rounded surface conules; average diameter of branches 7-22 mm (mean 13.6 mm) excluding conules, 15-35 (mean 23.3 mm) including conules. Basal stalk hard, woody in texture, 14-26 mm (mean 18.3 mm) in diameter. Branching pattern multiplanar. Specimens range in size from 60-65 cm (mean 63 cm) total length, from basal attachment to apex of branches.

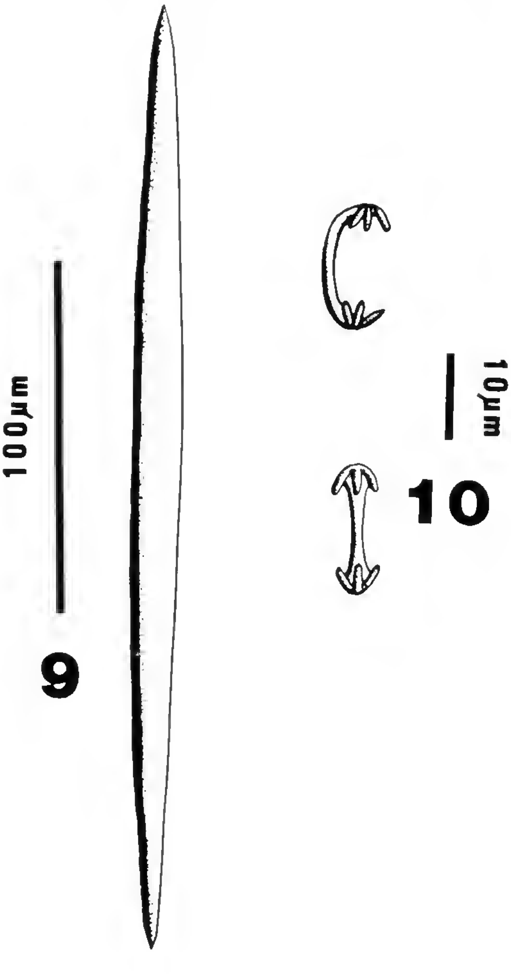
Texture: rubbery, tough, difficult to cut; stalk rigid, branches compressible.

Surface characteristics: optically smooth between conules, with evenly distributed, tapering conules with rounded apices. Conules range from 4-12 mm (mean 8.6 mm) in length, 3-8 mm (mean 6.4 mm) basal diameter. Oscula minute (0.2-0.8 mm diameter in preserved specimens), and distributed evenly over surface. Surface between conules microscopically hispid and rugose, composed of interconnected ridges.

Ectosome: dense, relatively easily detached, containing heavy concentrations of euasters. Ectosome pierced at regular intervals (0.5-1.0 mm apart) by ascending tracts of choanosomal/subectosomal (extra-axial) styles. These hispidating megascleres form a more-or-less continuous but light dermal palisade. Ectosomal spongin heavily pigmented.

Choanosome: peripheral (subectosomal) skeleton is moderately dense, containing plumose, non-anastomosing extra-axial tracts of styles, which radiate from the axial core, between which are scattered euasters. Collagenous spongin abundant and heavily pigmented, but mostly obscured by euasters. Subdermal cavities not observed (except in 1 specimen — NTM Z1424; see below). Extra-axial spicule tracts between 60-110 µm in diameter, cored with up to 8 rows of spicules. No fibre-spongin visible surrounding spicules. Choanocyte chambers oval, 12-42 µm in diameter, and mostly obscured by euasters. The peripheral skeleton occupies up to 66% of branch diameter, decreasing towards the stalk and branch tips. Central axis is massive, irregular in cross-section, and irregularities correspond to the distribution of surface conules. Axis consists entirely of styles, tightly packed together, and mostly running longitudinally along branches. Occasional extra-axial tracts diverge from the axial core, usually at right angles to it, and ascend towards the periphery. No choanosomal fibres observed, and if present, they are hidden totally by dense aggregation of styles at the core. There is a suggestion of regional (axial versus extra-axial) differentiation of megascleres, whereby the peripheral skeleton has larger, thicker megascleres, but this is not distinctive, or easily discerned.

Megascleres: fusiform styles, straight or slightly curved near base, with sharply pointed or rounded apices, occasionally stepped. Bases smooth, rounded and non-tylote. (N=75) Length 474.59 µm (mean) (range 178-912 µm), width 11.07 µm (1.5-22 µm).



Figs 9-10. *Plumocolumella anchorata* holotype: **9**, oxea; **10**, unguiferous anchorate isochelae.

Microscleres: euasters of very variable morphology, and relatively large diameter. Shape ranges from hexaradiate to true stellate, less commonly cruciform. Rays non-tylote and bear large spines at tips. Distribution of rays often assymmetrical. (N=75) Maximum mean diameter 24.27 µm (8-37 µm).

Reproduction. Sexual reproductive products were recorded for one specimen of *A. cliftoni*. The species appears to be oviparous, and parenchymella larvae were recorded in April 1983 (NTM Z1424). Larvae are solid, oval, white to pale yellow (preserved) parenchymella, 0.5-0.8 mm in diameter (Fig. 25). Cilia were not observed (preserved material), but juvenile megascleres and microscleres are abundant at the posterior pole. A peculiar behaviour is indicated, whereby a large population of larvae occur on the external surface of the sponge, predominantly on the lower part of branches and basal stalk. No embryos were found below the ectosome, nor where they observed in the deeper choanosomal regions, but subdermal cavities were relatively numerous (up to 1 mm in diameter). Larvae appear to be in contact with the adult, but not attached to it. It is speculated that attachment to the parent may involve a mucous envelope (oocyte strands) surrounding the parenchymella, released by the adult along with the larvae, as described by Reiswig (1976) for *Agelas* and *Hemectyon* (Axinellida).

These observations can be interpreted in several ways. It is possible that larvae resident on the external surface of the adult are foreign to the sponge, using it merely as a substrate for settlement. Larval spicules present (thin wispy styles and small euasters) are clearly of *Axos* origin, and that hypothesis is unlikely. Alternatively, it seems plausible that eggs have been extruded by the adult, together with gelatinous oocyte strands (e.g. Reiswig 1976), and the subsequent larval development is external to the sponge. The abundance of larvae resident on the external surface poses questions as to the duration of their association with the "parent", and the age of those larvae, all of which appear to be of similar developmental morphology.

Comparable reproductive strategies for the Hadromerida and Axinellida have been reported by Lévi (1956), Reiswig (1976) and Bergquist (1978).

The specimen of *A. cliftoni* recorded here with reproductive products was obtained from a relatively deep, isolated locality. No other reproductive activity has been recorded for this species, nor for the closely related, and more abundant *A. flabelliformis* (see below), despite a relatively widespread local distribution for both species, and repeated observations and collections over several seasons by the author.

Remarks. *A. cliftoni s.l.* has two distinct euaster morphologies (Figs 18-24). The first morph (Figs 18-21) is identical to the holotype, and to Bowerbank's (1864) figure. Figures of *Dictyocylindrus dentatus* and *Echinospongia australis* (Bowerbank 1873; Gray 1870) depict the same form of euaster as *A. cliftoni s.s.*, viz. asymmetrical, large spines on aster rays, and a statistically larger size than the other morph (Table 1). For this reason, and other morphological attributes (growth form, megasclere size), those species are considered as junior synonyms of *A. cliftoni s.s.*

The second euaster morph (Figs 22-24) is much more symmetrical, mostly hexaradiate, with minutely spined euaster rays, and microscleres are significantly smaller (F=**95.81**, $P < 0.0005$) than those of *A. cliftoni s.s.* That morph is identical with *A. flabelliformis s.s.* (Carter 1879; holotype BMNH 1883.1.25.8; see below). *A. cliftoni, sensu* Carter (1879: 284) and Barnard's (1879) figures depicting the Northern Territory specimen (labelled *A. elegans* by Lendenfeld (BMNH 1886.8.25.557)) have identical euasters to *A. flabelliformis s.s.* Despite differences in growth forms (the holotype of *A. flabelliformis* is thin, flabelliform; other specimens listed above are digitate, dichotomously branched, cylindrical sponges), those specimens are considered here to be synonymous. Thus, *A. cliftoni* is restricted to specimens with euasters bearing large-spined rays, whereas *A. flabelliformis* has minutely spined, more-or-less hexaradiate and symmetrical asters. Morphometric differences between these closely allied species are summarized in Table 1.

Euasters of *A. cliftoni* superficially resemble chiasters of *Timea* (*Hymedesmia*) *trigonostellata* (Carter, 1880: 52) and *T. granulata* Bergquist, 1965: 186, whereas those of *A. flabelliformis* resemble *Tethya* sp. (Bergquist 1978: Pl. 6A). Consequently, there are few grounds to accept de Laubenfels (1936) arguments on the uniqueness of *Axos* euasters.

Axos flabelliformis Carter
(Figs 3-5, 14, 16, 17, 22-24, Pl. 1B-D)

Axos flabelliformis Carter, 1879:285-286, Pl.26, Figs 1-4; Carter 1882:362; Burton, 1934:549.

Unidentified sponge — Barnard 1879:14-15, Pl.1, Figs 5-7.

Axos cliftoni (part) — Carter 1879:284, Pl.26, Figs 5-7.

"Axos elegans"; label name, in Lendenfeld's hand, of specimen (BMNH 1886.8.25.557) from the Northern Territory, presumably the one figured by Barnard (1879).

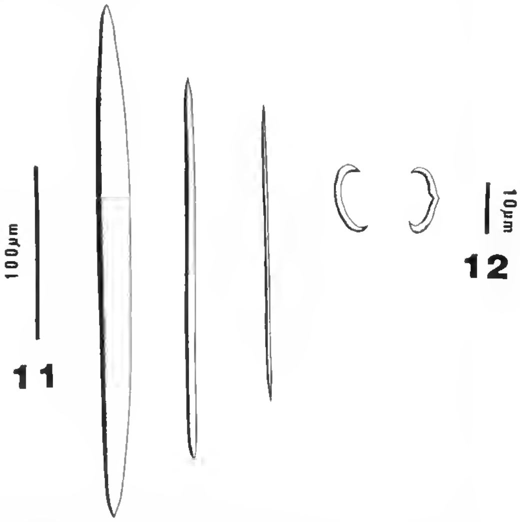
Type material. HOLOTYPE - BMNH 1883.1.25.8 (dry: label "E.h. 20e"; photograph NMV 41/11 sponge archives — F. Wiedenmayer).

Additional material. BMNH 1886.8.25.557, *"Axos elegans"*; (photograph NMV 40/25 sponge archives — F. Wiedenmayer); NTM Z149, Sandy Island No.2, Cobourg Peninsula Marine Park (CPMP), Northern Territory (NT), 11°05.5'S 132°17'E, 21 October 1981, 10 m depth, coll. J.N.A. Hooper, SCUBA; NTM Z2499, Coral Bay, Port Essington, CPMP, NT, 11°09.4'S 132°04'E, 13 September 1985, 7 m depth, coll. A. Hoggett, SCUBA; NTM Z2505 (3 specimens), NW of Table Head, Port Essington, CPMP, NT, 11°13.5'S 132°10.5'E, 14 September 1985, 3 m depth, coll. J.N.A. Hooper, SCUBA; NTM Z2055, East Point Fish Reserve, Darwin, NT, 12°25.0'S 130°48.4'E, 10 May 1984, 6 m depth, coll. J.N.A. Hooper, SCUBA; NTM Z2084, 20 July 1984, 7 m depth; NTM Z2699, Z2690, 2 April 1986, 9-12 m depth; WAM 143-82, 15 nautical miles NW of Port Hedland, NW Shelf, Western Australia (WA), 20°12'S 118°25'E, 3 August 1982, 14 m depth, coll. J. Fromont, RV "Soela" S04/82, stn 09, trawl (fragment NTM Z1705); NTM Z1031, NW of Dampier Archipelago, NW Shelf, WA, 20°20'S 117°28'E, 22 October 1982, 26 m depth, coll. J. Blake, RV "Soela", shot 64, trawl; NTM Z1168, North of Bedout I., NW Shelf, WA, 19°29.6'S 118°52.2'E, 26 April 1983, 38 m depth, coll. J.N.A. Hooper, RV "Soela" S02/83, stn B8, epibenthic sled; NTM Z1216, 1261, 19°28.5'S 118°55.3'E, 26 April 1983, 40 m depth, stn B9, beam trawl; NTM Z1270, 1271, 1273, 19°33.1'S, 118°43.8'E, 26 April 1983, 35 m depth, Frank and Bryce trawl; NTM Z1756, West of Port Hedland, NW Shelf, WA, 19°03.3'S 118°49.9'E, 29 August 1983, 82 m depth, coll. T. Ward, RV "Soela" S04/83, stn 121, trawl; NTM Z1792, 19°04.1'S 118°57.9'E, 29 August 1983, 84 m depth, stn 124; NTM Z1822, 19°26.9'S, 118°54.2'E, 30 August 1984, 50 m depth, stn 126; NTM Z1871, 19°05.7'S 118°57.4'E, 1 September 1983, 83 m depth, stn 133; NTM Z1886, 19°02.2'S 118°04.1'E, 1 September 1983, 84 m depth, stn 136; NTM Z2299, NW of Lacepede Is., NW Shelf, WA, 16°29-33'S 121°27-29'E, 17 April 1985, 38-40 m depth, coll. B.C. Russell, BYLA "Pao Yuan No.1", pair trawl.

Distribution. Type Locality: unknown, suspected to be "Australia" (Carter 1879). Other: Northern Territory, coll. Dr C. Sturt (Barnard 1879). In the present study the species is recorded throughout Northwest Australia.

Ecology. Attached to dead coral, rock or shell grit conglomerates; basal portion rhizomous in soft substrate, or encrusting on hard substrates. Bathymetric range is intertidal (3 m) to deeper offshore waters (84 m).

Description of holotype. Flabelliform, paper-thin, with aculeated surface formed by minute papilliform projections and longitudinal ridges. Sponge 12 cm high, 11.5 cm long, 3 cm thick, with basal attachment and small basal stalk. Texture cork-like in dry state, and colour white to brownish. Pores not observed.



Figs 11-12. *Gelliodes fibulatus*, NTM Z1050: **11**, oxeas; **12**, centrangulate sigmas.

Ectosome: packed with euasters, without projecting subectosomal megascleres, although some choanosomal spicules pierce the surface. Ectosome opaque and very thin in the dry state.

Subectosome: region has few plumose (extra-axial) tracts of megascleres.

Choanosome: axial condensation of anastomosing spongin fibres, lightly invested with spongin, cored by uni-or paucispicular tracts of styles. Fibres are probably not composed of type A spongin but merely type B (interfibril) spongin, which has contracted in the dry state around megascleres. Fibre diameter ranges from 6-12 μm (mean 8.8 μm). Few loose megascleres were observed between fibres, or in the subectosomal region. Choanocyte chambers not conspicuous, but subdermal cavities scattered throughout the subectosomal region, ranging from 25-110 μm (mean 56.8 μm) in diameter.

Megascleres: smooth, straight or slightly curved styles, with varying apices, from rounded (styloid) to stepped tips, occasionally hastate. (N=25) Length 385.12 μm (mean) (range 193-691 μm), width 7.12 μm (2-12 μm).

Microscleres: euasters, variable in morphology, relatively small, usually hexaradiate or cruciform, in 2 planes, with slightly tylote endings of rays, and mostly profusely microspined. (N=25) Maximum mean diameter 14.08 μm (range 9-21 μm).

Description of other specimens. NTM specimens (N=21).

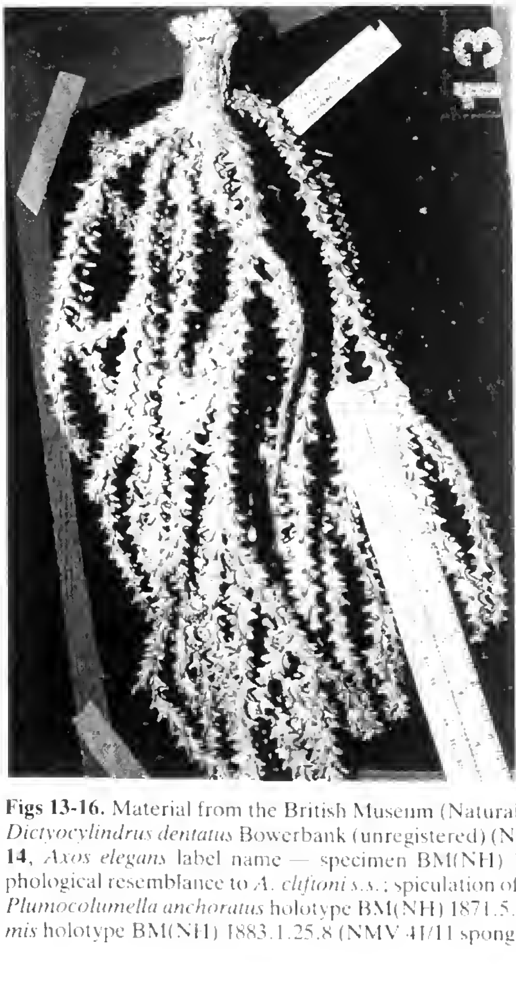
Colour: most commonly orange to orange-red alive (Munsell 10R 5-6/ 10-12). Ectosome silt-covered in subtidal specimens *in situ*, with a fine trace or lace-like pattern radiating from minute oscula, clear of silt. Pigmentation mostly even, except in some deeper water specimens, which have more darkly pigmented conules than remainder of ectosome. Colouration variable, unstable, ranging from bright red (5R 5/10) (Pl. 1B), orange (10R 5/10) (Pl. 1C), dark brown (5YR 4/4), grey-yellow (2.5Y 7/4), to beige (2.5Y 8/2) (Pl. 1D) alive. Colour variability may be related to bathymetric distribution, but not definitely so: subtidal specimens invariably have orange to orange-red pigmentation; deeper-water specimens more variable. Pigments are alcohol soluble, and preserved specimens are grey to beige in colour. Carotenoid pigment characteristics of the typical colour form are shown in Fig. 17.

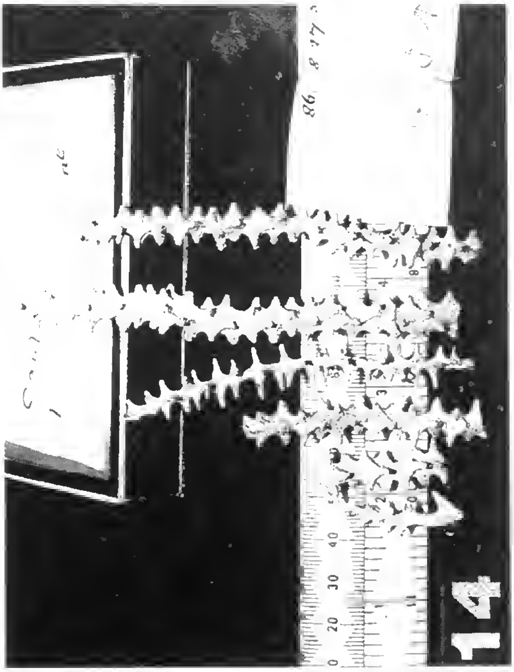
Shape: characteristically arborescent, stipitate, with thick basal stalk and holdfast attachment, which burrows into gravel, bearing rhizomous appendages and attaching to shell and gravel particles, or without rhizomes, and merely tightly adhered to dead coral or rock substrate. Stalk is variable in length (up to 12 cm long), free from surface conules and with woody texture. Basal stalk ranges from 8-24.5 mm (mean 13.4 mm) in diameter. Branches thinly or thickly cylindrical, bearing large conules. Average branch diameter ranges from 3.5-16 mm (mean 8.2 mm) excluding conules; 9.5-24 mm (mean 14.5 mm) including conules. Branching planar or multiplanar. Planar specimens from subtidal waters orientated with maximum surface area facing direction of currents; multiplanar subtidal specimens often found in crevises or in lee of coral heads. The orientation of deeper water specimens is unknown. Branching patterns variable, from dichotomously branched with repeated bifurcation, to simply digitate with few branches, or loosely reticulate with 1 or more anastomoses. Specimens range in size from 10-64 cm (mean 31.5 cm) high from basal attachment to apex of branches.

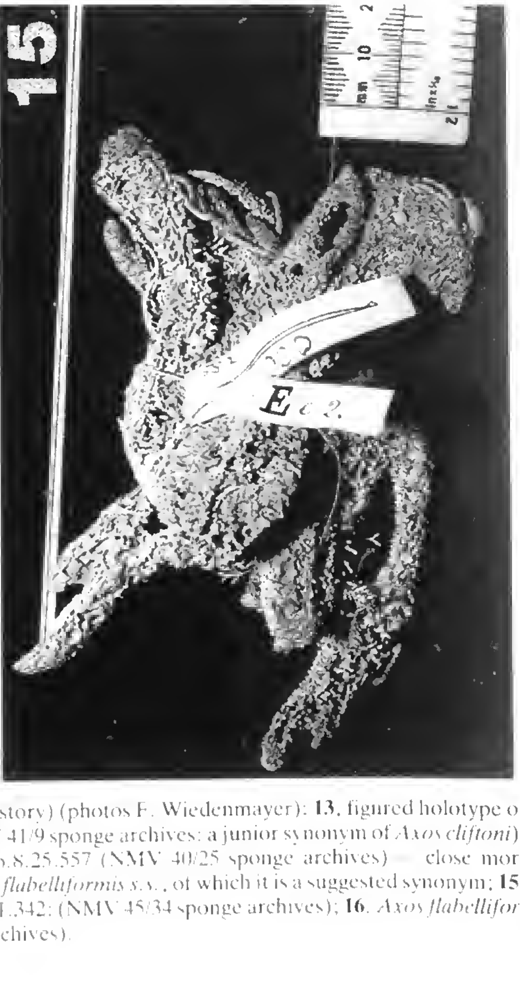
Texture: extremely tough, hard and woody texture at base, difficult to cut. Branches only slightly compressible, firm in texture. The ectosomal, pigmented layer more easily compressed than axis, which is more-or-less rigid.

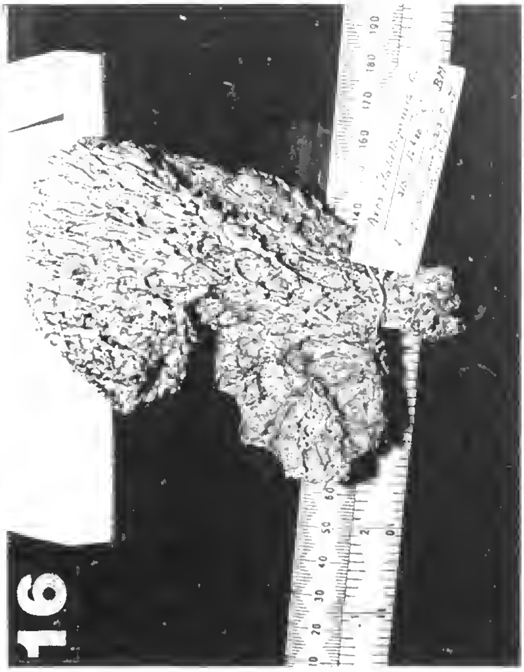
Surface characteristics: optically smooth, microscopically hispid surface, with evenly distributed, prominent, tapering conules on all branches. Conules range from 2-4mm (mean 2.6 mm) in diameter at their bases, and are 2-5 mm (mean 3.1 mm) high. Oscula minute and distributed evenly over surface. Pores visible in subtidal specimens *in situ* only by absence of silt immediately surrounding and radiating from them, due to water movement. Pores range from 0.2-1.0 mm in diameter in preserved specimens. Surface microscopically rugose, bearing a series of interconnected low-lying ridges, between which there are numerous pores.

Ectosome: dense, not translucent, and relatively easily detached. Ectosome contains heaviest concentrations of euasters, by comparison with subectosomal regions, and


13


14


15


16

Figs 13-16. Material from the British Museum (Natural History) (photos F. Wiedenmayer): **13**, figured holotype of *Dictyocylindrus dentatus* Bowerbank (unregistered) (NMV 41/9 sponge archives: a junior synonym of *Axos cliftoni*); **14**, *Axos elegans* label name — specimen BM(NH) 1886.8.25.557 (NMV 40/25 sponge archives) — close morphological resemblance to *A. cliftoni s.s.*; spiculation of *A. flabelliformis s.s.*, of which it is a suggested synonym; **15**, *Plumocolumella anchoratus* holotype BM(NH) 1871.5.12.1.342; (NMV 45/34 sponge archives); **16**, *Axos flabelliformis* holotype BM(NH) 1883.1.25.8 (NMV 41/11 sponge archives).

pierced by extra-axial tracts of subectosomal styles, which radiate towards surface, and form a more-or-less continuous dermal palisade. Ectosomal spongin is heavily pigmented but mostly obscured by dense layer of euasters.

Choanosome: peripheral skeleton moderately dense, containing scattered euasters and extra-axial tracts of relatively thick styles, which radiate from dense axial core. Spongin abundant, heavily pigmented and granular. Subdermal cavities not common, not lined by fibre-spongin, although usually lined with euasters, and occur closer to axial core than periphery. Subectosomal spicule tracts 30-120 μm in diameter, cored by 4-10 rows of styles. Tracts do not appear to have fibre component associated with them. Tracts more or less at right angles to axial core and mostly plumose, diverging towards periphery. Spicule tracts rarely anastomosing. Thin flexuous rhaphidiform styles may be present, strewn between subectosomal spicule tracts, but their presence/absence and abundance varies between specimens. Choanocyte chambers 18-35 μm in diameter, but they are difficult to discern due to high densities of euasters. Peripheral skeleton occupies nearly 50% of diameter of sponge in cross-section, near basal stalk. By comparison, axial component of branches diminishes towards apex of sponge. Central axis massive, irregular and stellate in cross-section, and irregularities of axis correspond with distribution of surface conules. Axis consists entirely of relatively thin styles. These megascleres core anastomosing fibres, which are only lightly invested with spongin. Styles mostly longitudinally orientated, running in the direction of branch growth, but closer to the periphery of the axial skeleton tracts of styles begin to diverge radially, giving rise to the extra-axial component of the skeleton. Styles forming axial skeleton appear to be shorter and thinner than those forming subectosomal tracts, but not distinctly so, and examples of each occur in both regions.

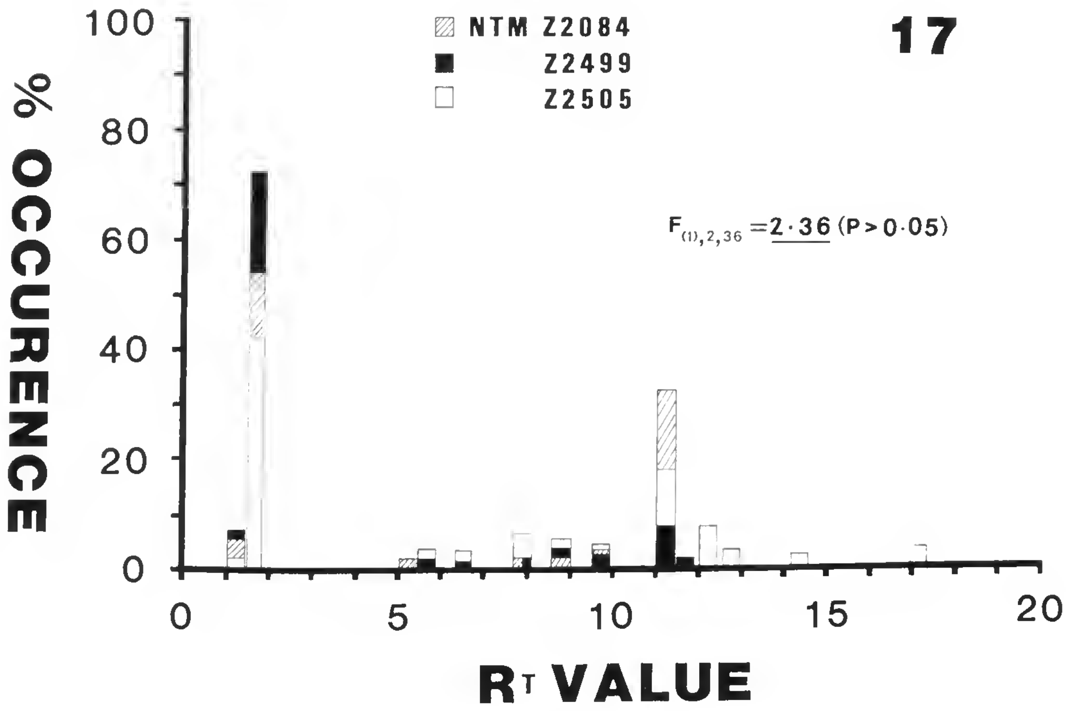


Fig. 17. Percentage occurence of carotenoid pigments in 3 specimens of *Axos flabelliformis* (all bright orange, shallow-water morphs). Retention times (RT values) of major peaks were detected using normal phase High Pressure Liquid Chromatography and UV adsorption at 370 nm. Peak at RT 1.9 is probably authentic β-carotene (R. Capon, personal communication). Results of 2-way ANOV are given (Model II, without replication) showing level of significance.

Table 1. Summary of morphometric comparisons between *Axos cliftoni* and *A. flabelliformis*. Data show mean (± 1 standard error) and range of measurements. Results of statistical comparisons are given (R x 2 ANOV — Model II, and Student's t-test), showing levels of statistical significance.

CHARACTER	SPECIES		
	A. cliftoni		*A. flabelliformis*
STYLES			
Holotype			
Length:	517.68 μm (217-851 μm)		385.12 μm (193-691 μm)
Width:	9.08 μm (2-15 μm)		7.12 μm (2-12 μm)
Other			
Length:	474.59 μm (178-912 μm)		382.71 μm (118-795 μm)
		F=**183.95** (P<0.0005)	
Width:	11.07 μm (1.5-22 μm)		9.33μm (0.8-28μm)
		F=**166.55** (P<0.0005)	
EUASTERS			
Holotype			
Diameter:	23.36μm (12-29μm)		14.08μm (9-21μm)
Other			
Diameter:	24.27μm (8-37μm)		18.34μm (4-29μm)
		F=**95.81** (P<0.0005)	
GROWTH FORM			
Length:	630±15.3 mm (600-650 mm)		386.6±36.6mm (120-640mm)
		t(2), 16=**2.89** (P<0.01)	
Basal diameter:	18.3±3.85 mm (14-26mm)		13.37±1.04mm (8-24.5mm)
		t(2),16=**1.77** (P>0.05)	
Maximum branch diameter:	23.3±2.85 mm (15-35 mm)		14.5±0.52 mm (9.5-24 mm)
		t(2), 44=**5.23** (P<0.001)	
Mean branch diameter:	13.6±2.28 mm (7-22 mm)		8.21±0.42 mm (3.5-16 mm)
		t(2), 44=**3.86** (P<0.001)	

Megascleres: fusiform styles, straight or slightly curved near base, with sharply pointed or rounded apices, often with mucronate or stepped tips. Bases smooth, rounded, and without subtylote swellings or constrictions. (N=525) Length 382.71 μm (mean) (range 118-795 μm), width 9.33 μm (0.8-28 μm).

Microscleres: euasters, very variable in morphology, relatively small in size. Typically euasters hexaradiate, symmetrical, in 2 planes, with slightly swollen rays, bearing numerous minute microspines. (N=525) Maximum mean diameter 18.34 μm (range 4-29 μm).

Remarks. Burton (1934:549) placed *A. flabelliformis* into synonymy with *A. cliftoni*, without giving reasons. Burton may have been fully justified in his actions, on the basis of differences in characters between the two species known at that time. However, it has been shown above that *A. cliftoni s.s.* and *A. flabelliformis s.s.* have marked differences in the morphology of euasters, and they are maintained here as distinct species for that reason alone (Figs 18-24). There is no correlation between habit and euaster morphology; indeed, no flabelliform examples of *A. flabelliformis*, apart from the holotype, are known. This separation is tenuous, and it is possible that euaster morphology is related to age of the sponge or conditions for growth. Other characters which do appear to be correlated with euaster morphology include branch diameter. *Axos cliftoni s.s.* has thickly cylindrical branches (mean diameter 13.6 mm), whereas *A. flabelliformis s.l.* is thinner and less rubbery in appearance (mean branch diameter 8.2 mm). This difference is significant at the 0.1% level ($\mathbf{t}_{(2),\,44} = \mathbf{5.23}$) (Table 1).

Biochemical evidence (carotenoid pigments and protein electrophoresis) is presently available for *A. flabelliformis* only

(Fig. 17 and unpublished data), but these data are merely descriptive without comparable results for *A. cliftoni*. The latter species is uncommon and known only from a relatively isolated locality in northwest Australia.

Other species associated with the genus

Three other species have been defined in *Axos*. Brief redescriptions and their affinities are as follows.

Latrunculia spinipoculum (Carter), comb. nov.

(Figs 6-8)

Axos spinipoculum Carter, 1879: 286-291, Pl. 25, Figs 1-9.
Diacarnus spinipoculum — Burton 1934:549
Negombo spinipoculum — de Laubenfels 1936:132-3

Type material. HOLOTYPE - BMNH 1846.10.14.174 (wet: label "no 619, donated by J.B. Jukes Esq."; photograph NMV 34/1-2 sponge archives — F. Wiedenmayer).

Distribution. Type locality: Port Jackson, New South Wales (33°51′S 151°16′E) (Carter 1879).

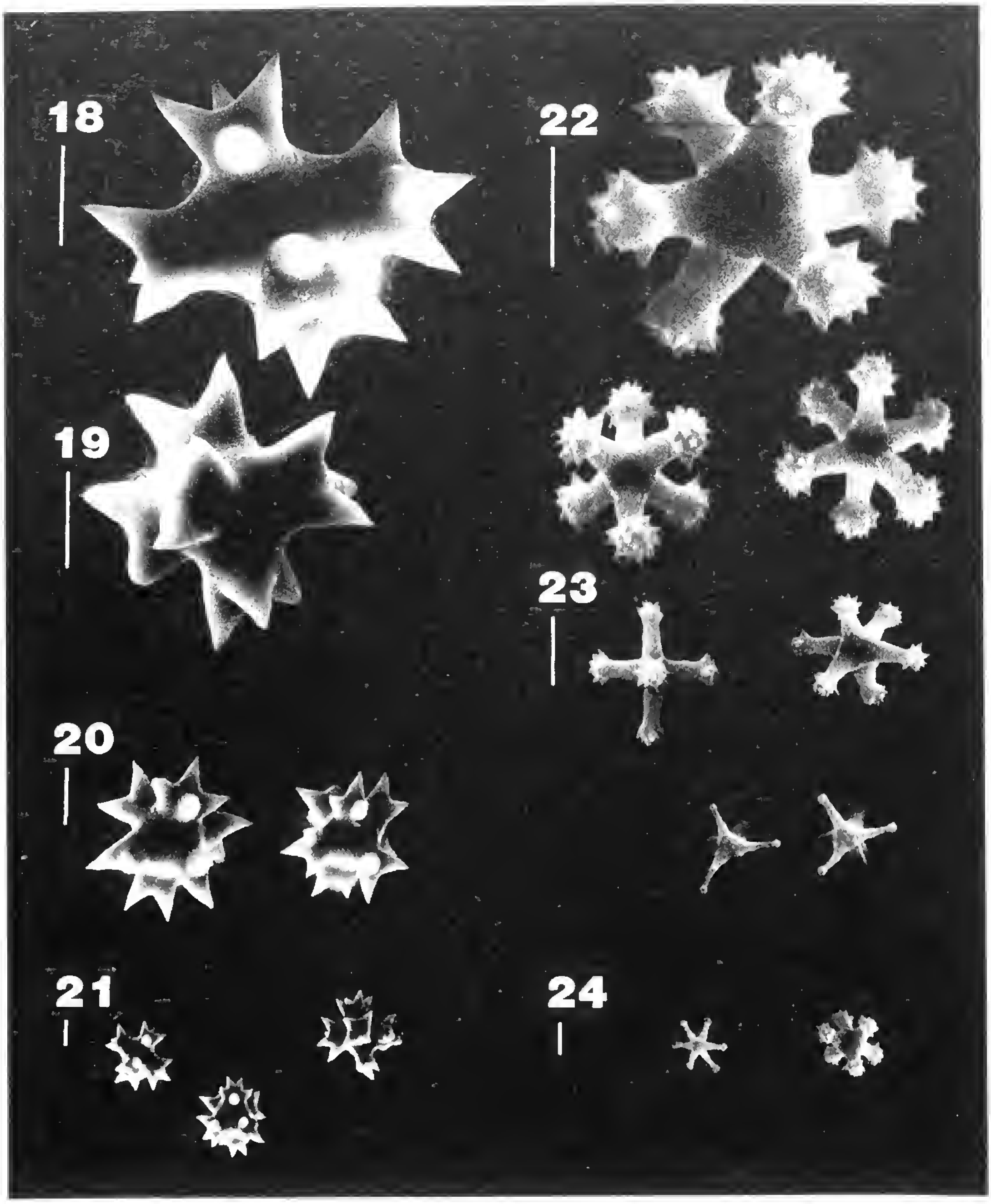
Ecology. Growing "on hard objects" (Carter 1879). Depth unknown.

Description of holotype. Massive, elongate, subcylindrical, solid cup-shaped sponge, with an apical depression. Total length 14.5 cm from basal attachment to apex, 10.1 cm maximum diameter, 4.5 cm basal diameter. Basal end with holdfast adhering to gravel and shell fragments. No stalk. Surface highly ornamented with irregularly distributed ridges, depressions and conules, up to 15 mm high. Conules rounded, occasionally sharply poiinted, up to 10 mm basal diameter. Surface optically smooth between ridges and conules, microscopically hispid. Minute pores scattered between surface projections. Oscula grouped together into sieve-plates, occuring on apical and exterior surfaces. Colour in preserved state is dark grey externally and beige internally. Texture tough and compressible. Ectosome spiculose, containing light paratangential brushes of choanosomal megascleres from ascending plumose tracts, which poke through surface. Ectosome and subectosomal regions are conspicuously more darkly pigmented than deeper regions. Few microscleres present in ectosomal or subectosomal regions. Subectosome with distinct plumose, mostly non-anastomosing spicule tracts arising from choanosome and ascending to surface. Tracts diverge and form brushes, mainly in darkly pigmented peripheral region of sponge, which is up to 300 μm thick. Plumose tracts multispicular, heavily cored by megascleres (4-8 spicules per track). Subectosomal fibres well-developed and heavily invested with spongin (20-120 μm in diameter). Collagenous spongin filamentous, heavy and abundant throughout choanosomal region, resembling filamentous algal strands. Choanocyte chambers ovoid (25-50 μm diameter), but difficult to distinguish between collagenous filaments. Subdermal cavities abundant (65-190 μm diameter). Deeper regions of choanosome less well-organised, megascleres scattered between fibres. Fibres form tight meshes of irregular anastomoses. Microscleres scattered mainly throughout deeper regions of choanosome.

Megascleres: smooth, straight hastate styles, often with styloid and stepped tips. Basal ends rounded or slightly constricted. (N=25) Length 277.04 μm (mean) (range 232-305 μm), width 5.72 μm (4-7 μm).

Microscleres: verticillate sanidasters or discorhabd morphology, resembling a number of euasters fused onto a thin strongyle. Microsclere morphology and spination is relatively consistent, varying only in length and thickness. (N=25) Length 57.52 μm (40-65 μm), width 3.72 μm (2-6 μm).

Remarks. This species has been figured by Carter (1879), and his drawing is an accurate representation of the holotype. *Negombo* Dendy (type species *N. tenuistellata* Dendy, 1905: 127) is characterised in having peculiar "sanidaster" microscleres, consisting of a slender rod, terminating at each end with spines, and bearing slender spines along its length. Megascleres are smooth styles, and skeletal architecture consists of wispy plumose tracts throughout the choanosome, and a reticulation of styles on the surface. *Latrunculia* Bocage (type species *L. cratera* Bocage, 1869:161) is very similar (e.g. *L. conulosa* Hallmann, 1912:126), and I agree with de Laubenfels (1936) that the two genera are synonymous. *L. spinipoculum* has similar architecture to *N. tenuistellata*, but microscleres are much more regular than those of *Negombo s.s.*.



Figs 18-24. Scanning electron micrographs comparing euasters of *Axos cliftoni* and *A. flabelliformis*: **18-21**, *A. cliftoni* NTM 1274; **22-24**, *A. flabelliformis*, NTM Z2499. All scale lines 10 µm.

In growth form and surface ornamentation, *L. spinipoculum* closely superficially resembles an *Ircinia* Nardo (order Dictyoceratida). By its spiculation, *L. spinipoculum* has affinities with *Sigmosceptrella* Dendy (type species *S. quadrilobata* Dendy, 1922:137 from Mauritius), which has double asters or discorhabd microscleres and smooth styles as megascleres. *L. spinipoculum* is particularly close to *S. fibrosa* (Dendy, 1897:254; holotype NMV G2353), and it is possible, but not definite that the two species are synonymous. Dendy's species has occasional, small sigmatose verticillate sanidasters, whereas those of *spinipoculum* are always straight. In any case, *S. fibrosa* should be transferred to *Latrunculia* also.

Unlike *N. tenuistellata, Sigmosceptrella s.s.* and *Latrunculia s.s.*, the microscleres of *L. spinipoculum* and *L. fibrosa* do not form an ectosomal crust, but are more common in the deeper regions of the choanosome. However, this probably does not warrant the creation of a separate genus for the species (cf. *Diacarnus* Burton, 1934:549).

This species is certainly not closely related to *Axos* (cf. Carter 1879) or *Acarnus* (cf. Burton 1934) either by microsclere form or skeletal architecture. Nor are those microscleres typical of the discorhabds of *Latrunculia s.s.* or *Didiscus* Dendy, which have more pronounced discoid whorls, but rather they resemble several euasters fused onto smooth strongylote spicules. It is possible also that *Sigmosceptrella* is synonymous with *Latrunculia*, as suggested by Vosmaer (cited in Dendy 1922:137), and it is certainly probable that it should be placed with the Latrunculiidae Topsent, as suggested by Lévi (1973: 611).

The higher systematics of Latrunculiidae are uncertain. Dendy (1922), Bergquist (1978) and others place the family with the Hadromerids. Lévi (1973) includes it with the Poecilosclerids. Van Soest (1984: 146) follows Lévi, but defines the family as an *Ordo Incerta*. The skeletal architecture of *L. spinipoculum* described above is suggestive of the Poecilosclerida.

Plumocolumella anchorata (Carter)

(Figs 9-10, 15)

Axos anchorata Carter, 1881: 382-383, Pl. 18, Fig. 3a-f.

Phorbas anchorata — Carter 1882: 288.

Plumocolumella anchorata — Burton 1934: 549-550.

Type material. HOLOTYPE - BMNH 1871.5.12.1.34a (slide; photograph NMV 45/35-36 sponge archives — F. Wiedenmayer).

Distribution. Type locality: Bass Strait, Victoria 39°S 145°E. Other: Turtle Island, Great Barrier Reef, Queensland, 22°21′S, 149°47′E (Burton 1934).

Ecology. Holotype found growing on a mussel shell. Queensland specimen recorded from 16 m depth, in a mud and shell grit substrate.

Description of holotype. Thickly cylindrical, unbranched digit growing from an encrusting base. Basal stalk 4.1 mm in diameter, and maximum diameter of stalk 8.2 mm. Length of the whole specimen is unknown. Surface ornamented with small pointed conules and longitudinal ridges. Oscula scattered between conules. Colour alive is unknown, and brown in the dry state (NMV sponge archives 45/35-36, and Carter 1881). Texture is firm and compressible (Carter 1881:382). The choanosome is reticulate, formed of regularly anastomosing spongin fibres, without axial condensation or regional differentiation. Fibres cored by oxeas in multispicular tracts. Ectosome contains some megascleres at right angle to it, and piercing surface, particularly on conules. Microscleres scattered throughout mesohyl matrix.

Megascleres: oxeas, fusiform, mostly straight. (N=25) Length 265.34 μm (mean) (range 105-318 μm), width 8.44 μm (3-16 μm).

Microscleres: unguiferous anchorate isochelae. (N=25) Mean chord length 12.4 μm (9.5-21 μm).

Remarks. Regardless of their similarities in growth form (Fig. 15) (Carter 1881), *P. anchorata* bears little resemblance to *A. cliftoni*. *Plumocolumella* Burton (type species *P. carnosa* (Carter, 1886)) is characterised by a choanosomal skeletal architecture consisting of plumose to plumo-reticulate fibres and tracts of oxeas, which terminate in brushes on the ectosome, and unguiferous anchorate

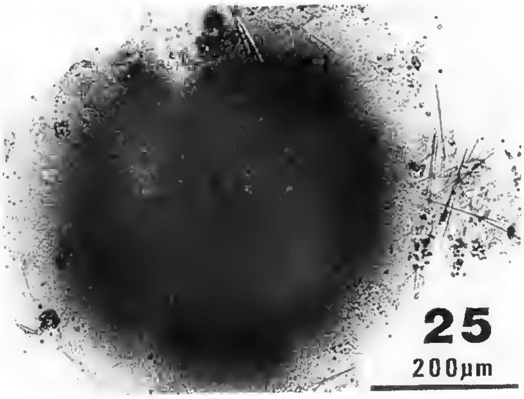


Fig. 25. Light micrograph of preserved larva of *Axos cliftoni*, found in abundance on the external surface of the adult sponge, NTM Z1424.

isochelae and occasionally sigmas (Burton 1929:424). There is no evidence of distinct ectosomal brushes in the type specimen of *P. anchorata*, although single or few spicules pierce the ectosome in places, particularly at the apices of conules. Through its similarity with the type species, *P. anchorata* appears to be appropriately placed in that genus (cf. Burton 1934).

In possessing chelate microscleres and plumo-reticulate architecture, *Plumocolumella* is an obvious Poecilosclerid. Burton (1934) placed the genus in the Myxillidae Topsent, but more recently Van Soest (1984), following de Laubenfels (1936) and Lévi (1973) referred the genus to the family Desmacididae Schmidt (=Esperiopsidae Hentschel).

Gelliodes fibulatus (Carter)

(Figs 11-12, Pl. 1E)

Axos fibulata Carter, 1881: 383, Pl. 18, Fig. 4.
Phorbas fibulata — Carter 1882: 288.
Gelliodes fibulata — Ridley, 1884: 427, Pl. 39, Fig. 1, Pl. 41, Fig. bb; Ridley and Dendy 1887: 47, Pl. 12. Fig. 2; Topsent 1897: 470, 1932: 114; Hentschel 1912: 393: Burton, 1934: 549; Lévi 1961: 141, Fig. 16; Wiedenmayer 1977a:95; Desqueyroux-Faundez 1981: 744, Figs 56, 117, 1984: 780-781, Figs 6, 51, 52, 58, 61.

Type material. HOLOTYPE - Lost from BMNH collection (Burton 1934: 549).

Additional material. NTM Z1000, East Point Fish Reserve, Darwin, NT, 12°24.5′S 130°48.0′E, 26 October 1982, 8-10 m depth, coll. J.N.A. Hooper, SCUBA; NTM Z1050, 9 November 1982, 13 m depth; NTM Z1445, Blue Hole, Gunn Point Reef, NT, 12°09.0′S 131°00′E, 19 August 1983, 25 m depth, coll. P.N. Alderslade, SCUBA; NTM Z980, NW Vernon I., Gunn Point, NT, 12°03.0′S 131°05.5′E, 27 September 1982, 15 m depth, coll. P.N. Alderslade, SCUBA; NTM Z48, Trepang Bay, Cobourg Peninsula Marine Park (CPMP), NT, 11°10′S 131°58′E, 16 October 1981, 1 m depth, coll. J.N.A Hooper, by hand; NTM Z44, 11°07′S 131°58′E, 15 October 1981, 5 m depth, SCUBA; NTM Z357, Z349, Coral Bay, Port Essington, CPMP, NT, 11°11.2′S 132°03.6′E, 23 June 1981, 3-5 m depth, coll. J.N.A. Hooper, SCUBA; NTM Z53, 17 October 1981, 6 m depth; NTM Z79, 18 October 1981, 4 m depth; NTM Z1362, 1366, 1368, 1373, 16 May 1983, 0.5-5.5 m depth; NTM Z1392, 17 May 1983, 6 m depth; NTM Z105, Sandy I. No.2, CPMP, NT, 11°05.5′S 132°17′E, 20 October 1981, 7 m depth, coll. J.N.A. Hooper, SCUBA.

Distribution. Type locality: Bass Strait, Victoria, 39°S 145°E. Other: Torres Strait, North Queensland, 10°30′S 142°E; Northern Territory, 11-12°S 131-132°E; Ambon and Aru I., Indonesia, 4°30′ – 6°S 128°05′ – 134°20′E; Vietnam, 11°30′N 108°30′E; New Caledonia, 21°35′S 166°14′E.

Ecology. Bathymetric range 0.5-25 m depth. Commonly found growing on dead and live corals, and other sponges as an epizootic growth. Occasionally found on rock or sand substrates (present observations).

Description. Cylindrical digitate; anastomosing at multiple points of contact with substrate, and with meandering stoloniferous habit; variable in size. Colour in life grey to pale blue (Munsell 5G 8/2-2.5B 8/4) (Pl. 1E). Surface bears numerous, strong, slender, sharp spines, 4-13 mm long, upon which smaller secondary spines occur. Ectosomal region membraneous, opaque, and contains an obvious, regular reticulation of multispicular tracts, through which protrude ascending primary and secondary choanosomal spicule tracts, forming spines. Choanosomal fibres heavily invested by spongin, and divided into ascending, relatively irregular primary lines, fully cored by multispicular tracts of megascleres (150-310 μm diameter), from which diverge multispicular secondary tracts (45-110 μm) at various angles, forming loose anastomoses and an open network (spaces up to 280-720 μm diameter). Non-fibre spongin relatively heavy in mesohyl matrix, with abundant, loosely strewn megascleres and microscleres. Choanocyte chambers oval, 80-150 μm in diameter.

Megascleres: very variable in thickness. Larger category smooth, hastate, mostly straight oxeas, with abruptly pointed apices, often with stepped tips. Smaller category fusiform, sharply pointed. (N=25) Length 264 μm (mean) (range 139-279 μm), width 11.8 μm (2-16 μm).

Microscleres: minute, thin smooth sigmas, invariably c-shaped, with slight (but not definite) tendency to be centrangulate. (N=25)

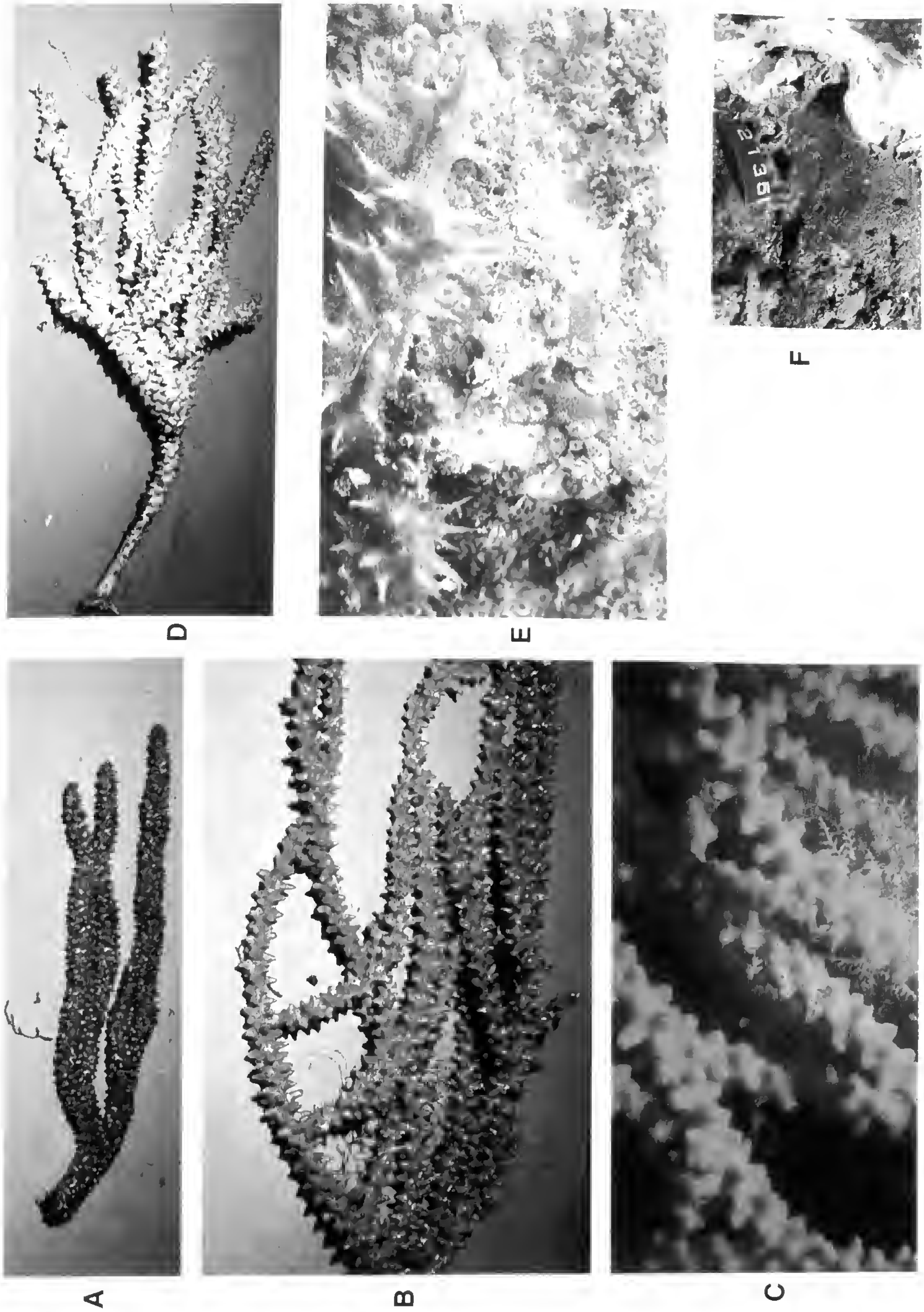


Plate 1. Marine Sponges: **A**, *Axos cliftoni*, NTM Z1821 "on deck", photo T. Ward; **B**, *Axos flabelliformis*, red colour morph, NTM Z1808, "on deck" photo T. Ward; **C**, *A. flabelliformis*, orange colour morph, NTM Z2688, *in situ*, photo J. Hooper; **D**, *A. flabelliformis*, beige colour morph, NTM Z1822, "on deck" photo T. Ward; **E**, *Gelliodes fibulatus*, NTM Z44, *in situ*, photo J. Hooper; **F**, *Timea lowchoyi* holotype, NTM Z2135, *in situ*, photo J. Hooper.

Mean chord length 13.6 μm (10-17 μm), maximum mean width 0.85 μm (0.5-1.2 μm).

Remarks. *G. fibulatus* is the type species of the genus (by monotypy; Ridley 1884). It is a well documented species, and from published accounts (Carter 1881; Ridley and Dendy 1887; Lévi 1961; Desqueyrouz-Faundez 1981, 1984) and present observations, it is distinctive and easily recognizable (Pl. 1E), and easily differentiated from *Axos*. It is superficially characterised in having razor-sharp surface spines, which may vary considerably in length. The meandering, anastomosing stoloniferous habit, often with multiple points of attachment, appears to be usual for the species. Therefore, it is unlikely that *G. fibulatus* is synonymous with Lamarck's (1814-15) *Spongia rubispina* (as suggested by Ridley and Dendy 1887). The spiculation of Lamarck's species is unknown (the type specimen is missing; Topsent 1932: 114), but there is a significant variability in growth form between *G. fibulatus* and Lamarck's species (Desqueyrouz-Faundez 1984).

For the Northern Territory specimens, *G. fibulatus* is often epizootic in habit. Its association with coelenterates and sponges appears to be deleterious to the host/substrate, usually causing etching of live coral or necrotic spots on sponges. However, damage is minimal and localized to the points of contact only. This association is comparable to that of *Sigmadocia symbiotica* Bergquist and Tizard (=*Gellius cymiformis* (Esper)) (see *a.o.* Vacelet, 1981)) (Haliclonidae, Haplosclerida) from Northern Australia, which has been observed to kill square metres of live coral (personal observation).

In the most recent revision of the Haplosclerida (Van Soest 1980; Desqueyroux-Faundez 1984), *Gelliodes* is placed with the Niphatidae Van Soest. By comparison, Lévi (1973) and Wiedenmayer (1977a) include it with the Haliclonidae de Laubenfels.

ACKNOWLEDGEMENTS

This study would not have been possible without the generous assistance from various institutions in obtaining type (and other) material: AM (Dr Frank Rowe), BM(NH) (Ms Shirley Stone), NMV (Dr C.C. Lu and Dr Felix Wiedenmayer), WAM (Mrs Loisette Marsh), and ZMA (Dr Rob Van Soest). I also thank Ms Anne-Marie Mussig and Mr Alan Howard for their assistance with the preparation of figures; Mr Phil Alderslade for his continual help during the development of the computer software to measure and analyse skeletal components; Dr Clive Wilkinson (AIMS) and the EM Unit (James Cook University) for assistance with scanning electron microscopy; Dr Trevor Ward (CSIRO Fisheries) for specimens and photographs; and Dr Rob Capon (ANU) for carotenoid pigment analyses of *Axos flabelliformis*. I acknowledge the Heritage Commission for providing a Departmental grant, which enabled access to the marine fauna of Cobourg Peninsula Marine Park.

REFERENCES

Barnard, F. 1879 Notes on sponge from Northern Territory. *Quarterly Journal of the Microscopy Society of Victoria* **1**: 14-15.

Bergquist, P.R. 1965 The sponges of Micronesia, Part 1, The Palau Archipelago. *Pacific Science* **19**(2): 123-204.

——— 1968 The Marine Fauna of New Zealand: Porifera, Demospongiae, Part 1 (Tetractinomorpha and Lithistida). *Bulletin of the New Zealand Department of Scientific and Industrial Research. Memoirs of the New Zealand Oceanographic Institute* **37**(188): 1-106.

——— 1978 *Sponges*. Hutchinson: London.

Bocage, J.V. Barboza du 1869 Éponges siliceuses nouvelles de Portugal et de l'île de Saint-Iago (archipel du Cap-vert). *Jornal de Scienzas Academie Lisboa* **2**: 159-161.

Bowerbank, J.S. 1864 *A Monograph of the British Spongiadae*. Volume 1 Ray Society: London.

——— 1866 *A Monograph of the British Spongiadae*. Volume 2. Ray Society: London.

——— 1873 Contributions to a general history of the Spongiadae. Parts IV and V. *Proceedings of the Zoological Society of London* **1873**: 3-25, 319-333.

Brien, P. 1973 Les Démosponges. Morphologie et Reproduction. In: P. Brien, C. Lévi, M. Sarà, O. Tuzet, and J. Vacelet (eds) *Spongiares. Traité de Zoologie. Anatomie, Systématique, Biologie*. Volume 3(1): 133-461. Masson et Cie: Paris.

Burton, M. 1929 Porifera. Part II - Antarctic Sponges. *British Antarctic (Terra Nova) Expedition, 1910. Natural History Report, Zoology* **4**: 393-458.

——— 1934 Sponges. *Scientific Report on the Great Barrier Reef Expedition* **4**(14): 513-621.

Carter, H.J. 1879 On *Holostrella*, a fossil sponge of the Carboniferous era, and on *Hemiasterella*, a new genus of recent sponges. *Annals and Magazine of Natural History* (5) **3**: 141-150.

——— 1880 Report on specimens dredged from the gulf of Manaar and presented to the Liverpool Free Museum by Capt. H. Cawne Warren. *Annals and Magazine of Natural History* (5) **6**: 129-156.

——— 1881 Supplementary report on specimens dredged up from the Gulf of Manaar, together with others from the sea in the vicinity of the Basse Rocks and from Bass's Straits respectively, presented to the Liverpool Free Museum by Capt. H. Cawne Warren. *Annals and Magazine of Natural History* (5) **7**: 361-385.

——— 1882 Some sponges from the West Indies and Acapulco in the Liverpool Free Museum described, with general and classificatory remarks. *Annals and Magazine of Natural History* (5) **9**: 266-301, 346-368.

——— 1886 Descriptions of sponges from the neighbourhood of Port Phillip Heads, South Australia. *Annals and Magazine of Natural History* (5) **17**: 40-53, 112-127, 431-441, 502-516.

De Laubenfels, M.W. 1936 see Laubenfels, M.W. de.

Dendy, A. 1897 Catalogue of non-calcareous sponges collected by J. Bracebridge Wilson in the neighbourhood of Port Phillip Heads. Part 3. *Proceedings of the Royal Society of Victoria* **2**(9): 230-259.

——— 1905 Report on the sponges collected by Prof. Herdman at Ceylon in 1902. In: W.A. Herdman *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar*. Volume 3, Supplement 18: 57-246. Royal Society: London.

——— 1921 The tetraxonid sponge spicule: a study in evolution. *Acta zoologica (Stockholm)* **2**: 95-152.

——— 1922 Report on the Sigmatotetraxonida collected by H.M.S. "Sealark" in the Indian Ocean. In: Report of the Percy Sladen Trust Expedition to the Indian Ocean in 1905. Volume 7. *Transactions of the Linnean Society of London, Zoology* **18**: 1-164.

Descatoire, A. 1966 Sur quelques, Démosponges de l'Archipel de Glenan. *Cahiers de Biologie Marine* **7**: 231-246.

Desqueyroux-Faundez, R. 1981 Révision de la collection d'eponges d'Amboine (Moluques, Indonésie) constituée par Bedot et Pictet et conservée au Muséum d'histoire naturelle de Genève. *Revue Suisse de Zoologie* **88**(3): 723-764.

——— 1984 Description de la faune des Haplosclerida (Porifera) de la Nouvelle-Calédonie. I. Niphatidae — Callyspongiidae. *Revue Suisse de Zoologie* **91**(3): 765-827.

Gray, J.E. 1867 Notes on the arrangement of sponges, with description of some new genera. *Proceedings of the Zoological Society of London* **1867**: 492-558.

——— 1870 Note on a new genus of sponge from West Australia. *Annals and Magazine of Natural History* (4) **6**: 272.

Hallmann, E.F. 1912 Report on the sponges obtained by the F.I.S. "Endeavour" on the coasts of New South Wales, Victoria, South Australia, Queensland and Tasmania, 1909-10, Part 1. *Zoological Results of the Fisheries Expedition of "Endeavour"* **2**: 117-300.

——— 1916 A revision of the genera with microscleres included or provisionally included in the family Axinellidae; with descriptions of some Australian species. Parts i-iii. *Proceedings of the Linnean Society of New South Wales* **41**(3-4): 453-491, 495-552, 634-675.

Hartman, W.D. 1982 Porifera. In: S.P. Parker (ed) *Synopsis and Classification of Living Organisms*. Volume 1: 640-666. Mc Graw-Hill: New York.

Hentschel, E. 1912 Kiesel-und Hornschwämme de Aru und Kei-Inseln. *Abhandlungen Senckenbergische Naturforschende Gesellschaft* **34**: 295-448.

Hooper, J.N.A. 1984a A new genus and two new species of Haplosclerid sponges (Porifera: Demospongiae) from the Timor Sea, Northwest Australia. *Proceedings of the Royal Society of Victoria* **96**(2): 55-60.

——— 1984b *Sigmaxinella soelae* and *Desmacella ithystela*, two new desmacellid sponges (Porifera, Axinellida, Desmacellidae) from the Northwest Shelf of Western Australia, with a revision of the Family Desmacellidae. *Northern Territory Museum of Arts and Sciences, Monograph Series* **2**: 1-58.

Kirkpatrick, R. 1903 Descriptions of South African Sponges, Part III. *Marine Investigations of South Africa* **2**: 233-264.

Lamarck, J.B.P.A. de Monet, de 1813-4 Sur les polypiers empâtés. *Annales Muséum d'Histoire Naturelle Paris* **20**: 294-312, 370-386, 432-458.

———1814-15 Suite des polypiers empâtés. *Mémoirs de Muséum d'Histoire Naturelle Paris* **1**: 69-80, 162-168, 331-340.

Laubenfels, M.W., de 1936 A discussion of the sponge fauna of the Dry Tortugas in particular, and the West Indies in general, with material for a revision of the families and orders of the Porifera. *Publications of the Carnegie Institution (Washington). Papers of the Tortugas Laboratory* **30**: 1-225.

Lendenfeld, R., von 1889 *A Monograph of the Horny Sponges*. Truebner and Co.: London.

Lévi, C. 1955 Les Clavaxinellides, Démosponges Tétractinomorphes. *Archives de Zoologie Expérimentale et Génerale* **92**(2): 78-87.

——— 1956 Etude des *Halisarca* de Roscoff. Embryologie et systématique des Démosponges. *Archives de Zoologie Expérimentale et Génerale* **93**: 1-181.

——— 1961 Spongiaires des Îles Philippines, principalment recoltees au voisinage de Zamboanga. *Philippines Journal of Science* **88**(4): 509-533.

——— 1973 Systématique de la classe des Demospongiaria (Démosponges). In: P. Brien, C. Lévi, M. Sarà, O Tuzet and J. Vacelet (eds) *Spongiaires. Traitè de Zoologie. Anatomie, Systématique, Biologie*. Volume 3(1): 577-631. Masson et Cie: Paris.

Montagu, G. 1814 An essay on sponges with descriptions of all the species that have been discovered on the coast of Great Britain. *Memoirs of the Wernerian Natural History Society* **2**(1): 67-122.

Pulitzer-Finali, G. 1977 Report on a collection of sponges from the Bay of Naples. III. Hadromerida, Axinellida, Poecilosclerida. *Bollettino dei Musei e degli Istituti Biologici dell' Universita di Genova* **45**: 7-89.

——— 1983 A collection of Mediterranean Demospongiae (Porifera) with, in appendix, a list of the Demospongiae hitherto recorded from the

Mediterranean Sea. *Annali del Museo Civico di Storia Naturale di Genova* **84**: 445-621.

Reid, R.E.H. 1970 Tetraxons and demosponge phylogeny. In: W.G. Fry (ed) *The Biology of the Porifera*. Symposia of the Zoological Society of London 25: 63-89. Academic Press: London.

Reiswig, H.M. 1976 Natural Gamete Release and oviparity in Caribbean Demospongiae. In: F.W. Harrison and R.R. Cowden (eds) *Aspects of Sponge Biology*. Academic Press: New York, San Francisco, London.

Ridley, S.O. 1884 Spongiida. In: *Report on the Zoological Collections Made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert", 1881-1882*. British Museum (Natural History): London.

——— and Dendy, A. 1887 Report on the Monaxonida collected by H.M.S. "Challenger" during the years 1873-76. *Report on the Scientific Results of the Voyage of H.M.S. "Challenger". Zoology* **20**(59): 1-275.

Schmidt, E.O. 1862 *Die Spongien des Adriatischen Meeres*. Wilhelm Engelmann: Leipzig.

Soest, R.W.M., van 1980 Marine sponges from Curaçao and other Caribbean localities. Part II. Haplosclerida. *Studies on the Fauna of Curaçao and other Caribbean Islands* **62**(191): 1-173.

——— 1984 Marine sponges from Curaçao and other Caribbean localities. Part III. Poecilosclerida. *Studies on the Fauna of Curaçao and other Caribbean Islands* **66**(199): 1-167.

Sollas, W.F. 1888 Report on the Tetractinellida collected by H.M.S. "Challenger" during the years 1873-1876. *Report on the Scientific Results of the Voyage of H.M.S. "Challenger", Zoology* **25**(63): 1-458.

Steel, R.G.D. and Torrie, J.H. 1960 *Principles and Procedures of Statistics*. McGraw-Hill: New York.

Stephens, J. 1912 Marine Porifera of the Clare Island Survey. *Proceedings of the Royal Irish Academy* **31**(59): 1-42.

——— 1914 Sponges of the coasts of Ireland. I. The Triaxonida and part of the Tetraxonida. *Department of Agriculture and Technical Instruction for Ireland. Fisheries Branch. Scientific Investigations* **1914**(4): 1-43.

——— 1915 Atlantic sponges collected by the Scottish National Antarctic expedition. *Transactions of the Royal Society of Edinburgh* **50**: 423-467.

Topsent, E. 1893 Note sur quelques Éponges du Golfe de Tadjoura recueillies par M. le Dr. L. Faurot. *Bulletin de la Societe Zoologique de France* **18**: 177-182.

——— 1897 Sur la genre *Halicnemia* Bowerbank. *Mémoirs de la Societe Zoologique de France* **10**: 235-251.

——— 1900 Étude monographique des spongiaires de France. III. Monaxonida (Hadromerida). *Archives de Zoologie Expérimentale et Génerale* **8**: 1-331.

——— 1904 Spongiaires des Açores. *Résultats des Campagnes Scientifiques par Prince Albert I de Monaco* **25**: 1-280.

——— 1919 Notes sur les genres *Semisuberites* et *Hemiasterella*. *Bulletin de l'Institut Océanographique de Monaco* (359): 1-11.

——— 1928 Spongiaires de l'Atlantique et de la Méditerranée provenant des croisiéres du Prince Albert Ier de Monaco. *Résultats des Campagnes Scientifiques par Prince Albert I de Monaco* **74**: 1-376.

——— 1932 Éponges de Lamarck conservées au Muséum de Paris. Deuxiéme partie. *Archives de Muséum Nationale d'Histoire Naturelle, Paris* (6) **8**: 61-124.

Vacelet, J. 1981 Algal-sponge symbioses in the coral reefs of New Caledonia: a morphological study. *Proceedings of the Fourth International Coral Reef Symposium, Manilla*. Volume 2: 713-719.

Wiedenmayer, F. 1977a *Shallow-water sponges of the western Bahamas*. Birkhauser: Basel, *Experimentia Supplementum* **28**: 1-287.

——— 1977b The Nepheliospongiidae Clarke, 1900 (Demospongea, Upper Devonian to Recent) an ultraconservative chiefly shallow-water sponge family. *Ecologae Geologica Helvitica* **70**(3): 885-918.

Wilson, H.V. 1925 Silicious and horny sponges collected by the U.S. Fisheries steamer "Albatross" during the Philippine Expedition, 1907-10. In: Contributions to the biology of the Philippine Archipelago and adjacent regions. *United States National Museum Bulletin* **100**(2/4): 273-532.

Zar, J.H. 1974 *Biostatistical Analysis*. Prentice-Hall: Englewood Cliffs, New Jersey.

Accepted 16 September 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 191-194

A NEW SPECIES OF *TIMEA* GRAY (PORIFERA: HADROMERIDA) FROM NORTHERN AUSTRALIA

JOHN N.A. HOOPER
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

A new species of *Timea* Gray (Timeidae: Hadromerida: Porifera), *T. lowchoyi* sp. nov., is described from East Point Fish Reserve, Darwin, Northern Australia.

KEYWORDS: taxonomy, new species, Porifera, Hadromerida, Timeidae, *Timea*, north Australia.

INTRODUCTION

Timea Gray contains numerous species, all of which have few morphological characters of known systematic importance. Consequently, differentiation of species relies largely upon the form and spination of the euaster microscleres, which are reportedly fairly characteristic and consistent within many nominal species (e.g. Bergquist 1965:186). Additional characters may be found for taxa described from live specimens, particularly colour and surface ornamentation, and these too are apparently characteristic and stable (e.g. Bergquist 1965, 1968; Pulitzer-Finali 1977). These characters are certainly useful for field studies, but they are of little importance in the study of preserved museum specimens, which unfortunately comprise the majority of nominal taxa. As a consequence, a specific revision of *Timea* would be difficult, and at the present time authors are required to erect new species on the basis of megasclere size and microsclere form alone (e.g. Pulitzer-Finali 1983).

Methods of preparation and examination are described elsewhere (Hooper 1984a, 1984b).

SYSTEMATICS

Order Hadromerida Topsent
Family Timedae Topsent
Genus *Timea* Gray

Timea Gray, 1867:544 (type species *Hymedesmia stellata* Bowerbank, 1866:150, 1874:71, Pl.28, Figs 5-8, 1882:67, by original designation and monotypy).

Diagnosis. Thinly incrusting sponges with choanosomal tylostyles standing erect on substrate and protruding through ectosome. Ectosome and choanosome packed with euasters of variable form, ranging from oxyasters to spherasters and calthrops-like asters. Megascleres in bundles or singly, without fibre component or definite tracts.

Timea lowchoyi sp.nov.
(Figs 1-4, Pl. 1F)

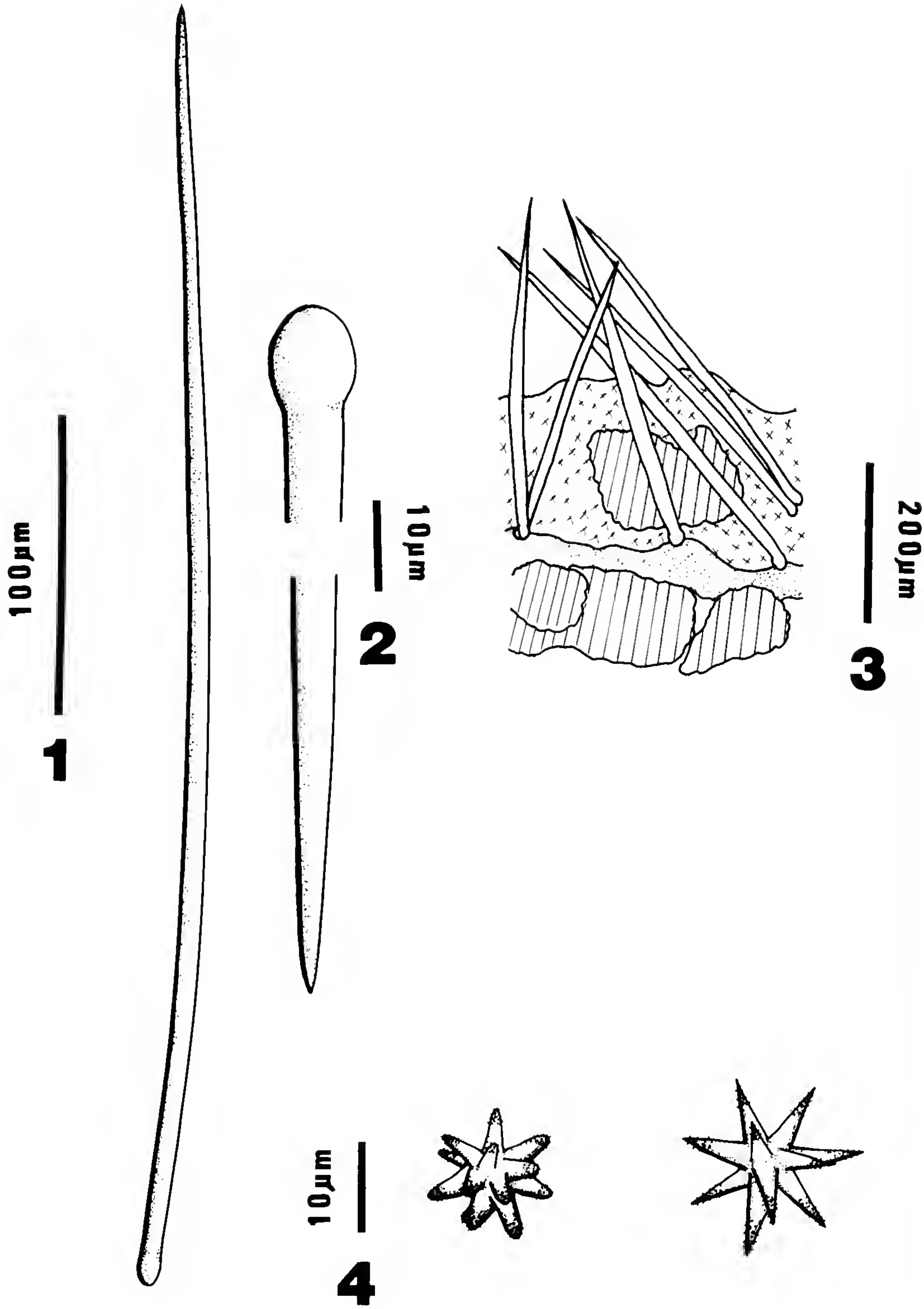
Type material. HOLOTYPE - Northern Territory Museum (NTM) Z2135, East Point Fish Reserve, Darwin, NT, 12°25.0'S 130°49.1'E, 27 September 1984, intertidal, Coll. J.N.A. Hooper.

Diagnosis. Thin, dark red-brown incrustation with hispid ectosome and radially grooved canals draining into small oscula. Megascleres straight, sharply pointed tylostyles, erect on substrate, 332-547 x 4-10 µm. Microscleres oxyasters and strongylasters with microspined and uniform rays, abundant in ectosome and choanosome, 12-28 µm maximum diameter.

Ecology. Found on an intertidal laterite rock and coral reef close to the city of Darwin. Located under a loose dead faviid coral head, incrusting near compound ascidians, coralline algae and sponges. Rare.

Description. Thinly incrusting, 1-3 mm thick, with dimensions 70 x 60 mm. Colour in life dark red-brown (Munsell 10R 5/12); colour in ethanol light grey (10R 8/12) (Pl. 1F). Texture is compressible and elastic. Surface hispid and sculptured by long, deep, meandering and bifurcating drainage canals and grooves, which radiate from oscula. Oscula slightly raised in thicker areas of sponge, or flush with the surface in thinner regions, and measure 0.8-1.5 mm in diameter.

Ectosome opaque, heavily pigmented in life in thicker sections, or translucent in the thin sections of the incrustation.



Figs 1-4. *Timea lowchoyi* holotype: **1**, tylostyles; **2**, extremities of megascleres; **3**, euasters; **4**, section of peripheral skeleton (hatched areas are coral inclusions; stippled area is basal spongin layer).

Choanosomal megascleres stand erect on substrate, occuring singly or in groups of 2 or 3, and extend up to 100 μm out of ectosome. Tylote bases of megascleres are embedded in non-fibre spongin which coats substrate (13-20 μm thick).

Choanosomal architecture a mass of euaster microscleres and vertically disposed megascleres. Coral debris and sand particles incorporated into choanosome in places. Mesohyl matrix mostly obscured by euasters, but contains abundant light spongin. Choanocyte chambers not observed.

Megascleres: straight, long, smooth, tylostyles, with fusiform apex and prominently swollen bases. (N=25) Length 432.4 μm (mean) (range 332-547 μm), maximum width 7.4 μm (4-10 μm).

Microscleres: euasters (oxyasters and strongylasters) with microspined and uniform rays, and moderately large centrum. (N=25) maximum mean diameter 19.52 μm (12-28 μm).

Remarks. *T. lowchoyi* is comparable with *T. aurantiaca* Bergquist, 1968, in colour (the latter being bright orange to red), texture (elastic), thickness (0.8-0.9 mm), habit (thinly incrusting), and surface sculpturing (radial grooves). Tylostyles of *T. aurantiaca* frequently bear subterminal swellings, and are sometimes asymmetrical and with roughened bases; those of the present species are invariably smooth, symmetrical and have terminal bases. Megascleres are of similar size (193-677 x 2.3-6 μm; 332-547 x 4-10 μm, for *T. aurantiaca* and *T. lowchoyi* respectively). Microsclercs of *T. aurantiaca* are smaller, and are recorded as tylo- to strongylo-spherasters, and normal spherasters with oxeote rays (4.6-22.2 μm; cf. 12-28 μm, respectively). Bergquist's (1968) figure (Plate 11e) suggests that the rays of euasters are microspined (indicated by the stippling in the figure), although not explicitly stated in the text. However, her comparison of the affinities between *T. aurantiaca* and *T. spherastraea* Burton, 1959, which does not have microspined euasters, would indicate that her species is similar in that respect.

Differences in the size of euasters, the (possible) absence of microspination of euaster rays, the position of tylote swellings on megascleres, and their geographical and climatic separation may differentiate *T. lowchoyi* and *T. aurantiaca*. Those differences may be tenuous; intraspecific variability for *Timea* has not been substantially documented (cf. *T. hazelli* Topsent, 1900).

Timea tetractis Hentschel (1912) from the Arafura Sea may be distinguished from the present species in having two distinct forms of asters (strongylasters and a heavily spined quadriradiate aster, "chelotropartige aster" of Hentschel).

Etymology. The specific name is given in respect to the late W.R. Low Choy, Lecturer in Marine Biology at the Darwin Institute of Technology, who was the main instigator in the declaration of East Point Reef as a Marine Fish Reserve (April 1984).

REFERENCES

Bergquist, P.R. 1965 The sponges of Micronesia, Part 1, The Palau Archipelago. *Pacific Science* **19**(2): 123-204.

——— 1968 The Marine Fauna of New Zealand: Porifera, Demospongiae, Part 1 (Tetractinomorpha and Lithistida). *Bulletin of the New Zealand Department of Scientific and Industrial Research. Memoirs of the New Zealand Oceanographic Institute* **37**(188): 1-106.

Bowerbank, J.S 1866 *A Monograph of the British Spongiadae*. Volume 2. Ray Society: London.

——— 1874 *A Monograph of the British Spongiadae*. Volume 3. Ray Society: London.

——— 1882 *A Monograph of the British Spongiadae*. Volume 4. Ray Society: London.

Burton, M. 1959 Sponges. *Scientific Report on the John Murray Expedition* **10**(5): 151-281.

Gray, J.E. 1867 Notes on the arrangement of sponges, with description of some new genera. *Proceedings of the Zoological Society of London* **1867**: 492-558.

Hentschel, E. 1912 Kiesel-und Hornschwämme de Aru und Kei-Inseln. *Abhandlungen Senckenbergische Naturforschende Gesellschaft* **34**:295-448.

Hooper, J.N.A. 1984a A new genus and two new species of Haplosclerid sponges (Porifera: Demospongiae) from the Timor Sea, Northwest Australia. *Proceedings of the Royal Society of Victoria* **96**(2):55-60.

——— 1984b *Sigmaxinella soelae* and *Desmacella ithystela*, two new desmacellid sponges (Porifera, Axinellida, Desmacellidae) from the Northwest Shelf of Western Australia, with a revision of the Family Desmacellidae. *Northern Territory Museum of Arts and Sciences, Monograph Series* **2**:1-58.

Pulitzer-Finali, G. 1977 Report on a collection of sponges from the Bay of Naples. III. Hadromerida, Axinellida, Poecilosclerida. *Bollettino dei Musei e degli Istituti Biologici dell' Universita di Genova* **45**: 7-89.

——— 1983 A collection of Mediterranean Demospongiae (Porifera) with, in appendix, a list of the Demospongiae hitherto recorded from the Mediterranean Sea. *Annali del Museo Civico di Storia Naturale di Genova* **84**:445-621.

Topsent, E. 1900 Étude monographique des spongiaires de France. III. Monaxonida (Hadromerida). *Archives de Zoologie Expérimentale et Generale* **8**:1-331.

Accepted 17 September 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 195-211

PROPALORCHESTES NOVACULACEPHALUS GEN. ET SP.NOV., A NEW PALORCHESTID (DIPROTODONTOIDEA: MARSUPIALIA) FROM THE MIDDLE MIOCENE CAMFIELD BEDS, NORTHERN TERRITORY, AUSTRALIA

P. F. MURRAY
Northern Territory Museum Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Propalorchestes novaculacephalus gen. et sp.nov. is a comparatively small *Ngapakaldia* Stirton-like diprotodontoid marsupial represented by an edentulous, extremely narrow, high braincase fragment with a marked postorbital constriction. Details of its cranial base, glenoid fossa morphology and auditory region indicate that it is aligned with the Palorchestinae. The overall morphology of *P. novaculacephalus* braincase morphology emphasizes the uniqueness of this evolutionary lineage of marsupials.

KEYWORDS: Medial Miocene, Ngapakaldia, *Palorchestes,* Diprotodontoidea.

INTRODUCTION

Placement of the enigmatic Palorchestidae among diprotodontoid marsupials was supported by the discovery of the mid Miocene species *Ngapakaldia tedfordi* (Stirton, 1967). Stirton, Woodburne and Plane (1967) placed *Ngapakaldia* Stirton close to the ancestry of *Palorchestes* Owen on the basis of synapomorphies in the auditory region and neurocranium. These features also closely aligned *Ngapakaldia* with the diprotodontidae confirming Woods (1958) diagnosis of diprotodontid affinity of *Palorchestes*, while simultaneously implying that palorchestids might lie close to the stem of the Diprotodontoidea. The key characteristics aligning these groups - the squamosal contribution to the floor of the middle ear, narrow mastoid strip on the occiput, large epitympanic fenestra, reduced postglenoid process and extensive squamosal lamina on the neurocranium - are features shared with the Vombatoidea and could be interpreted as symplesiomorphies of the greater superfamilial designation (Archer 1984). Notwithstanding, the palorchestids have greater affinity with the diprotodontoids than with the macropodoids, where they resided for decades (Owen 1874; Raven and Gregory 1946; Tate 1948) until Woods (1958), noting the lack of the large masseteric fossa in the dentary of *Palorchestes*, realigned them.

While *Ngapakaldia tedfordi* shares a number of features with *Palorchestes*, it is devoid of synapomorphic specializations in dental structure and in the development of retracted nasal bones indicating the presence of a tapir-like trunk (Bartholomai 1978). Unfortunately, the *Ngapakaldia*-like *Propalorchestes novaculacephalus* lacks these critical portions of anatomy, but preserves enough structure to indicate a closer affinity to *Palorchestes painei* Owen than does *N. tedfordi* and some functional attributes of the specimen imply specialization of the facial region. Its morphology also confirms Archer's (1984) suspicion that *N. tedfordi* is unlikely to have been ancestral to the palorchestids and it expresses a constellation of unique features that seem to enhance its distinction from the diprotodontids. There is a strong didelphoid character to the shape of the neurocranium of *Propalorchestes* in its extreme narrowness, marked postorbital and postsquamosal constrictions, lateral position of its ventral squamosoalisphenoid suture and well developed sagittal crest, in contrast to the low, broad, weakly-crested crania of most other mid-Miocene diprotodontids. Palorchestids have not previously been reported from the Bullock Creek local Fauna but in view of their presence in older and younger local faunas their occurrence at Bullock Creek was anticipated.

SYSTEMATICS

Family Palorchestidae Tate, 1948
Propalorchestes gen. nov.
Type species *P. novaculacephalus* sp. nov.

Diagnosis. Size of neurocranium intermediate between *Ngapakaldia tedfordi* and *Palorchestes painei*; narrower, higher than species of either genus; more constricted interorbitally and postsquamosally than *P. painei*, markedly more so than in *N. tedfordi;* sagittal crest longer, higher and more robust than in *N. tedfordi*; dorsal profile of cranium nearly straight in contrast to the convex profile of *N. tedfordi*; maximum cranial height at level of alisphenoid postoptic ala 94.5 mm; differs from *N. tedfordi* in having massive, long squamosal root at nearly a right angle to the lateral wall of braincase, similar in robustness and morphology to *P. painei*, depth of zygomatic arch 37.0 mm; zygomatic sulcus wider and deeper than either *P. painei* or *N. tedfordi*; longer squamosojugal suture, more closely paralleling the apparent plane of cranial base than in *N. tedfordi* or *P. painei*; zygoma less arched than in *P. painei*, similar to *N. tedfordi*. Temporal fossa of *Propalorchestes* considerably wider than in species of *Ngapakaldia* and *P. painei*; postglenoid process broad, with well developed sinus, more robust than in either *P. painei* or *N. tedfordi*; glenoid fossa in two distinct parts, flat and broad anteriorly, narrow, long and grooved posteriorly with conspicuous medial glenoid process developed on either side of the squamosoalisphenoid suture, similar to *P. painei* except for more lateral course of suture in *Propalorchestes*; epitympanic fenestra large but relatively smaller, than either *N. tedfordi* or *P. painei*; differs from *N. tedfordi* and *P. painei* in having an alisphenoid contribution to the floor of the middle ear. Features that align *Propalorchestes* with the palorchestids include the dorsolaterally extensive and ventrally invasive squamosal lamina, morphology of the pterygoid, alisphenoid and palatine remnants of the palate, the distinctive morphology of the glenoid fossa and zygomatic arch; large epitympanic fenestra and epitympanic sinus development and the presence of a narrow mastoid contribution to the external occipital wall. It is distinctive in having an alisphenoid tympanic wing contributing to the anteromesial third of the bulla, a well developed postglenoid process, narrower, higher cranium and deep supracondylar fossae on the occiput.

Derivation of name. pro (L) 'before' + *Palorchestes* (GK) 'old dancer', a genus of tapir-like marsupial = (latinized Greek) 'before *Palorchestes*.'

Propalorchestes novaculacephalus sp.nov.
(Figs 1-6)

Type material. HOLOTYPE - Northern Territory Museum (NTM) P8552-10, left and part of right side of neurocranium with most of the left zygomatic arch; partial endocranial fossa from which a latex endocast was prepared, also designated NTM P8552-10 (the endocast will be described in a separate contribution).

Diagnosis. (Compare with *Ngapakaldia tedfordi* and *N. bonythoni* Stirton) length of neurocranium from the anterodorsal lacrimal suture to the squamosal wall of the occiput 152.3 mm; maximum cranial height 94.5 mm, height of occiput from condylar remnant to supraoccipital 69.3 mm; estimated bizygomatic width 166.4 mm; interorbital width 28.0 mm; temporal fossa width 55.0 mm; shape of occiput triangular with height to width proportion of 1:1.5; narrow, deep cranial base, large pterygoid fossae, broad condylar sulcus; deeply scarred, rugose occiput for attachment of nuchal musculature; major foramina of large dimensions; well developed infratemporal crest consisting of irregular-shaped bony protuberances; stout, long posterolaterally directed postoptic ala of alisphenoid defining posterior position of narrow, possibly convergent molar alveolus; extensive endocranial sinuses resulting in inner and outer braincase walls; endocranium with minimal flexion, long, low and broad. Overall size closer to that of *N. tedfordi* than to *Palorchestes painei* but expressing substantially different dimensions in interorbital width, bizygomatic width and height to width proportions of the occiput.

Type locality and age. Camfield Beds, described by Plane and Gatehouse (1968) as "16 miles Southeast of Camfield Homestead in the north central Northern Territory." The Camfield Beds consist of light-coloured calcareous sandstone, siltstone and limestone with basal ferruginization and silicification at

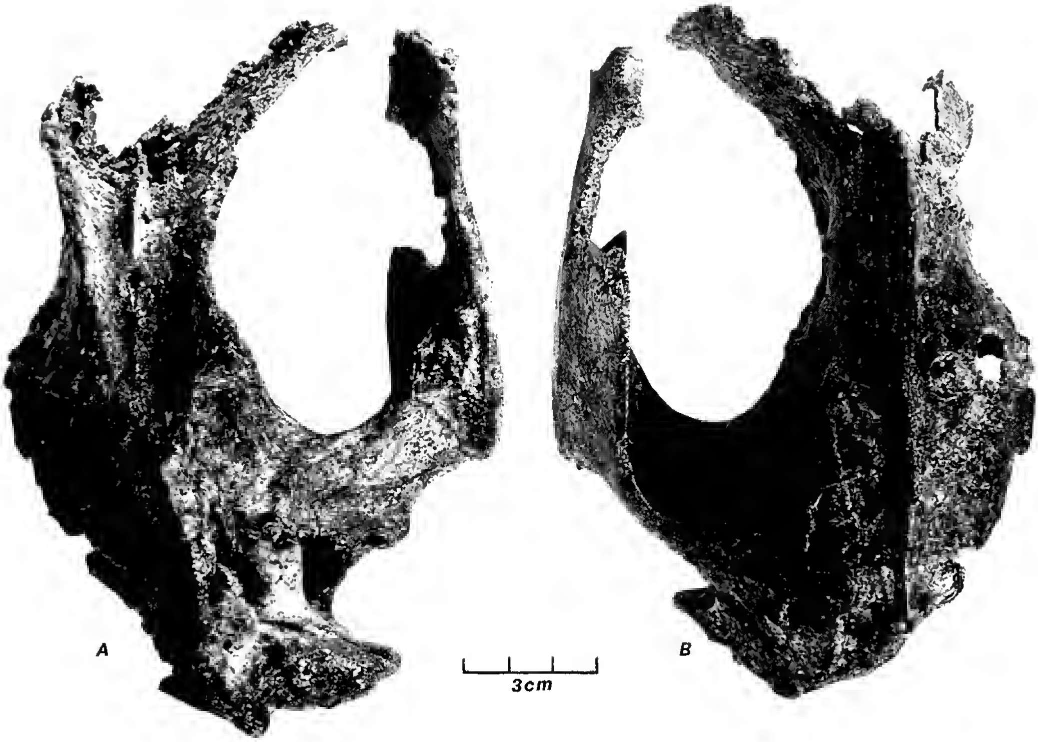


Fig. 1. *Propalorchestes novaculacephalus* holotype: **A**, ventral aspect, note warping of the frontal orbital walls to the left; long, stout but low sagittal crest and punctures in the braincase, some of which closely match the shape of crocodile teeth; **B**, dorsal aspect.

the top. P8552-10 was acid extracted from a single limestone boulder collected among rubble from previous excavations in an area known informally as the 'Top Site'. The base of the cranium was encased in a band of distinctive ferruginized silicious material of which no other samples could be located in the immediate area. Age — ? middle Miocene. Fauna — Bullock Creek

Derivation of name. novaeula (L) 'razor' + kephali (GK) 'head' = (latinized Greek) 'razorhead' with reference to its narrow braincase and long sagittal crest.

Description of external braincase. The braincase of P8552-10 is long and narrow, constricted in the ventral postorbital region to 28.0 mm wide relative to an estimated length of 152.3 mm from the anterodorsal lacrimal suture to the posterior surface of the mastoid (Fig. 1). Its width, estimated from the midline to the lateral surface of the squamosal immediately anterior to the glenoid fossa is 83.2 mm x 2 = 166.4 mm. A prominent sagittal crest 3.0 mm to 6.0 mm thick and 4.0 mm to 8.0 mm high extends from the occiput to the commencement of the frontal expansion. The crest is highest and thickest in the anterior third of the cranium, corresponding to the area of its greatest overall depth. The cranium is crushed, possibly slightly compressed anterolaterally and the orbital walls are warped to the left about 10°-15°. In addition to numerous cracks and crushed areas, the upper half of the cranial vault is marked by a number of large, oval punctures that match the sectional shape of crocodile teeth recovered from the Camfield Beds. In lateral view the broad, gently curving zygoma is confined to the lower half of the cranial profile (Fig. 2). The squamosal process expands dorsoventrally from a robust, rounded crest arcing inferiorly to meet the anterodorsal jugal process which includes a 16.0 mm long portion of the lateral orbital margin. The squamosojugal suture is straight and runs parallel to the apparent horizontal plane of the cranial base. The masseteric crest is

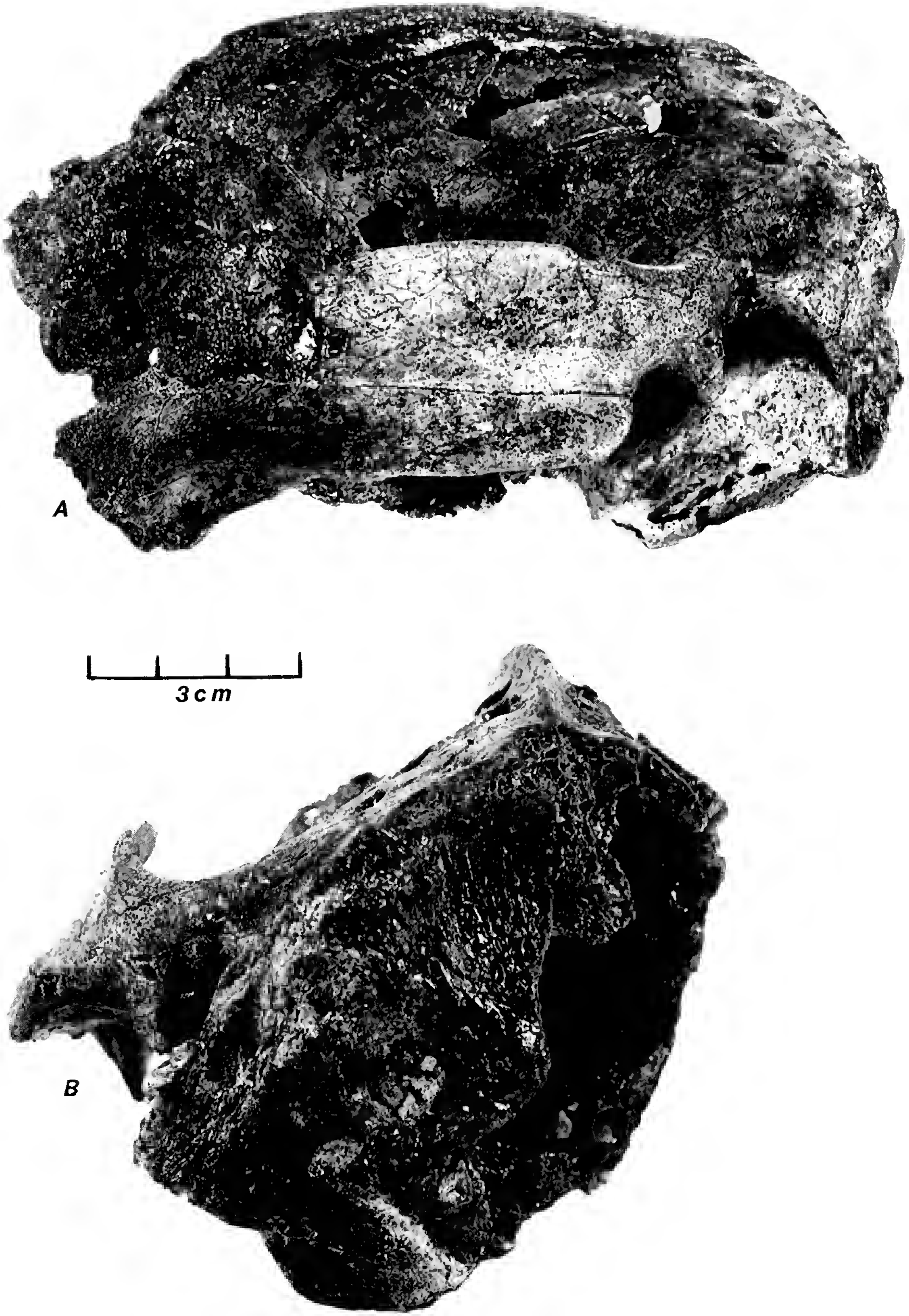


Fig. 2. *Propalorchestes novaculacephalus* holotype: **A**, lateral aspect; **B**, posterior aspect.

deepest and widest on the anterior third of the portion of jugal process present. The inferior border of the jugal is irregular and rounded on its narrow posterior margin, becoming thin and broad anteriorly. There is no evidence of a suture at the point of separation of the jugal from its missing counterpart. The width of the jugal and squamosal at 25.0 mm anterior to the jugal border of the glenoid fossa is 37.0 mm. The squamous process of the zygoma is triangular in section, measuring 30.0 mm anteroposteriorly at its base. In lateral profile, the glenoid fossa is a 23.5 mm wide notch opening obliquely posterolaterally. The length of the entire fossa, from its mesial margin half way down the medial glenoid process, to its lateral margin defined by a fine ventral crest on the jugal, is 42.0 mm. The fossa is composed of two distinct functional surfaces. The anterior surface is a shallow, oval concavity developed on a broad, low crest that becomes gradually narrower and more rounded mesially and makes a smooth, tight turn posteriorly to form the medial glenoid process. The hollowed-out, oval portion of the anterior glenoid cavity continues across the ventral squamosojugal suture and terminates in a rounded depression that occupies the entire width of the ventral surface of the jugal articulation. It is bounded anteriorly by a complexly roughened surface and a prominent torus that projects into the temporal fossa from its anteromesial edge. The ventral crest of the jugal forms its lateral boundary (Fig. 3).

The posterior glenoid concavity is a deep (3.0-4.0 mm) narrow (6.0 mm) and long (30.0 mm) groove bounded mesially by the medial glenoid process and open laterally, posterior to the preglenoid process of the jugal. Anteriorly, it is separated from the shallower articular surface by a pair of fine parallel crests that define a gently arcing, elongated transitional surface. Both articular surfaces show textural differences from the surrounding bone; the posterior groove having oblique anteroposteriorly trending striations and the anterior oval fossa having circular and oblique lines. The presence of glenoid cavity wear is a function of aging. The postglenoid process is low, broad and long. The posterior portion and crest is broken, possibly because it was fused to the missing ectotympanic. The lateral margin is 8.2 mm thick anteroposteriorly at its base and extended about 10.0 mm below the posterior glenoid surface. Its mediolateral extent is about 27.0 mm. The enormous size and clearly defined two phase functional aspect of the glenoid region is a distinctive feature of P8552-10, which will emerge in the discussion.

Propalorchestes cranial suture lines are badly obscured by fusion and by numerous cracks, depression fractures, tooth punctures and essential Bedacryl infilling for support (Fig. 4a). What can be discerned is sufficient to indicate a similarity of P8552-10 to *N. tedfordi* in having narrow, long parietals, enormously expanded squamosals and a ventrally disposed dorsal alisphenoid suture. In areal extent, the squamosal comprises about half of the braincase, extending dorsally to within 12.0 mm of the sagittal crest, 17.0 mm anterior to a line drawn vertically through the opening of the sphenorbital fissure and ventrally to comprise two-thirds of the tympanic bulla. Its vertical height from a point anterior to the glenoid fossa to the parietosquamosal suture is about 50.0 mm. Its length from the posterior squamosal crest on the occiput to its anterior parietosquamosal suture is 84.0 mm. The squamosoalisphenoid suture runs in a straight line from the medial glenoid process to the ventral infratemporal crest where it is no longer visible. Presumably it ascends the cranial wall in an arc, making a narrow contact with the long, narrow parietal wing thus separating the squamosal from the frontal. The parietal is clearly defined posteriorly, becoming lost in a depressed fracture until it reappears on the anterodorsal margin of the squamosal. The parietal is broadest at this point, but narrows into a wing where again, the sutures are lost among holes and cracks. It extends approximately 45.0 mm below the top of the sagittal crest at its inferior junction with the alisphenoid. The orbitosphenoid suture is entirely obliterated dorsally. The palatoalisphenoid suture is visible immediately inferior to foramen rotundum. Its posterodorsal contact with the orbitosphenoid is also visible but it cannot be traced anterior to the level of the ethmoidal foramen and its grooved continuation of the sphenorbital fissure. The palatine fragment retains the dorsal half of the sphenopalatine foramen, measuring 6.5 mm x 3.9 mm. The sphenopalatine foramen lies close to the

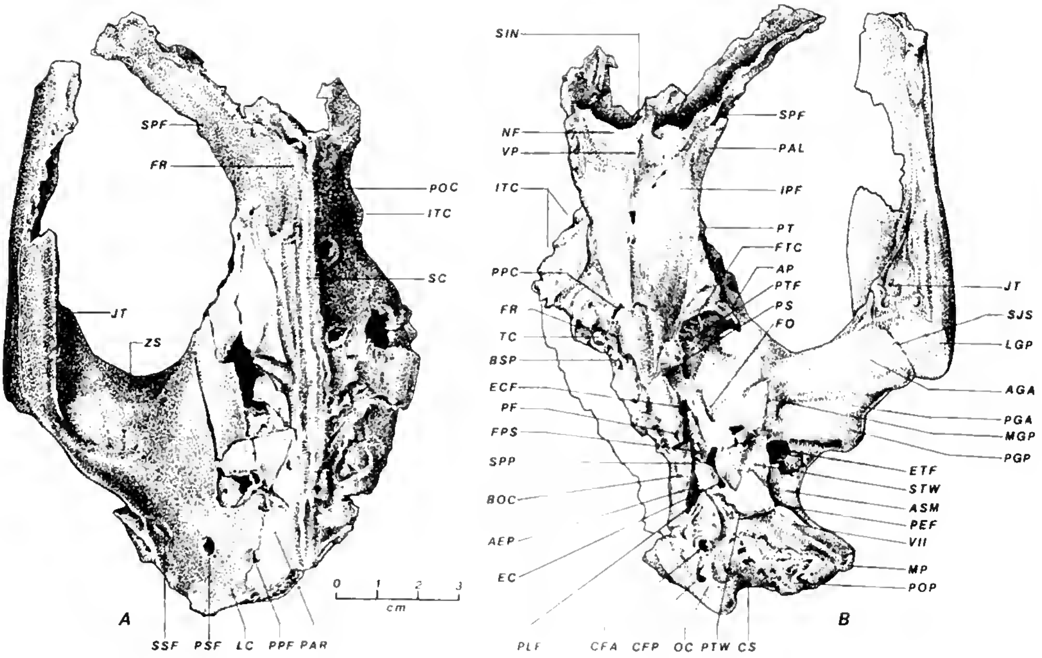


Fig. 3. *Propalorchestes novaculacephalus* holotype: **A**, structures in dorsal aspect; **B**, structures in lateral aspect. Abbreviations: **AEP**, posterior entocarotid artery; **AGA**, anterior glenoid articulation; **AP**, alisphenoid process; **ASM**, auditory superficial meatus; **BSP**, basisphenoid; **BOC**, basioccipital; **CFA**, anterior condylar foramen; **CEP**, posterior condylar foramen; **CS**, condylar sulcus; **EC**, eustacian canal; **ECF**, (anterior) entocarotid foramen, **ETF**, epitympanic fenestra; **FO**, foramen ovale; **FPS**, Foramen pseudovale **FR**, foramen; rotundum; **FTC**, foramen of transverse canal; **IPF**, interpterygoid fossa; **ITC**, infratemporal crest; **JT**, jugal tuberosity; **LGP**, lateral glenoid process; **LC**, lambdoid crest; MGP, medial genoid process; MP, mastoid process; **NF**, narial fossa; **OC**, occipital condyle base; **PAL**, palatine bone; **PAR**, parietal bone; **PEF**; posterior epitympanic fossa; **PF**; pterygopalatine foramen; **PGA**, posterior glenoid articulation; **PGP**, postglenoid process; **PLF**, posterior lacerate foramen; **POC**, postorbital constriction; **POP**, paroccipital process; **PPC**, pterygopalatine canal; **PPF**, posterior parietal foramen; **PT**, pterygoid bone; **PTF**, pterygoid fossa; **PTW**, petrous periotic tympanic wing; **PSF**, postsquamosal foramen; **SC**, sagittal crest; **SIN**, septum internal nares; **SJS**, squamosojugal suture; **SPF**, sphenopalatine foramen; **SPP**, superior periotic process; **SSF**, subsquamosal foramen; **VII**, groove for facial nerve; **VP**, vomerine process; **ZS**, zygomatic sulcus.

sphenorbital opening (40.0 mm anteriorly) the latter extending anteriorly as a 30.0 mm long, 8.0 mm deep, complex groove, 8.0 to 10.0 mm wide. Foramen rotundum is immediately posterolateral to the confluent anterior lacerate and optic foramina. The opening of the sphenorbital fissure is large, (10.0 x 6.0 mm). Foramen rotundum is approximately half the size of the former (5.5 x 4.0 mm).

The alisphenoid is produced into a stout (16.0 mm long) ventrolaterally flared pillar behind the sphenorbital and rotundum foramina which separates them from a deep, oval pterygoid fossa 17.5 x 11.0 mm in size. In contrast to most living diprotodontans, there is no abrupt transition to a horizontal shelf that defines the ventrolateral extension of the pterygoid and palatine bones for the alveolus of the molar row. The remnant palatine and alisphenoid processes of P8552-10 develop a smooth ventrolaterally curving surface, confluent anteriorly with the mesial orbital wall. The development of a long, stout ventrally disposed postoptic alisphenoid process is characteristic of diprotodontans, as it relates structually to the posteromesial position of the molar row. This structural configuration is absent in Australian marsupicarnivora, with the exception of peramelids which have an incipient development of it. In P8552-10 specific features of its configuration can be seen in *Ngapakaldia* and *Palorchestes painei*, in the exaggerated lateral flare of the alisphenoid process and pterygoids and the smooth, concave transition to the palatine alveolus, in contrast to the development of a prominent shelf-like suborbital process, clearly inscribed with a groove for the infraorbital nerve as found in phalangeroids, macropodids and diprotodontids.

The lacrimal-frontal contact cannot be discerned, although a possible lacrimopalatine suture extends inwards a few millimetres from the broken edge of the orbital wall. Dorsally, the frontal bone is entirely missing from the area normally occupied by the frontal depression. A low, oval boss near the superior margin of the break probably represents the supraorbital eminence. Warping and distortion makes some difficulty of the correct interpretation of the anteriormost extension of the sagittal crest and the commencement of its bifurcation into temporal lines. I suspect that the anterior portion is laterally compressed somewhat and that the temporal crests have been adpressed and warped to the left side of the cranium. The extreme narrowness at the postorbital contriction however, is unaffected as indicated by the absence of distortion in the thin horizontal septum that forms the roof of the inner braincase.

The back of the braincase is relatively narrow and subtriangular (Figs. 2b, 4c). The

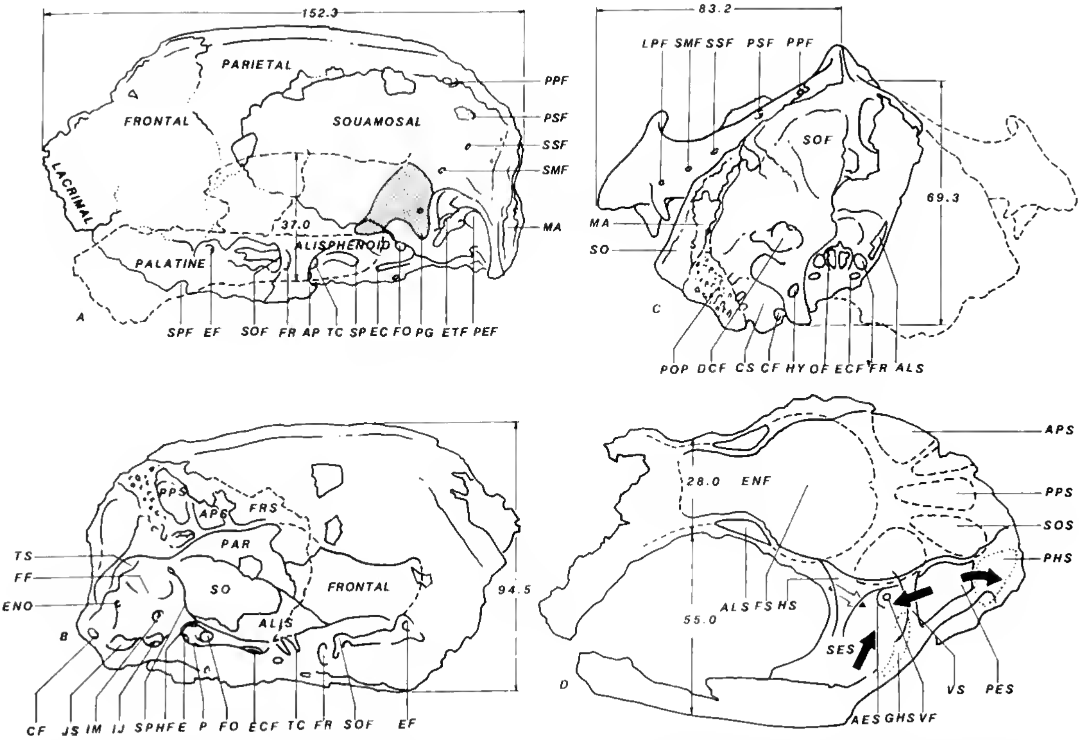


Fig. 4. *Propalorchestes novaculacephalus* holotype, lateral aspect, showing probable sutural contacts of bones of the cranial vault: **A**, solid lines represent reasonably clear sutures, stipple indicates possible sutures; **B**, endocranial sutures, frontoparietal suture is posterior to the missing area; **C**, Posterior aspect showing the narrow strip of mastoid bone interposed between the squamosal laterally and the basioccipital mesially; **D**, Auditory and non-auditory sinuses shown in dorsal aspect. Epitympanic sinuses are depicted as solid lines; dotted lines are non-auditory sinuses surrounding the inner brain case. Abbreviations: **AES**, anterior epitympanic sinus; **ALS**, anterolateral sinus; **AP**, alisphenoid process; **APS**, anterior parietal sinus; **CF**, condylar foramen; **CS**, condylar sulcus; **DCF**, doral condylar fossa; **E**, entocarotid (posterior); **EC**, **ECF**, entocarotid foramen; **EF**, ethmoid foramen; **END**, endolymphatic canal; **ENF**, endocranial fossa; **ETF**, epitympanic fenestra; *FF*, floccular fossa; **FO**, foramen ovale; **FS**, **FRS**, frontal sinus; **FR**, frontal bone; **GHS**, glenoid hypotympanic sinus; **HF**, facial nerve hiatus; **HS**, horizontal septum (squamosal); **HY**, hypoglossal or condylar foramen; **IJ**, internal jugular foramen; **IM**, internal auditory meatus; **JS**, jugular sinus; **LPF**, lateral postglenoid foramen; **MA**, mastoid; **OF**, optic foramen; **PEF**, posterior epitympanic fossa (squamosal); **PES**, posterior epitympanic sinus; **PG**, postglenoid process; **PHS**, posterior hypotympanic sinus (mastoid-squamosal); **POP**, paroccipital process; **PPF**, posterior parietal foramen; **PPS**, posterior parietal sinus; **PS**, pseudovale foramen; **PSF**, postsquamosal foramen; **RF**, foramen rotundum; **SES**, squamosal epitympanic sinus; **SMF**, suprameatal foramen; **SP**, sulcus in pterygoid fossa; **SPF**, sphenopalatine foramen; **SOF**, suboccipital fossa; **SOS**, supraoccipital sinus; **TC**, foramen transverse canal; **TS**, transverse sinus; **VF**, venous foramen; **VS**, vertical septum.

supraoccipital and/or postparietal apex is damaged. A low lambdoidal crest extends from the inferolateral squamosal to the sagittal crest where it undoubedly formed a prominent overhang in the midline. Situated a few millimetres anterior to the lamdoidal crest is a row of small, equidistantly spaced emissary foramina (sub-squamosal, postzygomatic ff., etc.) that connect with the intracranial venous sinuses. The outline of the 'occiput' is higher and narrower than that of *Ngapakaldia*, but shares with it and *Palorchestes painei*, a narrow mastoid interposition between the squamosal and the exoccipital. Immediately dorsal to the occipital condyle is a large, deep (9.0 mm) conical pit, containing on its medial aspect, an emissary foramen. Ventral to it is a deep, wide condylar sulcus encompassing a pair of condylar foramina on its medial border. The distal portion of the mastoid is broken but sufficiently preserved to indicate a wing-like transverse projection as in *Palorchestes painei*. The missing paroccipital process has a broad triangular base. Above the foramen magnum is a deep fossa for the *rectus capitus dorsalis* muscle bordered inferolaterally by a conspicuous crest that forms the mesial side of an elongated, deep, irregular crescent-shaped muscle scar that occupies the area invaded by the mastoid interpositus. The sutures are wandering and irregular in relation to its rugose surface.

Description of endocranial fossa.

Non-Auditory Sinuses: The dorsolateral relations of the thin walled inner braincase consist of a series of large sinuses and their septa (Fig. 4d). Anterodorsally, commencing from paired concave septa developed just posterior to the area of the internal coronal suture, a large frontal sinus extends anterior to the cribiform plate. The frontal sinus appears to be continuous with the narial fossa, but may have had partial transverse and vertical septa with vacuolated bony infilling. The sinus is approximately 35.0 mm high dorsoventrally and continues laterally into the alisphenoid and squamosal on the ventrolateral side. The septa separating the frontal sinus from the much smaller paired parietal sinuses form a robust bulkhead-like supporting wall over the widest part of the inner braincase. The parietal sinuses appear to have been continuous and form an arcing tunnel over the dorsoposterior part of the inner braincase. The smaller pair of lozenge-shaped parietal sinuses are located dorsal to the cerebellar chamber. These sinuses trend obliquely posteroventrally into the squamosal region and may represent dorsal continuation of the epitympanic sinuses. Grooves and small foramina perforate the floor and septa of the sinuses. These transmit small emissary vessels that conduct venous blood to larger channels emerging in the row of foramina that perforate the outer cranial wall (post squamosal, post zygomatic ff). The anterodorsal wall of the inner braincase is very thin (1.0-1.5 mm.) where it ascends over the frontoparietal lobes of the brain. Anterolaterally, the roof of the inner braincase makes contact with the outer wall forming a transverse roof of bone over the olfactory-prefrontal region that continues anteriorly to the cribiform plate. A pair of lateral sinuses are developed between the outer wall of the orbitosphenoid-alisphenoid and frontal contributions to the orbit and the olfactory tubercle and bulbar region of the inner braincase. Approximately one third of the neurocranium surrounding the endocranium is therefore hollow or partially filled with thin inflated bony processes. Extensive sinus development is present in the much larger zygomaturine and diprotodontine diprotodontoids.

In Bullock Creek *Neohelos* Stirton and related forms, the frontal and parietal sinuses are divided into cells that curve around the braincase. The interparietals and supraoccipital are similarly inflated so that the back of the brain case is essentially double walled. Among dasyuroids only *Thylacinus* Temminck and *Sarcophilus* Cuvier show an extensive anterolateral invasion of the anterior epitympanic sinus, though this double-walled condition is present in the form of shallower invaginations in all of the larger dasyurids. The development of an extensive sinus system in the larger marsupials is directly related to negative allometry of the brain. With increased body size, a greater area for the attachment of the muscles of mastication is required. In most diprotodontids the width of the braincase is greatly increased over the actual width of its proportionally small brain. In P8552-10, the increase is principally in the height of the external braincase to serve as attachment area for large temporalis muscles and is possibly related to a specialized rostrum. Its didelphoid-like shape may therefore be a secondary attribute relating to temporalis muscle emphasis. More parsimonious is a condition in which the temporalis function has been retained in *Propalorchestes*; representing a functional transistion in retaining approximately equal masseter and temporalis contributions.

Endocranial sutures: The endocranial sutures are difficult to follow throughout their course, becoming lost in a maze of cracks in the critical area of juncture dorsolateral to the middle cranial fossa (Fig. 4b). Because of the wide separation between the double walls of the braincase, the relationships of the inner and outer representations of the neurocranial lamina are difficult to interpret. However, the septa of the sinuses that connect the walls of the inner and outer braincase could provide an indication of their origin. By this criterion, the internal representation of the squamosal is sufficiently large to make contact with the frontal as in peramelids and thylacinids. The extreme alternative is that the squamosal makes no contribution at all to the inner wall of the endocranial fossa in which case there is a broad parietofrontal contact, and only a small triangular area where the squamosal keys into posterior alisphenoid and parietal sutures.

I discern that while the squamosal is indeed represented and is reasonably large, it is interposed from the frontal by a narrow anteroinferior projection of the parietal. The internal suture pattern of P8552-10 is interpreted in the following manner: the alisphenoid suture runs obliquely posterolaterally for 15.0 mm then due posteriorly for 6.0 mm. It then descends obliquely inferiorly across the temporal fossa to the superior petrosal ridge where it disappears behind the petrous periotic bone. Dorsally, the squamosal forms the posterior half of the temporal fossa, its anterodorsal extent bounded by a suture about 25.0 mm long trending across the top of the temporal fossa where it continues to ascend dorsally, immediately superior to the petrous periotic and into the superior cerebellar fossa. The coronal suture defines the anterior margin of the parietal which descends towards the alisphenoid intercranial wing in the form of a gently curved, narrow triangular process of the parietal.

The endocranial suture pattern of P8552-10 is very similar to that of *Didelphis virginiana* Linnaeus lacking a palorchestid for comparison, except that the coronal suture is situated more posteriorly, relative to the length of the braincase, indicating a greater contribution to the walls of the endocranial fossa by the frontal. The parietoalisphenoid contact is also much narrower than that of *Didelphis* Linnaeus. P8552-10 differs from the perameloid condition only in that a narrow spur of parietal interposes the anterior edge of the squamosal at the suture junctions. It is therefore structurally intermediate between the two.

Structures within the cranial fossa: The cerebellar fossa contains a pair of dorsal concavities at the midline for the vermis posteriorly and the confluence of the sagittal and transverse sinuses anteriorly. A deeply invaginated, narrow, lateral fossa accomodates the left transverse sinus and posterior portion of the cerebellar hemispheres. The thin dorsal lamina of the petrous periotic is partially missing but the entire structure is triangular in shape. The internal auditory meatus is small compared to the floccular fossa — a size related feature. It has a notch and foramen situated posterior to the internal auditory meatus for the orifice of the endolymphatic duct. Inferoposteriorly, a larger notch represents the internal orifice of the posterior lacerate foramen which continues inferolaterally into a short, longitudinally divided sinuous canal confluent with the internal opening of the internal jugular canal, for which a shallow anteroinferior notch is provided in the petrous periotic. The anterior edge of the petrous periotic apparently followed the course of the superior petrosal ridge, overlying on its squared-off, anteroinferior margin, the canal for the hiatus in the facial nerve. The concavity in the petrous bone, apparently related to this structure, is poorly developed and the margin is thick. Inferiorly there is a remnant of a long, spurlike process. The superior petrosal ridge is very prominent and sharp in P8552-10 in relation to the deep trough for foramen ovale posteriorly and foramen rotundum anteriorly. The internal fossa for foramen ovale is a large, deep tear-shaped structure 10.5 mm wide, but the actual nerve orifice is perfectly round, 5.0 mm wide and directed inferolaterally towards the mandibular foramen and muscles of mastication. In the posterior extremity of the foramen ovale fossa, a small foramen pierces the floor immediately anterior to the petrous periotic. Inferior to foramen ovale, a pair of small foramina, separated from foramen ovale by a thin lamination of alisphenoid, open posteriorly into foramen pseudovale and inferoanteriorly into the roof of the canal for the internal carotid artery. Anterior to foramen ovale, a deep, wide trough about 20.0 mm long narrows to a round, anteriorly directed internal canal for foramen rotundum. The foramen rotundum canal is very long (17.5 mm) and practically horizontal. Medial to foramen rotundum internal orifice is the large, deep oval internal carotid foramen. This structure is approximately 8.0 mm maximum diameter. Posteriorly, the canal leads to a long, straight canal of approximately 14.0 mm length before reaching its external orifice. Anteriorly, a small foramen opens into the tranverse sinus canal in the basisphenoid. The internal opening of the sphenorbital fissure commences anterior to the foramen rotundum canal. It is a widely confluent, triangular structure occupying the midline. A separate, partially enclosed canal for the ophthalmic nerve lies dorsolateral to the much larger optic-ophthalmic neurovascular

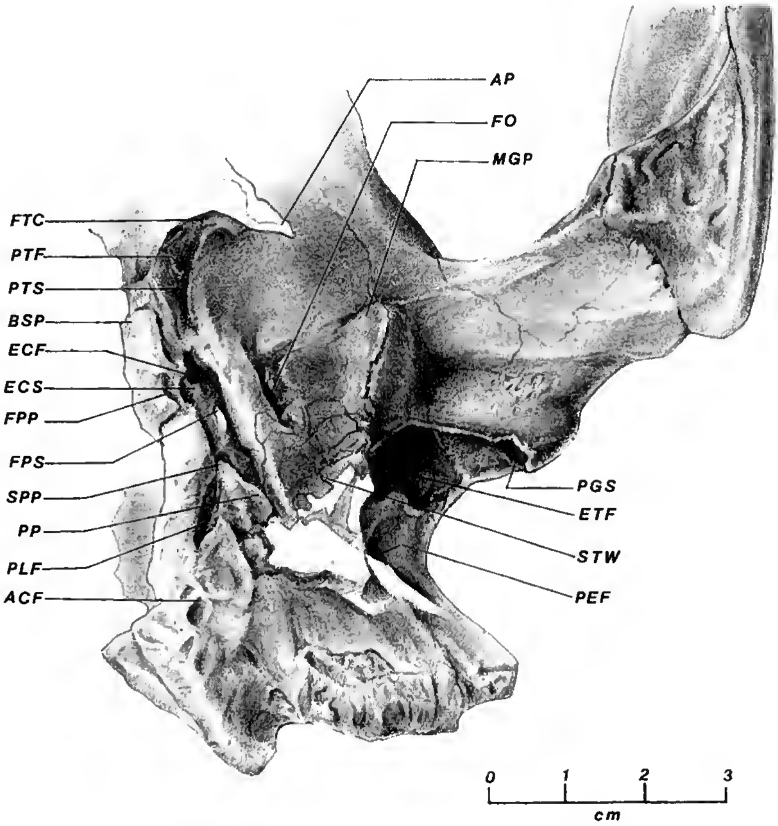


Fig. 5. *Propalorchestes novaculacephalus* holotype, ventral aspect of the auditory region. Abbreviations: **ACF**, anterior condylar foramen; **AEP**, posterior entorcarotid artery; **AP**, alisphenoid process; **ECT**, ectotympanic (remnants); **ECS**, entocarotid (anterior) sulcus and foramen; **ETF**, epitympanic fenestra; **FO**, foramen ovale; **FPS**, foramen pseudovale; **FR**, fenestra rotundum; **FTC**, foramen transverse canal; **LPF**, lateral postglenoid foramen; **MGP**, medial glenoid process; **OF**, fenestra ovalis; **PF**, **P**, pterygopalatine foramen; **PEF**, posterior epitympanic fossa (squamosal); **PF**, pterygoid fossa; **PGS**, postglenoid (glenoid hypotympostsquamosal foramen; **PTF**, pterygoid fossa; **PTS**, pterygoid sulcus; **SAS**, squamosoalisphenoid suture; **SC**, sagittal crest; **SMF**, suprameatal foramen; **SPP**, superior periotic process; **STW**, squamosal tympanic wing; **TC**, tympanic cavity; **TTY**, tegmen tympani; **VII**, groove facial nerve.

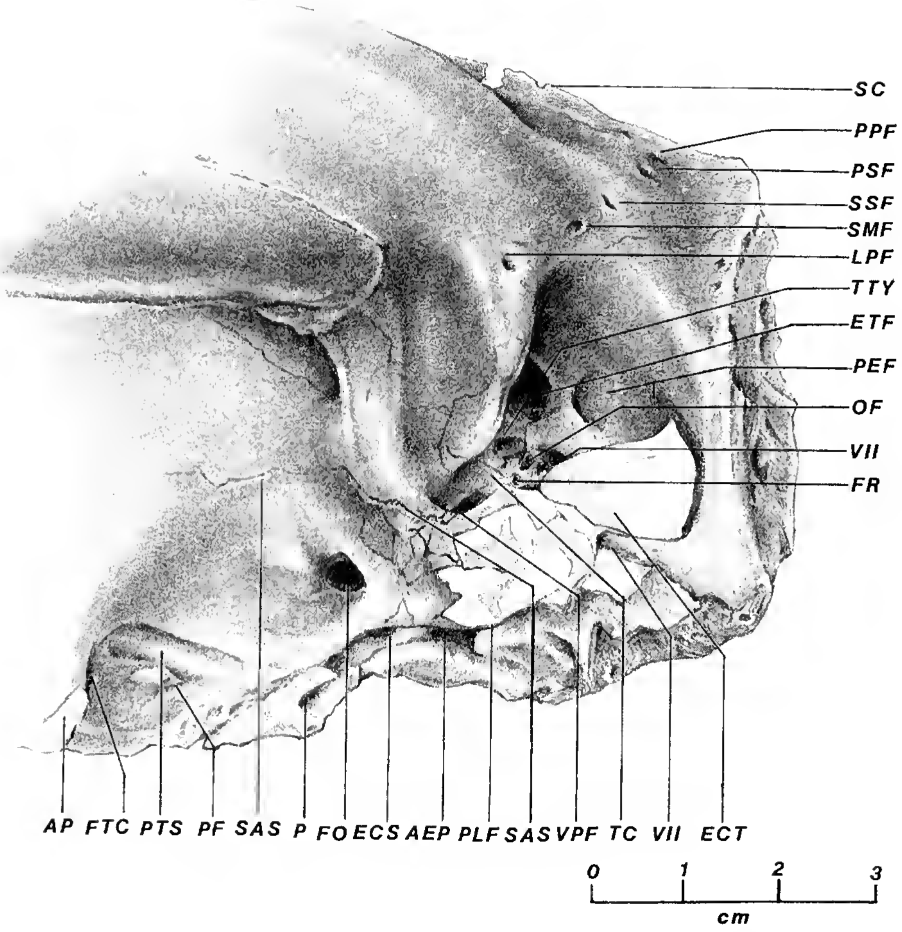


Fig. 6. *Propalorchestes novaculacephalus* holotype, ventrolateral aspect of the auditory region. Abbreviations: **ACF**, anterior condylar foramen; **AEP**, posterior entorcarotid artery; **AP**, alisphenoid process; **ECT**, ectotympanic (remnants); **ECS**, entocarotid (anterior) sulcus and foramen; **ETF**, epitympanic fenestra; **FO**, foramen ovale; **FPS**, foramen pseudovale; **FR**, fenestra rotundum; **FTC**, foramen transverse canal; **LPF**, lateral postglenoid foramen; **MGP**, medial glenoid process; **OF**, fenestra ovalis; **PF**, **P**, pterygopalatine foramen; **PEF**, posterior epitympanic fossa (squamosal); **PF**, pterygoid fossa; **PGS**, postglenoid (glenoid hypotympostsquamosal foramen; **PTF**, pterygoid fossa; **PTS**, pterygoid sulcus; **SAS**, squamosoalisphenoid suture; **SC**, sagittal crest; **SMF**, suprameatal foramen; **SPP**, superior periotic process; **STW**, squamosal tympanic wing; **TC**, tympanic cavity; **TTY**, tegmen tympani; **VII**, groove facial nerve.

orifice. The canal of the sphenorbital fissure is 19.5 mm long on the right side, where it can be measured accurately. The internal sphenorbital fissures and the internal carotid foramina lie in a broad, boat-shaped, 18.0 mm wide basin bounded posteriorly by a smooth crest, anteriorly by a midline septum and dorsolaterally by the walls of the trough that steepen and increase in height anteriorly. Sella turcica (pituitary fossa) is represented by a shallow depression formed between the right and left internal carotid orifices. The posterior portion of the basisphenoid has a pair of deep longitudinal canals. These seem rather too far posterior to be the transverse sinus canals. However, they could be connected with the internal jugular and therefore may be a continuation of the venous sinus system.

Description of Cranial base.

Morphology of the cranial base: P8552-10 has a narrow, deep cranial base (Figs 3b, 5, 6). Its minimum width is at the opening of the sphenorbital fissure where the cranium is a mere 9.0 mm wide. The ventral surface extending posteriorly from the presphenoid to the basioccipital describes a pair of diverging arcs, the convexities of which are most closely approximated in the middle of the basisphenoid about 15.0 mm posterior to the openings of the canals for the transverse sinus. Associated with this constriction are well developed ventral crests that are composed of the alisphenoids laterally and the pterygoids medially, through which passes the canal for the pterygopalatine nerve. The presphenoid-basisphenoid suture is entirely overlapped by the pterygoids which convege at the midline in a low crest.

Anteriorly, the vomer is represented by a thin blade-like process that separates the roof of the internal nares and may have made contact with the midline of the palate. Deep choanal fossae are developed on either side of the palatovomerine septum. The floor of the orbital region is a broad, convex surface that abruptly terminates posteriorly about 10.0 mm behind foraman rotundum in a stout pillar of bone that flares laterally towards the glenoid fossa. This structure indicates the posterior extension of a long posterior palatine process and posteriorly forms the anterior wall of a deep pterygoid fossa. Its broken ventral surface indicates that a thin lamina of pterygoid formed a floor for the fossa and probably continued posterolaterally in the form of a crest that reached the tympanic wing on its anteromedial surface, ventral to foramen ovale. It seems unlikely that the pterygoid alae flared laterally much more than what is represented on the fossil. A similar buttressing of the postoptic - postpalatine region is present among diprotodontids and macropodids where it forms the posterior margin of the alveolar shelf. As noted, *Propalorchestes* and *Palorchestes painei* are synapomorphic in the morphological detailing of this region. The pterygoid fossa contains two foramina, both of which enter the transverse canal in the basisphenoid. Posterior to the larger of the two foramina is a deep, wide sulcus of approximately the same diameter as the foramen. The sulcus ends posteriorly on a ventrally disposed crest of the alisphenoid which forms the lateral margin of the internal carotid canal and foramen medially and the floor of the large, round foramen ovale laterally. It continues to the alisphenoid portion of the tympanic wing of which it is a part, the crest forming the lateral wall of foramen pseudovale. The medial and lateral walls and floor of the internal carotid canal and margin of the foramen are damaged, the actual extent of the canal, as opposed to the foramen, being difficult to determine. It is likely that the canal lay in a sulcus confluent with foramen pseudovale and was partially roofed by a crest arising from the pterygoid and basisphenoid, continuing posteriorly as the alisphenoid. The actual orifice of the internal carotid foramen was probably an elongated oval shape. A posterior entocarotid canal cannot be readily differentiated from the large, elliptical posterior lacerate foramen that opens immediately mesial to the petrous periotic. Except for a low crest on the latter, partially dividing the foramen, there is no other indication of its presence.

The basisphenoid-basioccipital suture is located immediately posterior to the internal carotid foramen. In a bilateral restoration, a narrow trapezoidal shape of the bone is indicated, with a lateral expansion between the posterior lacerate foramen and the entocarotid foramen. Both the basisphenoid and the basioccipital surfaces extend a considerable distance inferior to these openings — that is — they are situated well within the lateral margins of the posterior basicranial axis rather than developed level with the ventral surface of the cranial base. This is a reflection of a pronounced posteroventral convexity of the basisphenoid. Paired condylar foramina (condylar and hypoglossal ff.) pierce the basioccipital a short distance posterior to the posterior lacerate and internal jugular foramina. They lie in a wide, shallow sulcus between the broken process for the occipital condyles medially and the damaged base of the paroccipital and mastoid processes laterally.

Auditory Region: A general feature of the tympanic region of P8552-10 is its mesial confinement, as though crowded towards the basisphenoid suture by the wide and invasive squamosal root with its enormous glenoid fossa and correspondingly broad postglenoid process (Figs 5, 6). The auditory region is damaged and partially obscured by siliceous matrix, although its basic morphology can be appraised. The tympanic wing of the auditory bulla is predominately derived from the

Table I. Raw comparison of character states of 38 structures of the neurocranium of *Propalorchestes novaculacephalus* (P8552-10) with various diprotodontan taxa based on a subjective rating of the expression of a morphocline from O = absent to 5 = highly developed.

	Phalangeroids	*Macropodoids*	*Vombatids*	*Thylacoleonids*	*Phascolarctids*	*Zygomaturines*	*Diprotodontines*	*Palorchestids*	*Wynyardiids*	*P8552-10*
Parietal width	5	4	2	5	3	2	1	1	3	1
Squamosal lamina	4	2	4	3	3	5	5	5	3	5
Squamosal tuberosity	4	2	4	1	3	5	5	5	3	5
Squamosal tympanic wing	0	0	3	3	5	5	4	3	3	3
Thickness tympanic bulla	2	4	3	3	4	3	4	1	—	1
Size tympanic bulla	5	1	1	1	5	2	2	2	2	2
Epitympanic fenestra	0	0	5	0	2	1	2	5	3	3
Posterior epitympanic fossa	1	1	3	2	2	1	2	4	1	4
Epitympanic sinuses	1	1	2	2	2	4	4	4	2	5
Non-auditory sinuses	0	0	1	0	0	5	5	5	0	5
Postglenoid process	4	1	0	4	5	4	2	1	3	4
Medial glenoid process	2	1	3	4	3	4	1	5	1	5
Lateral glenoid process	0	0	1	2	5	0	0	5	2	5
Complexity glenoid fossa	1	1	1	1	3	3	2	5	3	5
Postorbital constriction	2	4	3	2	2	4	1	5	5	5
Postglenoid constriction	2	4	3	2	2	4	1	5	5	5
Width neurocranium	4	2	4	4	4	3	3	3	2	1
Mastoid interpositus	0	0	5	5	0	0	3	4	—	3
Dorsal condylar fossa	0	0	2	2	2	2	2	—	—	5
Zygomatic curvature	2	3	2	4	2	3	4	5	2	3
Zygomatic width	3	4	3	4	3	3	5	5	3	5
Temporal fossa width	2	4	4	5	2	2	2	3	3	5
Sagittal crest	2	0	0	3	0	3	0	2	5	5
Lambdoid crest	2	2	2	5	2	1	1	3	4	5
Mastoid process	2	3	3	3	3	1	1	3	—	3
Paroccipital process	2	5	5	3	5	3	2	2	—	2
Everted inf. al. proc.	0	3	0	0	0	0	0	5	0	5
Infraorbital shelf	3	5	5	0	5	5	5	0	4	2
Vomerine septum	1	0	1	5	3	0	0	—	3	3
Narial fossa	0	0	1	5	2	0	2	—	3	5
Interpterygoid overlap	2	5	2	2	3	5	5	5	4	5
Pterygoid fossa	1	5	3	2	1	3	1	4	3	4
Pterygoid sulcus (c.t.s.)	0	5	3	2	1	3	1	4	3	4
Postglenoid arch	4	3	4	2	3	3	1	5	4	5
Entocarotid groove	0	0	5	0	0	5	1	3	2	3
Basisphenoid crest	0	0	5	2	3	2	1	3	1	3
Alisphenoid crest	0	0	5	0	0	3	3	4	4	5
Condylar Sulcus	0	0	2	0	0	5	3	5	—	5

squamosal. The squamosoalisphenoid suture is clearly visible as it traverses the crest of the medial glenoid process. It then becomes lost among cracks, but appears to trend obliquely posteromesially to encompass ½ to ⅔ of the bulla, depending on the original extent of the structure, as the original shape of the tympanic bulla cannot be determined due to damage. It was certainly small, subrectangular, perhaps and appears to have been incomplete or extremely thin walled posteriorly. A thin bony crest arising either from the mastoid or the petrous periotic may have formed its posterior wall. The oval epitympanic fenestra is exposed in the superficial meatus, its lateral wall interrupted by a break that exposes a deep tubular sinus within the postglenoid process. The posterolateral wall of the epitympanic fenestra measures approximately 12.0 mm x 16.5 mm. Its mesial wall is damaged. Posteromesially, a stout process of squamosal appears to have formed an arched lateral portion of the roof of the very confined tympanic cavity. It was continuous with or made contact with a horizontal process that extends posteriorly from a long, thin vertical septum that divides an enormous epitympanic sinus into an anterior and posterior portion (Fig. 4d). Its posteroinferior wall forms a wide facial sulcus, the nerve of which, although its course is interrupted by matrix and perhaps remnants of the ectotympanic, appears to pass out of the auditory region in a long, shallow groove in the anterolateral surface of the mastoid. The tympanic cavity is approximately 6.0 x 6.0 mm in diameter and extends mesially as a deep hollow dorsolateral to the scarcely visible lateral wall of the petrous bone. The small fenestra ovalis is visible in lateral view approximately 4.0 mm anteroventral to the facial foramen. Fenestra rotundum is located approximately 3.0 mm inferior to fenestra ovalis. *Propalorchestes* is therefore more like *N. tedfordi* than *Palorchestes painei* in having the sulcus facialis posterior to and on a level between the fenestrae. Also preserved is the rounded incudal fossa and a small bony spur which may represent the attachment of the suspensory ligament of the malleus. Immediately within the facial sulcus is a shallow groove that appears to have accommodated the tympanic. The tympanic and its absent membrane were therefore comparatively small structures.

The petrous periotic is exposed in a large, triangular depression bounded posteromedially by foramen lacerum posterior and the confluent posterior entocarotid canal; posteriorly by the mastoid wall; anteriorly by the long, wide entocarotid groove and its thin roof; anterolaterally by a narrow opening from above the tympanic wing that probably represents the eustacian canal. The superior periotic process makes contact with the basioccipital immediately posterior to its most lateral expansion. The promontorium is a broad, triangular dorsolateral expansion defined anterolaterally by a cleft above which fenestra rotundum is located. Fenestra rotundum is not visible in ventral aspect. Partially visible is a dorsolateral extension of the periotic that represents the tegman tympani. The ventral surface of the periotic is developed into a thick rounded crest that may contribute a wing to the posterior wall of the tympanic bulla. Dorsomedially, the petrous periotic wings over a short deep sinus, divided by a thin triangular process into a dorsal and ventral channel which is confluent posteriorly and terminates in a deep, round fossa with a foramen penetrating its roof; part of the system of channels representing the internal jugular-sigmoid and transverse sinus anastomoses. The anterodorsal portion may have accomodated an arterial branch from the posterior entocarotid. Nerves IX, X and XI must also traverse the posterior lacerate foramen, presumably along the course of the internal jugular vein.

The dorsal portion of the medial side of the internal petrous periotic is absent. There is a broad depression corresponding to the maximum depth but not the total circumference of the floccular fossa. The ventral half of the fossa is preserved indicating that it was a broad, shallow depression. The internal auditory meatus is developed with a broad, shallow, elliptical depression on the ventromedial surface of the petrous bone. A septum dividing the facial from the vestibuloacoustic nerve is located deep within the foramen. The posterior margin of the petrous is damaged in the area of the orifice of the endolymphatic duct. It appears to have a broad, shallow depression associated with it that extends anteriorly to the posterior margin of the internal meatus. The endocranial portion of the petrosal is approximately 20.5 mm long dorsoventrally and 18.5 mm wide, oriented perpendicularly and lies at an angle of approximately 6O° in the endocranial wall relative to the sagittal plane.

SUMMARY AND CONCLUSION

Propalorchestes novaculacephalus is slightly larger than *N. tedfordi* and slightly smaller than *Palorchestes painei*. The cranium is relatively narrower and higher overall than the species of either genus. The squamosal root is longer and more closely approximates a right angle in its slightly anterior and primarily lateral projection to the zygoma. Consequently, P8552-10 has a wider, narrower and deeper zygomatic sulcus than either genus. The squamosal zygoma is deeper than in these forms and the squamosojugal suture is longer than in *P. painei* and closer to paralleling the plane of the cranial base than it is in the species of either genus. The zygoma is less arched than in *P. painei*, approximating that of *N. tedfordi*. The temporal fossa of P8552-10 is much wider than in either genus. The maximum height of the cranium occurs far anterior to that of either *P. painei* or *N. tedfordi*. The dorsal profile of the cranium differs from that of species of both genera in being relatively straight rather than markedly convex at a vertical intersection with the postoptic ala of the alisphenoid. P8552-10 differs from *N. tedfordi* and *P. painei* in having a comparatively smaller epitympanic fenestra and a well-developed postglenoid process. In P8552-10 the fenestra ovalis is directly dorsal to the fenestra rotundum as in *N. tedfordi*. The facial foramen is posteriorly disposed and slightly dorsal to fenestra ovalis, thus differing from either *P. painei* or *N. tedfordi*. However, the sulcus facialis is posterior to and at a level intermediate to the two fenestrae as in *N. tedfordi*. P8552-10 has an irregularly shaped mastoid strip that ascends the external mastoid wall of the lateral occiput as in diprotodontids and vombatids. It differs from *N. tedfordi* and probably *P. painei* in having deep supracondylar fossae with a large emissary foramen (supracondylar f.) in its medial wall.

P8552-10 has a foramen ovale of large diameter bridged by an oblique crest of alisphenoid and deeply excavated on its mesial surface by a wide entocarotid groove. This region is damaged in casts examined by me of *N. tedfordi* and *P. painei*. The foramen ovale is vertically oriented and in total view from a lateral aspect in P8552-10. A series of shallow grooves radiate from the anterodorsal surface of foramen ovale in *Propalorchestes*. These grooves appear to be present in *P. painei* indicating that a similar morphological detail was present.

The postsquamosal constriction is much more pronounced in P8552-10 than it is in *P. painei* or *N.tedfordi*. It is doubtful that the transverse flare of the mastoid and squamosal crest of the occiput approached that of *P. painei*. Notwithstanding, there is general morphological agreement between P8552-10 and *P. painei* in the profile and in the morphology of the ventral occiput. These points of agreement include the presence of a deep, wide, condylar sulcus and the precipitous anterior wall of the paroccipital and mastoid process behind the petrous bone. Poe's illustration of *P. painei* suggests that the posterior border of the epitympanic fenestra and, by proximity, the floor of the middle ear is developed from a thin bony flange of the mastoid (Woodburne 1967). P8552-10 suggests this possibility. However, it seems to be more intimately related to the petrous in *Propalorchestes*. In any case, the petrosal and the posterior wall of the epitympanic fenestra are close to the anterior wall of the mastoid in both P8552-10 and *P. painei*.

The diagnosis of *Propalorchestes* as a palorchestid rests on synapomorphic features including 1) the morphology of the glenoid fossa; 2) the morphology of the alisphenoid-ptergyopalatine processes in relation to the alveolus; 3) the squamosal involvement in the tympanic bulla; and 4) the mastoid interpositus in the occiput. This strongly suggests an interrelated functional and developmental complex that is unlikely to develop as a parallelism. *Propalorchestes* is generally more primitive and simultaneously more specialized than *Palorchestes painei*. The pronounced sagittal crest, wider temporalis fossa, narrower anteroposterior dimension of the zygomatic sulcus and apparently even more robust zygomatic arches indicate that powerful masticatory forces, possibly surpassing those exerted by the larger *P. painei*, were required by this comparatively small diprotodontan. The stout alisphenoid strut behind the sphenorbital fissure and foramen rotundum, combined with its curving, slightly flared palatine remnant, are also indicative of extraordinary masticatory forces relative to the animal's size. The apparent lack of an abrupt transition laterally to form a suborbital shelf for the molar alveolus is similarly a modification for reducing bony strain to the posterior palate. These features are all present in *P. painei* to approximately the same degree of development as P8552-10 but on a larger, wider cranial base and broader neurocranium. The glenoid structure is of the same unique type in both, although in P8552-10 the postglenoid process is comparatively more robust, longer and probably wider. It is still a modest structure compared to the postglenoid process development in, for example, a Bullock creek *Neohelos* sp. but seems to indicate a proportionally larger condyle and heavier dentary in P8552-10 than in *P. painei*. P8552-10 differs also from *P. painei* and *N. tedfordi* in having a smaller epitympanic fenestra. This could be functionally related to the proportionally larger glenoid and longer squamosal tuberosity anteriorly and the wider postglenoid arch posteriorly, combined with the overall narrowness of the cranium, but more likely it is an expression of structural conservatism.

The occiput of P8552-10 is narrower and higher than in *P. painei* and *N. tedfordi*. The muscular attachments indicated by deep fossae and prominent crests indicate that the nuchal musculature in these palorchestids was highly developed, certainly more so than it was in *N. tedfordi*. The large fossa for the *rectus capitus posterior major* muscle indicates that a powerful elevator of the head was required, either to support a very heavy skull or to assist in elevating the head for feeding. The deep pits for tendinous insertions of the *rectus capitus posterior minor* muscles imply that powerful pulling moments were exerted on the occipitoatlantic joint. The large lateral scar probably served mainly as the insertion for the *obliquus capitus superior*, another elevator of the skull.

The construction of the cranial base and its associated foramina is essentially plesiomorphic among diprotodontans. Similarly, the endocranial fossa, its internal suture pattern and lack of internal basicranial flexion are reflections of this plesiomorphy which is similar to didelphoids and Australian polyprotodonts. It is however conceivable that the lack of brain flexion could be associated with the possible specializations of the facial skeleton. I am inclined to conclude that the entire basicranial-endocranial complex is conservative, symplesiomorphic with the stem diprotodontans and indicative of an early separation of palorchestids from diprotodontids. However it is conceivable that the relationship of *N. tedfordi* to *Palorchestes* is likely to be modified by *Propalorchestes novaculacephalus*. It is improbable that the very generalized morphology of *N. tedfordi* or *N. bonythoni* could lie in direct ancestry to *Propalorchestes* within the confines of the Medial Miocene. The generalized tooth morphology, wide cranial base and collective synapomorphies of *Ngapakaldia* with other medial Miocene diprotodontids indicate that the genus progressed further with the diprotodontids than with the more plesiomorphic palorchestids. Within the framework of our present state of knowledge, *Ngapakaldia* is an excellent candidate for a sister taxon the palorchestidae. From the same frame of reference, *Propalorchestes* might also lie in an indirect relationship to *Palorchestes* with respect to its conservative middle ear region and moderate degree of development of the epitympanic fenestra. Therefore the genus *Palorchestes* might eventually be recognized as a contemporary of both *Propalorchestes* and *Ngapakaldia*. Alternatively, some degree of parallel evolution must have been involved in the reduction of alisphenoid contribution to the middle ear, reduction of the postglenoid process and enlargement of the epitympanic fenestra in *Propalorchestes novaculacephalus* if it was directly ancestral to *Palorchestes*.

ACKNOWLEDGMENTS

My sincere thanks and gratitude are extended to Dirk Megirian, Mike Archer, Allan Howard and Lorna Watt.

REFERENCES

Archer, M. 1984 The Australian Marsupial Radiation. M. Archer and G. Clayton (eds) *Vertebrate Zoogeography and Evolution in Australasia*: 633-808. Hesperian Press: Western Australia.

Bartholomai A. 1978 The rostrum in *Palorchestes* Owen (Marsupialia: Diprotodontidae) results of the Ray E. Lemley Expeditions, part 3. *Memoirs of the Queensland Museum* **18**: 145-149.

Owen, R. 1874 On the fossil Mammals of Australia part IX family Macropodidae; Genera *Macropus, Pachysiagon, Leptosiagon, Procoptodon and Palorchestes*. 2 Volumes. *Philosophical Transactions of the Royal Society*: London.

Plane, M. and C. Gatehouse 1968 A new vertebrate fauna from the Tertiary of Northern Australia. *Australian Journal of Science* **30**: 271-273.

Raven, H. and Gregory, W. 1946 Adaptive branching of the Kangaroo family in relation to habitat. *American Museum Novitates* **1309**: 1-33.

Stirton, R. 1967 The Diprotodontidae from the Ngapakaldi fauna, South Australia. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics Australia* **85**: 1-44.

Stirton, R. Woodburne, M. and Plane, M. 1967 A phylogeny of the Tertiary Diprotodontidae and its signifaee in correlation. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics Australia* **85**: 149-60.

Tate G. 1948 Results of the Archbold Expeditions, No 59. Studies on the Anatomy and Phylogeny of the Macropodidae (Marsupialia). *Bulletin of the American Museum of Natural History* **91**: 233-352.

Woodburne, M. 1967 The Alcoota Fauna, Central Australia: an integrated paleontological and geological study. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics Australia* **85**: 53-103.

Woods, J. 1958 The extinct Marsupial genus *Palorchestes* Owen. *Memoirs of the Queensland Museum* **13**: 177-193.

Accepted 19 September 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 213

METAPHRIXUS INTUTUS BRUCE (CRUSTACEA: ISOPODA), A BOPYRID PARASITE NEW TO THE AUSTRALIAN FAUNA

A.J. BRUCE
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

The first occurrence of the bopyrid isopod *Metaphrixus intutus* Bruce in Australian waters is recorded. This parasite is previously known only from Zanzibar.

KEYWORDS: Crustacea, Isopoda, Bopyridae, parasites, marine zoogeography, Australia.

The unusual bopyrid isopod parasite *Metaphrixus intutus* Bruce is known from a two male-female pairs found attached to specimens of the shrimp *Palaemonella rotumana* (Borradaile) found at Pange Reef, Zanzibar (Bruce 1965). There have been no subsequent reports of this species.

Through the kindness of Dr P. Doherty, it has been possible to study a further example found attached to a species of *Periclimenes* Linnaeus collected from a depth of 10m, in a dead colony of the coral *Pocillopora damicornis* Linnaeus, on the outer side of John Brewer Reef, Queensland, in 1982. Unfortunately the host is not sufficiently complete to be identified with certainty but it is most probably *Periclimenes grandis* (Stimpson), specimens of which were found at the same locality. The non-ovigerous parasite corresponds closely to the type specimen but is less mature and relatively smaller in size, about 1.5mm in length, and poorly pigmented. It is attached over the posterior right branchiostegite, with the cephalon placed beneath a raised flange derived from the hosts first abdominal pleuron. The mode of attachment is precisely as in the type material and is characteristic of the genus.

A further specimen has also been collected in the Northern Territory. R. Williams collected another example from Weed Reef, Darwin Harbour (12°29.2′S 30°47.4′E), Stn. AJB/14, at a depth of 7-10 m, on 10th April 1984, infesting a male *Palaemonella rotumana* (Borradaile), also on the right side. The female is subcircular in shape, diameter about 2.5 mm, packed with ova, with bands of dark pigmentation as described in the type specimen. No male could be found attached to female, in the marsupium or on the host. The female was attached to host in the same fashion as previously described specimens.

These further occurrences of *Metaphrixus intutus* represent a considerable extension of the range of the species, as well as an association with a new host genus. It would appear that the species must be naturally rare as the author has had occasion to examine large numbers of specimens of the genera *Palaemonella* Dana and *Periclimenes* from throughout most of the Indian and western Pacific Oceans and these records constitute only the second occurrence in over 20 years.

The specimens are deposited in the Northern Territory Museum collection, catalogue numbers NTM Cr. 000407 (John Brewer Reef) and NTM Cr. 001463 (Weed Reef).

REFERENCE

Bruce, A.J. 1965 An interesting new phryxid (Epicaridea) parasitic on a pontoniinid shrimp. *Annals and Magazine of Natural History* (13)**8**: 385-390.

Accepted 7 October 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1): 215-221

CO-OPERATIVE EFFORT IN A NEW SPECIES OF TUBE DWELLING WORM, *EUNICE METATROPOS* (POLYCHAETA:EUNICIDAE)

J. RUSSELL HANLEY
Northern Territory Museum of Arts and Sciences,
GPO Box 4646, Darwin, NT 5794, Australia.

ABSTRACT

Eunice metatropos sp. nov., a species of eunicid polychaete from Western Australia, is described and illustrated. It is compared with other species of *Eunice* Cuvier which also inhabit tough pliable parchment-like tubes. Unlike other tube dwelling eunicids, all twelve specimens had acted in concert during the early stages of tube building, entwining the tubes together for about one third of their length. After this initial phase each tube separates and diverges from the others producing a remarkable tree-like structure.

KEYWORDS: Polychaeta, Eunicidae, *Eunice metatropos*, new species, unusual tubes, Western Australia.

INTRODUCTION

An aggregation of worm tubes were presented to me recently by a colleague, Mr Wayne Houston who came upon them while sorting material collected by trawl from the north-west shelf off the coast of Western Australia. At first he thought it was a "gorgonian" because of its tree-like habit, however, closer inspection revealed a group of parchment-like tubes inhabited by polychaete worms.

Unfortunately, as the material has been frozen before fixation in formalin the eunicid worms extracted from the tubes are generally in poor condition. There is however, enough material to allow the conclusion the specimens represent a hitherto undescribed species.

SYSTEMATICS

Eunice metatropos sp. nov.
(Figs 1-3)

Type material. HOLOTYPE - Northern Territory Museum (NTM) W3886, north-west shelf off western Australia, 19°12.0'S 118°32.0'E, stn 85-5, coll. observer crew, bzcp "Chieh Fa" No 1, depth 80 m, 1 July 1985. PARATYPES - NTM W 3887, NTM W 3888, NTM W 3889, NTM W 3953, United States National Museum (USNM) 101342, USNM 101343, Australian Museum (AM) W 201437, AM W 201438, British Museum of Natural History (BMNH) ZB 1986-251, BMNH ZB 1986-250, data as for holotype.

Description. The holotype is complete and has 87 segments. The body is flesh-coloured with reddish-brown longitudinal blazes of pigment on the dorsal surfaces of anterior segments.

The prostomium is shorter than wide, bilobed anteriorly with indistinct palps (Figs 1A, 2B). Two eyes are present lateral to the bases of the inner lateral antennae. The eye pigment is reddish-brown and faint in the holotype. The five antennae are smooth with swollen bases; the single median antenna is 2.14 mm long, the inner lateral pair are shorter measuring 1.32 and 0.94 mm, the outer lateral pair are the shortest at 0.74 and 0.78 mm. The first peristomial ring is cylindrical and longer than the prostomium. The second peristomial ring is less than half the length of the prostomium and has a pair of dorsal cirri measuring 0.42 and 0.38 mm respectively.

Parapodia are uniramous (Figs 1B,C, 2 C, D) Anterior parapodia are low, rounded becoming more prominant and triangular posteriorly. The dorsal cirri are digitiform. The ventral cirri are stouter, shorter, conical and from about setiger 10 have a proximal pad. Ventral cirri retain proximal pads on all posterior segments.

Branchiae are present from setiger 6 to setiger 60. The maximum number of branchial filaments is 3 and this is the number found on the majority of middle body segments. Branchiae are absent from the posterior body segments.

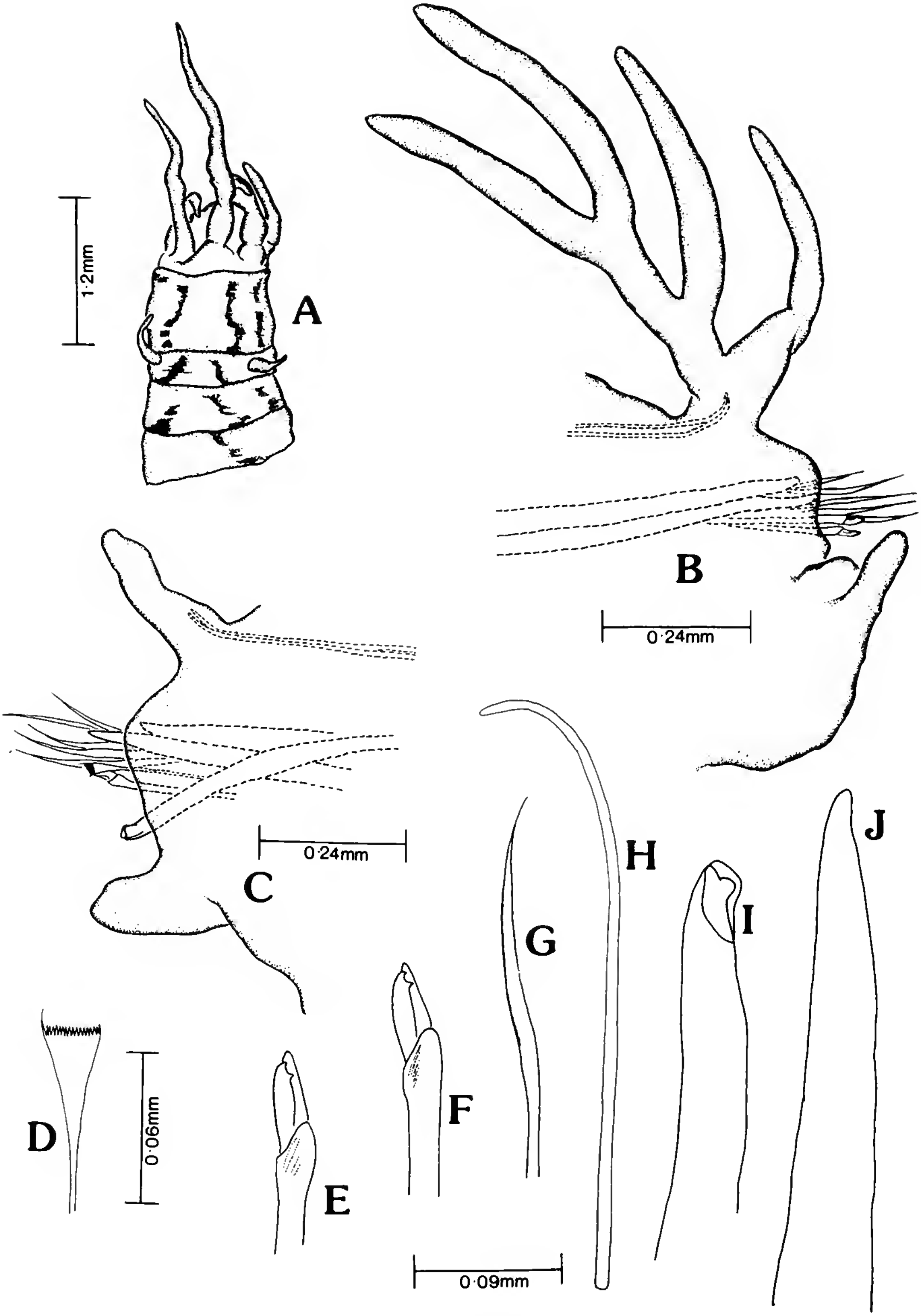


Fig. 1. *Eunice metatropos* holotype: **A**, anterior end, parapodia cannot be seen in this view; **B**, 27th setiger; **C**, 60th setiger; **D**, pectinate seta; **E**, **F**, falcigers; **G**, unilimbate capillary seta; **H**, notoacicula; **I**, subacicular hooded hook; **J**, neuroacicula. E-J, same scale.

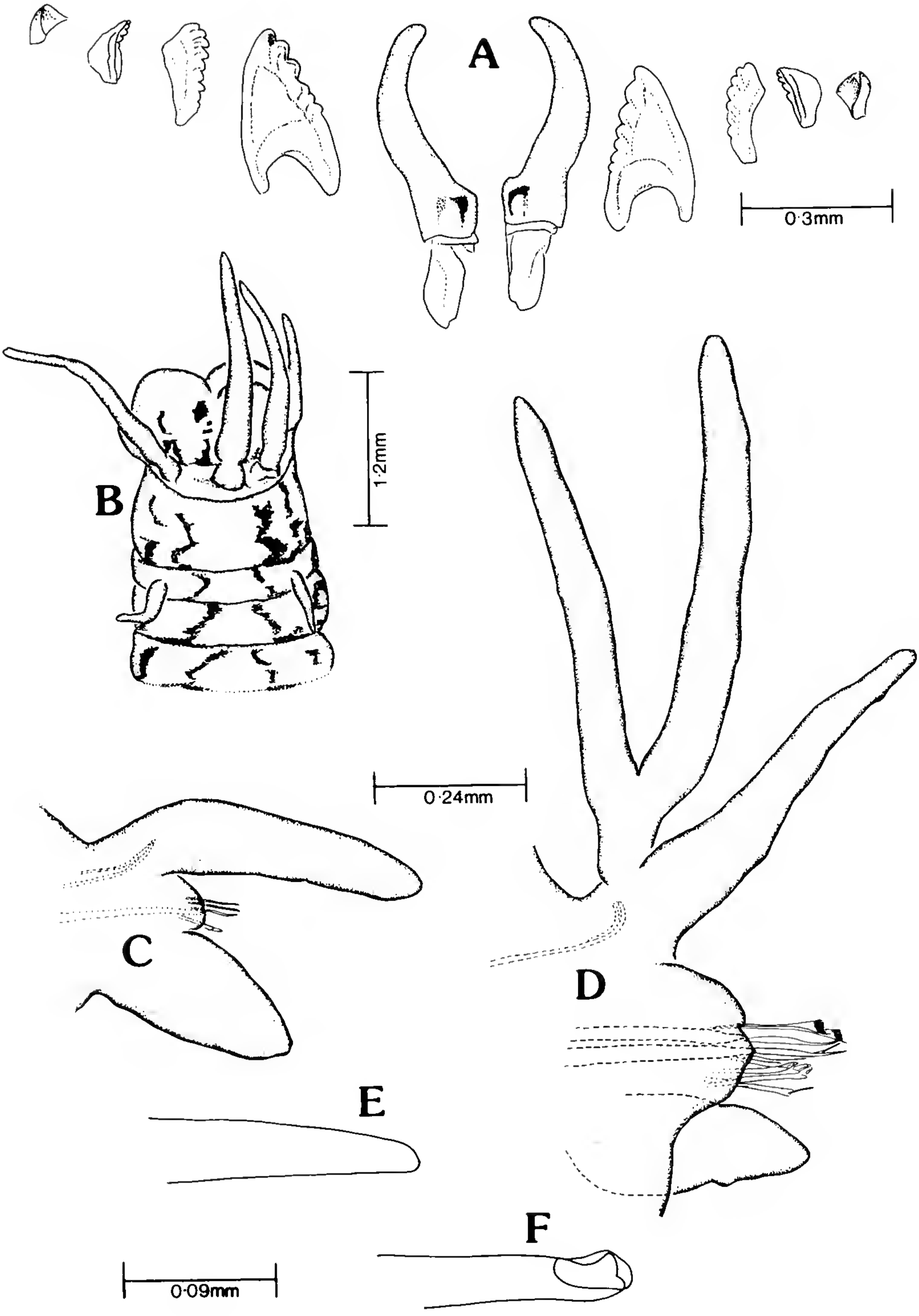


Fig. 2. *Eunice metatropos* paratype, NTM W3888: **A**, exploded view of jaws; **B**, anterior end, parapodia cannot be seen in this view; **C**, first setiger; **D**, parapodium from middle of body; **E**, neuroacicula; F, subacicular hooded hook. E, F same scale.

Table 1. Measurements of the type material of *Eunice metatropos* sp. nov. (— indicates missing or incomplete structures).

Specimen	*Body length (mm)*	*No. of segments*	*Branchiae begin segment No.*	*Antennae length left to right (mm)*	*Tentacular cirri length (mm)*
NTM W3886	37.00	87	7	0.74; 1.32; 2.14; 0.94; 0.78	0.42; 0.38
NTM W3887	44.25 (incomplete)	105	12 on right 8 on left	0.60; 1.16; 2.10; 1.24; 0.62	0.30; 0.44
NTM W3888	60.00	140	8	0.90; 1.66; 1.74; 1.50; 0.88	0.36; —
NTM W3889	50.00	104	8	0.74; 1.68; —; —; —	0.48; 0.50
USNM 101342	(incomplete)	(incomplete)	8	0.72; —; —; —; 0.64	0.32; 0.28
USNM 101343	32.25 (incomplete)	63 (incomplete)	10	0.68; 0.92; 1.80; 1.00; 0.60	0.32; 0.36
AM W201 437	38.70 (incomplete)	95 (incomplete)	8	0.54; —; —; —; 0.76	0.32; 0.32
AM W201 438	31.80 (incomplete)	71	8	0.68; 1.86; —; 2.00; 0.70	0.54; 0.60
BMNH ZB 1986-250	51.75	120	8	—; —; —; —; —	0.34; 0.52
BMNH ZB 1986-251	52.95 (incomplete)	101	8	0.72; 1.10; 1.36; —; 0.70	0.36; —
NTM W 3953	(incomplete)	91	8	0.50; —; —; 2.08; 0.62	0.54; 0.52

Aciculae are yellow, most with slightly bent tips. There are two in each parapodium except in a few of the posterior parapodia which have a single acicula only. A single yellow bidentate subacicular hook is present in each parapodium from about the middle of the body (Figs 1C, I, 2F). Each setal fasicle usually contains a few capillary setae, several stout, compound falcigers and one to three pectinate (comb) setae (Fig. 1 D-G). The capillary setae are unilimbate with fine serrations. Each pectinate seta has 16-18 teeth, only one margin is extended as a filament and is much longer than the other. The compound falcigers are hooded with straight shafts which are expanded and slightly curved near the distal end. The tips of the compound falcigers are stout; each has a bluntly rounded hood; the distal tooth is only slightly curved and the proximal tooth is triangular and pronounced. In addition each setiger also contains a pair of distinctive yellow notoaciculae which provide support to the base of the dorsal cirri. The notoaciculae are slender and, at their distal end curve upwards into the dorsal cirrus.

The pharyngeal apparatus was dissected in the holotype and one of the paratypes (NTM W3888). The maxillary formula of the holotype is Mx.I=1+1, Mx.II=7+7, Mx.III=9+8, Mx.IV=7+6, Mx.V=1+1. The paratype differs only on the fourth pair of jaws Mx.IV=6+5.(Fig 2A)

Description of Paratypes. Table 1 lists the measurements of all the material. The maximum number of body segments is 140. About half of the specimens are incomplete posteriorly, a reflection of the poor state of preservation.

Tubes. There are 14 tubes present. The walls of the tubes are of the same tough, pliable, parchment type constructed by a number of species of *Eunice* Cuvier. The tubes are entwined for about one third of their length then they separate, producing a tree-like structure (Fig. 3). Each tube is roughly cylindrical for the first, entwined third of its length. Once separated from the surrounding tubes, each tube exhibits the alternate branching or zig-zag appearance seen in the tubes of other Eunice species such as *E. tubifex* (Crossland, 1904). The overall height of the tubes is 170 mm.

Distribution. The species is known only from the type locality, the north-west shelf of Western Australia.

DISCUSSION

Hartman (1944) recognised four major groups in the genus *Eunice* based upon the colour and dentition of the subacicular hooks. Fauchald (1970) adopted this scheme and extended it to cover all known species of *Eunice*. Group A1 of Fauchald's scheme (1970:204) is characterised by species in which the subacicular hooks are yellow and bidentate (Hartman's Flavus-bidentatus group) with branchiae occurring before segment 10 and absent after segment 100. These characters are all found in *E. metatropos* and

Fig. 3. Tubes of *Eunice metatropos*. Maximum height of structure is 170 mm.

accordingly it is placed in this group. Fauchald lists 13 species in group A1. The new species *E. metatropos* differs from all of these in the unusual shape of the notoaciculae which are markedly curved near their tips. In addition the presence of five pairs of symmetrical jaws distinguishes the new species from all other members of the genus, for I can find no reference to this phenomenon in the literature.

Finally there is the nature of the tubes. Few species of *Eunice* construct tough parchment tubes, and none of these species are members of the A1 group. The two species with tubes most like those of *E. metatropos* are *E. tubifex*, *E. tibiana* (Pourtales, 1869) and *E. conglomerans* (Ehlers, 1887). However a comparison with material collected from Northern Territory waters indicates *E. tubifex* has branchiae which begin after segment 10 and continue to the end of the body, and the pectinate setae have fewer teeth (10-12).

E. conglomerans differs in the colour of the subacicular hooks, which are black, and therefore places the species in Fauchald's group B3, in conjunction with the absence of branchiae before segment 10 and their presence thereafter to the end of the body.

E. tibiana was originally described as *Marphysa tibiana* by Pourtales (1869) from 270 fathoms off Cuba. The species is poorly known and Fauchald (1970) indicates the color and dentition of the subacicular hooks are unknown.

The remarkable structure of the entwined tubes warrants further comment as their appearance demonstrates co-operative behaviour in members of this new species. I have observed aggregations of polychaetes among specimens of several species of Serpulidae, Sabellidae, Spionidae, Terebellidae and Nereidae. There are records of polychaete species of these and other families which can be found in dense aggregations with many individuals in close proximity to each other (see Day 1967). However, in these cases, the phenomenon is often the result of environmental conditions which permit the successful settlement of recently metamorphosed juveniles and is often characterised by intense intra-specific competition with mortality the price of failure in the battle for scarce resources (see Woodin 1974 for a review). Indeed such is the level of competition for space (and indirectly, food), that some tube dwelling polychaetes are significant predators on juveniles of their own species (Woodin 1974).

In this new species of eunicid, we have an example of harmony in which each individual apparently exhibits a positive response to the presence of other members of its own species. The entwining of the tubes implies there may be a benefit to be gained by each worm from the association,perhaps from the construction of a rigid base to the tree-like cluster of tubes. Then, suddenly, after showing a positive tropism towards each other during the early stages of tube-building the worms exhibit a negative tropism, and the tubes quickly diverge producing the marvellous "tree" shape.

Whether the structure is deliberate or accidental cannot be determined without additional material. The "tree" may be an aid to feeding, the distal ends of the tubes are flexible allowing the occupants some freedom in foraging. The feeding strategies of most Eunicidae are poorly known, however what we do know of tube-dwelling *Eunice* and the closely related Onuphidae (Day 1967; Fauchald and Jumars 1979) indicates the worms forage over the surface of the substrate surrounding their tubes. Spacing of individuals of these species often reflects this foraging, as the distance between a pair of tubes is presumably the sum of the two radii marked out by the foraging activities of the occupants of those two tubes. The spacing of tubes by the interactions between foraging individuals could explain the orientation of the distal two-thirds of each tube in the aggregation of specimens of *E. metatropos*. Unfortunately, it gives no clue to the reasons for the earlier positive tropism demonstrated by the entwined portions of the tubes. Perhaps the base is the result of the occupants of these tubes all settling after metamorphosis into the same narrow crevice within coral rubble, sponge or other substrate. *E. tubifex* builds a tall flexible tube with its base lying in a crevice in coral rubble. The basal part of the tube is often twisted and looped around itself. However, the basal parts of *E. tubifex* tubes are always very firmly attached to the substrate and are not easily detached. The tubes of this new species show no evidence of attachment to the substrate save for the very base of the structure which is flared in a manner reminiscent of tree roots and the holdfasts of algae. All indications are, therefore, this is a free-standing structure. Trees and algae have a physiognomy which reflects the forces of wind and water respectively. It may be that the "tree-like" aggregate of tubes of *E. metatropos* is an adaptation to provide rigidity to flexible tubes subject to powerful currents. These same currents may provide an adequate supply of water-borne food to an otherwise overcrowded group of worms.

The name assigned to this species reflects the apparent change in tropism exhibited by individuals of the species during the construction of their tubes.

REFERENCES

Crossland, C. 1904 The marine fauna of Zanzibar and British East Africa from collections made by Cyril Crossland in the years 1901 and 1902. The Polychaeta Part 3. With which is incorporated the account of Stanley Gardiner's collection made in the Maldive Archipelago in the year 1899. *Zoological Society of London Proceedings* **1904**: 287-330.

Day, J.H. 1967 *A monograph on the Polychaeta of Southern Africa* Part 1. Errantia. British Museum of Natural History: London.

Ehlers, E. 1887. Report on the Annelids of the dredging expedition of the U.S. coast survey steamer Blake. *Museum of Comparative Zoology of Harvard Memoirs* **15**: vi, 1-335 .

Fauchald, K. 1970 Polychaetous Annelids of the families Eunicidae, Lumbrinereidae, Iphitimidae, Arabellidae, Lysaretidae and Dorvilleidae from western Mexico. *Allan Hancock Monographs in Marine Biology* **5**: 1-335.

Fauchald, K. and Jumars, P.A. 1979 The diet of worms: A study of Polychaete feeding guilds. *Oceanographic and Marine Biology Annual Reviews* **17**: 193-284.

Hartman, O. 1944 Polychaetous annelids Part 5. Eunicea. *Allan Hancock Pacific Expedition* **10**: 1-238.

Pourtales, L.F. de 1863-1869 Contributions to the fauna of the Gulf Stream at great depths. *Museum of Comparative Zoology of Havard Bulletin* **1**: 103-120.

Woodin, S.A. 1974 Polychaete Abundance Patterns in a Marine soft sediment Environment: The importance of biological interactions. *Ecological Monographs* **44**(2): 171-187.

Accepted 10 October 1986

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, 3(1):223-226

GENERAL COMMUNICATION

"Singing" :accounts of some personal experiences of Aboriginal sorcery

E.C. EVANS[1]
Northern Territory Museum of Arts and Sciences,
G.P.O. Box 4646, Darwin, NT 5794, Australia.

Much has been spoken and written about the Australian Aboriginal phenomenon of "pointing the bone" and its effect on the victim, but it may not be generally known that the methods used to cause the physical decline and eventual death which characterise this type of sorcery are many and varied, and that bone-pointing is perhaps the least used. For example, whereas bone-pointing is a technique used by the so-called "desert" tribes of Central Australia, it is unknown in that form to the coastal peoples although sharpened wooden objects impregnated with evil power are sometimes used in much the same way. Other methods involve the use of some article belonging to, worn, or left by the intended victim (and the latter can include excreta and urine); the un-natural positioning of branches and twigs of bushes in the victim's path; and the establishment of an auto-suggestive conviction of boding evil through repetitive sounds, chanting and rarely, bizarre apparitions. These latter are usually confined to occasions of ceremonial associated with initiation or other age-grading rituals, and generally involve more than one sorcerer.

Such practices are usually referred to as "singing" and in my 30 years experience with Aboriginals I have had first hand knowledge of five cases and was involved in attempts to "un-sing" the victims of three of them. The following accounts briefly describe the circumstances surrounding these three experiences.

Case 1. I became involved in this case when a Darwin doctor sought my assistance with a patient in his care. The victim, who I shall refer to as Jack, was about 19 years of age and had been working on a cattle station as a yard and fence builder. He had attended the annual ceremonial "festival" which is a contrivance devised by the tribes of the Barkly Tablelands area to accommodate both the demands of their white employers and their traditional religious rites. Some three weeks after Jack's return to the station from the ritual gathering, the foreman noticed that he was listless, easily exhausted and seemed to be losing weight. Jack was regarded as a good employee who took pride in his work and this change was worrying to the foreman. He conveyed his suspicions to the manager that Jack was ill. It should be noted that while this concern for Jack's well-being may appear inconsistent with the generally negative image abroad regarding Northern Territory station management attitudes to Aboriginal employees, Jack was fortunate in that he worked for a resident owner.

Enquiries made directly of Jack revealed that he believed he was being "sung", but beyond that he was reluctant to give any other information except that the evil had been perpetrated at the "Big Corroboree". Further investigation seemed to focus suspicion on a group of elders at Alroy Downs, so the manager arranged for the foreman to travel to that cattle station and make enquiries through the local police. This was

---

[1] *1.* **Editor's Note:** Edward Condon Evans, O.A.M., has been a member of the Board of Trustees of the Museums and Art Galleries of the Northern Territory since its inception in 1966, and has for the last one and a half years been its Chairman. He is a prominent Territorian who, having served in the former Native Affairs and Welfare Branch and the Department of Aboriginal Affairs between 1946-1976, has worked and travelled extensively throughout the region, particularly in Arnhem Land. In 1957, Mr. Evans led the patrol which made first contact with the Pintubi people of the Central Western Desert, and for this he was granted the Royal Geographical Society's Mrs Patrick Ness Award for Geographical Exploration. He is an Associate Member of the Australian Institute of Aboriginal Studies. Mr Evans has submitted this account of personal experiences with cases of "singing" in the hope that it might contribute to the literature of recorded cases, and prove of interest to the general public.

completely abortive as the Aborigines, naturally, denied any knowledge of, or accepted any responsibility for Jack's condition. Meanwhile Jack's loss of weight became alarmingly apparent.

What followed was, in my experience, unique in Aboriginal/station management relations in the Northern Territory, in that the owner had Jack conveyed to Darwin, over 500 miles to the north, and arranged for his medical examination by a specialist in private practice — all at the station's expense. The doctor had Jack admitted to hospital and after a week of exhaustive tests was completely at a loss to account for Jack's condition on medical grounds. It was at this stage that the doctor invited me to interview Jack, in the hope that he would reveal more about the origin and cause of the "singing".

I visited Jack every day for a week, mainly to gain his confidence, but also to get him talking about himself as a tribal Aboriginal, his status in the traditional hierarchy and any other personal matters that might give a clue to his problem. Physically he was no longer deteriorating and whilst my enquiries were not helping the doctor, Jack seemed to derive some comfort, if not pleasure, from the attention he was getting. However, his conviction that he was being "sung" was not wavering although the effect of the sorcery seemed to have lessened because of the greater distance that had been put between him and his malefactors. He was, of course, making the acquaintance of other Aboriginal patients and one day he introduced me to a middle aged man whose country was not far from his own. Jack informed me that his new-found friend had had "the same sickness put in him" and was getting better "because of the pills he was taking", namely, one white, one red and one yellow capsule which were shown to me. Jack demanded the same pills.

The ward sister informed me that the middle aged man was on a course of treatment for a chronic lung condition, and that his illness was stable, allowing him to be discharged in the near future. On being told of this new development, the doctor readily agreed to simulate the treatment for Jack and arranged for a supply of similarly coloured capsules containing harmless powders. The change in Jack was immediate and within a few days it was apparent he could be discharged. He left Darwin in the company of the older Aboriginal and after a time returned to his home station and resumed his normal life.

I am convinced that Jack's cure was not brought about solely by the placebo-type treatment but was greatly helped by what went on between him and the other Aboriginal man. I was not privy to this nor did I presume to intrude into what was exclusively an Aboriginal domain. But I suspect that the second man had knowledge of the reason for and cause behind Jack being "sung" and that he chose to intervene. So he exploited the white man's hospital situation and thereby satisfied the doctor (and me), and at the same time removed Jack from his physical plight.

Case 2. Another case involved a young man who was a star in a football team of which I was Club President, so my interest in his recovery was stimulated by more than purely humanitarian and anthropological motives. Jimmy shall be his name and he collapsed quite suddenly one day at work. He immediately became semi-conscious and was rushed to hospital where his conduct and condition indicated a brain disorder. However, X-ray examinations and other tests failed to establish any physical brain abnormality or other cause of the condition. During consultations with the doctor, Jimmy, in his lucid moments, insisted he was being "sung" and this intrigued me for, compared with Jack, Jimmy was relatively sophisticated, having lived in and around Darwin since birth.

I had no trouble in having Jimmy confide in me, as we had known each other for some years and he immediately named an Aboriginal, who was unknown to me, as being the instrument of his being "sung". Jimmy told me that this man lived in the bush on the outskirts of Darwin and I went in search of him. I had little difficulty in locating him and was somewhat surprised to find he was a genial, bearded man in his sixties. He vehemently denied Jimmy's accusation and indignantly asked to be taken to his bedside. On being confronted with this outraged elder, Jimmy hastily withdrew his claim and I was back to square one.

Next day, a still very sick Jimmy told me he now believed that all his ills stemmed from a "dangerous" object hidden in the house of one of his countrymen, who lived in Darwin at Bagot Reserve. I went there post-haste and related Jimmy's claims to the house-owner who denied knowledge of any such object and invited me to make a search if I wished. This I did under the amused eyes of the owner and his friends. However, their attitude changed dramatically to one of dismay and fear when I revealed what I had found wrapped in a dirty dust-covered handkerchief on top of a rafter: a sharpened stick some eight inches long with a one foot length of human hair string attached to one end. No-one admitted prior knowledge of the presence of the object in the house, and they were unanimous as to its dangerous powers in the hands of a clever enemy. They implored me to re-wrap it before it could do any damage, unilaterally as it were, and some expressed genuine concern when, on complying with their request, I placed the package in my trousers pocket. They apparently felt I was placing my masculinity at risk.

Jimmy almost paled when I showed him the object, but he was obviously relieved and expressed his gratitude that I had located the cause of his problem and had plucked it from its hiding place. He agreed that whilst it remained in my possession it was not a menance to his well being, but I felt I had to somehow become its owner if Jimmy's fears were to be completely allayed. In other words, I thought that if he were certain that no Aboriginal malefactor could have access to it then his future was assured. I also hoped that he might believe that white ownership would exorcise the inherent evil in the thing.

I accordingly arranged a bedside meeting with a group of Jimmy's tribesmen and I put forward the proposal that I buy the object. After some discussion in their language, the men agreed that the unusual suggestion was worthwhile trying, although there was obviously some doubt as to the efficacy of such an arrangement in the face of what was obviously a powerful opponent. So I passed over to the eldest of the group an amount of money, four tins of tobacco and several packets of cigarettes — I do not recall how the value of the "thing" was determined. I think it was a case of a token gesture being a manifestation of goodwill.

The rest of the story is in the nature of an anti-climax. Having secreted the object in the furthest depths of a locked cabinet at home, I went gaily to the hospital next morning confidently expecting to see Jimmy up and about and rearing to get back to the football field. Alas, he was no better — if anything he was a little worse. The doctor received my admission of defeat somewhat enigmatically and informed me that he would continue with further tests. Imagine my reaction next day when he rang to advise that he had decided to perform a lumbar puncture and this had disclosed the existence of a brain haemorrhage which was not showing up on X-rays. Jimmy was still a very sick man, but with knowledge of the cause the doctor was then able to administer relevant treatment which, after some six weeks, resulted in Jimmy being discharged fit, not for football, which he never played again, but for an otherwise useful life.

Of course we will never know what lay behind Jimmy's knowledge of the presence of the "dangerous" object in that house at Bagot and to what extent this may have influenced his conviction that he was being "sung". I still like to think that my aquiring "ownership" of the object pre-disposed Jimmy's mental state to the extent that the white-man's medicine was able to take effect without any challenge from the evil influences of the "thing".

Case 3. The third case of "singing" in which I became involved was a most extraordinary affair which claimed the attention of eminent anthropologists and psychologists. The victim was an eighteen year old man from one of the missions located in Arnhem Land. He had received a westernised education and showed leadership potential in the new and confusing life-style which lay before tribal Aborigines confronted with and adapting to white civilization. He was brought to Darwin by aerial ambulance in a comatose state, experiencing grave breathing difficulties. He was immediately placed in an iron-lung and a long battle began to save his life.

The case history which accompanied him stated that the man had claimed he was being "sung", but there was a dramatic difference here in that he named the person responsible as his mother-in-law. To add further drama, his near relatives were of the same opinion but powerless to do anything about it, and it seemed that his claim was not denied by the lady concerned.

It should be explained that in Aboriginal society a man does not have to be married to acquire a mother-in-law, for under the promise system the mother of one's future wife has to be treated and respected as an in-law from the date of the birth of her daughter. There are also very strict taboos applying to the son-in-law/mother-in-law relationship, which are rigidly imposed. In this case the young man had not then yet assumed the role of husband with his promised wife and it was suspected that a few casual liaisons he had made had demanded the mother-in-law's defence of her daughter's honour. Or perhaps he had broken the behavioural taboo in some other important and more serious respect.

Anthropologically the case was unique, in that the sorcerer was a female and the community had seemingly acknowledged her right and ability to act as she did. It was never discovered by what means she had created the conviction in the young man that she had willed him to die, but it must have been powerful indeed, for in hospital he deteriorated to the point that he could not breathe outside the artificial lung. The doctors were of the opinion that it was a case of his not wanting to breathe, since they could find no medical condition that would halt his breathing. Argument then ensued as to whether a mental conviction could overcome the natural functions of the heart and lungs but as far as I know the issue remained unresolved.

Days passed into weeks and the only change was that the patient began to spend some time outside of the iron lung and that the period slowly increased day by day. At this stage he began to receive visitors from the Mission but, on the surface, this seemed to be merely the maintenance of friendly and social contacts. Interrogation of both the patient and his visitors during these periods failed to produce any helpful information and a stalemate had apparently been effectively reached between the powers of Western medicine and those of the Aboriginal occult.

This in effect was the ultimate result. The day arrived when the young man no longer required the artificial respirator and was quite well except that his physique had obviously taken a beating during the ordeal. When he was fit to travel, he elected to return to his home and it was apparent that he no longer had any apprehension at the prospect of once again being in the presence of his mother-in-law. There were in fact no overt problems following his return and he seemed to settle back into a normal life routine. He is now a happily married man and his wife in her turn is a mother-in-law.

Again we aliens to the secret Aboriginal world will never know what really went on. While it is easy to speculate, I believe that in this case we were dealing with a woman determined to wreak the ultimate punishment on a young man who, in turn, was prepared to accept his fate without demur or protest. However, both were frustrated by the intervention of the white man's medicine. Having regard to the period that elapsed between the young man's admission to hospital and his eventual discharge, it would seem reasonable to think that both parties were persuaded that the drama would not be played out to its intended finale and that a compromise was necessary. The lengthy absence of the young man from his country, his friends and his life's security was, I suggest, his mother-in-law's compromise. Whether this be right or not, there is one thing of which I am certain — that he did not again put a foot wrong during his mother-in-law's lifetime.

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1986, **3**(1): 227-228

BOOK REVIEW

The Kangaroo Keepers

Edited by H.J. Lavery

University of Queensland Press: St Lucia 1985 ISBN 0 7022 1875 8

Pp. xxii+211, R.R.P.: $35.00 (cloth)

When I was handed this book to review, I took it with mixed feelings. The conservation/exploitation of kangaroos in Australia is perhaps the most controversial area of wildlife management, both in Australia and internationally.

The book is quite disarming in its appearance and presentation. This largely stems from the incorporation of a series of coloured plates of illustrations done by Ruth Berry. The plates are of the Australian macropods; soft eyed, gentle creature which to me appeared a trifle anthropomorphic. They are effective, albeit a little disconcerting, and they definitely soften the blow for what is to follow; but that is their intention.

Dr J.H. Lavery who introduces this volume is the assistant director, Queensland National Parks and Wildlife Service. He has also edited the seven chapters which include: "Family Diversity Among Kangaroos" by P.M. Johnson; "Scarcity and Extinction" by H.J. Lavery and P.J. Tierney; "The Red Kangaroo and the Arid Environment" by M.J.S. Denny; "The Kangaroo Industry" by T.H. Kirkpatrick and P.J. Amos; "Kangaroos as Pests" by H.J. Lavery and T.H. Kirkpatrick; "Biology and Management" by T.H. Kirkpatrick; and "Conservation" by T.H. Kirkpatrick and C.A. Nance.

All of the authors are, or were, employed by the Queensland National Parks and Wildlife Service, and it is not altogether surprising to read on the front dust cover that this volume was published with the assistance of the Queensland National Parks and Wildlife Service. The people who have written the book are the "Kangaroo Keepers" of Queensland's wild populations.

In reality, this book is pure propaganda, designed to show the public how best to manage the wild kangaroo populations through the Queensland government's eyes. The incorporation of Ruth Berry's gentle creatures in a book which provides a biased perspective on kangaroo population management and on the "squeaky clean" kangaroo industry, might be interpreted by some as being a trifle cynical, but then that's life.

Be that as it may, the book is well illustrated with 15 colour plates, 14 black and white plates, 31 figures and 17 tables and there are some interesting and well written sections. Indeed, I found the chapter on scarcity and extinction most interesting, particularly the section on efforts to safeguard the populations of bridled nailtail wallabies and the studies undertaken to do so. But then, these aren't species which have any economic value and the remainder of the book, i.e. chapter 3 onwards, is devoted to the kangaroo industry and management of harvested species.

Indeed, this focus on the industry can be guaged from plate 7; what a minomer! Plate 7 covers 6 pages and is made up of 36 photographs, ranging from the firing of the bullet, through to the packages of meat and the cuddly koala bears at the end of it all. Mind you, they did spare us the sight of the projectile disintegrating the brain case. There are some wonderful quotations about those who disagree with the concept of kangaroo harvesting, which leaves the reader in no doubt as to where the book stands:

"...groups of persons committed to the prevention of kangaroo harvesting have acquired both numbers and notoriety in the community" "...the ethic behind these groups' activities is that the killing of animals, especially wild native animals, for profit is morally wrong. A double standard of morality that allows the deceptively inaccurate use of conservation arguments about the likelihood of extinction to support the entirely unrelated objective of preventing human use of native animals does not appear yet to be realized" (Kirkpatrick and Amos (Chapter 4: 100).

Kirkpatrick and Amos, in raising the issue of inaccurate use of conservation arguments really are treading on thin ice. Most of this book, in fact, is devoted to the presentation of information to show that the kangaroo industry in Queensland is the most effective in Australia, and that this state's methods of estimating population numbers and the ultimate effects of harvesting on those populations, are the most accurate. With this in mind, it is disturbing to recall the recent publicity surrounding the enormous tag quotas released for the killing of kangaroos in Queensland, compared to Federal governments' estimates of what a Queensland kill quota should be. Indeed, much of the sections on "Biology and Management" and "Conservation" are devoted to explaining the sampling techniques used by the Queensland National Parks and Wildlife Service, and in some cases arguing why they are more accurate than those used by other state services. For instance, Kirkpatrick and Nance go to some lengths to explain the problems associated with the aerial survey techniques used by C.S.I.R.O. and other institutions. They conclude that *in toto*, such problems "...make both aerial and ground counts over huge areas and involving indisputably enormous numbers of individuals highly suspect..." and that their results ..."support the proposal that the aerial index is not really of abundance but rather of visibility" (Chapter 7: 165,166).

These authors suggest that estimates produced by these survey methods are underestimates of real population size. They base their population estimates on a series of criteria involving shooter returns and sex/age composition of the population, in which they also employ estimates of visible abundance, which seems to be a litte contradictory after criticising the technique. To get to the point, the authors go to great lengths (for example, incorporating computer simulation and programming studies), to try and convince their audience that they have the best technique for estimating kangaroo numbers and that their information is the most reliable.

In fact, it is this approach that ruined the book for me. One doesn't have to be a preservationist to see that this book is simply an excuse for backing up current Queensland National Parks and Wildlife Service policy and methodology. It's a hard sell in soft camouflage. I must say that I was a little thunderstruck when I read in Kirkpatrick and Nance's introduction to chapter 7 (p. 161):

> "In this book, no attempt is made to coerce readers to accept a particular point of view".

Well, I'm sorry fellas: I don't believe you.

Max King
Northern Territory Museum of Arts and Sciences
GPO Box 4646
DARWIN NT 5794, Australia

The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences, 1985, **3**(1): 229-230

BOOK REVIEW

Seashore Ecology

by Thomas Carefoot with Rodney D. Simpson

University of Queensland Press: St Lucia 1985 ISBN 0 7022 1913 4

Pp. xxii+278; 89 Figs; 36 col. Pls., R.R.P.: $35.00 (cloth)

I was delighted when first asked to review this book, as I already owned copies of the other three volumes in the Australian Ecology series and consider them excellent. However, I was disappointed to learn that *Seashore Ecology* is a version of Thomas Carefoot's *Pacific Seashores: A Guide to Intertidal Ecology* which has been adapted for Australian conditions by Rodney Simpson.

My response to this revelation was to wonder why it had not been possible to find authors who could produce a book on Australian intertidal ecology and, after reading the book, I felt uncertain as to how successful the adaption of Carefoot's work to Australian conditions had been.

The book is well organised. The first chapter, "The Seashore", is a good summary of the origin and movement of continents. However, the section on the evolution of shorelines could have been expanded to include a discussion on the impact of rivers on coastal gemorphology.

In the second chapter a very good discussion of "Waves, Tides and Currents" is given. Many books of this nature often ignore a basic explanation of these important aspects of intertidal ecology, assuming that the reader is already familiar with them.

The next three chapters deal respectively with: "Distribution of Organisms on the Shore"; "The Causes of Zonation and Distributions of Organisms"; and "The Economy of the Shore". In these chapters the bias of the book towards temperate rocky shores becomes obvious.

It is true this bias is admitted to in the Preface, and that the reasons given are partly correct, i.e. that the diversity and accessibility of rocky shore organisms means more work has been done on rocky shores than in sandy or muddy habitats. However, I would contend that many muddy habitats are more diverse than their rocky counterparts, and that this volume inadequately covers the research that *has* been done on muddy, intertidal habitats. Reference to works such as Gray (1981) would have been valuable.

Perhaps much of my dissatisfaction stems from my position as a marine scientist working in the Northern Territory, where only 8.9% of the local coastline can be considered rocky and 47.5% muddy. These percentages are taken from Table 3 on page 197. By constrast, in New South Wales things are a little different, with coastlines comprising only 1.1% muddy versus 32.5% rocky shores.

Consequently, I consider that while the book's bias towards the eastern coastline (particularly the south-east intertidal habitats) is hardly surprising given the paucity of information on the intertidal ecology of the rest of the Australian coastline (especially the tropical sections of that coastline), a better attempt could have been made to include what we do know. There is, for example, no mention of the presence of corals in the intertidal zone of tropical and subtropical Australian waters.

The chapter on "Seashore Vegetation" is well done, although I was surprised to note that it was prepared by two other authors, Barson and Heatwole, who are acknowledged in a footnote on page 195. Mangroves are poorly treated here though this is justified in light of the forthcoming volume in this series entitled *Ecology of Mangroves*.

The last chapter is also quite a useful discussion of the problems of pollution and is a welcome addition to texts of this type.

The Glossary is larger than a lot of others I have seen and the definitions are concise and clear. The Bibliography and Index are also well laid out and easy to use.

I could find very few errors in the text and was generally impressed with the clarity of the figures. There were a couple of instances, however, when parts of the figures had been lost during production of the book. Figures 34 and 35 on pages 64 and 65, for example, are both incomplete on the right-hand margin.

Colour plates enhance the appearance of any work and the plates shown here are of a high standard.

In summary, I find this book to be limited in usefulness in those parts of Australia with coastlines that are not dominated by rocky shores. If you do live, as the majority of Australians do, on temperate shores with a preponderance of rocky habitats, then this work is the best summary of intertidal ecology currently available.

REFERENCES

Gray, J.A. 1981 *Ecology of Marine Sediments: An Introduction to the Structure & Function of Benthic Communities.* Cambridge University Press: Cambridge.

Russell Hanley
Northern Territory Museum of Arts and Sciences
GPO Box 4646
DARWIN NT 5794, Australia

GUIDE TO AUTHORS

Authors are advised to follow the layout and style in the most recent issue of *The Beagle*.

Manuscripts must be typewritten in English, double-spaced throughout, with a margin of at least 4cm on the left-hand side. Text should be on one side of good quality A4 bond paper. Where appropriate, articles should conform to the sequence: Title, Abstract, Keywords, Introduction, Materials and Methods, Text, Discussion, Acknowledgements, References.

The Title should be concise and informative. An abridged title (not exceeding 50 letter spaces) should be included for use as a running head.

The Abstract should not exceed 150 words, and should state concisely the scope of the work and give the principle findings.

Keywords, to facilitate information retrieval, of up to 10 in number should be chosen to outline the main subjects covered.

The Introduction, including a review of literature, should not exceed what is necessary to indicate the reason for the work and the essential background. Abbreviations used throughout the text may be explained at the end of the introductory material.

Footnotes are to be avoided, wherever possible, except in papers dealing with historical subjects.

The International System of units should be used.

In the descriptive text numbers from one to nine should be spelt out and figures used for numbers over 9. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

Systematic papers must conform with the International Codes of Botanical and Zoological Nomenclature and, as far as possible, with their recommendations.

Synonymies should be given in the short form (taxon, author, date, page) and the full reference cited at the end of the paper.

TABLES

Tables should be numbered with arabic numerals and accompanied by a title. Horizontal rules are inserted only above and below column headings and at the foot of the table. Footnotes on tables should be kept to a minimum and be reserved for specific items in columns. All other explanatory material should be incorporated with the title.

ILLUSTRATIONS

Line drawings, maps, graphs and photographs are generally regarded as "figures" and are to be numbered consecutively for interspersion through the text. Under special circumstances colour illustrations may be accepted. Drawings must be on drafting film or good quality board with appropriate lettering inserted. Black and white photographs must be sharp, of high contrast on glossy paper, and mounted on board. The author's name, title of paper and figure number must be indicated on the reverse side of all illustrations. Captions or legends should be typed together on pages at the end of the text.

CITATIONS AND REFERENCES

Citations of sources within the body of the text should include the author, year of publications and page reference (where appropriate), e.g. Drake 1976:2.

References should be arranged alphabetically and chronologically at the end of the paper. Titles of all references must be given in full. Where an author has published more than one work referred to in the same year, the references should be appended with the letter (a), (b), etc. The following examples show the style to be followed:

Brake, B., McNeish, J. and Simmons, D. 1979 *Art of the Pacific*. Oxford University Press: Wellington.

Buchmann, S.L. 1983 Buzz publication in angiosperms. In: C.E. Jones and R.J. Little (eds) *Handbook of experimental pollination biology*: 73-113. Van Nostrand Reinhold Co.: New York.

De Brosses, C. 1756 *Histoire des Navigations aux Terres Australes* 2 vols. Paris. (Texual reference, e.g. De Brosses 1756: II: 37-42).

Kaeppler, A.L. 1963 Ceremonial masks: a Melanesian art style. *Journal of the Polynesian Society* **72** (2): 118-138.

Skwarko, S.K. 1968 Mesozoic. In: Geology of the Katherine-Darwin Region, Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics Bulletin* **82**: 105-116.

AUTHORS OFFPRINTS

Twenty-five offprints are provided free for each published paper. Additional offprints may be ordered when returning proofs.

SUBMISSION OF MANUSCRIPTS

Contributions, including the original and two copies of each manuscript, with copies of art work should be addressed to:

The Editor, *The Beagle*
Northern Territory Museum of Arts
and Sciences
P.O. Box 4646, Darwin, NT 5794
AUSTRALIA

The BEAGLE, Occasional Papers of the Northern Territory Museum of Arts and Sciences

Volume 3 **Number 1** **1986**

CONTENTS

GENERAL COMMUNICATION

BOOK REVIEWS